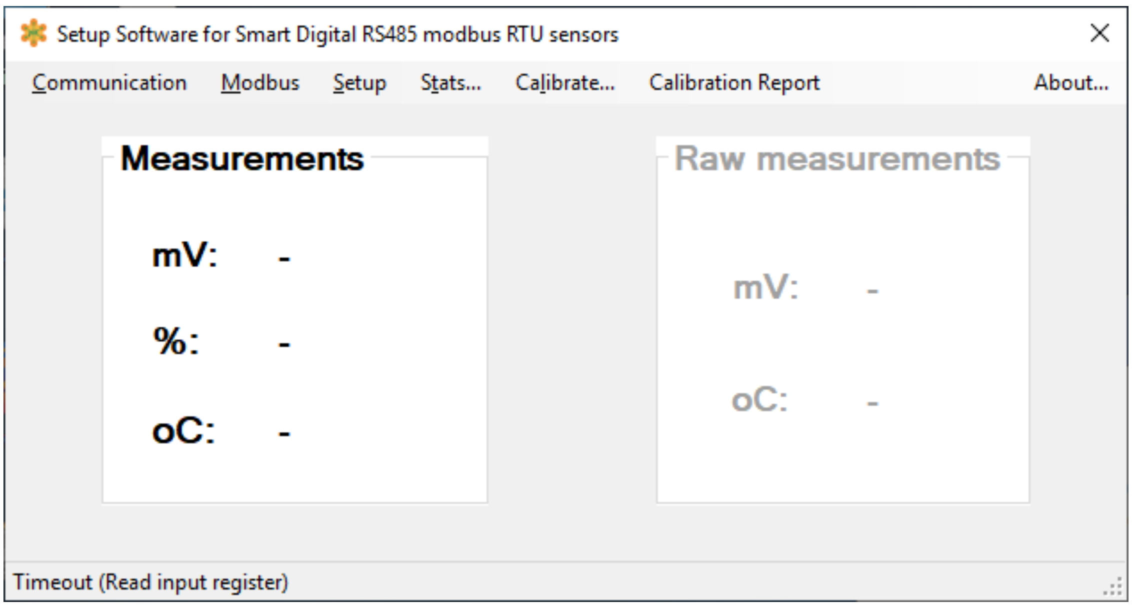
HiQDT Smart Digital RS-485 MODBUS RTU Sensor Setup & Calibration Windows Software Install and User Guide

Calibrate & Configure IOTRON™ & ZEUS ™
Smart Digital HiQDT RS-485 MODBUS RTU Sensors

Version 1.43



If no HiQDT sensor is connected there will be dash placeholders for the Calibrated & Temperature Compensated Process Value(s) as well as the raw absolute mV & ℃ values

INSTALLATION GUIDE

Welcome to the ASTI Windows software package for calibration and setup of HiQDT smart digital RS-485 MODBUS RTU sensors. This software & guide are provided free of charge for use with the HiQDT IOTRON™ & ZEUS™ series sensors. The HiQDT software installer is self explanatory & requires no license or registration code. To receive the software installer complete the form at the following URL:

http://www.astisensor.com/cgi-bin/ttx.cgi

There are **two requirements** to use this software with HiQDT 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) Your must have a means of powering the HiQDT sensor and converting the terminating male HiQ4M snap connector of the HiQDT sensor to tinned leads. There are a number of ways to accomplish this requirement. The ASTI supplied NEMA4X rated HiQDT 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 HiQDT to Windows bridge box assembly receives the HiQ4M snap connector termination of your IOTRON™ smart digital sensor via the installed HiQ4F female panel mount connector as the input signal. Power is supplied to the IOTRON™ smart digital HiQ sensor via a 9V battery inside of the assembly that has been pre-wired into the installed HiQ4FP female panel mount connector. This assembly contains the necessary industrial grade RS-485 to USB converter pre-wired into a Q6FP female panel USB snap connector which serves as the output signal. Connection to the Windows computer or tablet is made with a USB male "A" cable terminated with a Q6M snap connector to interface with the output port on the HiQ to Windows bridge box. Find below a link to download additional details about this HiQ to Windows bridge box hardware assembly:

http://www.astisensor.com/Windows_Interface_Bridge_Box_for_Smart_Digital_HiQ_Sensors.pdf

Alternatively, HiQDT bridge box assemblies with integral power used to commission HiQDT sensors in the field can instead serve the purpose of energizing the sensor & receiving the HiQ4M male snap connector. 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. See pages 6 to 13 of the field installation guide linked below:

http://www.astisensor.com/HiQDT_MODBUS_Smart_Digital_Sensor_Field_Installation_Guide.pdf

HARDWARE INSTALLATION SEQUENCE TO INTERFACE HiQDT 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 Q6M snap connector 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 HiQDT to Windows bridge box assembly was loaded by the HiQDT installer.

4) Select COM port and baudrate in "Communication" menu (see page 4 in this manual for details)

5) Connect IOTRON™ series smart digital HiQDT sensor to HiQ4F 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 deionzied 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.

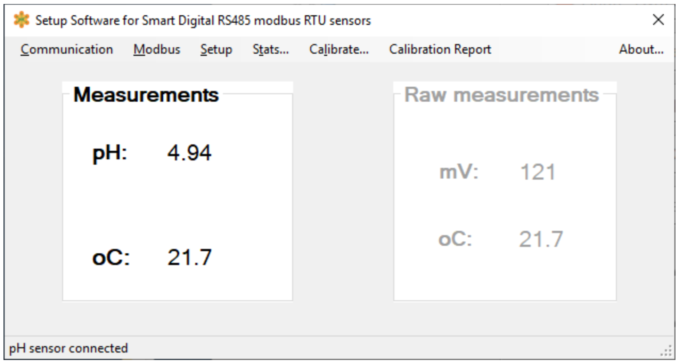
8) If the hardware installation was successful the calibrated and temperature compensated process readings and absolute raw mV and °C from the connector sensor will be shown in the main window display mode (see page 4 in this manual for details about this including an example screenshot).

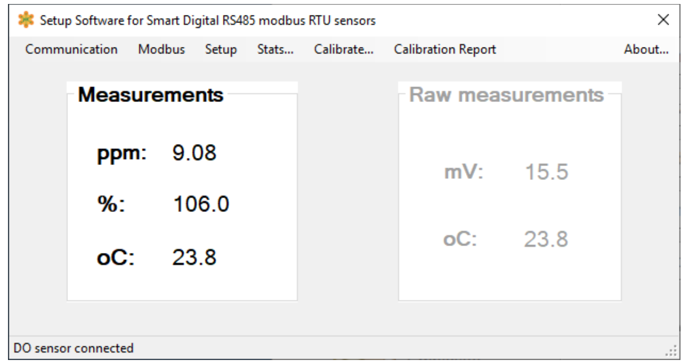
USER GUIDE

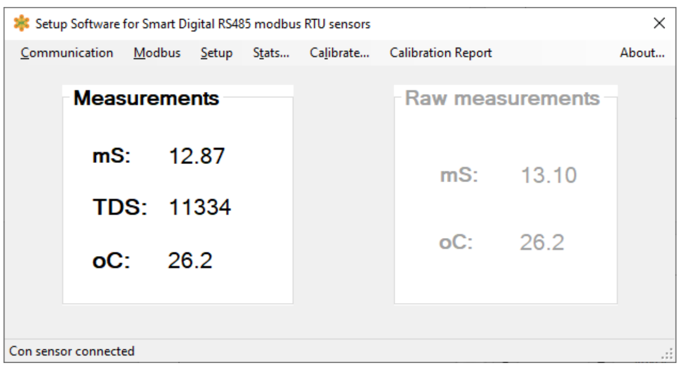
The ASTI Setup for HiQDT Sensors Windows Software is specifically designed to be used with IOTRON™ & ZEUS™ series smart digital RS-485 MODBUS RTU sensors. All functions performed by this software can also be accomplished with modbus function calls with the exception of setting the baudrate and node address. **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 ASTI supplied handheld battery powered communicator or implementing the appropriate modbus function calls on a PLC. The ASTI supplied HiQDT 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.

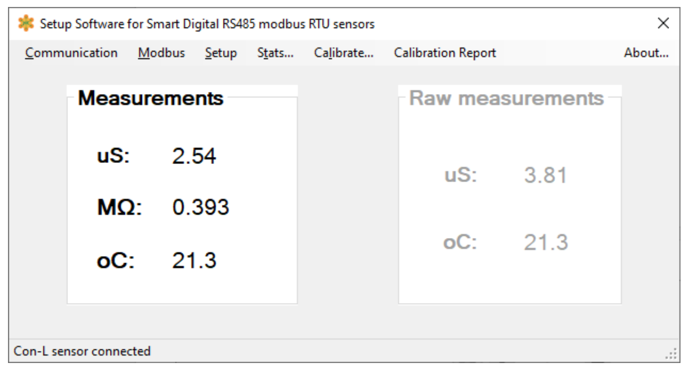
As an overview, the software contains the following **menus** and **fields**, all of which are accessible starting with the main window once the application has been installed and launched.

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 or mS/µS and temperature values will be displayed when a sensor is connected, provided that the COM port is properly configured and all cable & wiring connections are correct. In addition you must have chosen the correct baudrate and node address for the sensor that is connected. If the node address is not known use the search feature to determine the node of the connected sensor. Screens below reflect when a pH, dissolved oxygen (DO), standard/high range and ultralow range conductivity type sensor are connected (sensor type shown in bottom left). Screens would look slightly different when the standard or wide-range ORP or ion selective (ISE) sensors are connected reflecting what is appropriate for those measurement types.









"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 HiQDT 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 HiQDT to Windows bridge box assembly before starting the Setup Software for HiQDT 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 HiQDT sensor. The USB cable for this connection for the industrial grade USB to RS-485 converter inside your HiQDT 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 if no communication exists with sensor when the software is started.

"Baudrate" Submenu

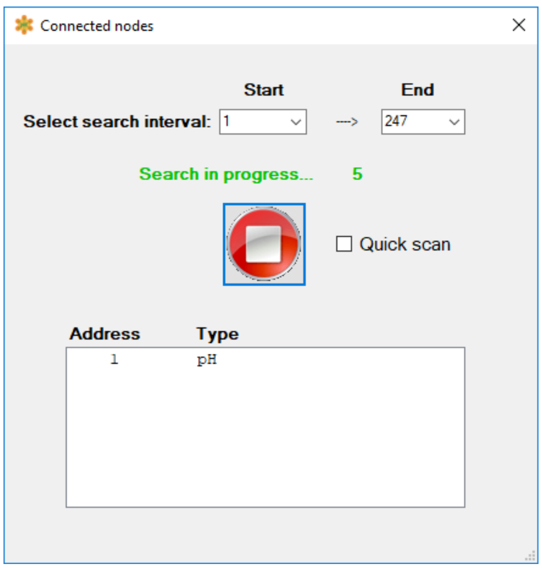
Clicking on the "Baudrate" submenu from the "Communication" drop-down will reveal the option to select either the 19,200 kbps (default) baudrate or else the slower 9,600 kbps baudrate instead. It is important to recall that ALL devices on a RS-485 MODBUS RTU network MUST have the same baudrate to successfully communicate. In general the 19,200 kbps setting should be fine for most situations and is the recommended baudrate to use barring some special circumstances.

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 HiQDT smart digital RS-485 MODBUS RTU sensors by means of the "Setup" window that is detailed later in this manual.**

"Modbus" Drop-Down Menu

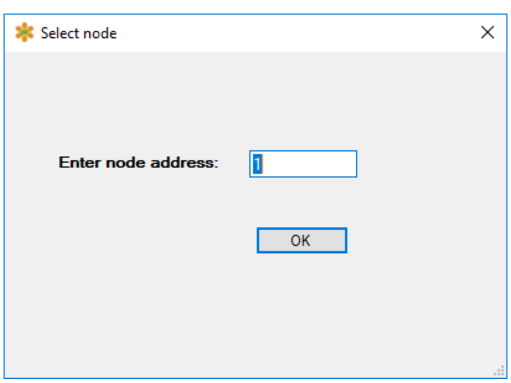
"Show nodes" Submenu

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 HiQDT sensor nodes that 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 ASTI supplied HiQDT 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 HiQDT 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. **<u>ONLY</u> this Windows software & the Handheld Communicator (HHC) can change node address of the HiQDT smart digital RS-485 MODBUS RTU sensors.**



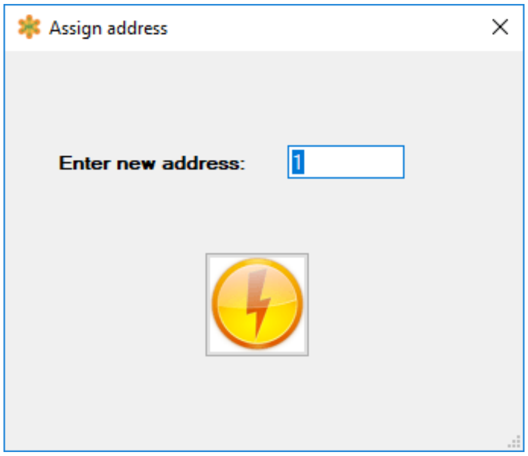
"Select node" Submenu

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.



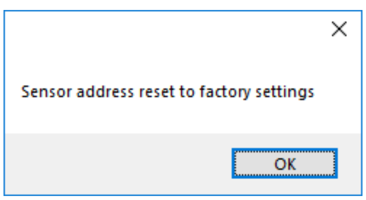
"Assign address" Submenu

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 <u>**ONLY**</u> **this Windows software and the Handheld Communicator (HHC) can change the node address of the HiQDT 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 ASTI Touchscreen HiQDT PLC Controller

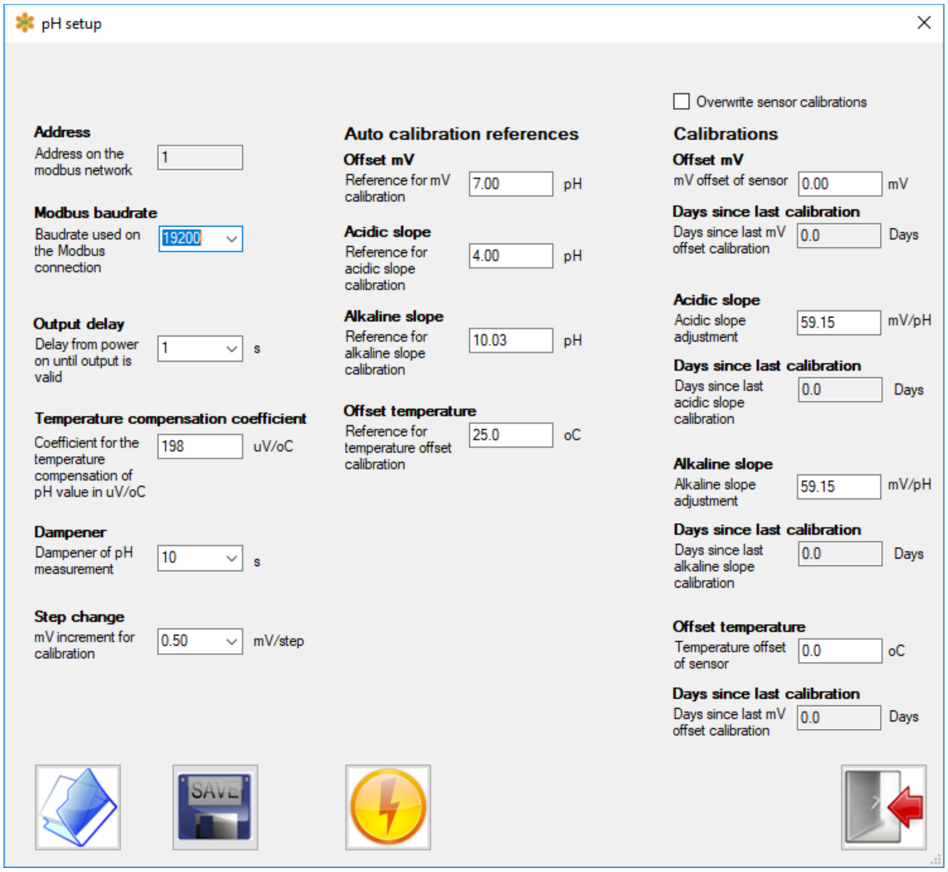
When the HiQDT sensor is to be used with the ASTI supplied Touchscreen HiQDT PLC Controllers then the node address MUST be set as defined in the table below. If the HiQDT sensor and controller are ordered as a paired set then the node addresses would be preset as defined below for each channel. Contact factory for assistance if there are any questions about properly setting up for the node address of your HiQDT 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
Dissolved Oxygen Sensor	4	44	84	124	164	204
Ion Selective (ISE) Sensor	5	45	85	125	165	205
Conductivity (EC) Sensor	6	46	86	126	166	206
Reserved for future HiQDT sensor types	7-40	47-80	87-120	127-160	167-200	207-240

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

"HiQDT-pH Setup" Menu – Part 1 of 3

Clicking on this menu will access the drop-down to select the HiQDT-pH (shown below), HiQDT-ORP, HiQDT-DO or HiQDT-ISE 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 will successfully load. If unsure of the type of HiQDT sensor that you are connecting, this information can be found at the top of the "Stats" menu.



