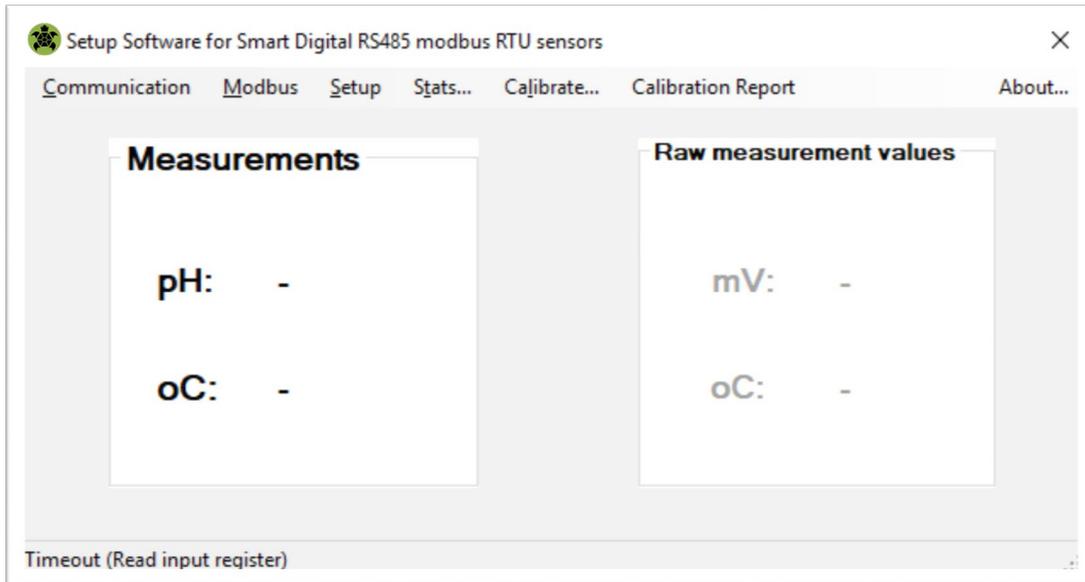


DSS Smart Digital RS-485 MODBUS RTU Sensor Setup & Calibration Windows Software Install and User Guide

Calibrate & Configure DSS Smart Digital RS-485 MODBUS RTU Sensors

Version 0.87



If no DSS sensor is connected there will be dash placeholders for the calibrated & Temperature Compensated Process Values as well as the raw absolute mV & °C values

INSTALLATION GUIDE

Welcome to the Turtle Tough Windows software package for calibration and setup of DSS smart digital RS-485 MODBUS RTU sensors. This software & guide are provided free of charge for use with the DSS series sensors. The DSS software installer is self explanatory & requires no license or registration code. To receive the software installer complete the form at: turtletoughsensors.com/downloads

There are **two requirements** to use this software with DSS calibration, setup and configuration software:

- 1) First, you must have a **Windows computer or tablet with a .NET framework 4.0 and a compatible operating system (OS)** AND an available USB port. Only these Windows operating systems are currently supported:
 - Windows 7 & Windows 7 SP1 or later
 - Windows 8 & Windows 8.1
 - Windows Server 2012
 - Window 10 Professional (Tested on Microsoft Surface Pro Tablet for Touchscreen Compatibility)

Windows 7 and above computers & tablets already have the .NET framework 4.0 (or higher compatible version) installed. If your computer does not already have it, the software installer will automatically prompt you to install this dependency.

- 2) You must have a means of powering the DSS sensor and converting the terminating male DSS4M quick connect plugs of the DSS sensor to tinned leads. There are a number of ways to accomplish this requirement. The Turtle Tough supplied NEMA4X rated DSS to Windows bridge box assembly is the most common option to achieve this. This assembly is available for use both in the lab or shop as well as out in the field with the portability package option. This DSS to Windows bridge box assembly receives the DSS4M quick connect plug termination of your DSS smart digital sensor via the installed DSS4FP female panel mount connect plug or as the input signal. Power is supplied to the DSS smart digital sensor via a 9V battery inside of the assembly that has been pre-wired into the installed DSS4FP female panel mount connect plug. This assembly contains the necessary industrial grade RS-485 to USB converter pre-wired into a QC6FP female panel USB quick connect plug which serves as the output signal. Connection to the Windows computer or tablet is made with a USB male "A" cable terminated with a QC6M quick connect plug to interface with the output port on the Windows bridge box.

Alternatively, DSS bridge box assemblies with integral power used to commission DSS sensors in the field can instead serve the purpose of energizing the sensor & receiving the DSS4M male quick connect plug. A mating RS-485 to USB converter (those with FTDI chipset recommended) will also need to be added if using this alternate approach to interface the sensors with this software.

HARDWARE INSTALLATION SEQUENCE TO INTERFACE DSS SENSOR TO SOFTWARE

1. Download and run installer for Smart RTU Sensor Software used for calibration, setup & configuration software on a supported Windows computers and tablets (see page 1 in this manual for details).
2. Connect USB male "A" to QC6M quick connect plug to output port on bridge box. The output port is labeled & keyed so that the sensor input and the USB output cable cannot be accidentally cross-wired.
3. Connect USB cable male "A" cable to Windows computer or tablet. The driver for the RS-485 to USB converter in the DSS to Windows bridge box assembly was loaded by the DSS installer.
4. Select COM port and baudrate in "Communication" menu (see page 4 in this manual for details)
5. Connect DSS series smart digital sensor to DSS4FP panel mount input port on bridge box. Sensor input port is labeled & keyed so the USB output cable cannot be accidentally connected.
6. Remove the protective cap from the sensor and rinse the tip with distilled or deionized water.
7. Place sensing tip in solution to be measured. Allow sufficient time for the temperature and reading to stabilize. If the sensor was removed from active hot/cold field service this might take significant time.
8. If the hardware installation was successful the calibrated and temperature compensated process readings and absolute raw mV and °C from the connector sensor will be shown in the main window display mode (see page 4 in this manual for details about this including an example screenshot).

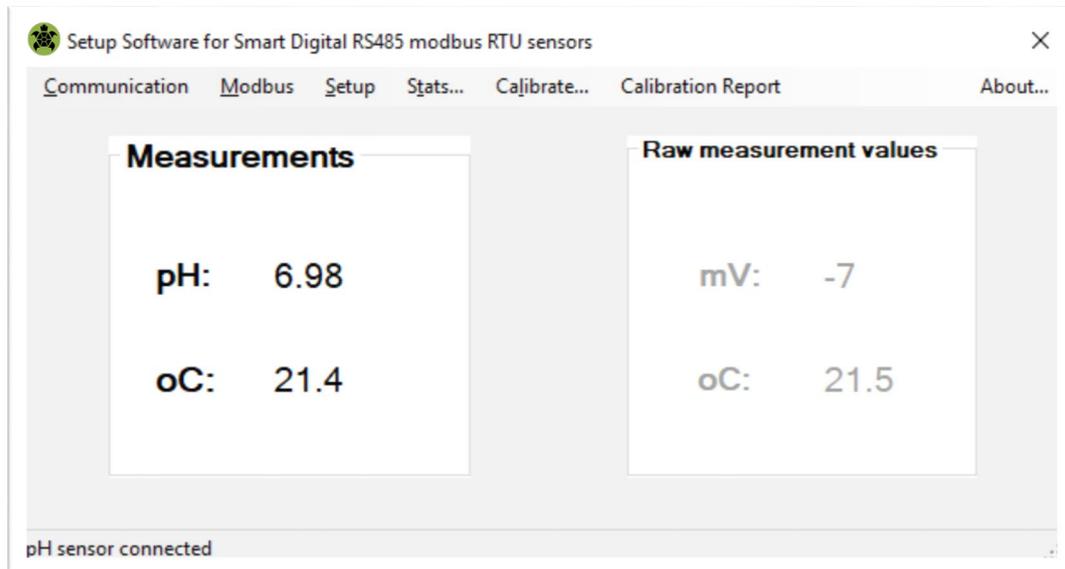
USER GUIDE

The Turtle Tough Setup for DSS Sensors Windows Software is specifically designed to be used with DSS smart digital RS-485 MODBUS RTU sensors. All functions performed by this software can also be accomplished with modbus function calls with the exception of setting the baudrate and node address. **The baudrate and node address can ONLY be modified by this Windows software.** All functionality detailed in this manual (excluding only changing of the baudrate and node address) can also be performed by the Turtle Tough supplied handheld battery powered field communicator (TT-HFC) or implementing the appropriate modbus function calls on a PLC. The Turtle Tough supplied DSS PLC touchscreen controller package that is a turn-key unit ready for plug and play commissioning with a robust software suite pre-programmed available for purchase or else any PLC of your choice can be programmed to accomplish the same features if you prefer.

As an overview, the software contains the following **menus** and **fields**, all of which are accessible starting with the main window once the application has been installed and launched.

MENUS (Top, left to right in the main window)	See page(s)
“Communication” menu <ul style="list-style-type: none"> • Select Port • Select Baudrate 	 4 4
“Modbus” menu <ul style="list-style-type: none"> • Show nodes • Select node • Assign Address • Reset Address • Setup nodes for Touchscreen DSS Controller 	 5 5 6 6 6
“Setup” menu <ul style="list-style-type: none"> • Setup Configuration, Download to Sensor & Save to File all user adjustable Parameter & Settings <ul style="list-style-type: none"> ○ For DSS Smart Digital pH Sensors ○ For DSS Smart Digital ORP Sensors 	 7-9 10
“Stats” menu <ul style="list-style-type: none"> • Snapshot of the current sensor status 	 11
“Calibrate” menu <ul style="list-style-type: none"> • Overview of Fields & Options • Temperature considerations for pH buffers • Setup pH Buffer References for Autoread Calibrations • Perform Calibrations on DSS Smart Digital pH Sensors • Summary of DSS pH Sensor Calibration Usage & Warnings • Perform Calibrations on DSS Smart Digital ORP Sensors 	 12 13-14 15-16 17 18 19
“Calibration Report” menu <ul style="list-style-type: none"> • Check • Print • Sample Certificate 	 20 20 21
“About” menu <ul style="list-style-type: none"> • Shows software revision and End-User License Agreement (EULA) 	 22-23

The menus and all available features there in are discussed in more detail in the following pages in the approximate order in which you will likely use them. The program loads to the main window from which the various menu options can be accessed. The calibrated and temperature compensated process readings as well as the raw absolute mV and temperature values will be displayed when a DSS smart digital sensor is connected, the COM port is properly configured and all cable & wiring connections are correct (see screenshot below).



“Communication” Drop-Down Menu

“Port” Submenu

Clicking on the “Port” submenu from the “Communication” drop-down will reveal all addressable COM port on the Windows PC or tablet on which this Setup Software for DSS sensors is installed. Please select the COM port to which your industrial grade USB to RS-485 converter has been assigned. The FTDI driver is automatically loaded by the software installer. The COM port shown as “VCPX” should be selected where X is some integer that the virtual COM port “VCP” driver has assigned to your USB to RS-485 device. Please allow about one minute after connecting this USB cable from the DSS to Windows bridge box assembly before starting the Setup Software for DSS sensors so that the Windows OS has sufficient time to assign this COM port. When the COM port is properly selected the engineered calibrated and temperature compensated process readings as well as the raw mV & temperature values will be shown from the connected DSS sensor. The USB cable for this connection for the industrial grade USB to RS-485 converter inside your DSS to Windows bridge box assembly is plug and play and so may be inserted and removed at will. Obviously the cable must stay connected for the entire time that the software is in use. Removing the cable and reinserting it may cause the virtual COM port assignment to change so please check that you COM port selection is correct from this communication menu each time.

“Baudrate” Submenu

Clicking on the “Baudrate” submenu from the “Communication” drop-down will reveal the option to select either the 19,200 kbps (default) baudrate or else the slower 9,600 kbps baudrate instead. It is important to recall that ALL devices on a RS-485 MODBUS RTU network MUST have the same baudrate to successfully communicate. In general the 19,200 kbps setting should be fine for most situations. Please contact the factory if you plan to use the 9,600 kbps for assistance. Note that this toggle between the 19,200 and 9,600 baudrates does not change the baudrate of the connected sensor but rather only selects which baudrate to use for communication with all nodes on the modbus network. It is best practice to write the baudrate on the label of the sensor for ease of tracking the sensor configuration.

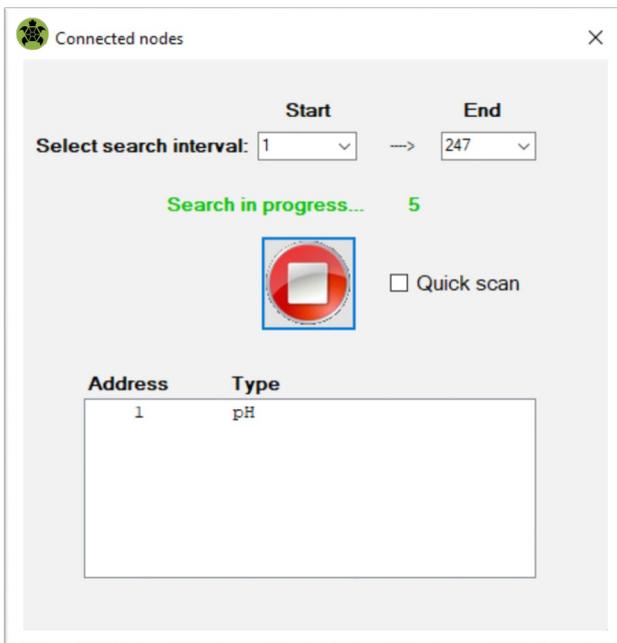
ONLY this Windows software can change the baudrate of the DSS smart digital RS-485 MODBUS RTU sensors by means of the “Setup” window that is detailed later in this manual. See page 7 of this manual for details in the “Setup” screen window.

“Modbus” Drop-Down Menu

“Show nodes” Submenu

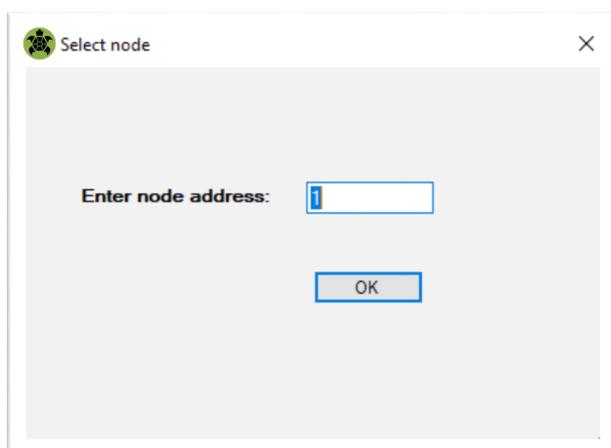
Clicking on the “Show nodes” submenu from the “Modbus” drop-down will launch a window that allows you to scan the modbus network for all DSS sensor nodes that are present. For each node detected the sensor type will be displayed. In the case that you are using sensors where the node address have been configured for use with the Turtle Tough supplied DSS touchscreen controller the “Quick Scan” mode can be used as this will scan for just the subset of nodes from 1-10, 41-50, 81-90, 121-130, 161-170 and 121-130 corresponding to the first 10 sensor types available for the channels 1, 2, 3, 4, 5 & 6 on the DSS touchscreen controller node configuration scheme (see manual for additional details). Clicking on any node address will select that node as the active one used in the software. It is best practice to write the baudrate on the label of the sensor for ease of tracking the sensor configuration.

ONLY this Windows software can change the node address of the DSS smart digital RS-485 MODBUS RTU sensors.



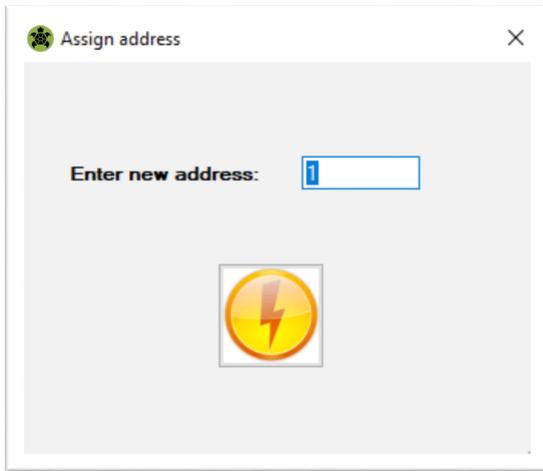
“Select node” Submenu

Clicking on the “Select node” submenu from the “Modbus” drop-down will launch a window that allows you to manually enter any node address as you wish (see screenshot below). This can be a quick way to navigate through the various connected nodes once they available options are determined by performing a “Show nodes” scan of the network. It is best practice to write the baudrate on the label of the sensor for ease of tracking the sensor configuration.



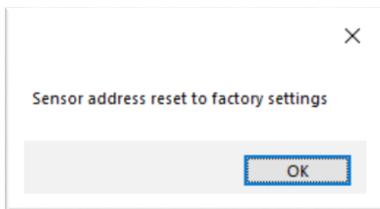
“Assign address” Submenu

Clicking on the “Assign address” submenu from the “Modbus” drop-down will launch a window that allows you to change the node address of the currently selected sensor. You may need to select the new node address in order to continue communication **ONLY this Windows software can change the node address of the DSS smart digital RS-485 MODBUS RTU sensors.**



“Reset address” Submenu

Clicking on the “Reset address” submenu from the “Modbus” drop-down for the selected node will redefine the address such that the node will be the same as the sensor type. That is to say that the node address after this reset node address call is made will be exactly the same as the sensor type. So for pH the sensor type is 1 and the node address would be reset to 1. Likely for the standard range ORP the sensor type is 2 and so the node address would be reset to 2. Lastly for the wide range ORP the sensor type is 3 and so the node address would be reset to 3.



Node Address Scheme when using mating with Turtle Tough Touchscreen DSS PLC Controller

When the DSS sensor is to be used with the Turtle Tough supplied Touchscreen DSS PLC Controllers then the node address **MUST** be set as defined in the table below. If the DSS sensor and controller are ordered as a paired set then the node addresses would be preset as defined below for each channel. Contact factory for assistance if there are any questions about properly setting up for the node address of your DSS sensor for any measurement channel.

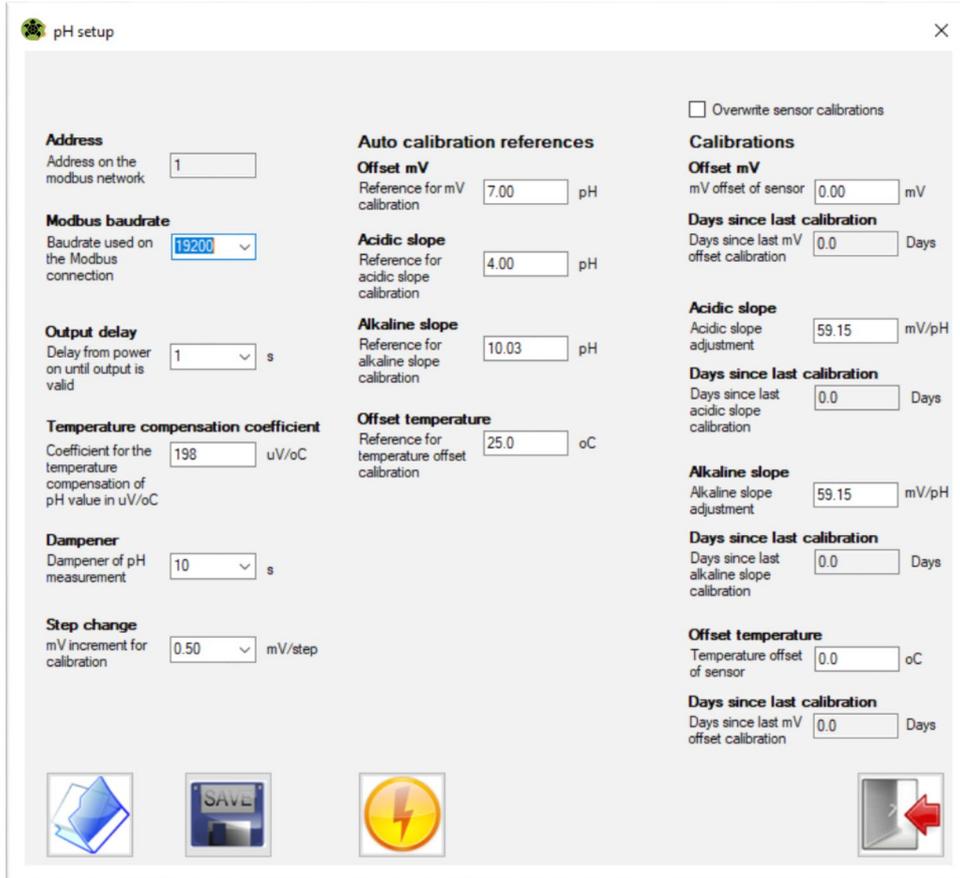
Channel #	1	2	3	4	5	6
Node Range	1-40	41-80	81-120	121-160	161-200	201-240
pH sensor	1	41	81	121	161	201
Standard ORP sensor	2	42	82	122	162	202
Wide Range ORP Sensor	3	43	83	123	163	203
Reserved for future DSS sensor types	4-40	44-80	84-120	124-160	164-200	204-240

NOTE: Quickscan mode in the “Show Nodes” window allows for searching for just the first ten DSS sensor types of each measurement channel for the DSS touchscreen controllers.