The values for your connected HiQDT sensor may differ from what is shown above depending upon the configuration that was performed at the ASTI 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.

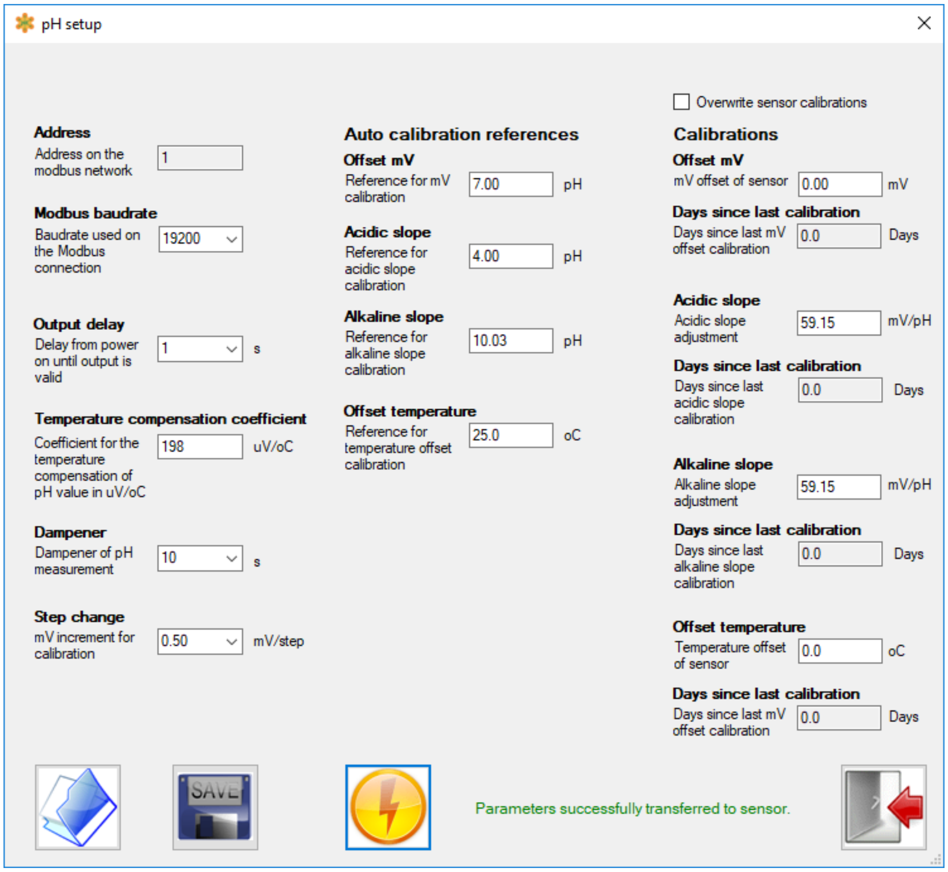
"Changing Baudrate"

The baudrate of the connected HiQDT 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 HiQDT 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 HiQDT 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 contast, 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 HiQDT sensor process readings will load onto this software after being connected.

"HiQDT-pH Setup" Menu – Part 2 of 3



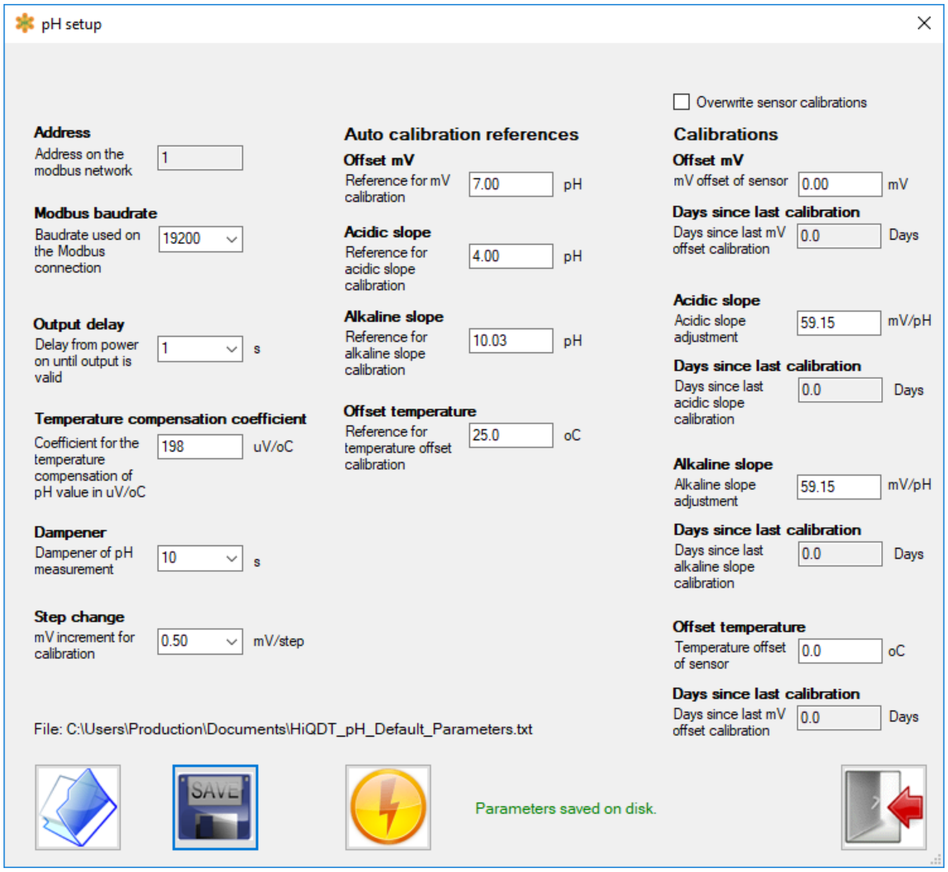
"Changing Dampener"

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 processreadings 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 HIQDT-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-Nerstian value). The values are loaded from the HiQDT 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 HiQDT 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 HiQDT-pH sensors to create a multiple 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.

"HiQDT-pH Setup" Menu – Part 3 of 3



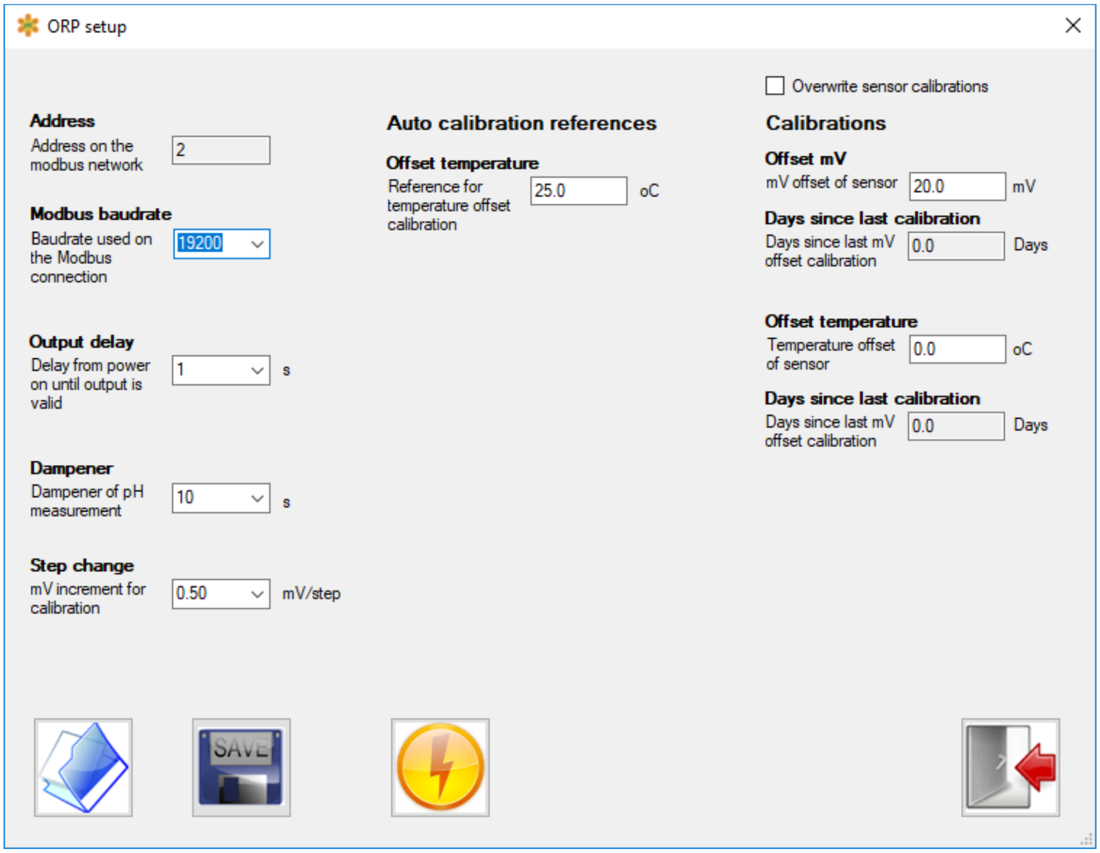
Shown above is a screen where the values for each parameter from this setup menu are saved to a setup configuration file in ASCII text format. The file extension should be *.txt and the location where this file is saved is shown in the window. When the configuration is saved a message indicating "Parameters 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 IOTRON™ HiQDT series smart digital RS-485 MODSBU RTU pH sensor than what is presently loaded and displayed on this HiQDT-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 ASTI factory may request that the currently employed configuration to be emailed for support and diagnostic purposes. The ability to save the HiQDT 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 HiQDT 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 smart digital HiQDT 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 MOBUDS communications is often helpful avoid any potential ground loops issues in facilities with problematic electrical issues. The HiQDT 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.

"HiQDT-ORP Setup" Menu



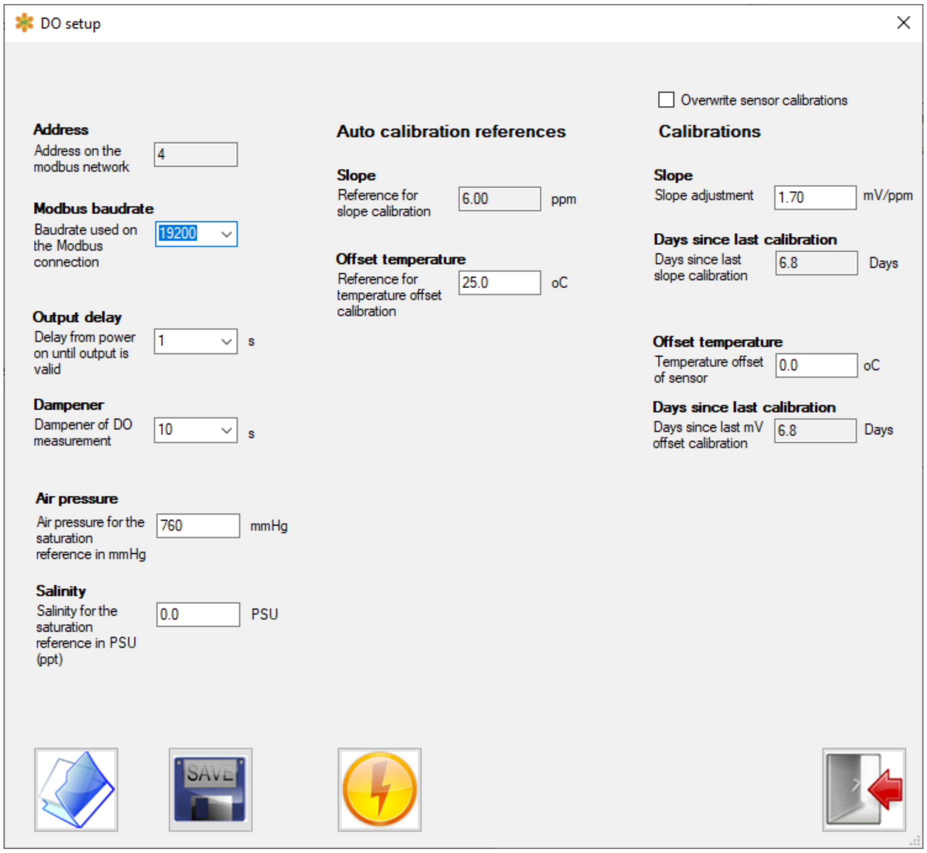
While all of the comments and notes from the preceding three pages for the setup of the HiQDT-pH sensors are generally also applicable to the setup of the HiQDT-ORP sensors there are naturally some differences owing to the nature of the ORP versus pH sensor type. For example the ORP measurement is not 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 on behavior.

The typical HiQDT-ORP setup values as shown in this menu above are a working copy. The values were initially loaded from the connected HiQDT-ORP sensor. The particular values for your sensor may vary depending upon how it was setup at the ASTI 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 HiQDT ORP sensor has a range of -1,000 to +1,000mV while the wide range HiQDT ORP sensor measures from -2,000 to +2,000 mV. The HiQDT-ORP setup can be saved as a file or else an existing previously saved configuration can be loaded just as with the HiQDT-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 HiQDT 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 smart digital HiQDT 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 MOBUDS communications is often helpful avoid any potential ground loops issues in facilities with problematic electrical issues. The HiQDT 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.