“DSS pH Setup” Menu

Part 1 of 3

Clicking on this menu will access the drop-down to select the DSS pH (shown below) or DSS ORP configuration screen. Although you can attempt to select any available sensor type from the drop-down, only the setup screen that is appropriate to your connected sensor type (pH or ORP) will successfully load. If unsure of the type of DSS sensor that you are connecting, this information can be found at the top of the “Stats” menu.



The values for your connected DSS sensor may differ from what is shown above depending upon the configuration that was performed at the Turtle Tough factory and/or your local distributor or agent. The assigned value or setting can be modified for any given parameter to an alternate choice within the permissible range or limits at any time as desired.

“Changing Baudrate”

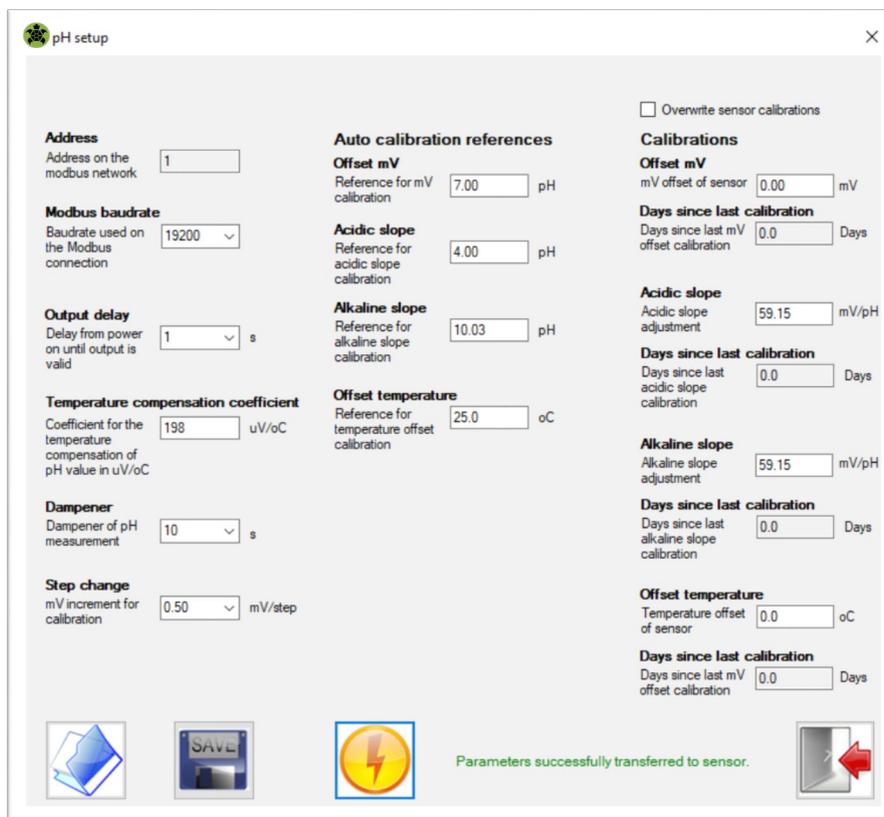
The baudrate of the connected DSS sensor can only be changed from this menu. If the menu shown above is also displayed on your computer then the baudrate that is currently selected is the valid one for the connected DSS sensor. In order to change the baudrate modify the choice to the other value and click on the flash icon to load. It is also a good idea to save this new configuration to file. It will then be necessary to modify the baudrate option in order to continue communication with the DSS sensor after the baudrate has been modified. It might be necessary power cycle the sensor and/or to restart the software for this baudrate change to take effect.

“Changing Output Delay”

The output delay variable is adjustable from the default (minimum) 1 second setting all the way up to 30 seconds. The default 1 second (min) setting is suitable for almost all continuous inline installations. In contrast, for some intermittent battery-powered installation it may be desirable to have a longer delay from boot before process values are sent to ensure that the receive data is a fully equilibrated reading. The delay from boot setting will defined the number of seconds after which the DSS sensor process readings will load onto this software after being connected.

“DSS pH Setup” Menu

Part 2 of 3



The screenshot shows the 'pH setup' menu with the following settings:

- Address:** 1
- Modbus baudrate:** 19200
- Output delay:** 1 s
- Temperature compensation coefficient:** 198 uV/oC
- Dampener:** 10 s
- Step change:** 0.50 mV/step
- Auto calibration references:**
 - Offset mV: 7.00 pH
 - Acidic slope: 4.00 pH
 - Alkaline slope: 10.03 pH
 - Offset temperature: 25.0 oC
- Calibrations:**
 - Offset mV: 0.00 mV
 - Days since last mV offset calibration: 0.0 Days
 - Acidic slope adjustment: 59.15 mV/pH
 - Days since last acidic slope calibration: 0.0 Days
 - Alkaline slope adjustment: 59.15 mV/pH
 - Days since last alkaline slope calibration: 0.0 Days
 - Temperature offset of sensor: 0.0 oC
 - Days since last mV offset calibration: 0.0 Days

At the bottom, there are icons for file operations and a green message: "Parameters successfully transferred to sensor."

“Changing Dampener”

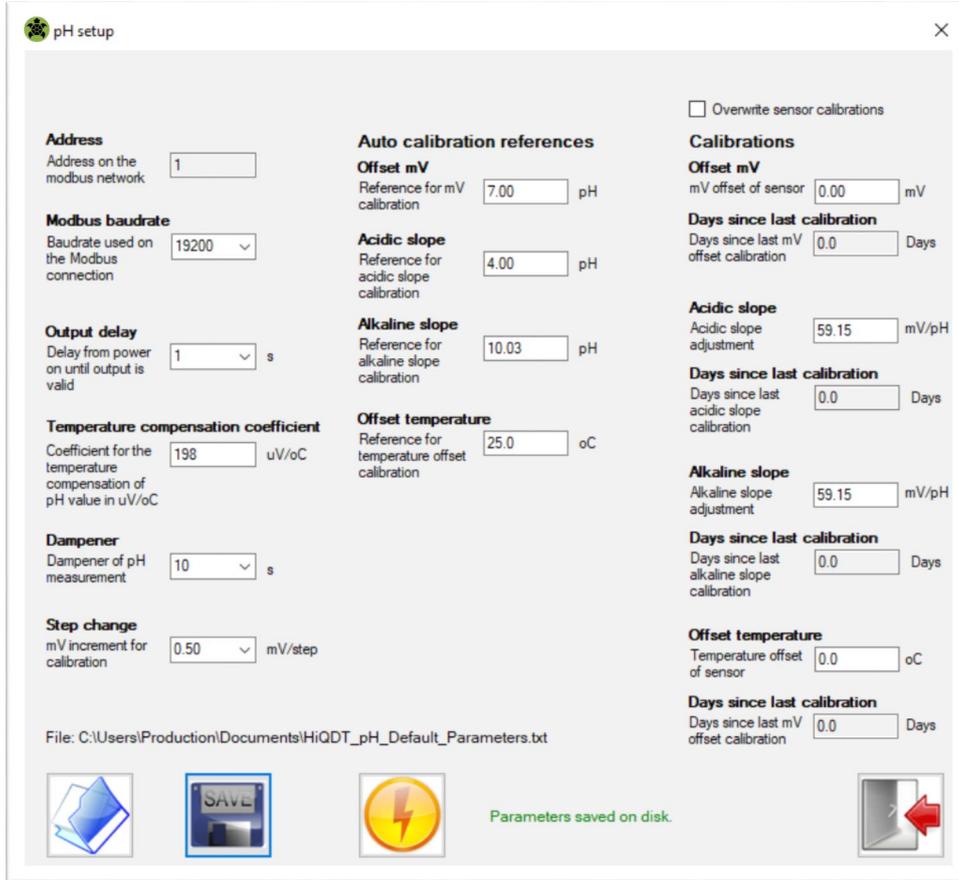
The dampener is a rolling time average of the raw data from the sensor. This setting is adjustable from the default 10 second setting all the way up to 30 seconds. The default 10 second is typically suitable for most all continuous inline installations and is prototype for industrial type process control setups. For some situations a shorter dampener may be desirable to make the sensor appear to be “faster”. A shorter dampener setting might be desirable for some high flow inline installations where process reading changes can occur very quickly. Alternatively the dampener can be adjusted to a higher value if the readings after to change to quickly for the process control scheme to handle. In reality the raw process readings will be exactly the same no matter the dampener setting selected but how they will appear from a process monitoring and/or control perspective will change and this can be quite useful to optimize the field use scheme.

The setup values for the DSS pH sensor configuration as shown in this menu above are the current working copy. The default 0.5 mV/step equates to ~0.01pH unit for each click of the button in manual calibration mode which is ideal for most situations. Likewise the default Nernstian value of 0.198mV per °C for the temperature compensation coefficient should not be changed (contact factory if you plan to use an experimentally determined non-Nernstian value). The values are loaded from the DSS pH sensor when it is first connected to the software. Changes made to the parameter settings & values will not be reflected in the connected sensor until the values are loaded using the “flash” icon. When current configuration on screen is loaded, a message indicating “Parameters successfully transferred to sensor” is briefly shown. It is best practice to save a configuration to file before loading it onto the connected DSS sensor for tracking purposes. It can be helpful to ensure that the parameter configuration filenames selected are intuitive and meaningful so that they can be readily differentiated and even recorded on the sensor label if desired for ease of field tracking purposes.

This configuration file can later be imported as a complete configuration to be loaded onto other DSS pH sensors to create a multiple DSS smart digital pH sensors with the same configuration. Alternatively the configuration files can be used for tracking the field installation settings of a given installation location over the course of time including the ability to revert to a previous setup if desired. In this second archival tracking type use, it is recommended to name the file in a logical manner to reflect the date the configuration file was created and the associated installation point in the plant.

“DSS pH Setup” Menu

Part 3 of 3



Address
Address on the modbus network: 1

Modbus baudrate
Baudrate used on the Modbus connection: 19200

Output delay
Delay from power on until output is valid: 1 s

Temperature compensation coefficient
Coefficient for the temperature compensation of pH value in uV/oC: 198

Dampener
Dampener of pH measurement: 10 s

Step change
mV increment for calibration: 0.50 mV/step

Auto calibration references

Offset mV
Reference for mV calibration: 7.00 pH

Acidic slope
Reference for acidic slope calibration: 4.00 pH

Alkaline slope
Reference for alkaline slope calibration: 10.03 pH

Offset temperature
Reference for temperature offset calibration: 25.0 oC

Overwrite sensor calibrations

Calibrations

Offset mV
mV offset of sensor: 0.00 mV

Days since last calibration
Days since last mV offset calibration: 0.0 Days

Acidic slope
Acidic slope adjustment: 59.15 mV/pH

Days since last calibration
Days since last acidic slope calibration: 0.0 Days

Alkaline slope
Alkaline slope adjustment: 59.15 mV/pH

Days since last calibration
Days since last alkaline slope calibration: 0.0 Days

Offset temperature
Temperature offset of sensor: 0.0 oC

Days since last calibration
Days since last mV offset calibration: 0.0 Days

File: C:\Users\Production\Documents\HiQDT_pH_Default_Parameters.txt

Parameters saved on disk.