"HiQDT-DO Setup" Menu



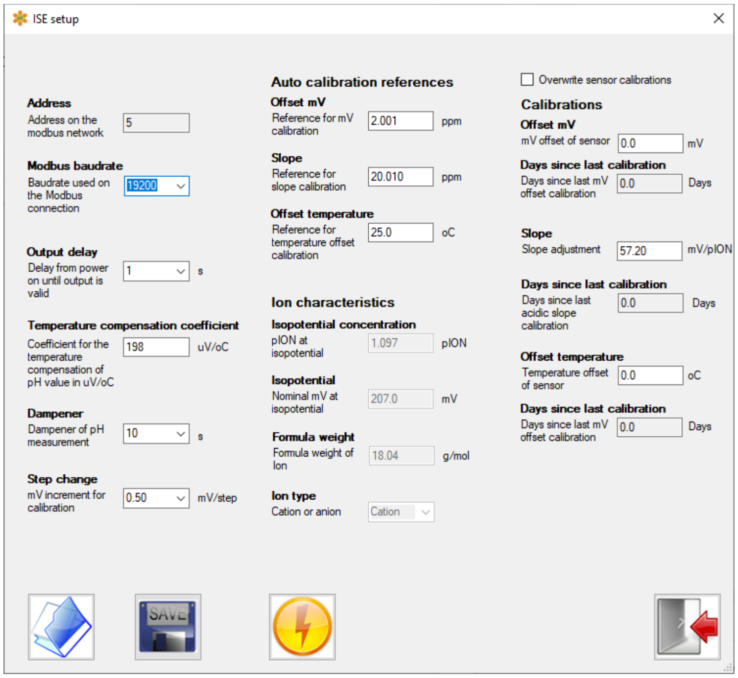
While all of the comments and notes from the preceding three pages for the setup of the HiQDT-pH & HiQDT-ORP sensors are generally also applicable to the setup of the HiQDT-DO sensors there are naturally some differences owing to the nature of the DO versus pH & ORP sensor type. For example the DO measurement is always internally temperature compensated at the sensor level. In addition galvanic dissolved oxygen cells have a two true zero such that no offset calibration is required. In this way only the slope is calibrated to define the mV per DO ppm response of the sensor. The upper limit for DO measurement ranges is 150 ppm and 1,500 percent (%) saturation. Actual max DO ppm range is limited by slope of the given DO cell. If the slope is 2.00 mV per DO ppm then the upper limit will be 125 ppm instead of the theoretical max of 150 ppm since the input range is +0.00 to +250.00 mV. The percent saturation is computed based upon measured DO ppm & temperature from sensor plus user entered air pressure and salinity. **Please see pages 22 & 23 for details about impact of temperature, air pressure and salinity on computed DO percent (%) saturation from ppm.**

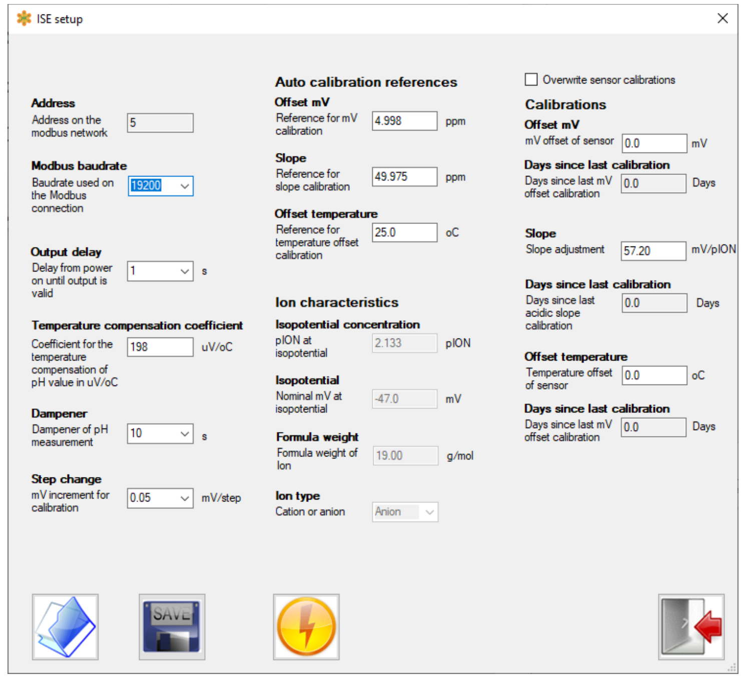
The typical HiQDT-DO setup values as shown in this menu above are a working copy. The values were initially loaded from the connected HiQDT-DO sensor. The particular values for your sensor may vary depending upon how it was setup at the ASTI factory and/or if any changes were made after time of dispatch. Each parameter can be modified as desired within the boundary condition limits. 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 HiQDT configuration system provides systematic & advanced management of the your field installations without the high cost and complexity of the HART®, Profibus or FOUNDATION™ fieldbus protocols. The smart digital HiQDT sensors employ the royalty free RS-485 MODBUS RTU digital communications for simple commissioning and extensive compatibility with any data acquisition device (PLC) acting as the RS-485 MODBUS RTU master where the HiQDT sensors are the RS-485 MODBUS RTU slaves. The MODBUS RTU protocol allows for adding or removing nodes at will as well as often being helpful to avoid any potential ground loops issues in facilities with problematic electrical issues. The HiQDT configuration system allows detailed tracking of the setup for each installation in a simple and low-cost manner. Save configuration files including the date and location in the filename for best practice archival tracking of any changes.

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

"HiQDT-ISE Setup" Menu



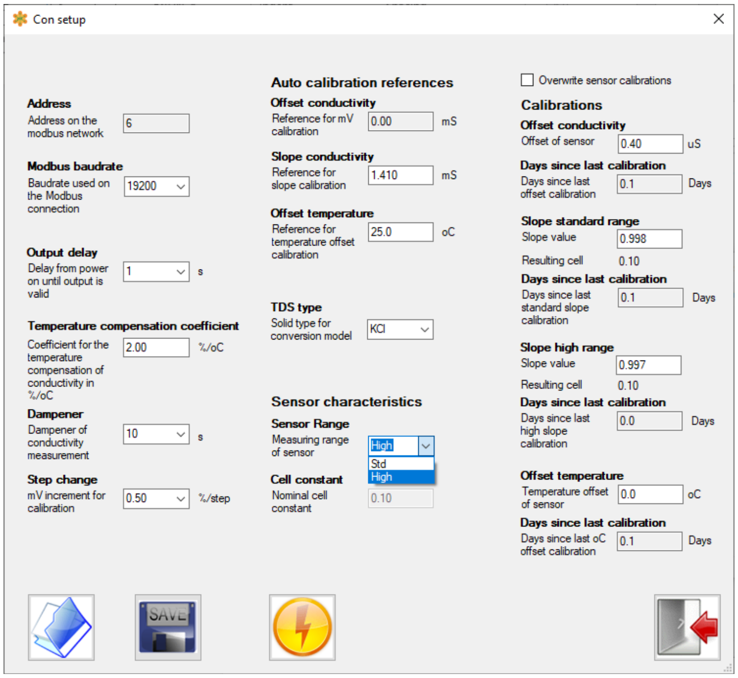


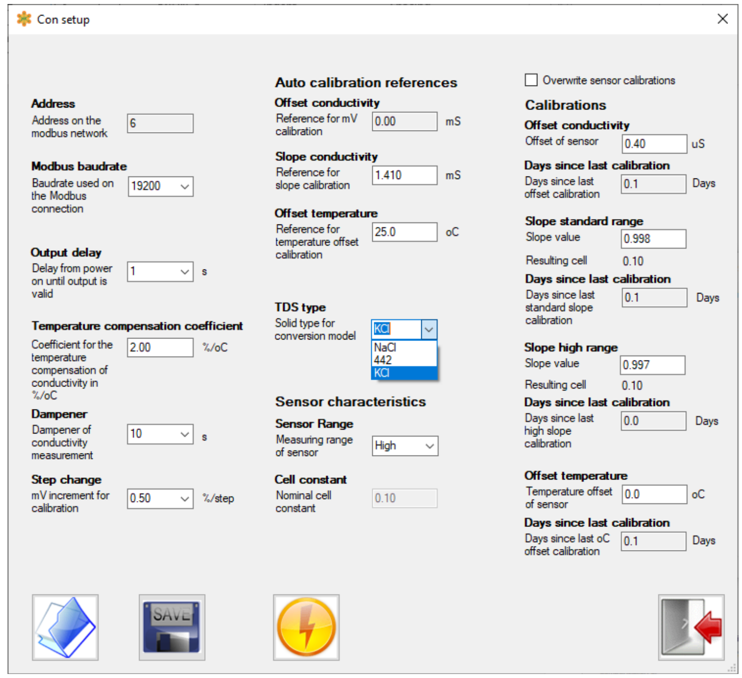
The left column in the setup screen is identical to that for the pH, ORP and dissolved oxygen (D.O.) sensors. There are differences for the middle and right columns due to the specifics for the ion selective parameter measurement. The typical HiQDT-ISE setup values as shown in the sample setup menus above are for ammonium (left) and fluoride (right). The values were initially loaded from the connected HiQDT-ISE sensor. The particular values for your sensor may vary depending upon how it was setup at the ASTI factory and/or if any changes were made after time of dispatch. Each parameter can be modified as desired within the boundary condition limits. 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 ion charactertistics portion of the setup parameters are fixed at time of dispatch and cannot be modified in the field since these settings are intrinsic to the specific type of ion selective sensor itself.

The auto calibration references define the ppm value which will be used for the offset and slope calibrations. Since the HiQDT-ISE sensors themselves operate in the scientific pION units the entered ppm values are converted into the native pION units for the purposes of performing the autocalibration calls. There can be some minor changes to the entered ppm values entered for these autocalibration setpoints due to when the non-linear transformation is made between the scientific pION units and the common ppm units. A such, minor deviations are be expected between these two units. If you will be connecting the HiQDT-ISE sensor to your own PLC please refer to the Appendix 0 for detailed instructions how to convert between the scientificn pION units in which these sensors operate to the common ppm units that you most likely will desire to receive in your data acquisition system. If using the HiQDT-ISE sensor with the touchscreen controller the transformation from the native scientific pION units to the common ppm units is all done automatically.

The mV offset is the deviation from the nominal mV at isopotential which is defined in the Ion characteristics. This can be manually changed in this setup screen if desired. It is NOT recommended to manually change the mV offset or slope values unless you are specifically instructed to do by the factory. The mV at the isopotential point for the ion selective sensor including the current calibration is the sum of the nominal mV at isopotential set at the factory and the mV offset derived from the field calibration. The slope value programmed at the factory should generally not be changed in the field unless you are instructed to do so by the facotry. The concentration at the isopotential voltage is defined in the Ion characteristics and cannot be changed in the field. The isopotential concentration cannot be changed. For example for ammonium sensor typically has an isoconcentration of 1.097 (1,443ppm) while the fluoride ion selective sensor typically has an isoconcentration of 2.133 (140ppm). Lastly the type of ion selective sensor is fully defined by a combination of whether it is a "Cation" with a positive slope or an "Anion" with a negative slope and the formula weight of the analyte ion which is being measured (18.04 for ammonium ions and 19.00 for fluoride ions). Please contact factory for assistance with your particular ion selective sensor in field use as there are specific differences that are best addressed case by case.

“HiQDT-CON Setup” Menu for Standard Range & High Range Mode Conductivity Sensors





The left column in the setup screen is identical to that for the pH, ORP, dissolved oxygen (D.O.) and ion selective sensors with the sole exception of the temperature compensation coefficient. Whereas for the pH & ISE sensors the temperature compensation coefficient is defined as µV per pH/pISE units for the conductivity sensors this is defined as % per degrees Celsius (limits are 0.00 to 9.99% per °C). The topic of finding the ideal temperature compensation coefficient is beyond the scope of this manual and questions about this topic should be directed instead to the ASTI factory instead. The default 2.00% temperature compensation coefficient is a rather reasonable approximation for most electrolyte systems.

There are differences for the middle and right columns due to the specifics for the conductivity measurement parameter for the standard & high range mode sensors. There exists two types of calibrations which can be performed for each conductivity sensor: 1) The zero dry in air offset calibration and 2) The gain (a.k.a. span or slope) wet calibration. The reference value for the dry in air offset calibration is always zero. The reference value for the slope wet calibration can be defined as appropriate to reflect the standard solutions to be used or else to reflect the value obtained from a grab sample analysis for an in-situ calibration without removing the sensor. The value to be entered is the temperature compensated conductivity to be used as the basis for the slope (a.k.a. gain or span) calibration. The result of the slope calibration can be anywhere between 0.300 to 1.700 which are the boundary limits. Most cases the result of the slope calibration will be quite close to the ideal 1.00 value (which is the case for the sensor confgiuration shown above). When a reset calibrations call is performed it will use these values rather than the gerenic parameter values. The product of the nomial cell constant multiplied by the slope value is the effective apparent cell constant which is the basis for the calibrated conductivity.

In addition to sending the temperature compensated and calibrated conductivity values there are two computed units which are also sent by the standard range mode and high range mode type conductivity sensors. These are the salinity in PSU units and the total dissolved solids (TDS) in ppm units. **On the main default display screen clicking on the “PSU” will switch to showing the “TDS” computed ppm units instead. In this way the “PSU” and “TDS” text acts as a toggle between these two computed units in this main default display screen.** For TDS units there are three preprogrammed types which can be selected as may most accurately reflect your measured sample: sodium chloride (NaCl) or potassium chloride (KCl) or 442 which is a mixture of 40% sodium sulfate, 40% sodium bicarbonate and 20% sodium chloride. The 442 choice is most commonly used for natural water sources (see page 15 to visualize these three TDS unit choices).

Shown above is the K=0.1/cm cell constant sensor in the high range mode. As can be visualized from the screenshot on the left there is a toggle available to switch between the standard range mode and high range mode (see page 14 for details for standard and high range mode each particular available cell constant). **The calibration reference value must lie within the permitted boundary limits for the cell constant of the connected sensor in order to change between the standard range mode and high range mode (or else you will receive an error message). A separate slope calibration is stored for the standard range mode (slope lo) and high range mode (slope hi) for best accuracy in any range mode.**

STANDARD RANGE MODE * - in microSiemens/cm

Range Scaling Factor	200		Max Temp. Compensated Conductivity using 2% per °C Coefficient			
Cell Constant (K)	Max Raw Input Limit	Resolution	Lowest Recommended Measurement @ 25°C	@ 25 °C	@ 75 °C	@ 125°C
0.01	200	0.004	2	200	100	66.67
0.02	400	0.008	4	400	200	133.33
0.05	1,000	0.02	10	1,000	500	333.33
0.10	2,000	0.04	20	2,000	1,000	666.67
0.20	4,000	0.08	40	4,000	2,000	1,333.33
0.50	10,000	0.2	100	10,000	5,000	33,33.33
1.00	20,000	0.4	200	20,000	10,000	66,66.67
2.00	40,000	0.8	400	40,000	20,000	13,333.33
3.00	60,000	1.2	600	60,000	30,000	20,000.00
5.00	100,000	2	1,000	100,000	50,000	33,333.33
10.00	200,000	4	2,000	200,000	100,000	66,666.67
20.00	400,000	8	4,000	400,000	200,000	133,333.33

HIGH RANGE MODE * - in microSiemens/cm

Range Scaling Factor	2,000		Max Temp. Compensated Conductivity using 2% per °C Coefficient			
Cell Constant (K)	Max Raw Input Limit	Resolution	Lowest Recommended Measurement @ 25°C	@ 25 °C to 75°C	@ 125°C	@ 175°C
0.01	2,000	0.04	20	1000	666.67	500
0.02	4,000	0.08	40	2,000	1,333.33	1,000
0.05	10,000	0.2	100	5,000	3,333.33	2,500
0.10	20,000	0.4	200	10,000	6,666.67	5,000
0.20	40,000	0.8	400	20,000	13,333.33	10,000
0.50	100,000	2	1,000	50,000	33,333.33	25,000
1.00	200,000	4	2,000	100,000	66,666.67	50,000
2.00	400,000	8	4,000	200,000	133,333.33	100,000
3.00	600,000	12	6,000	300,000	200,000.00	150,000
5.00	1,000,000	20	10,000	500,000	3333,33.33	250,000
10.00	2,000,000	40	20,000	1,000,000	666,666.67	500,000
20.00	4,000,000	80	40,000	2,000,000	1,333,333.33	1,000,000

* **Sensor can toggle between standard/high range mode range mode while in use.** Standard/high range mode sensor is one configuration and associated sensor board hardware. Ultralow range mode sensor is a different configuration and associated sensor board. While you can toggle between standard and high range modes you <u>cannot</u> toggle between the standard/high and ultralow modes since these are two different sensor boards. Two slope calibrations are stored in dual mode standard/high sensors; slope low is used for the standard mode and slope high for the high mode. Slope calibrations are automatically assigned based upon range mode in use for sensor at time when calibration is performed. The ultralow range mode only uses the single low slope (slope high is unused).