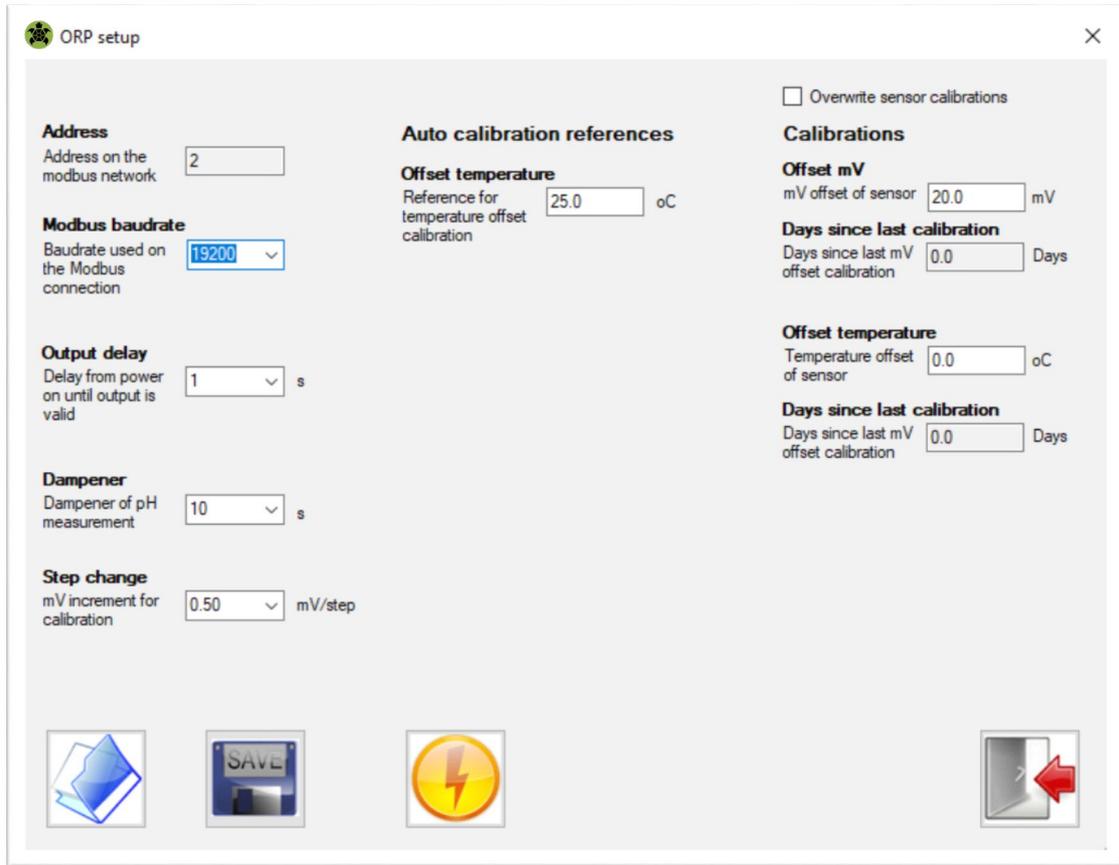
Shown above is a screen where the values for each parameter from this setup menu are saved to a setup configuration file in ASCII text format. The file extension should be *.txt and the location where this file is saved is shown in the window. When the configuration is saved a message indicating “Parameters saved on disk” will be briefly shown. The various uses of this configuration are described in the preceding page.

If you desire to load a different configuration on your DSS smart digital RS-485 MODSBU RTU pH sensor than what is presently loaded and displayed on this DSS pH setup window from a previously prepared configuration this can be done by selecting the “open” file icon. From this dialog box select the configuration file of your choice that you wish to load. The Turtle Tough factory may request that the currently employed configuration to be emailed for support and diagnostic purposes. The ability to save the DSS sensor configuration to a text file through this menu facilitates this type of remote support capability to assist with optimization and troubleshooting of your field setup.

The DSS configuration system provides systematic & advanced management of the your field installations without the high cost and complexity of the HART®, Profibus or FOUNDATION™ fieldbus digital protocols. In addition, the DSS smart digital sensors employ the royalty free RS-485 MODBUS RTU digital communications allowing for very simple commissioning and extensive compatibility with any PLC that can act as the RS-485 MODBUS RTU master where the sensors are always the RS-485 MODBUS RTU slaves. The MODBUS protocol allows for the flexibility to add or remove nodes at will. In addition the use of the digital MODBUS communications is often helpful avoid any potential ground loops issues in facilities with problematic electrical issues. The DSS configuration system allows for detailed tracking of both the setup for each installation point in a simple and low-cost manner. Saving configuration files including the date in the filename allows for archival tracking of any changes to the setup used for that sensor or installation location.

When completed with this menu simply click on the “exit” icon to return back to the main menu.

“DSS ORP Setup” Menu



The screenshot shows the 'ORP setup' menu with the following parameters and values:

- Address:** Address on the modbus network: 2
- Modbus baudrate:** Baudrate used on the Modbus connection: 19200
- Output delay:** Delay from power on until output is valid: 1 s
- Dampener:** Dampener of pH measurement: 10 s
- Step change:** mV increment for calibration: 0.50 mV/step
- Auto calibration references:** Offset temperature: Reference for temperature offset calibration: 25.0 °C
- Calibrations:**
 - Offset mV: mV offset of sensor: 20.0 mV
 - Days since last calibration: Days since last mV offset calibration: 0.0 Days
 - Offset temperature: Temperature offset of sensor: 0.0 °C
 - Days since last calibration: Days since last mV offset calibration: 0.0 Days

At the bottom of the menu, there are four icons: a folder icon, a 'SAVE' button, a lightning bolt icon (flash), and a right-pointing arrow icon.

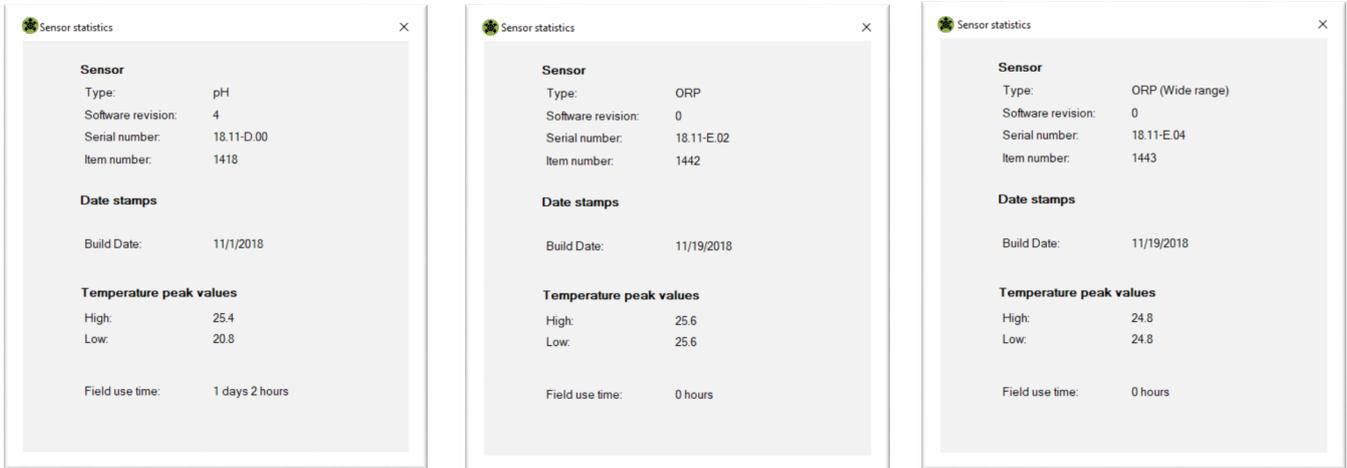
While all of the comments and notes from the preceding three pages for the setup of the DSS pH sensors there are naturally some differences owing to the nature of the ORP versus pH sensor type. For example the ORP measurement is not temperature compensated. While the ORP is in fact very temperature dependent (much more than for pH) there exists no systematic or universal temperature compensation scheme that can be employed since each particular system will have its own behavior.

The typical DSS ORP setup values as shown in this menu above are a working copy. The values were initially loaded from the connected DSS ORP sensor. The particular values for your sensor may vary depending upon how it was setup at the Turtle Tough factory and/or if any changes were made after time of dispatch. All of the values for each parameter can be modified as desired within the boundary condition limits detailed in the documentation. Standard DSS ORP sensor has a range of -1,000 to +1,000mV while the wide range DSS ORP sensor measures from -2,000 to +2,000 mV. The DSS ORP setup can be saved as a file or else an existing previously saved configuration can be loaded just as with the DSS pH setup. Any of the parameter settings and values may be changed as desired but these changes will not be reflected in the connected sensor until the values are loaded using the “flash” icon. When the configuration is loaded a message indicating “Parameters successfully transferred to sensor” will be briefly shown.

The DSS configuration system provides systematic & advanced management of your field installations without the high cost and complexity of the HART®, Profibus or FOUNDATION™ fieldbus digital protocols. In addition, the smart digital DSS sensors employ the royalty free RS-485 MODBUS RTU digital communications allowing for very simple commissioning and extensive compatibility with any PLC that can act as the RS-485 MODBUS RTU master where the sensors are always the RS-485 MODBUS RTU slaves. The MODBUS protocol allows for the flexibility to add or remove nodes at will. In addition the use of the digital MODBUS communications is often helpful avoid any potential ground loops issues in facilities with problematic electrical issues. The DSS configuration system allows for detailed tracking of both the setup for each installation point in a simple and low-cost manner. Saving configuration files including the date in the filename allows for archival tracking of any changes to the setup used for that sensor or installation location.

When completed with this menu simply click on the “exit” icon to return back to the main menu.

DSS pH & DSS ORP “Stats” Menu



An explanation for each field in this Windows “Stats” menu is below along with a description of that parameter. None of the fields in this menu can be modified. The information shown is to provide as a “snapshot” of the connected sensor. To share a screen of this “Stats” menu simply click on the window with your mouse and then use the “Alt+PrintScreen” key sequence on your keyboard. This will capture an image of this “Stats” menu as you see it on your screen and allow you to copy it into a document or email to send for support & collaboration purposes. This information is also contained in the calibration report that can be produced from this software. The Turtle Tough factory or agent may request a screenshot of this “Stats” menu to assist with any support questions regarding field commissioning or maintenance questions.