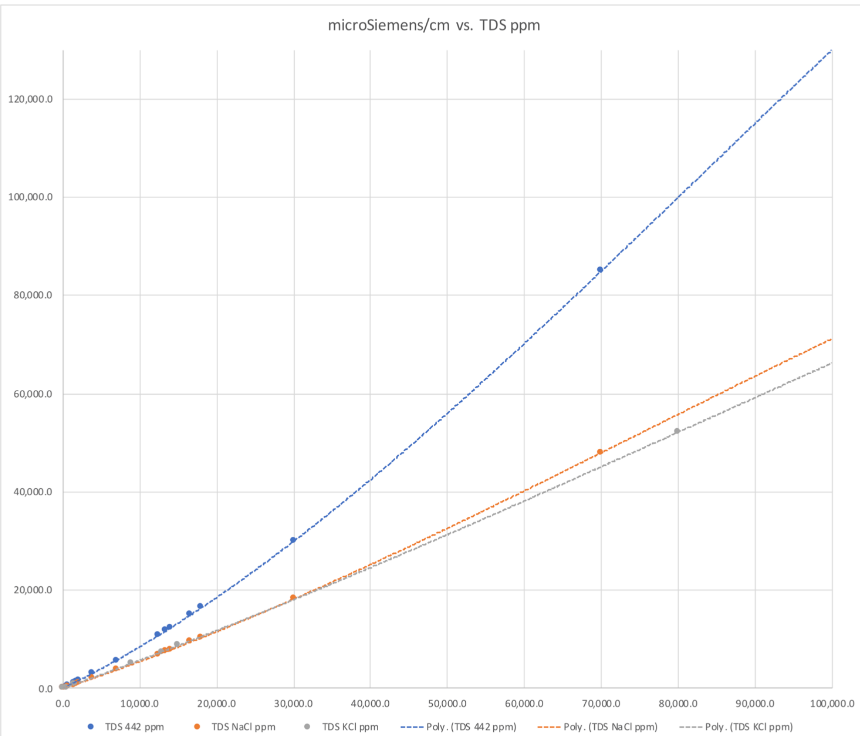
	CELL CONSTANT										
SENSOR	**0.01**	**0.02**	**0.05**	**0.10**	**0.20**	**1.00**	**2.00**	**3.00**	**5.00**	**10.00**	**20.00**
AST10	Red	Red	Red	Red	Blue	Red	Blue	Red	Blue	Red	Blue
AST51	Blue	Blue	Blue	Red	Blue	Red	Blue	Blue	Blue	Blue	Blue
AST41	Blue	Blue	Red	Red	Blue	Red	Red	Blue	Blue	Blue	Blue
ASTXX-TRI	Red	Red	Red	Red	Blue	Red	Red	Red	Red	Red	Blue
AST42	Red	Red	Red	Red	Red	Red	Red	Blue	Red	Red	Red
AST40	Red	Red	Red	Red	Red	Red	Red	Blue	Red	Red	Red
AST50	Blue	Blue	Blue	Red	Blue	Red	Red	Blue	Blue	Blue	Blue
AST60	Blue	Blue	Blue	Red	Blue	Red	Red	Blue	Blue	Blue	Blue
AST52	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Red	Blue

Color Coding: Red – Available in Cell Constant; Blue – Not available in that Cell Constant

All sensors are available in smart digital HiQDT MODBUS RTU configuration although not all cell constants are available for each model. Use the standard/high range mode cell constant table above and ultralow range mode tables on page 4 to determine the most suitable selection for your sample. ***Cell constants above K=2.00/cm are omitted from the ultralow range table on page 15.***

ULTRA-LOW RANGE MODE * - in microSiemens/cm

Range Scaling Factor	2		Max Temp. Compensated Conductivity using 2% per °C Coefficient			
Cell Constant (K)	Max Raw Input Limit	Resolution	Lowest Recommended Measurement @ 25°C	@ 25°C	@ 75°C	@ 125°C
0.01	2	0.00004	0.02	2	1	0.667
0.02	4	0.00008	0.04	4	2	1.333
0.05	10	0.0002	0.1	10	5	3.333
0.10	20	0.0004	0.2	20	10	6.667
0.20	40	0.0008	0.4	40	20	13.333
0.50	100	0.002	1.0	100	50	33.333
1.00	200	0.004	2.0	200	100	66.667
2.00	400	0.008	4.0	400	200	133.33

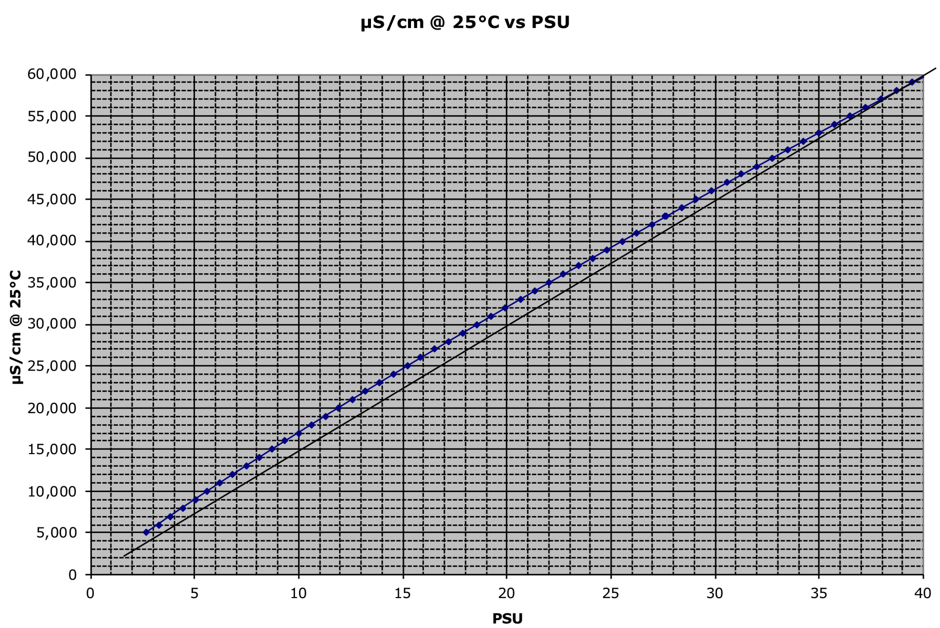


Total dissolved solids (TDS) *units are computed from measured conductivity. The curves that define relationship between the measured conductivity and user selectable total dissolved solid (TDS) units of NaCl, KCl or 442 are preprogrammed into sensor with full range of 0 to 100,000 ppm. The actual usable range may be limited by the choice of cell constant and range mode in which the sensor is operated.*

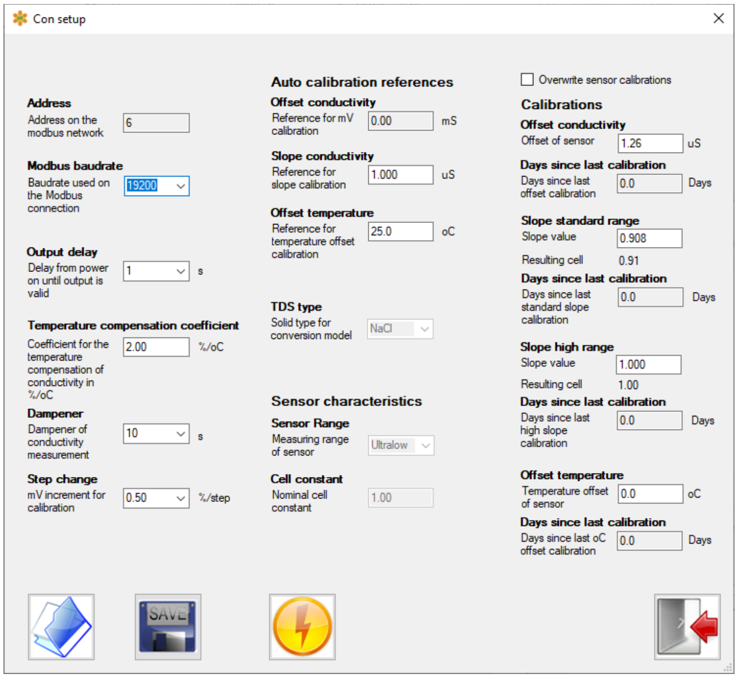
Other types of total dissolved solids (TDS) for other electrolytes or electrolyte mixtures can be programmed into the sensor on a special order basis (minimum order requirements apply for such special programming requests). Inquire to the factory if you have need for such special TDS units for your smart digital HiQDT MODBUS RTU conductivity sensors.

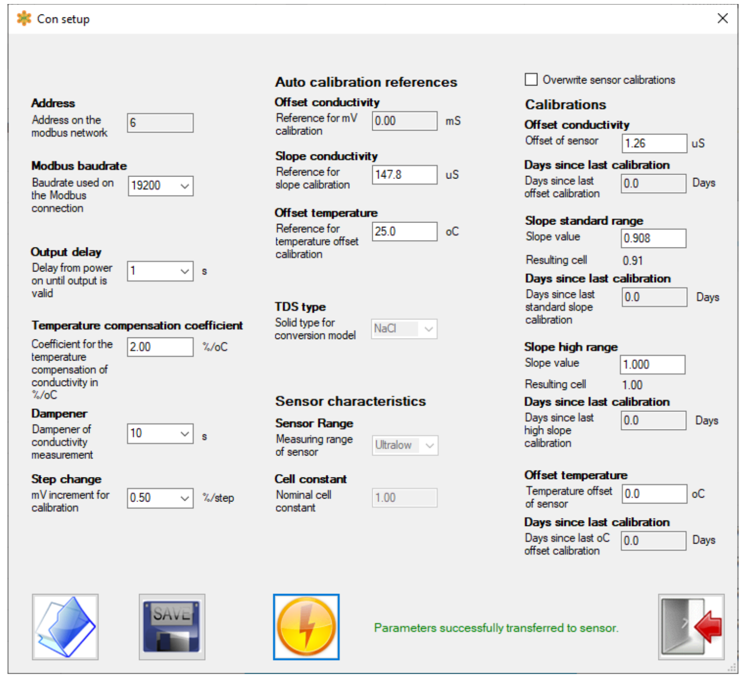
Salinity computed from the measured conductivity. *Curves that define the relationship between measured conductivity and the computed salinity in PSU are preprogrammed into the sensor with a full range of 0.000 to 50.000 PSU.*

The actual supported range may be limited by cell constant & range mode used). Contact the factory to determine the most suitable sensor model and cell constant configuration for your desired salinity range of interest.



"HiQDT-CON-L Setup" Menu for Ultralow Range Mode Conductivity Sensors





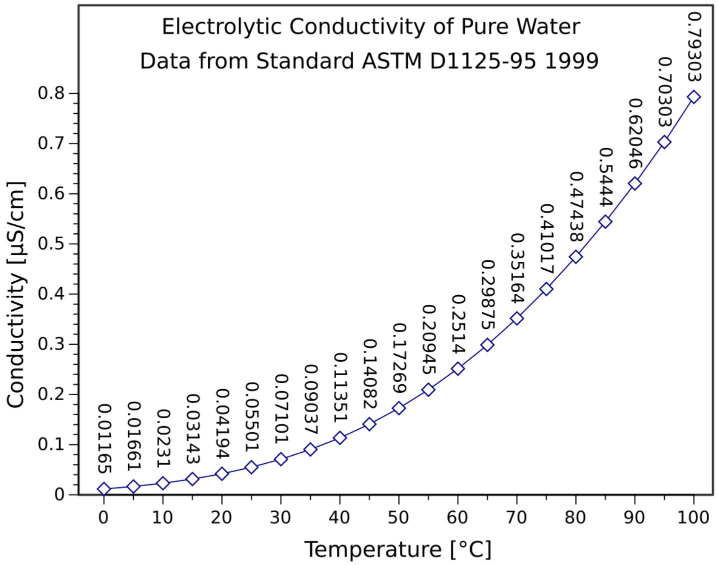
The left column in the setup screen is identical to that for the pH, ORP, dissolved oxygen (D.O.) and ion selective sensors with the sole exception of the temperature compensation coefficient. Whereas for the pH & ISE sensors the temperature compensation coefficient is defined as µV per pH/pISE units for the conductivity sensors this is defined as % per degrees Celsius (limits are 0.00 to 9.99% per °C). The topic of finding the ideal temperature compensation coefficient is beyond the scope of this manual and questions about this topic should be directed instead to the ASTI factory instead. The default 2.00% temperature compensation coefficient is a rather reasonable approximation for most electrolyte systems.

There are differences for the middle and right columns due to the specifics for the conductivity measurement parameter for the standard & high range mode sensors. There exists two types of calibrations which can be performed for each conductivity sensor: 1) The zero dry in air offset calibration and 2) The gain (a.k.a. span or slope) wet calibration. The reference value for the dry in air offset calibration is always zero. The reference value for the slope wet calibration can be defined as appropriate to reflect the standard solutions to be used or else to reflect the value obtained from a grab sample analysis for an in-situ calibration without removing the sensor. The value to be entered is the temperature compensated conductivity to be used as the basis for the slope (a.k.a. gain or span) calibration. The result of the slope calibration can be anywhere between 0.300 to 1.700 which are the boundary limits. Most cases the result of the slope calibration will be quite close to the ideal 1.00 value (which is the case for the sensor confgiuration shown above). When a reset calibrations call is performed it will use these values rather than the gerenic parameter values. The product of the nomial cell constant multiplied by the slope value is the effective apparent cell constant which is the basis for the calibrated conductivity.

In addition to sending the temperature compensated and calibrated conductivity values there are two computed units which are also sent by the ultralow range mode type conductivity sensors. These are the computed resistivity values in MegaOhm (MΩ) units which are the inverse of the measured conductivity units. The resistivity is sent using both the linear % per °C temperature compensation scheme as well as the special non-linear temperature compensation scheme which is suitable for ultrapure water (UPW) samples. Please see page 17 to visualize the non-linear behavior of UPW water samples at various temperatures. **On the main default display screen clicking on the "MΩ" will switch to showing the "MΩ*" which then displays the resistivity using the special non-linear UPW temperature compensation scheme. In this way the "MΩ" and "MΩ*" text acts as a toggle between displaying the resistivity with the user defined linear user defined temperature compensation and the special pre-programmed non-linear ATC scheme.**

Shown above is the K=1.0/cm cell constant sensor in the ultralow range mode. Please see pages 14 & 15 for details for recommended ranges available for each commonly employed cell constant available in the ultralow range mode style sensors. For low conductivity measurements the most optimal choice of cell constant and range mode necessitates checking both the standard and ultralow range modes for multiple cell constants (contact factory for assistance).

Ultralow Range Conductivity Sensors for Ultrapure Water (UPW)



The conductivity of pure water varies significantly with temperature in a well defined but non-linear fashion as detailed in the graph to left. This behavior is preprogrammed into the HiQDT-CON-L MODBUS RTU conductivity sensors for the automatic temperature compensation feature to make it suitable for ultrapure water (UPW) type applications.

Although the recommended cell constant for performing conductivity measurement in UPW is K=0.01/cm for best resolution and lower bounds of measurement there may be situations where this K=0.01/cm cell constant cannot be used for the planned installation location because of limitations such as piping arrangement and low-flow. The higher cell constants of K=0.05/cm or K=0.10/cm can be used instead in such cases albeit they require the sample to be at a higher temperature to ensure best results. Table below details recommended minimum temperature for various cell constants for use in UPW. The minimum temperature for UPW measurement for each cell is determined based upon the lowest absolute conductivity value for which the cell constant is recommended & temperature at which this conductivity occurs for UPW. Resistivity are computed units are the inverse of the measured conductivity value.

ULTRA-LOW RANGE MODE - MicroSiemens/cm unless otherwise indicated

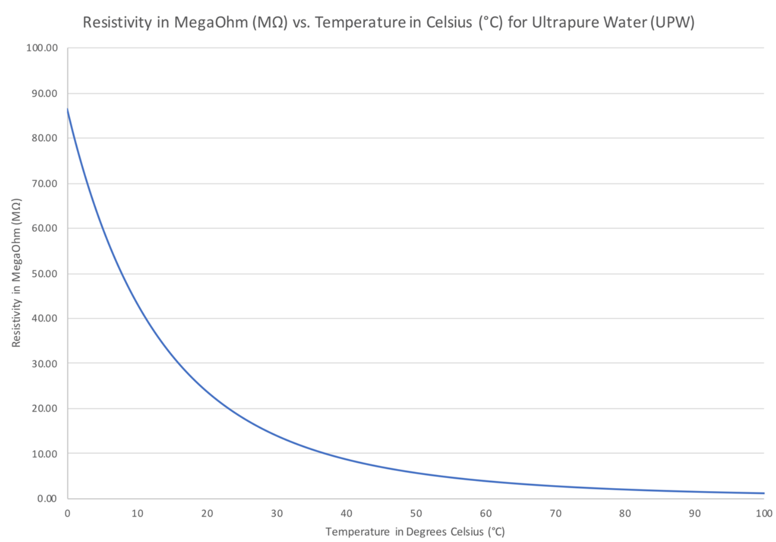
Range Scaling Factor	2

Cell Constant (K)	Raw Max Input @ 25°C	Resolution	Lowest Recommended Absolute Measurement	Minimum Temp °C *	Absolute MegaOhm (MΩ) @ Min Recommended °C *
0.01	2	0.00004	0.02	8	50
0.05	10	0.0002	0.1	40	10
0.10	20	0.0004	0.2	55	5

** Minimum recommended temperature is conductivity of UPW which is 1% of ultralow range mode for the given cell and the associated MegaOhm units. Measurements can be performed below the recommended minimum temperature with an associated higher uncertainty for those situations.*

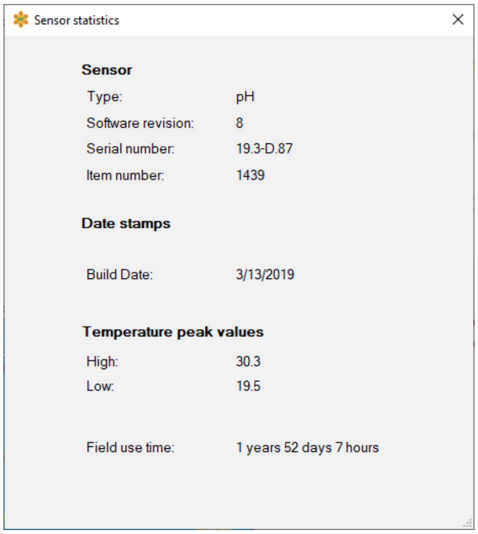
For ultralow range conductivity sensors the 5th read input register (30005) sends the computed resistivity MegaOhm (MΩ) using the user defined linear automatic temperature compensation (ATC) while the 6th read input register (30006) sends computed resistivity MegaOhm (MΩ) using the special non-linear ultrapure water style automatic temperature compensation. The resistivity values sent as 0 to 50,000 steps corresponding to 0.000-50.000 MegaOhm (MΩ) for both the 5th (30005) & 6th (30006) read input registers. Theoretical temperature compensated resistivity value can never go above 18.18 MegaOhm (MΩ) for uncontaminated pure water since this is the ideal value at 25 degrees Celsius.

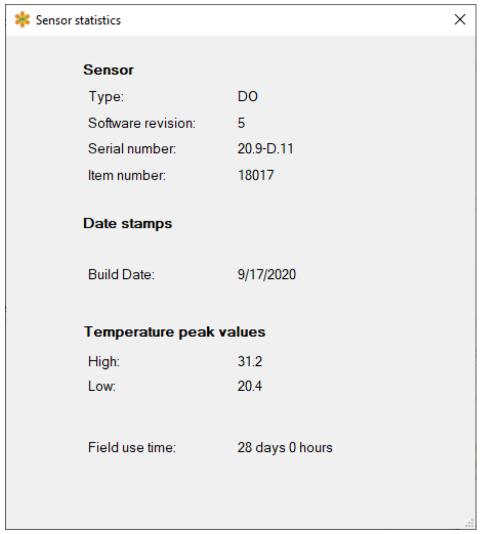
Temperature compenated conductivity and resistivity are referenced back to the 25 °C condition for all ATC. Ultrapure water with no contaminants has a value of 0.055 µS/cm conductivity or 18.18 MΩ in resistivity. The most common units for measurement of pure water is resistivity (MΩ) due to high resolution and convenient scaling in very low conductivity levels. Temperature compensated conductivity & computed resistivity values sent for the ultralow range mode smart digital HiQDT-CON-L style MODBUS RTU conductivity sensors as well as the raw conductivity.

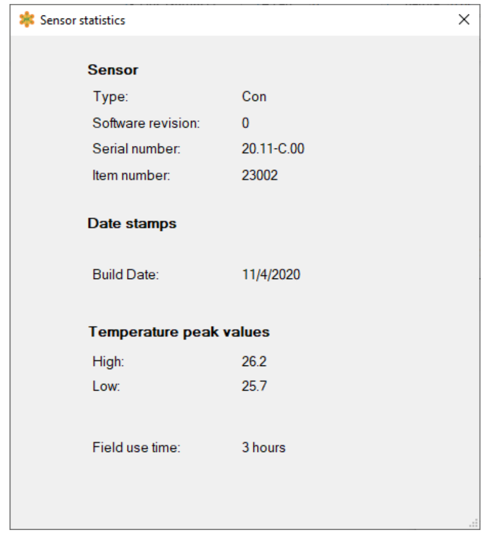


Graph above shows relationship between the resistivity of pure water at various temperatures. Computed resistivity MegaOhm (MΩ) units are the inverse of measured conductivity and so are the mirror image of the conductivity at various temperatures for ultrapure water (UPW). The graph above shows absolute raw resistivity at various temperatures. Resistivity values sent include ATC referencing reading to 25 °C state.

HiQDT-pH, HiQDT-ORP, HiQDT-DO, HiQDT-ISE & HiQDT-CON(-L) "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 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: pH, standard/wide-range ORP, DO, ISE or CON(-L) depending upon sensor
- Software Revision: Per firmware that has been loaded onto your HiQDT digital sensor board *
- Serial Number: For complete traceability of the individual sensor through the service life-cycle
- Item Number: Completely defines all features and capabilities of given sensor

Date Stamps:

- Buildate Date: When the smart digital HiQDT-pH/ORP/DO/ISE/EC sensor was shipped
    - 1-year shelf-life warranty begins from this date unless otherwise stated

Temperature Peak Values:

- High: Highest temp experienced by sensor after dispatch from factory when energized
- Low: Lowest temp experienced by sensor after dispatch from factory when energized

Field Use Time:

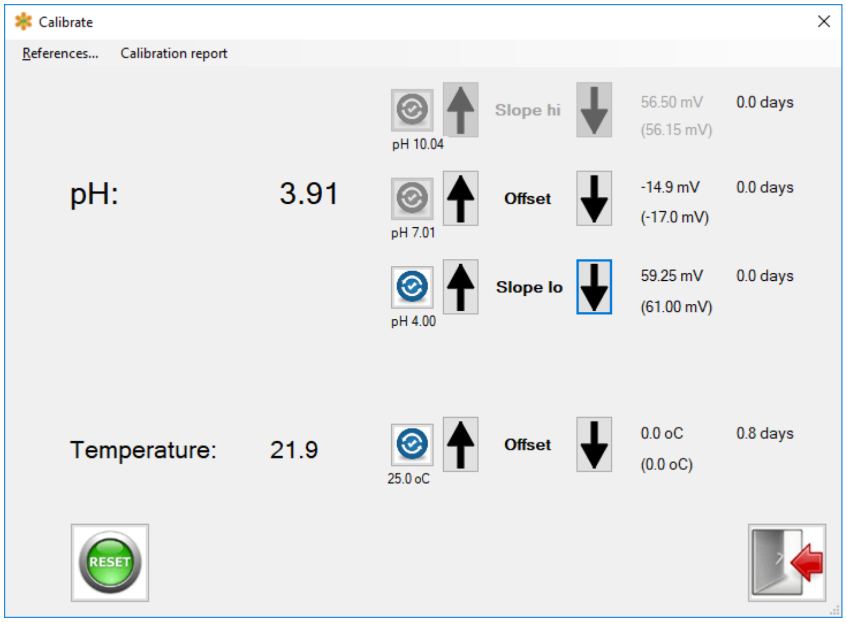
- Integral Time Tracking: The total time HiQDT sensor has been energized after dispatch from factory **

** Contact factory to confirm that your sensor is using the most current revision of the software for the given sensor type.*

*** This time tracking feature is incremented for each hour the sensor is continuous energized. The time since calibration was last done is similarly incremented one for each hour that the sensor is continuously energized since the calibration was performed.*

NOTE: Examples of the standard & wide range style ORP sensor and the ion selective (ISE) sensor stats screens are not shown above. The are similar in characteristic to the pH, dissolved oxygen (D.O.) and Conductivity (EC) sensor stats screens provided above.

HiQDT-pH "Calibrate" Menu – Overview of Fields & Options



Clicking on the "Calibrate" menu loads the screen shown above when a HiQDT-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 IOTRON™ series smart digital HiQDT 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 (parentheses).

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 HiQDT 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 HiQDT 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

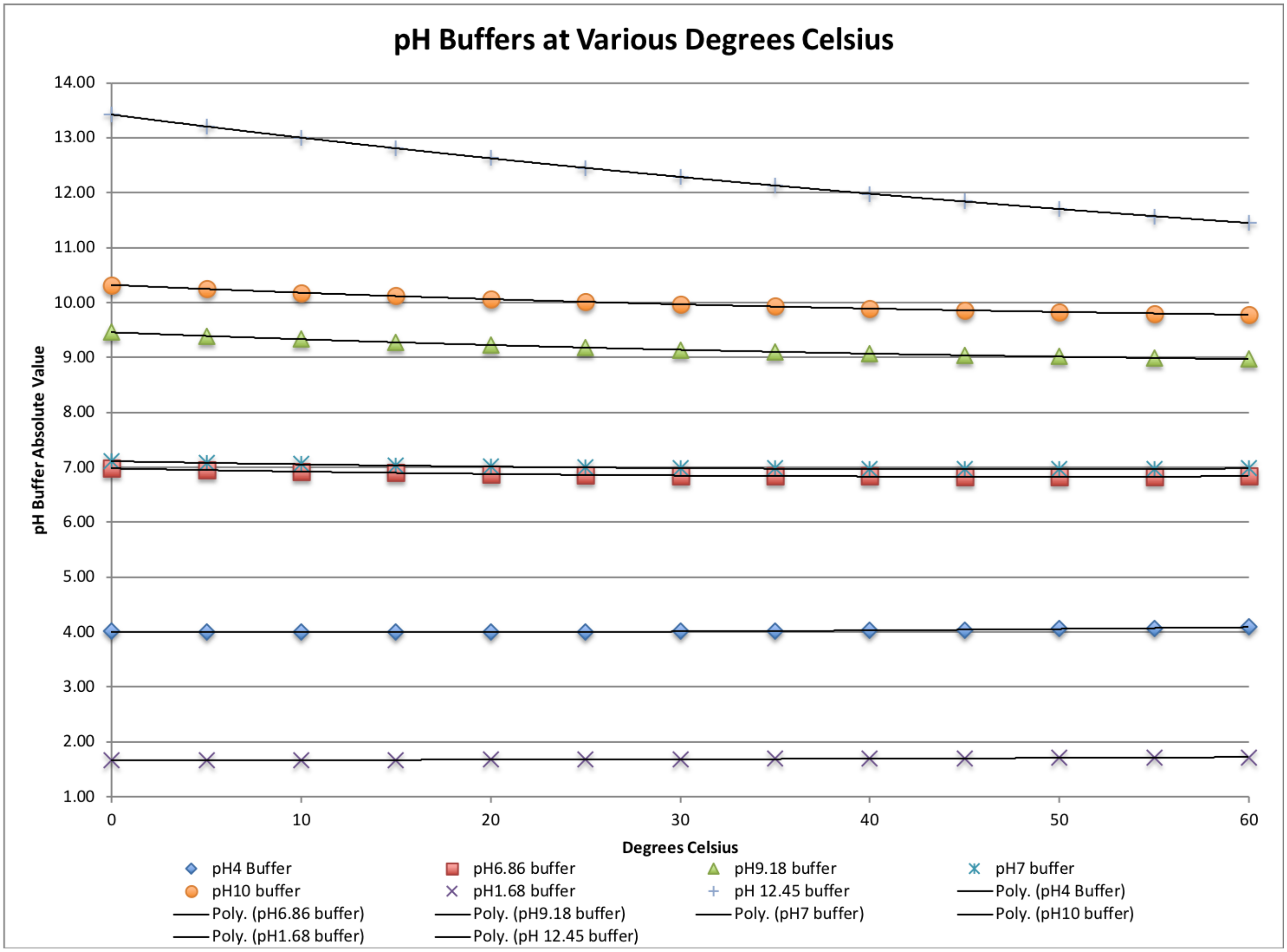
NIST traceable pH buffers are the most commonly used methods for calibration of industrial pH sensors. On each pH buffer bottle is written the exact pH value of the buffer at variety of temperature conditions. Listed above are the exact pH values for the most commonly used pH buffers between 0 and 60 °C. When using the ASTI Windows HiQDT Digital System Setup & Calibration Software for calibration of your IOTRON™ series Smart Digital HiQ 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 obtained 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 the 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 HiQDT pH sensor is displayed in the calibrate menu. This may differ from the nominal value of the buffer at the reference 25 degree Celsius 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 HiQDT 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 relativley 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

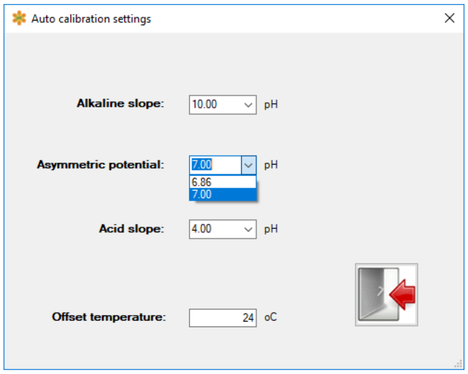


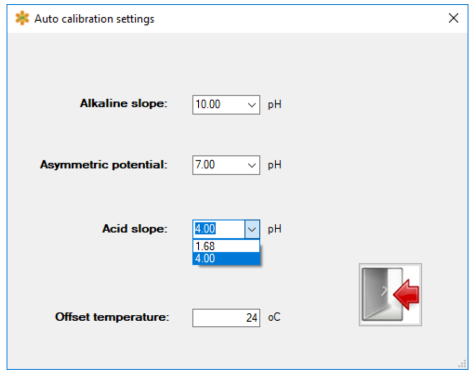
The HiQDT Windows software automatic calibration mode computes the exact values of the pH 1.68, 4.00, 6.86, 7.00, 9.18, 10.01 and 12.45 buffers in the automatic calibration mode for anywhere between 0 to 60 °C. If calibrating with pH buffers in the temperature condition below 0°C or above 60 °C automatic 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 HiQDT 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.

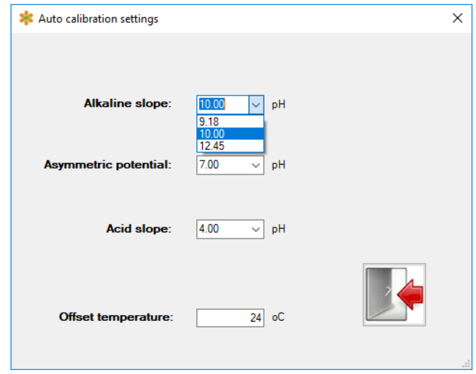
Temperature compensation only accounts for the change in the mV response of the pH sensor itself with temperature. The type of temperature induced shifts such as those demonstrated in the table above for the pH buffers are NOT corrected in default Nernstian temperature compensation scheme. For process 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 HiQDT-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 ASTI 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.