Sensor Statistics

Type:

- Software Revision:
- Serial Number:
- Item Number:

pH, standard ORP or wide range ORP depending upon connected sensor
Per firmware that has been loaded onto your DSS digital sensor board
For complete traceability of the individual sensor through the service life-cycle
Completely defines all features and capabilities of given sensor

Date Stamps

- Dispatch from Factory:

When the DSS smart digital pH or ORP sensor was shipped

- 1-year shelf-life warranty begins from this date

Temperature Peak Values

- High:
- Low:

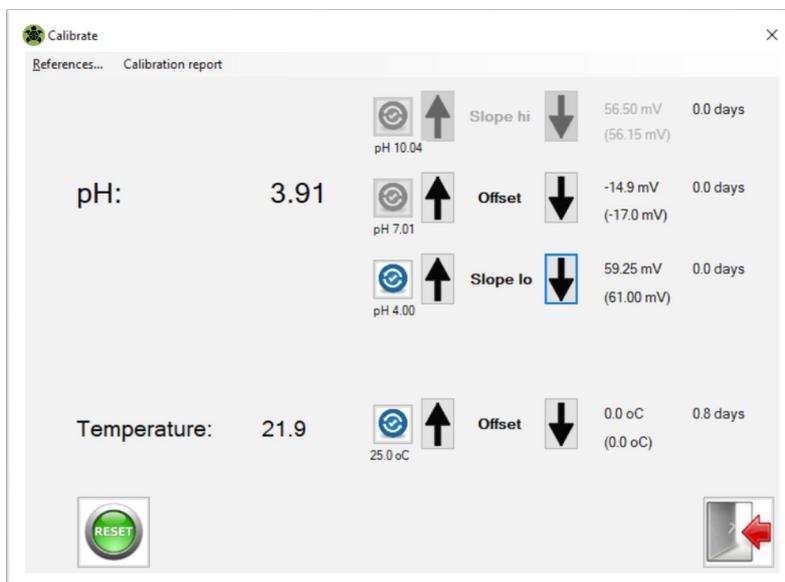
Highest temp experienced by sensor after dispatch from factory when energized
Lowest temp experienced by sensor after dispatch from factory when energized

Field Use Time

- Integral Time Tracking:
-

The total time DSS sensor has been energized after dispatch from factory

DSS pH “Calibrate” Menu Overview of Fields & Options



Clicking on the “Calibrate” menu loads the screen shown above when a DSS pH sensor is connected. The temperature compensated pH reading as well as the temperature reading is displayed based upon the current calibrations for the connected sensor. Before performing a calibration click on the “References” menu to allow you to configure the autocalibration buffer scheme to be employed for your connected DSS series smart digital DSS pH sensor. The setup of the buffer calibration scheme is critical to achieving an optimal measurement result and discussed in depth in subsequent sections with best practice recommendations. The best practice calibration procedures for various types of pH measurement installations are also detailed in later sections of manual.

Overview of Display Fields

Displayed **pH:** and **Temperature:** values shown are computed based upon the current calibration values as shown on the far right. Calibration values displayed upon launch in this window are loaded from the connected sensor. The values on the lower line in (parantheses) are the factory calibrations. The current calibration and time since this calibration was last performed are shown in the upper line without parantheses. When a autoread or manual calibration is performed in the session, then the time since last calibration will change to zero confirming that this calibration was performed.

Reset Calibrations

Clicking on the green “Reset” button will reset the calibrations for the connected sensor back to those from the factory. These factory default calibrations values are shown in (parantheses).

Display of Exact pH Values for offset (a.k.a. Asymmetric Potential), Acid Slope & Alkaline Slope Buffers Selected

As discussed later in this manual, the exact pH values for each buffer is a function of temperature. Based upon the temperature value obtained from the connected sensor the exact pH value for the selected buffer is computed and used as the basis for performing the autoread calibration. The “Up” and “Down” buttons are clicked to performed manual calibrations in steps defined by the user adjustable mV step per button whereas the autoread calibrations are performed by clicking on the blue icon next to the calibration type to be performed.

Slope Calibrations:

The DSS pH stores both an acid slope and alkaline slope. This means that a separate slope calibration is stored for acidic (below pH7) and alkaline (above pH7) conditions. You must perform a slope calibration in both an acidic and an alkaline pH buffer to ensure calibrated readings for both the below 7 and above 7 pH conditions in measurement.

“Grab Sample” Calibration

The DSS pH sensor can be adjusted to agree with an offline laboratory determined value for any given process solution. Such adjustment should always be done in the ‘Offset’ mode after all pH buffer calibrations are performed.

Temperature Considerations for Calibrating pH Sensors with pH Buffers

Part 1 of 2

Exact pH Values of the NIST Traceable pH buffers at Various Temperatures
Nominal pH Buffer Designation @ 25°C Shown in Gray at Top of Column

Temp °C	1.68	4.00	6.86	7.00	9.18	10.01	12.45
0	1.67	4.01	6.98	7.11	9.46	10.32	13.42
5	1.67	4.00	6.95	7.08	9.39	10.25	13.21
10	1.67	4.00	6.92	7.06	9.33	10.18	13.00
15	1.67	4.00	6.90	7.03	9.28	10.12	12.81
20	1.68	4.00	6.88	7.01	9.23	10.06	12.63
25	1.68	4.00	6.86	7.00	9.18	10.01	12.45
30	1.68	4.01	6.85	6.98	9.14	9.97	12.29
35	1.69	4.02	6.84	6.98	9.10	9.93	12.13
40	1.69	4.03	6.84	6.97	9.07	9.89	11.98
45	1.70	4.04	6.83	6.97	9.04	9.86	11.84
50	1.71	4.06	6.83	6.97	9.02	9.83	11.71
55	1.72	4.07	6.83	6.97	8.99	9.80	11.57
60	1.72	4.09	6.84	6.98	8.97	9.78	11.45

NIST traceable pH buffers are the most commonly used methods for calibration of industrial pH sensors. On each pH buffer bottle is written the exact pH value of the buffer at variety of temperature conditions. Listed above are the exact pH values for the most commonly used pH buffers between 0 and 60 °C. When using the Turtle Tough Windows DSS Digital System Setup & Calibration Software for calibration of your DSS series Smart Digital type RS-485 MODBUS RTU pH sensors you should use the autocalibration mode if using the pH buffers detailed above. If using any pH buffer other than those shown above you will need to obtain the exact pH value for the current temperature condition. This information is typically provided on the label of the pH buffer.

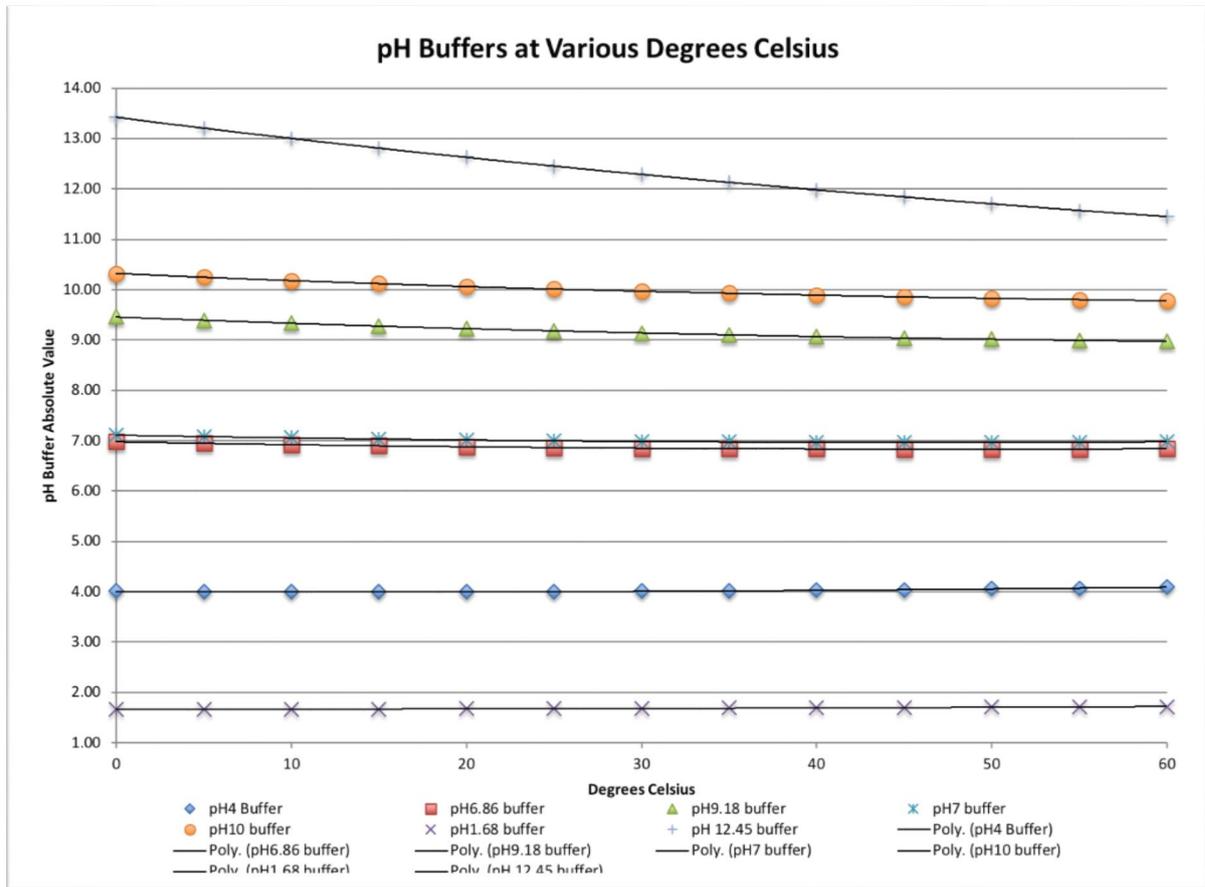
NOTE: This Windows software automatically corrects for the temperature induced change to compute the exact pH value of the buffer automatically when pH sensor calibrations are performed with the autocalibration mode. This exact pH value of the buffer at the current temperature obtained from the connected DSS pH sensor is displayed in the calibrate menu. This may differ from the nominal value of the buffer at the reference 25°C condition.

To use any pH buffer besides 1.68, 4.00, 6.86, 7.00, 9.18, 10.01 or 12.45 you will need to account for the temperature induced shift of the pH value for the buffer in both the Windows software as well as any other devices used to perform calibrations of the DSS pH sensors. There are no reliable pH buffers below 1.69 and above 12.45 and so specialized and custom calibration schemes needed to be used for these situations. Contact factory for assistance in such cases.