HiQDT-pH "Calibrate" Menu – Buffer Setup schemes for Autocalibration – Part 1 of 2

AVAILABLE pH BUFFERS FOR AUTOCALIBRATION MODE (see drop-downs shown below)

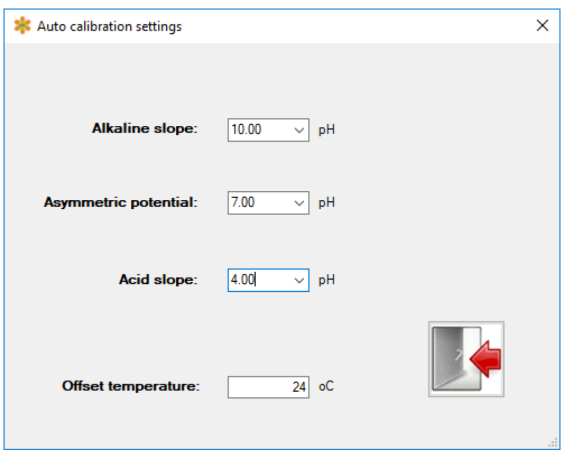






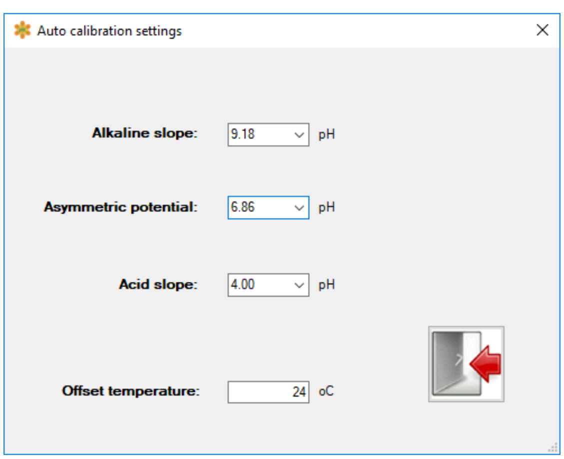
The reference temperature value is not selected from a drop down but rather is entered into the appropriate field.

<u>CALIBRATION SCHEME # 1</u> – 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 relaible alkaline slope calibration results.

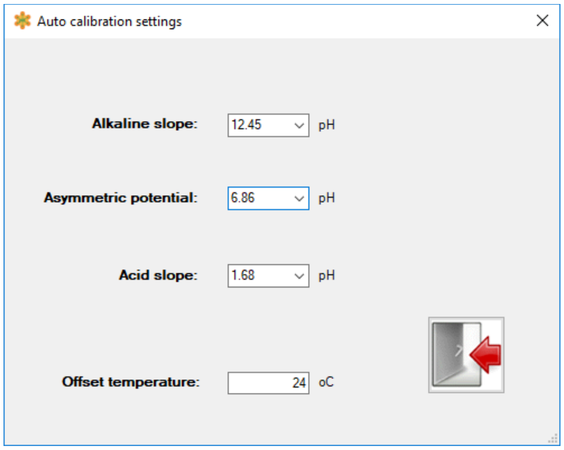
<u>CALIBRATION SCHEME # 2</u> – Typical for most installations in Europe



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 then 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

HiQDT-pH "Calibrate" Menu – Buffer Setup schemes for Autocalibration – Part 2 of 2

<u>CALIBRATION SCHEME # 3</u> – For batch style installations where pH can vary quite considerably



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 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.

<u>TEMPERATURE OFFSET CALIBRATION SETUP FOR AUTOREAD:</u>

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 <u>FIRST</u> 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.

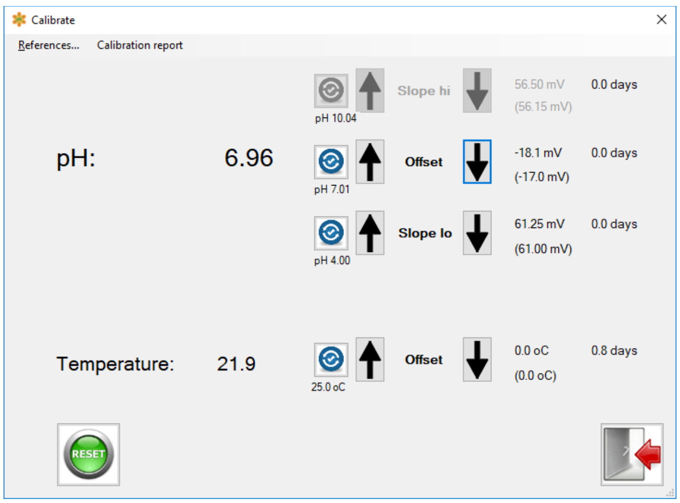
<u>GENERAL BEST PRACTICE COMMENTS FOR CALIBRATION WITH pH BUFFERS</u>

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 loose 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 at a stable ambient temperature before performing any calibration.

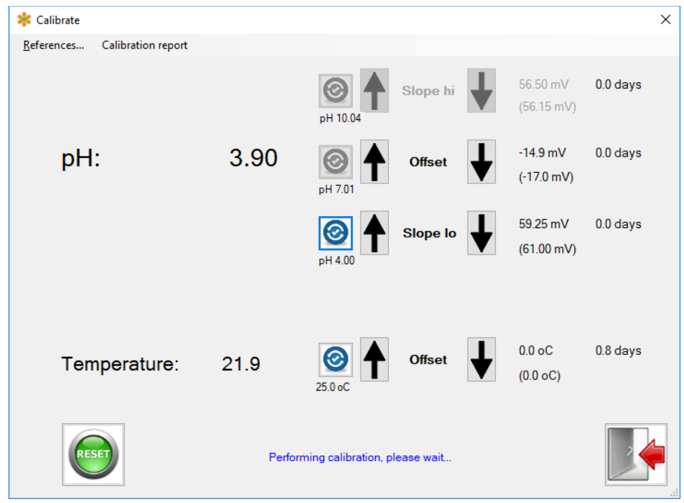
HiQDT-pH "Calibrate" Menu – Perform Temperature & pH Calibrations

SUMMARY OF CORRECT SEQUENCE FOR CALIBRATION OF HiQDT pH SENSOR WITH BUFFERS

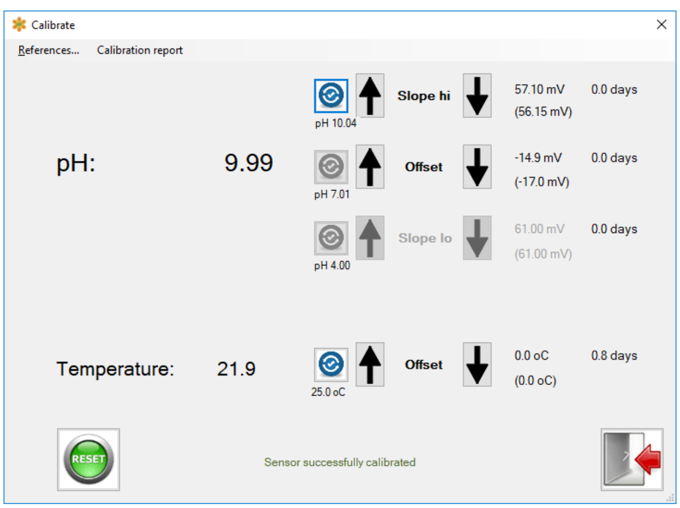
1. **Select the three pH buffers to be used to perform the calibration** *(see pages 17 & 18)*
2. Perform **pH 'Offset'** Calibration (Autoread or Manual) THIS CALIBRATION MUST BE DONE FIRST!
3. Perform **pH 'Slope lo'** Calibration (Autoread or Manual)
4. Perform **pH 'Slope hi'** Calibration (Autoread 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*



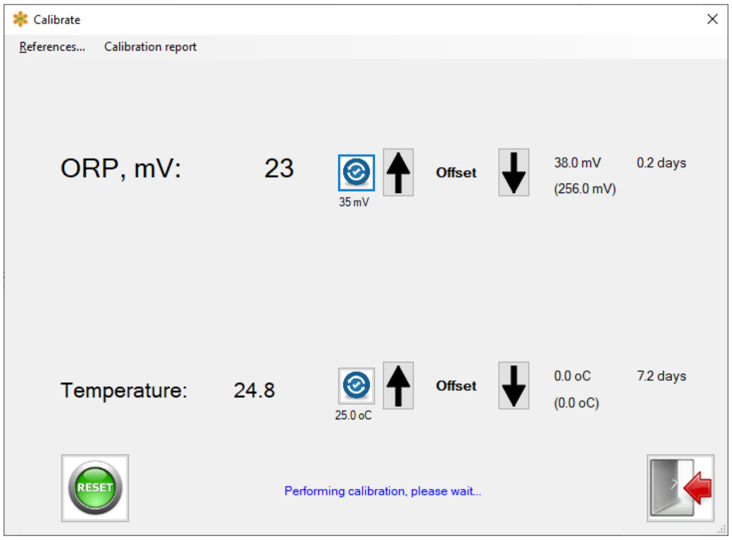
Step 3 *– Perform "Slope Hi" calibration in the alkaline range*

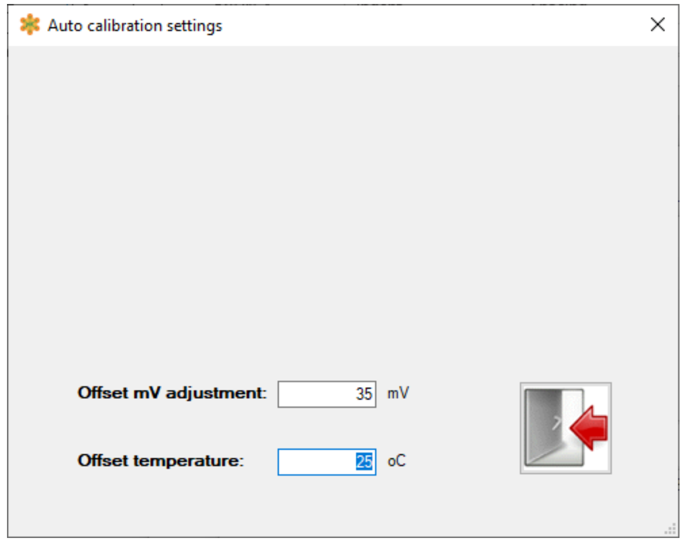
GENERAL NOTE:

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 occuring.
- 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.

HiQDT-ORP "Calibrate" Menu - Perform & Load Temp. & ORP mV Offset Calibrations





Clicking on the "Calibrate" menu loads screen above when HiQDT-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.

<u>Overview of Display Fields:</u>
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 (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 calibration is performed in the session, then the time since last calibration will change to zero confirming that this calibration was performed.

<u>Reset Calibrations:</u>
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).

<u>Exact ORP Value for Calibration</u>
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).

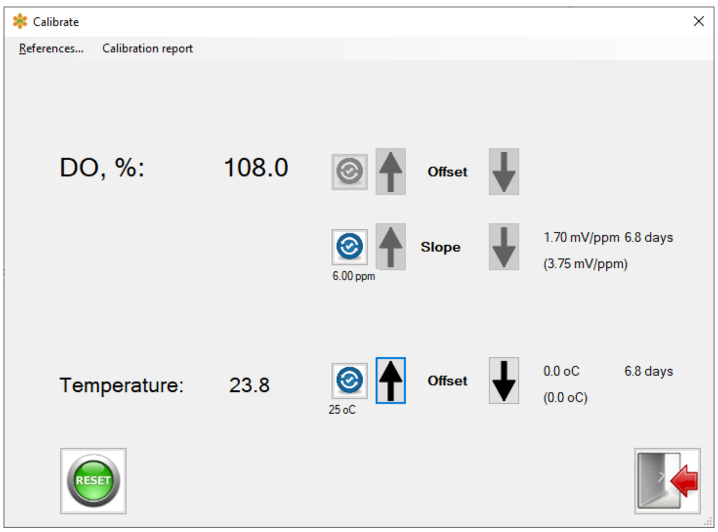
<u>General Notes:</u>
- Temperature stability of both the sensor and measured solution is required for good calibration of ORP sensor.
- Sensor temperature should be stable and the same as ambient condition for best results.
- Offset calibration for ORP can also be used to adjust the reading to a laboratory 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 ASTI factory for assistance to choose the best ORP standard solution and procedures for your application.

HiQDT-DO "Calibrate" Menu – Summary of Usage

The AST-DO-UNIVERSAL galvanic dissolved oxygen sensors do not require any offset calibration as they have a true 0mV potential at 0ppm dissolved oxygen. Calibration of the dissolved oxygen sensor is then only performed in the 'Slope' LED mode. Removing the DO sensor from service and allow sufficient time for temperature & sensor reading to be quite stable to ensure a good gain calibration result. The slope calibration (a.k.a. gain) is performed when the sensor is clean & dry and exposed to only air. If the relative humidity is not 100% suspend the sensor in air over a source of water for best results. Be sure to wait a sufficient time until the sensor reading is quite stable before performing the span (slope) calibration. Note that the salinity correction is automatically disabled when performing this calibration since this is only valid when the sensor is immersed in solution and not dry in air. That is to say that the "salinity" for the dry in air condition is zero.

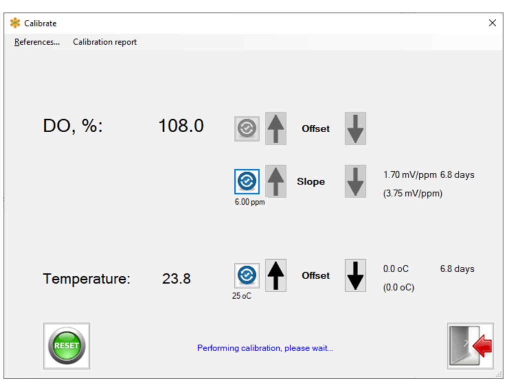
IMPORTANT!! Perform precise temperature calibration before slope (a.k.a. gain) calibration on DO sensor.

The correct 100% saturation value at any temperature from -5 to +50°C is programmed in the HiQDT-DO sensor board software allowing for a fully automated calibration procedure.

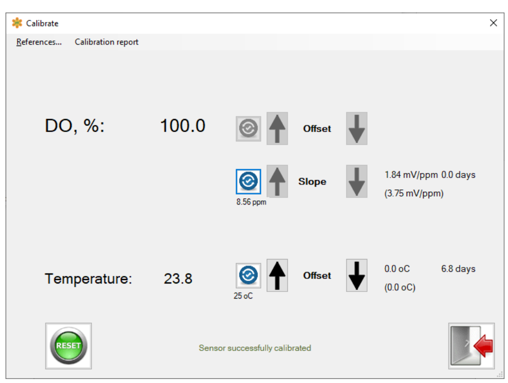


- For temperature calibration please use the 'Up' and 'Down' arrows to adjust temperature as desired.
  - **You should always perform temp cal FIRST!**
- DO ppm used for the previous calibration is shown below the blue autocalibration button. After the completion of new calibration this value will update.
- The current working slope in mV/ppm shown along with time since this calibration was last performed.
  - Default factory slope shown in parentheses. Performing a 'Reset' call reverts to this value.
- Slope will change after successful calibration is done and time since calibration will display 0.0 days
- If percent saturation does show close to 100.0% after completion of calibration, then repeat calibration.

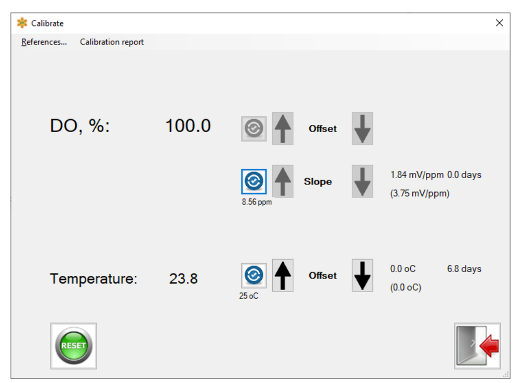
AUTOREAD CALIBRATION STAGES:



When autoread calibraton is initiated, "Performing calibration, please wait…" shown while stability test is performed.