Inquire to the factory if you plan to measure consistently below pH=1.0 or above pH=13.0 for special assistance. As can be seen from mere inspection the temperature dependence of high pH buffers is much more significant than for low pH buffers. Similarly for process solutions with high pH the temperature induced pH dependence may be quite significant and should be considered when trying to control such systems with fluctuating temperature. Process solutions with relatively weak ionic strength (low conductivity) are also rather prone to higher temperature induced pH shifts whereas process solution with relatively high ionic strength (high conductivity) are less prone to temperature induced pH shifts.

Temperature Considerations for Calibrating pH Sensors with pH Buffers

Part 2 of 2



The DSS Windows software automatic calibration mode computes the exact values of the pH 1.68, 4.00, 6.86, 7.00, 9.18, 10.01 and 12.45 buffers in the automatic calibration mode for anywhere between 0 to 60°C. If calibrating with pH buffers in the temperature condition below 0°C or above 60°C automatic calibration mode cannot be used (manual mode must be used instead). This Windows software can also perform manual calibration to any pH value for Offset, Slope Low (Acidic) or Slope High (Alkaline). In this way this DSS Windows software is not limited to pH 1.68, 4.00, 6.86, 7.00, 9.18, 10.00 and 12.45 buffers for calibration but rather can perform offset and slope calibrations to any value desired.

Temperature compensation only accounts for the change in the mV response of the pH sensor itself with temperature. The type of temperature induced shifts such as those demonstrated in the table above for the pH buffers are NOT corrected in default Nernstian temperature compensation scheme. For process solutions the change in the pH value with temperature can be significantly more pronounced than for pH buffers which are inherently designed to shift in only the most minimal way due to changes in temperature, dilution, evaporation and other typical conditions in field use. Thankfully the DSS pH sensors allow for a user defined temperature compensation coefficient to account for the NET temperature effects. The temperature impact on the pH sensor and the temperature impact on the measured solution cannot be cleanly separated (deconvoluted). It is, however, possible to determine the effective net mV per °C change and enter this as a custom temperature compensation coefficient.

Contact the Turtle Tough factory for assistance with such situations requiring special temperature compensation schemes. The default temperature compensation setting is the classical Nernstian 198µV (0.198mV) per °C with the allowable range of 000-999 µV to support most any custom value for your given process installation situation. The temperature compensation coefficient can be changed from the "Setup" screen.

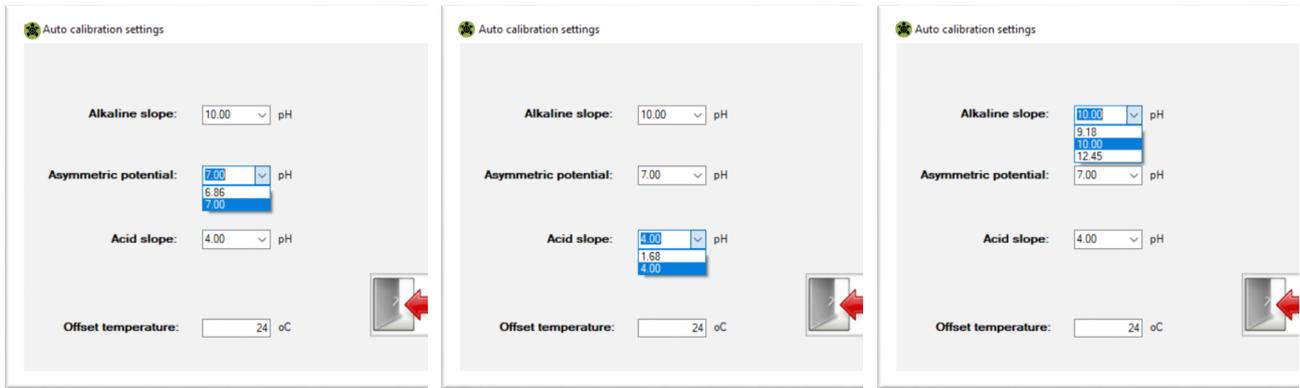
DSS pH “Calibrate” Menu

Buffer Setup schemes for Autocalibration

Part 1 of 2

Available pH Buffers for Autocalibration Mod

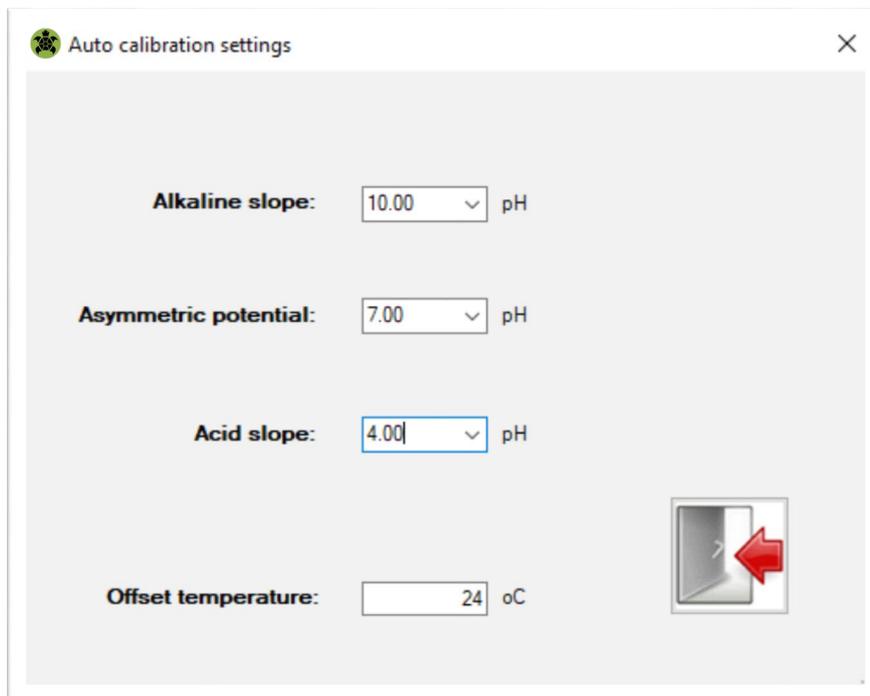
(see drop-downs shown below)



The reference temperature value is not selected from a drop down but rather is entered into the appropriate field.

Calibration Scheme 1

Typical for most installations in the USA

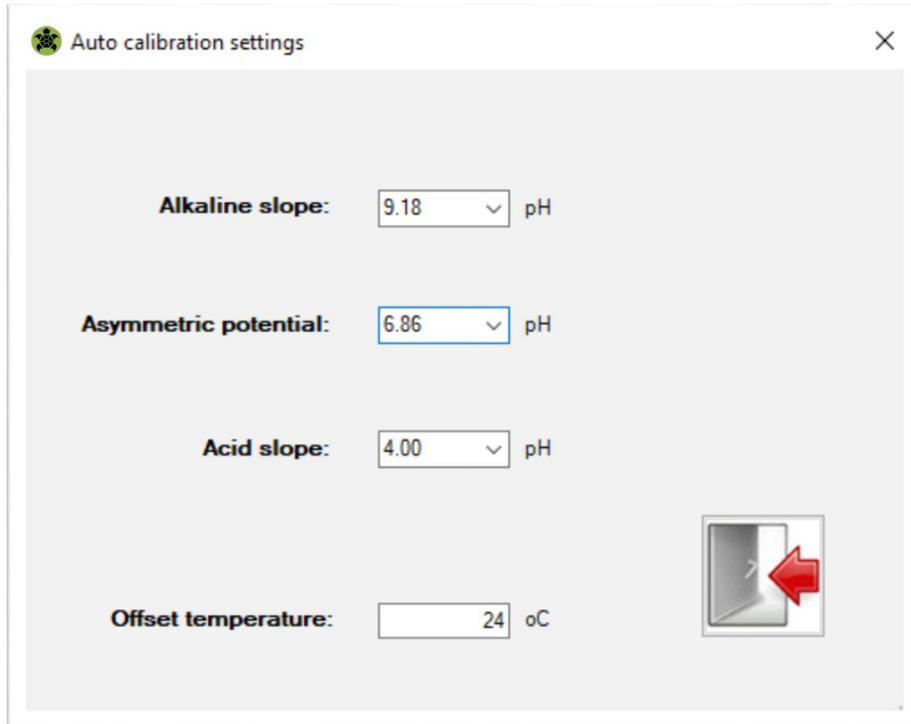


This scheme is the most common pH buffer scheme for most customers in the USA. The 10.01 pH buffer must be used carefully since it is more prone to shifting substantially more than the very stable 4.00 or even the 7.00 pH buffer. Intrusion of carbon dioxide into the 10.01 pH buffer from the atmosphere is the main culprit creating an erroneous non-temperature

induced shift in pH by exceeding the buffer capacity. Care should be taken that the pH10 buffer is fresh to ensure reliable alkaline slope calibration results.

Calibration Scheme 2

Typical for most installations in Europe



Auto calibration settings

Alkaline slope: 9.18 pH

Asymmetric potential: 6.86 pH

Acid slope: 4.00 pH

Offset temperature: 24 °C

Typical values for most European pH installations are 4.00, 6.86 and 9.18 pH buffers. This is the best practice pH buffer scheme for most pH measurements that do not commonly go much below pH 4.00 and or else much above pH 9.20. The 6.86 & 9.18 pH buffers are most stable than the 7.00 & 10.01 pH buffer counterparts but are still more prone to shifting than the very stable 4.00 pH buffer.

Care should be taken that the pH 9.18 buffer is fresh to ensure best alkaline slope calibration results

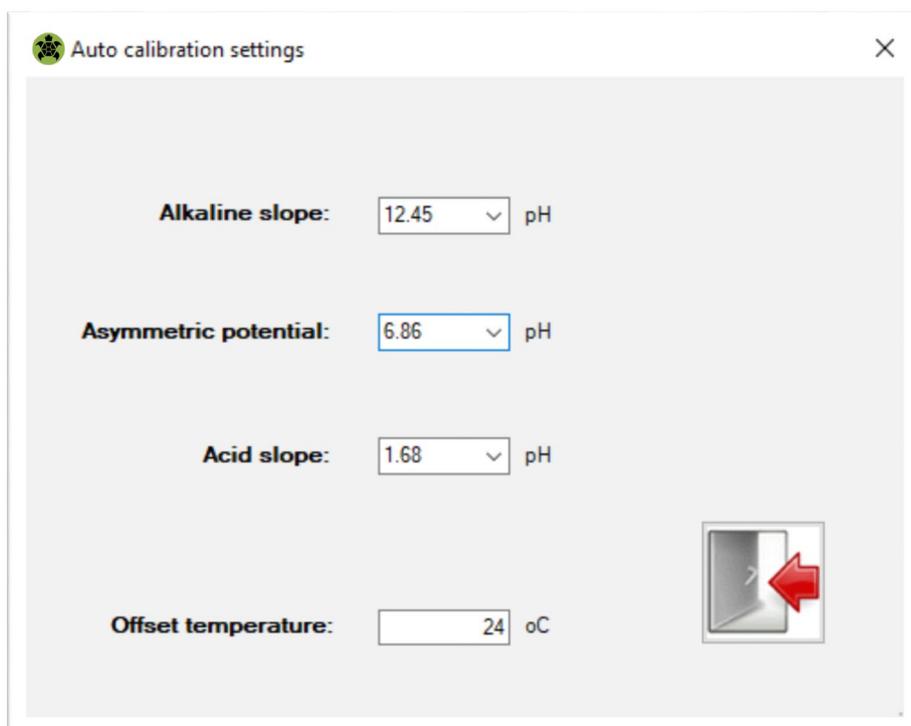
DSS pH “Calibrate” Menu

Buffer Setup schemes for Autocalibration

Part 2 of 2

Calibration Scheme 3

For batch style installations where pH can vary quite considerably



The screenshot shows a dialog box titled "Auto calibration settings" with a close button (X) in the top right corner. It contains four settings, each with a label, a value in a text box, and a unit:

- Alkaline slope:** 12.45 pH
- Asymmetric potential:** 6.86 pH
- Acid slope:** 1.68 pH
- Offset temperature:** 24 °C

At the bottom right of the dialog, there is a small icon of a box with a red arrow pointing to the right.

This pH buffer calibration scheme is typical for batch type process applications that often go below pH2 and above pH12. The 1.69 and 6.86 pH buffers are quite stable but the 12.45 pH buffer shifts in value quite easily. Great care should be taken when using the 12.45 pH buffer to ensure accurate results. In particular this buffer should always be in code, well stored in a cool dry place and not exposed to light or air. Make sure that the 12.45 pH buffer is always fresh to ensure reliable alkaline slope calibrations results.

Temperature Offset Calibration Setup for Autoread

The autoread value for the temperature offset calibration is entered in the same “References” window as where the three pH buffer values are selected from the drop-down choices. **Selection of the reference temperature should always be done FIRST** as it is necessary to properly compute the exact pH values of the buffers used to ensure optimal calibration results.

It is best practice to wait until the temperature reading on the sensor is no longer moving before selecting the setup temperature and starting calibration(s) with pH buffers. The temperature of the sensor may take some time to reach the ambient conditions of the pH buffer solution(s) if it was previously installed into field service at conditions that are significantly below or above the ambient temperature.

General Best Practice Comments for Calibration with pH Buffers

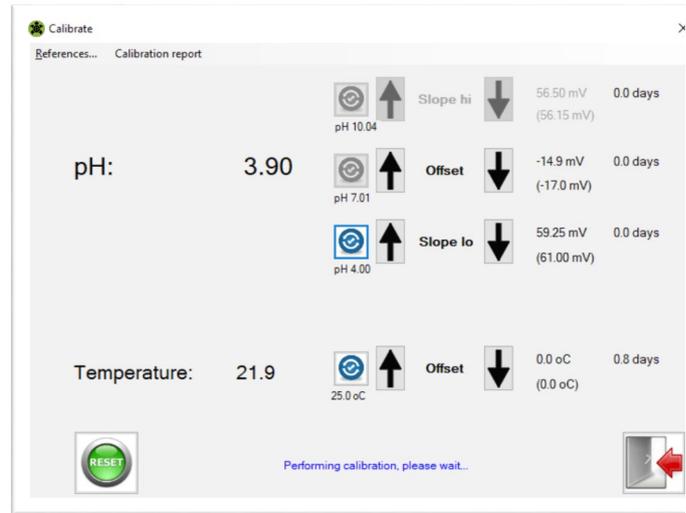
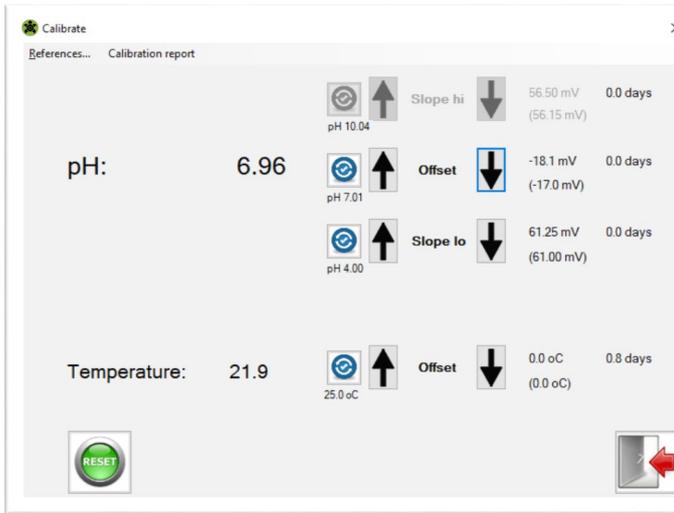
Only the amount of buffer required for the given calibration should be dispensed. Buffers should not be reused to avoid dilution & cross-contamination. Buffers should not be left exposed to air or direct light for prolonged periods of time to avoid the impact of dissolved carbon dioxide from the atmosphere and other potential decomposition pathways.

Special care should be taken the pH buffers above 7.00 are always fresh when used for calibrations as these tend to lose the integrity of their values much faster than pH buffers below 7.00. Buffers should be stored in a cool, dry location away from light and chemicals. The pH sensor should be at a stable ambient temperature before performing any calibration.

DSS pH “Calibrate” Menu Perform Temperature & pH Calibrations

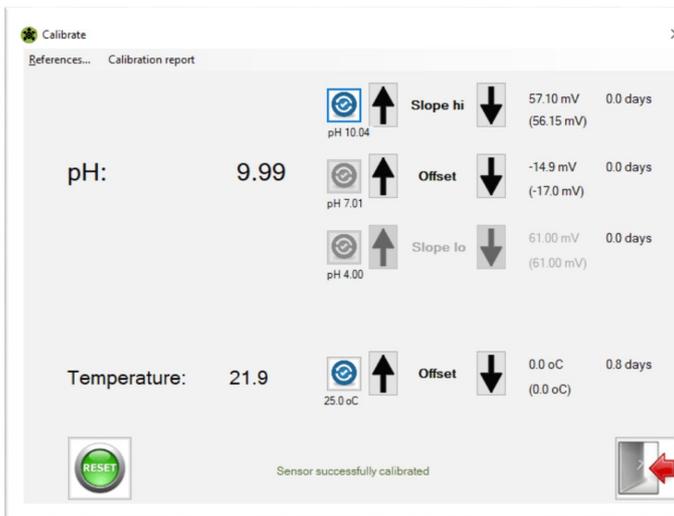
Summary of correct sequence for calibration of DSS pH Sensor with Buffers.

1. Select the three pH buffers to be used to perform the calibration (see pages 15 & 16)
2. Perform pH ‘Offset’ Calibration (Autoread or Manual) **THIS CALIBRATION MUST BE DONE FIRST!**
3. Perform pH ‘Slope lo’ Calibration (Autoread or Manual)
4. Perform pH ‘Slope hi’ Calibration (Autoread or Manual)
5. If desired, perform adjustment for agreement with laboratory reference value of process grab sample with pH ‘Offset’ mode. Account for all temperature induced effects if this last step is performed.



Step 1 Perform the pH buffer “Offset” calibration near pH7

Step 2 Perform the “Slope Lo” calibration in the acidic range



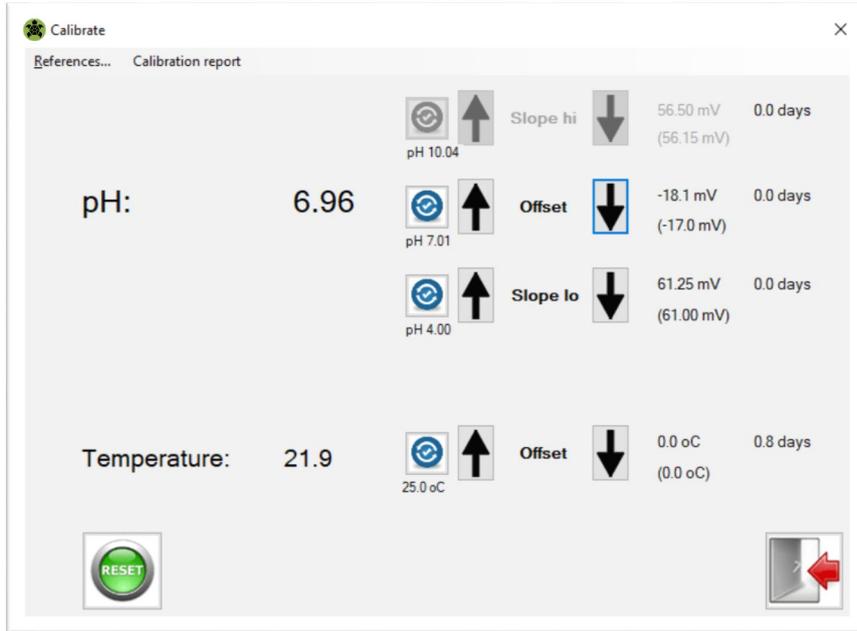
Step 3 – Perform “Slope Hi” calibration in the alkaline range

General Note

The user adjustable dampener is always on when viewing the pH reading. Always wait until reading is stable and settled before proceeding to the next calibration step.

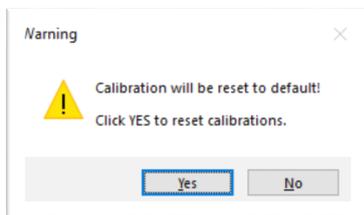
- Temperature stability of both the sensor & measured solution is required for good calibration of pH sensor. Sensor temperature should be stable and the same as ambient condition for best results. **Temperature offset calibration (if it is performed) should always be done BEFORE ALL pH buffer calibrations.**
- Manual calibration is done by clicking on the ‘Up’ or ‘Down’ buttons until the desired value is achieved. Each time a button is clicked a new calibration is performed in units of the adjustable mV step setting.
- Automatic calibration (a.k.a. autoread) is done by clicking on the blue icon next to the calibration to be performed. The software will not allow any other actions while this autoread calibration is in process. “Performing calibration, please wait...” will display when the autocalibration is occurring.
- If the autoread calibration is successful then “*Sensor successfully calibrated*” notification is displayed for a brief period of time. After waiting for dampener time, reading will adjust to the exact pH value of buffer.