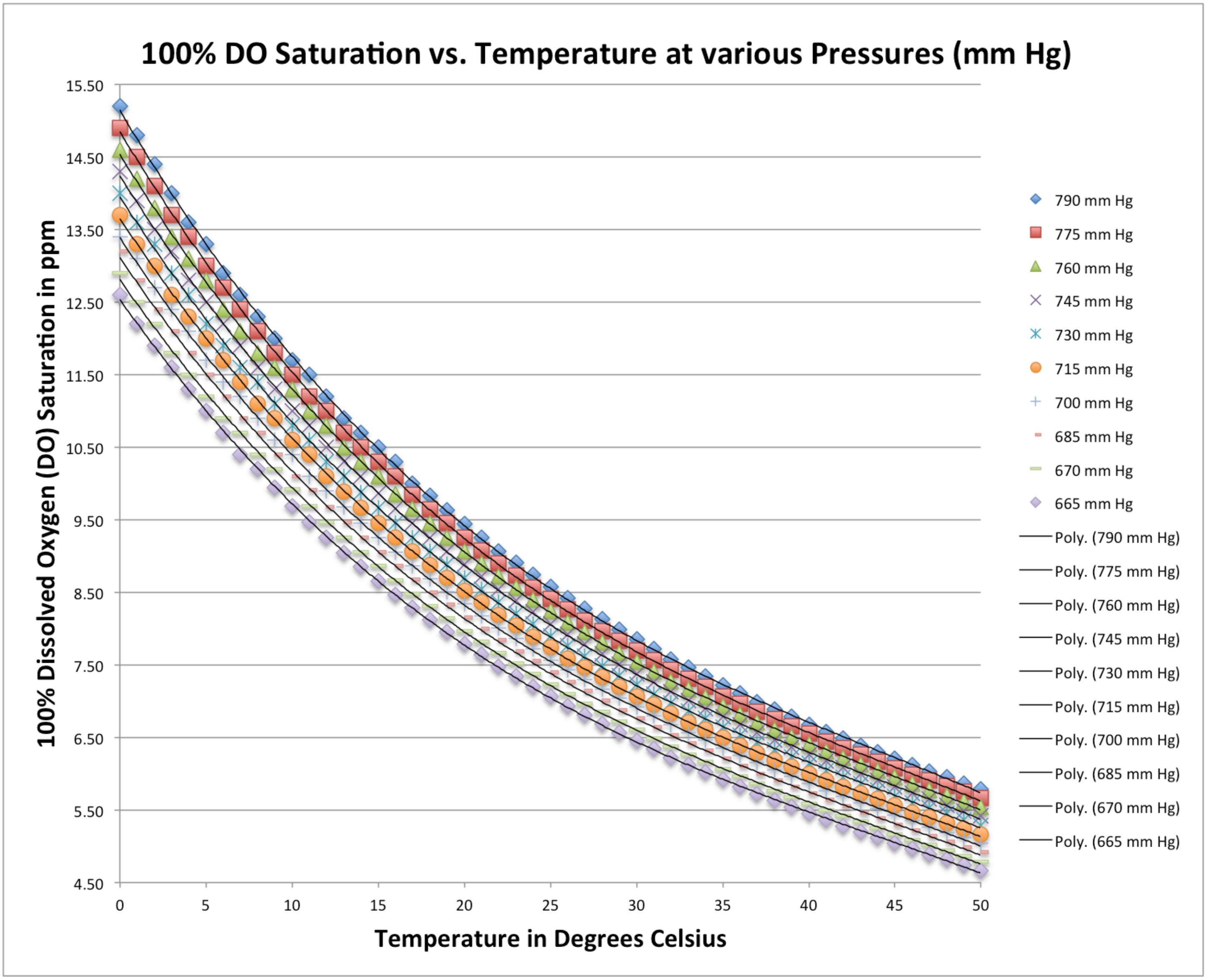
If autoread calibration is completed, "Sensor successfully calibrated" is shown for a period of time as confirmation.



Reading shows 100% saturation in the number of seconds set for dampener & shows the DO ppm used for calibration at current temperature and air pressure.

Automatic Calculation of Theoretical 100% Dissolved Oxygen Saturation at any Temperature & Pressure for Accurate Calibration & Measurement

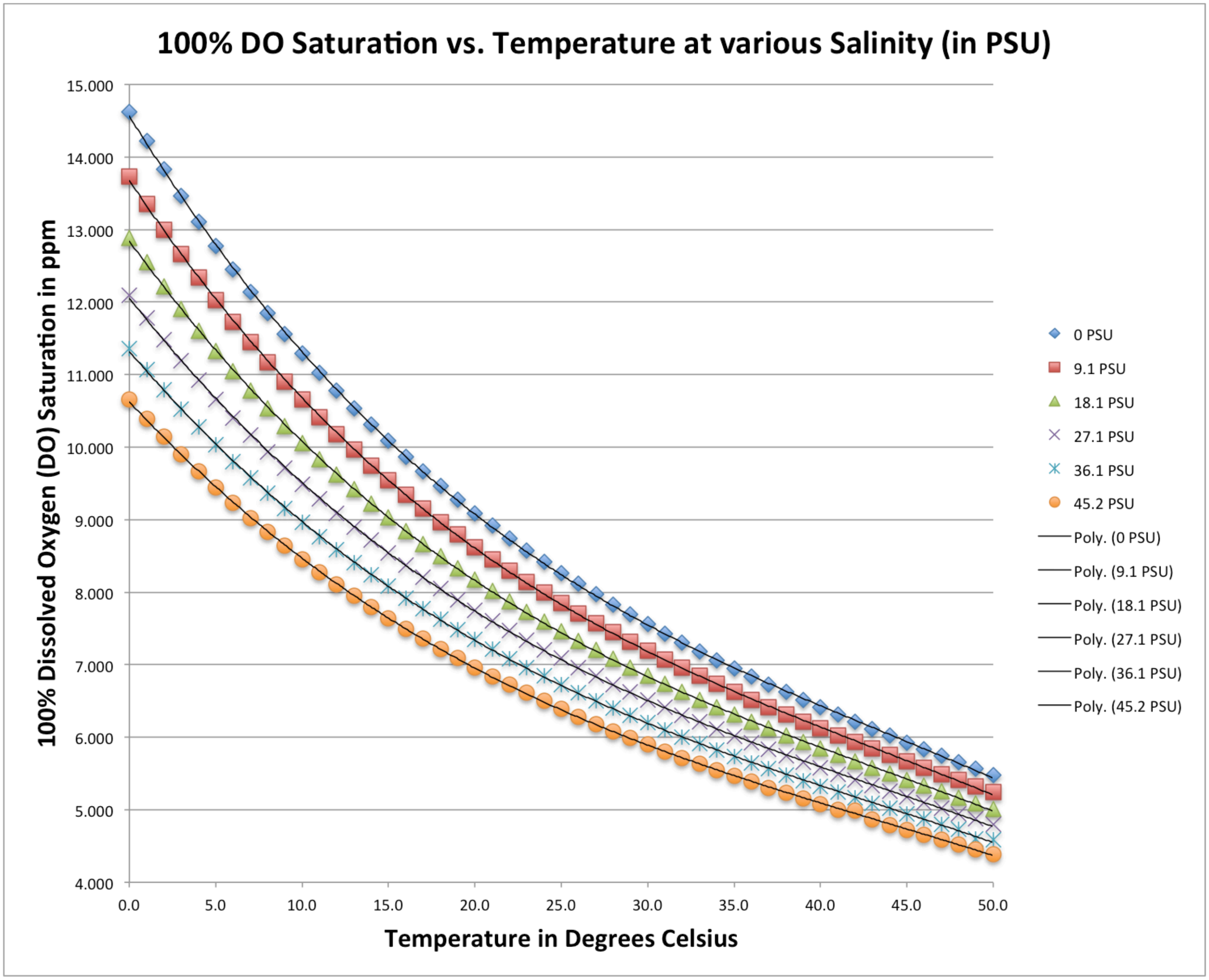
The HiQDT-DO sensor has preprogrammed the correct 100% dissolved oxygen saturation levels valid at any temperature and pressure. This is important for two main purposes: 1) to ensure accurate calibration of the sensor which is performed dry in air and 2) when the percent (%) saturation is displayed and output for purposes of monitoring and control. The graph below demonstrate the impact of both temperature and pressure on the dissolved oxygen (DO) ppm levels that constitute 100% saturation condition.



For the calibration function, either the field condition should be 100% relative humidity for best accuracy or else the sensor should be suspended dry in air but over a water source to simulate locally the 100% relative humidity condition. The water molecule in air (humidity) is then saturated with oxygen in manner that can be fully described by the ambient temperature and pressure as shown above. When placed into service, the galvanic DO sensor will measure the ppm levels at the installation depth. To convert this measured ppm value into percent (%) saturation the HiQDT-DO sensor uses the internally stored curve visualization above.

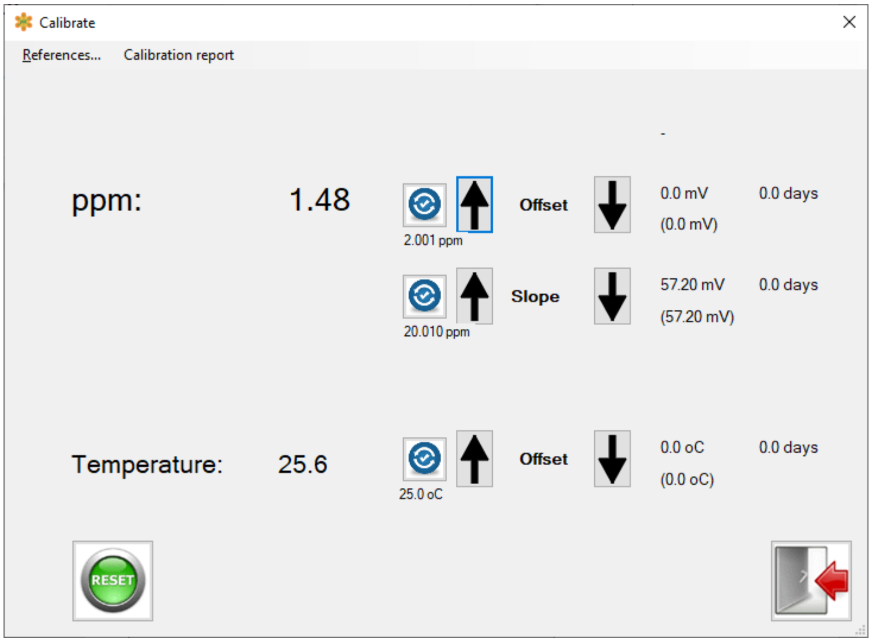
Automatic Calculation of Theoretical 100% Dissolved Oxygen Saturation at any Temperature & Pressure for Accurate Calibration & Measurement

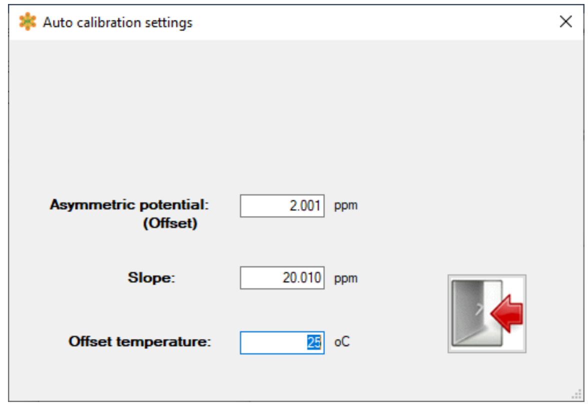
The HiQDT-DO has preprogrammed the correct 100% dissolved oxygen saturation levels valid at not only any temperature and pressure but also corrected for salinity. This is important for applications where not only fresh water will be present but also for brackish and salt water sources in variable amounts. The graph below demonstrates the impact of salinity on the dissolved oxygen (DO) ppm levels that constitute 100% saturation condition at the nominal 760mm pressure condition. For simplicity of visualization just one set of curves is shown although the analyzer can perform this compensation any temperature, pressure or salinity.



This salinity correction is only required as a correction to the computation of the % saturation from the measured DO ppm levels for the inline measurement. Since the calibration is done dry in air, salinity correction is not required for this part of operation. Since the impact of salinity is considerable as shown in the graph above, it must be corrected carefully at any level of salinity and temperature. The salinity value in standard PSU (PPT) units can be entered into the HiQDT-DO sensor to perform this correction. The value of the salinity can be determined by a handheld meter or else monitoring continuously using a conductivity transmitter from which one can readily convert into common salinity units.

HiQDT-ISE "Calibrate" Menu – Overview of Fields & Options





The autocalibration ppm values which are used when performing the offset and slope calibrations are defined by clicking on the "References" and entering the ppm values in the screen as shown directly above.

Clicking on "Calibrate" menu loads the screen shown above when a HiQDT-ISE sensor is connected. The temperature compensated ppm reading as well as the temperature reading is displayed based upon the current calibrations for the connected sensor. Before performing a calibration click on "References" menu to configure the autocalibration vaues to be employed for your connected IOTRON™ series smart digital HiQDT ISE sensor.

<u>Overview of Display Fields:</u>
Displayed **ppm:** 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.

<u>Reset Calibrations:</u>
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).

<u>"Grab Sample" Calibration – MANDATORY FOR ALL ION SELECTIVE SENSOR INSTALLATIONS:</u>
The HiQDT ISE 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 while the the sensor is left installed in field service after it is fully stabilized to the process media.** In addition to this Windows software the offset calibration can also be performed by means of the handheld communicator or the touchscreen controller (either locally or remotely).

<u>Offset Auto Calibrations – FOR ADVANCED USERS ONLY – CONTACT FACTORY FOR ASSISTANCE:</u>
The HiQDT ion selective (ISE) sensors stores deviation from the nominal mV at the isopotential concentration. This value is called the mV offset. If you wish to perform any calibration with standard solutions you must consult with the factory before perforuming such actions as you may badly skew the field readings is not properly performed.

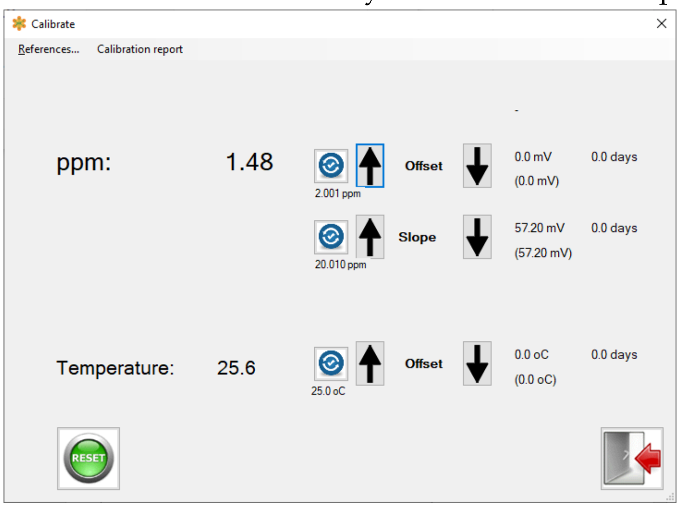
<u>Slope Auto Calibrations – FOR ADVANCED USERS ONLY – CONTACT FACTORY FOR ASSISTANCE:</u>
The HiQDT ion selective (ISE) sensors stores the sensitivity to changes in the measured analyte ion with a slope variable which is defined in mV per pION units. For most installations the factory defined slope should be used with adjustment. It is important to note that the mV response of the sensor is NOT linear to the common ppm units but rather to the scientific pION units. The following pages detail the relationship between the changes in mV and the associated pION and ppm units that correspond for the ammonium and fluoride ion selective sensors assuming all factory default settings.

The "Up" and "Down" buttons are clicked to performed manual calibrations in increments defined by user adjustable mV step per button whereas autoread calibrations are performed by clicking on blue icon next to calibration type performed.