DSS pH “Calibrate” Menu Summary of Usage & Warnings

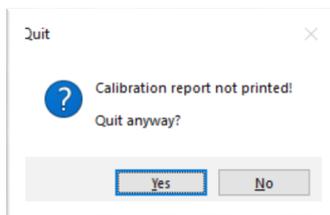


Upon successful autoread pH buffer calibration then “*Sensor successfully calibrated*” is briefly displayed. The time since last calibration will change to zero if either an autoread or manual calibration is performed.

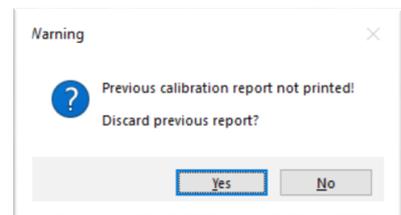
ⓘ WARNINGS



Warning to confirm calibrations reset to time of dispatch from the factory which are shown in (parentheses)

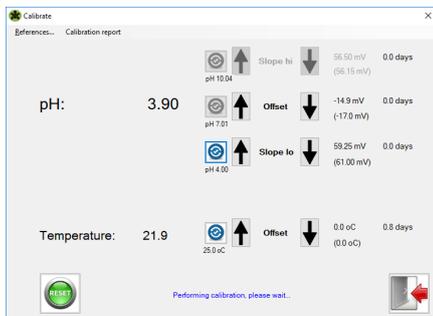


Warning upon quitting without printing calibration certificate.

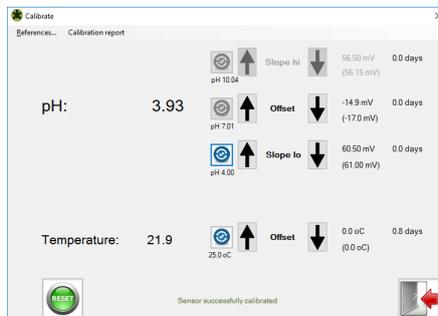


Warning if new calibration session is started without printing certificate for the previous calibration session

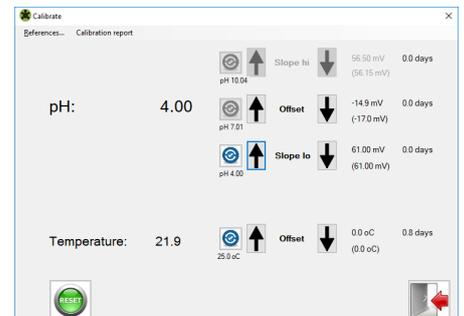
AUTOREAD CALIBRATION STAGES



When autoread calibration is initiated, “*Performing calibration, please wait...*” shown while stability test is performed.

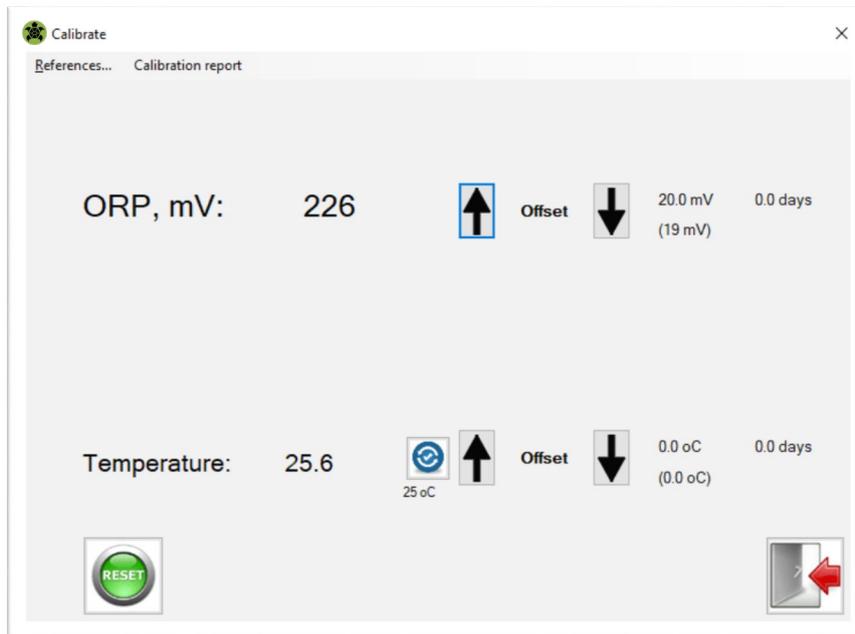


If autoread calibration is completed, “*Sensor successfully calibrated*” is shown for a period of time as confirmation.



Reading will change to exact pH of buffer at current temperature in the number of seconds set for dampener.

DSS ORP “Calibrate” Menu Perform & Load Temp. & ORP mV Offset Calibrations



Clicking on the “Calibrate” menu loads screen above when DSS ORP standard or wide-range sensor is connected. The calibrated ORP (mV) and temperature reading is displayed based upon the current calibrations for the connected sensor.

Overview of Display Fields

Displayed **ORP, mV:** and **Temperature:** values shown are computed based upon the current calibration values as shown on the far right. Calibration values displayed upon launch in this window are loaded from the connected sensor. The values on the lower line in (parentheses) are the factory calibrations. The current calibration and time since this calibration was last performed are shown in the upper line without parentheses. When a calibration is performed in the session, then the time since last calibration will change to zero confirming that this calibration was performed.

Reset Calibrations

Clicking on the green “Reset” button will reset the calibrations for the connected sensor back to those from the factory. These factory default calibrations values are shown in (parentheses).

Exact ORP Value for Calibration

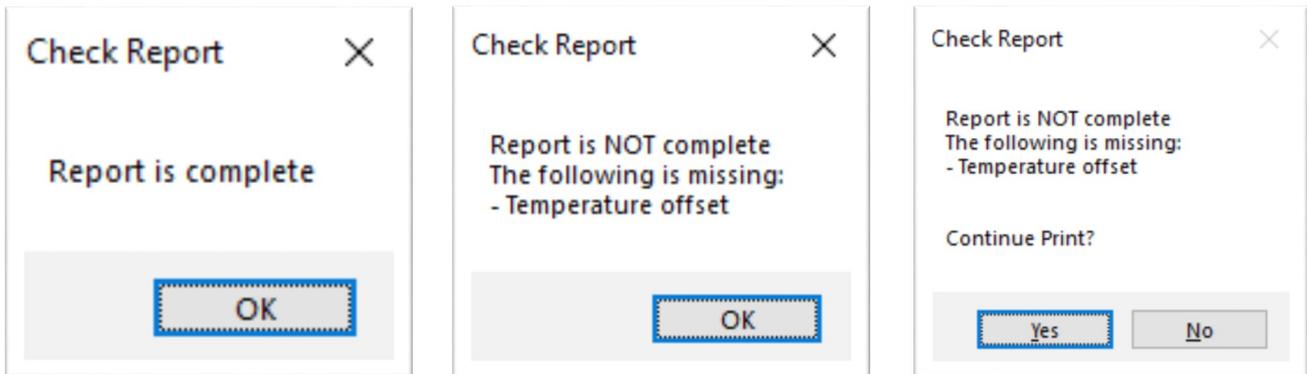
The ORP value for each solution is a function of temperature. Based upon the temperature value obtained from the connected sensor find the appropriate mV value to which you should adjust the ORP sensor for calibration for the standard solution that is used. The “Up” and “Down” buttons are clicked to performed calibration in steps defined by the user adjustable mV step per button parameter. The ORP sensors can only undergo an offset type calibration (no slope calibrations are possible for ORP sensors).

General Notes

- Temperature stability of both the sensor and measured solution is required for good calibration of ORP sensor.
- Sensor temperature should be stable and the same as ambient condition for best results.
- Offset calibration for ORP can also be used to adjust the reading to a laboratory grab sample reference value. This is done by leaving the sensor in service and adjusting from the connected PLC or handheld communicator. It is also possible to use this Windows software to perform this adjustment of the inline value to an offline determined grab sample value using the Windows bridge box with portability option and a suitable field ready Windows laptop.
- Contact Turtle Tough factory for assistance to choose the best ORP standard solution and procedures for your application.

DSS pH & DSS ORP “Calibration Report” Menu

Each time that a calibration session is initiated a working copy of the relevant sensor information is stored for purposes of creating a calibration report certificate. If a previously calibrated session had been done and the certificate was not printed a warning will be shown that the previous sensor information will be wiped out and replaced with that from the currently connected sensor (see page 18 for screenshot). Likewise if you attempt to exit the calibration window without printing the calibration report certificate a warning will also be displayed (also see page 18 for the screenshot). The calibration report certificate can either be printed from within the Calibrate window or else accessed directly from the main window. There are two tasks that can be performed. The first is to run a “Check Report” to see if all calibration tasks have been performed. As an example of this “Check Report” task the screenshot shows that all tasks with the exception of the temperature offset calibration have been performed. When printing the same check is always run automatically as well resulting in a similar warning message if some of the calibrations tasks have not been performed.



The calibration report certificate details the following information:

Sensor Description and Analytics

Sensor Type, Sensor Item Number, Sensor Serial Number, Sensor Manufacture Date
MODBUS Node Address, Baudrate, Total Days in Use, Min Temp in Use, Max Temp in Use

Sensor Calibrations

- Temperature Offset Calibrations (Factory, Previous and Current Values)
Time Since Last Temperature Offset Calibration was Performed
- mV Offset Calibrations (Factory, Previous and Current New Values) → a.k.a. Asymmetric Potential (A.P.) for pH Sensors
Time Since Last Temperature Offset Calibration was Performed
- Slope for Acidic Measurements Calibration – pH Only (Factory, Previous and Current Values)
Time Since Last Temperature Offset Calibration was Performed
- Slope for Alkaline Measurements Calibration – pH Only (Factory, Previous and Current Values)
Time Since Last Temperature Offset Calibration was Performed
- Time & Date New Calibration Performed (Windows Time Stamp)

It is recommended to print calibration report certificate to PDF for archival storage as well as sharing and collaboration. The report has been tested to print cleanly onto a single page for A4 or US Letter paper. Any suitable PDF print driver will allow you to print to PDF this certificate. If a PDF print driver is not installed contact your system administrator (many Windows 10 machines come with a Microsoft provided PDF driver installed as part of the core OS).

Many free options are available to allow for printing to PDF such as pdfforge (www.pdfforge.org). When saving to PDF the default filename will be the sensor type + serial number + time date stamp for systematic naming of the calibration report. If for any reason this default filename is now displayed it is recommended to use the same type of scheme when manually creating a filename. In the next page an example calibration certificate is provided for illustration purposes.

When completed with this menu simply click on the “exit” icon to return back to the main menu.

Turtle Tough Windows Setup Software for DSS Smart Digital MODBUS Sensor License Agreement

Version 1.2 December 2018

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