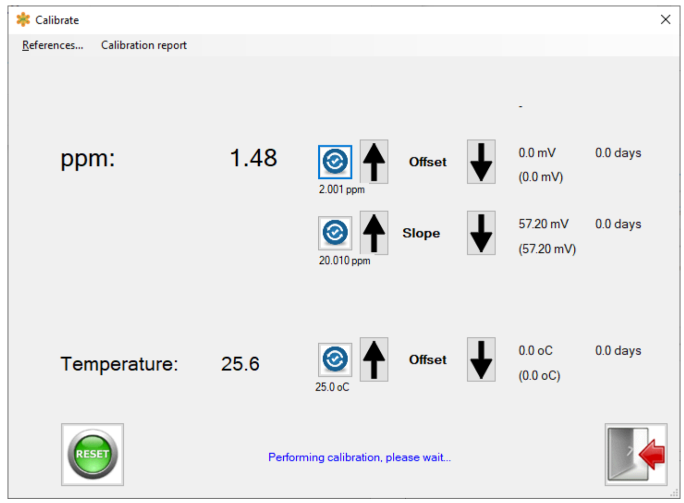
HiQDT-ISE "Calibrate" Menu – Perform Temperature & Ion Selective ppm Calibrations

SUMMARY OF CORRECT SEQUENCE FOR CALIBRATION OF HiQDT ISE SENSORS

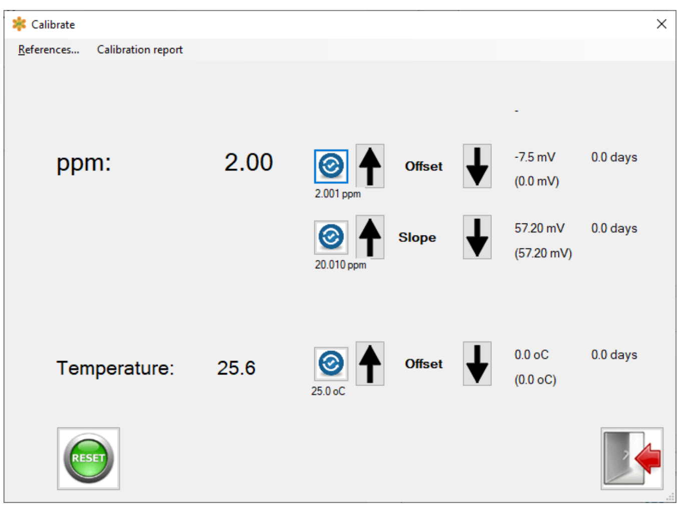
1. **Select the ppm values to be used for the offset & slope autocalibrations in "References"**
2. Perform **ISE 'Offset'** Calibration (Autoread or Manual)
   - **a.** Grab sample adjustment in 'Offset' MUST ALWAYS BE DONE. **Calibration with standard solutions is only recommended for advanced users with extensive factory assistance.**
   - **b.** 'Offset' autocalibration must be done BEFORE performing 'Slope' autocalibration
3. Perform **ISE 'Slope'** Calibration (Autoread or Manual)
   - a. Factory programmed slope is best for use in the vast majority of applications. If slope calibration is to be done by means of standard addition to process sample and/or construction of ionic background for standard solutions that very closely mimic process solution measured.
   - b. Contact factory if calibration is to be performed with standard solutions for assistance.



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*

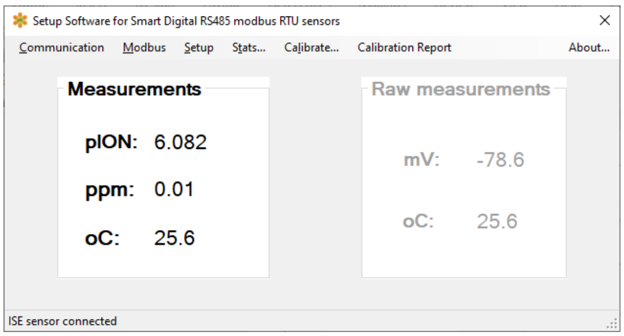
GENERAL NOTE:

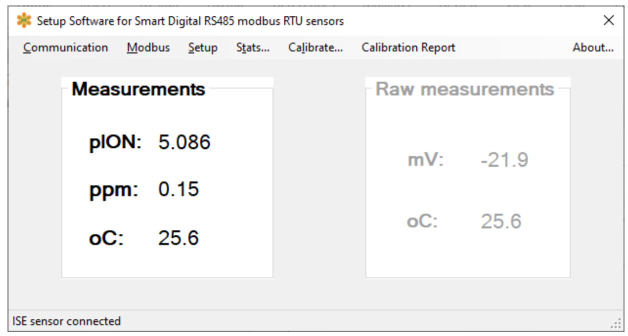
User adjustable dampener is always on. Wait until the reading is stable before proceeding to the next calibration step. Lag between when "Sensor successfully calibrated" is displayed & reading shows expected value based upon autocal reference will be equal to the dampener setting.

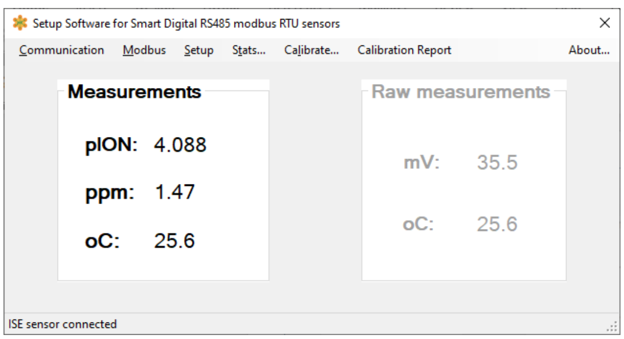
- Temperature stability of both the sensor & measured solution is required for good calibration of ISE sensor. Sensor temperature should be stable and the same as ambient condition for best results. **Temperature offset calibration (if it is performed) should always be done BEFORE ALL pH buffer calibrations.**
- 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 occuring.
- 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 ppm value.

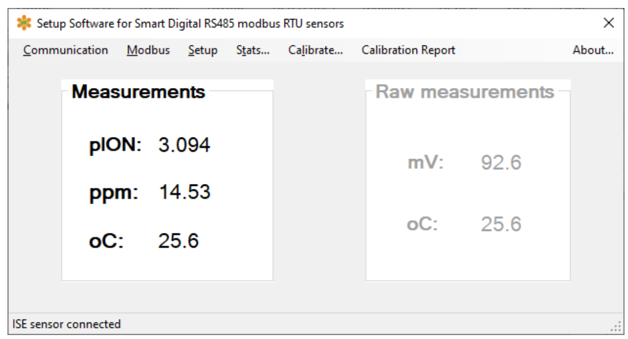
Changes in pION & ppm readings for Ammonium (NH_4^+) ISE Sensors

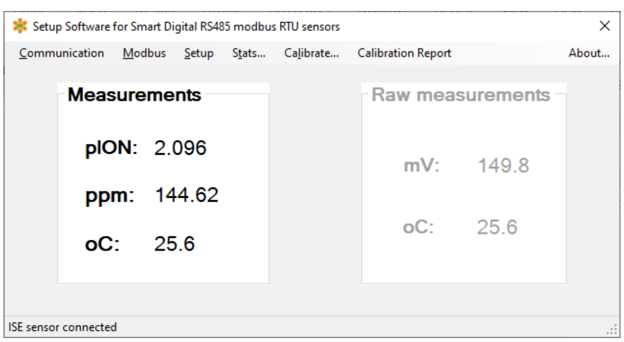
The HiQDT-ISE sends the temperature compensated and calibrated readings in scientific pION units. The mV response of the sensor is linear to changes in these scientific pION units. These pION units can be converted to the common ppm units by means of following the instructions in Appendix 0 of the modbus implementation guide. Shown below is an example of the ammonium ion selective sensors with the default calibration values across six decades of concentration for illustration purposes. Note the differences in the scientific pION concentration units as well as the common ppm units. Note that there exists only three (3) siginficant figures no matter which units are employed. At high ppm readings it would appear that there are more than 3 significant figures when in reality this is not the case. Depending upon the actual field offset, the exact mV values may differ for each corresponding concentration, especially if the default slope has been modified. For simplicity, screenshots below illustrate concentrations decades above & below the isopotential concentration.

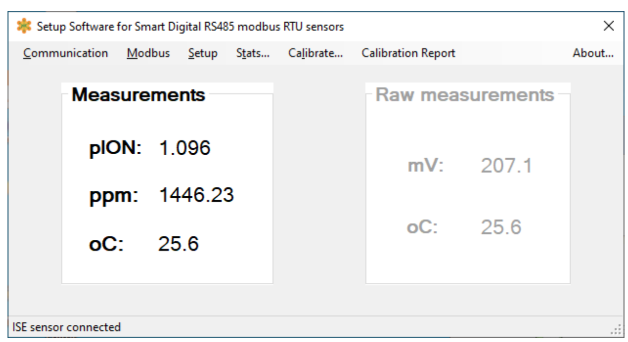


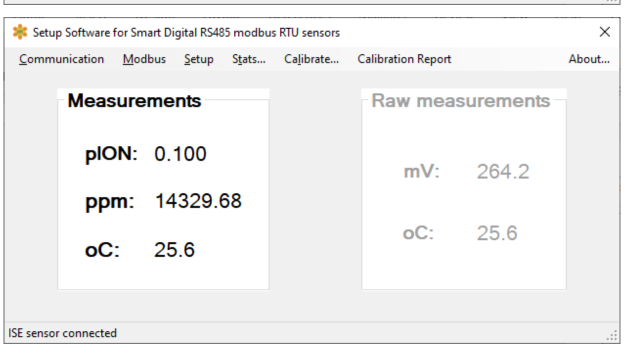












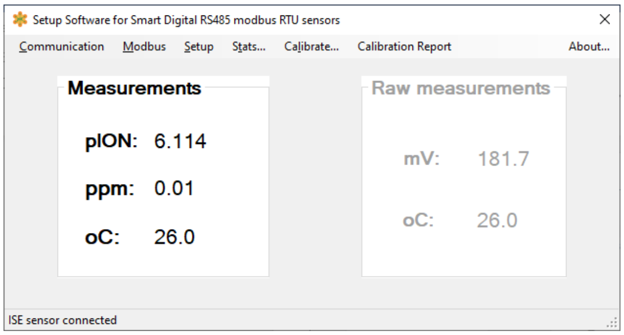
A 0.1mV change in the ISE sensor always produces a systematic corresponding response in pION units. In contrast, the same 0.1mV change in the ion selective sensor reading produces a non-linear response in ppm.

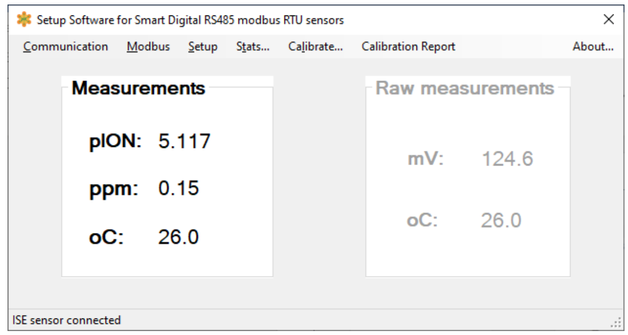
NOTE:

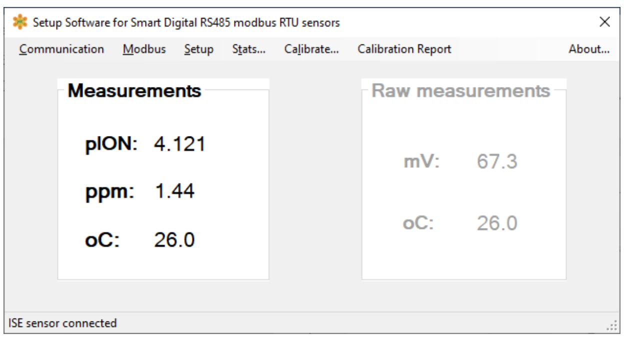
Actual linear measurement range for your particular ISE sensor will vary based upon a variety of factors. Examples shown here are only meant to illustrate how mV changes manifest in pION & ppm units.

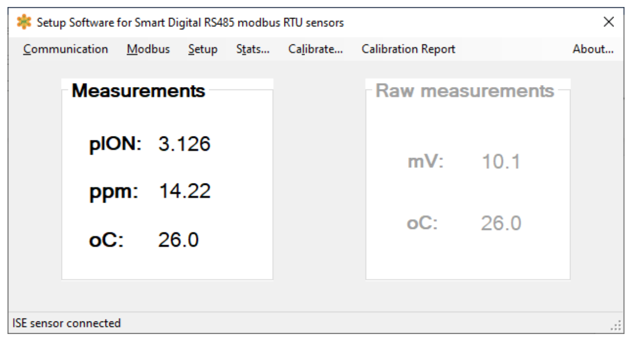
Changes in pION & ppm readings for Fluoride (F^-) ISE Sensors

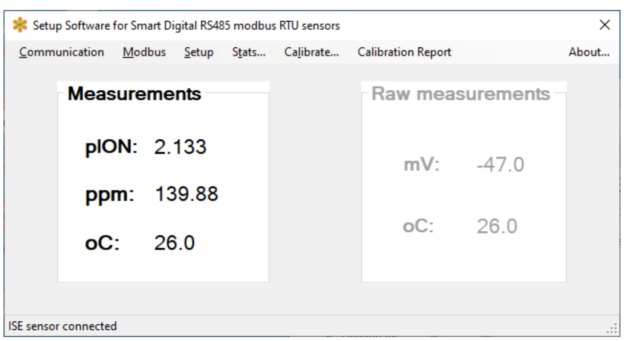
The HiQDT-ISE sends the temperature compensated and calibrated readings in scientific pION units. The mV response of the sensor is linear to changes in these scientific pION units. These pION units can be converted to the common ppm units by means of following the instructions in Appendix 0 of the modbus implementation guide. Shown below is an example of the ammonium ion selective sensors with the default calibration values across six decades of concentration for illustration purposes. Note the differences in the scientific pION concentration units as well as the common ppm units. Note that there exists only three (3) siginficant figures no matter which units are employed. At high ppm readings it would appear that there are more than 3 significant figures when in reality this is not the case. Depending upon the actual field offset, the exact mV values may differ for each corresponding concentration, especially if the default slope has been modified. For simplicity, screenshots below illustrate concentrations decades above & below the isopotential concentration.

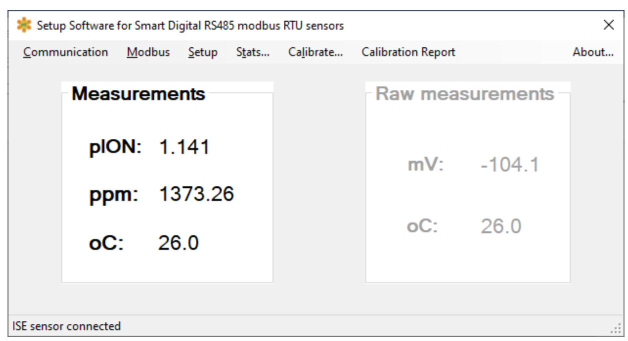


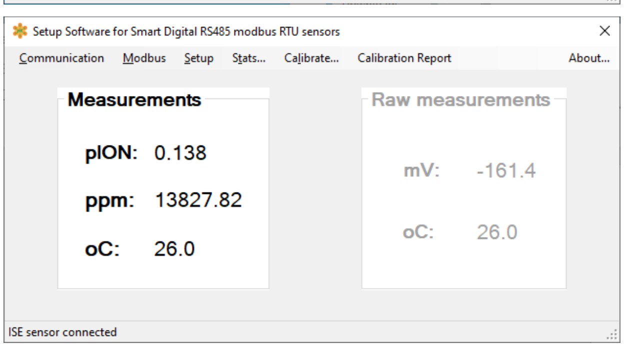










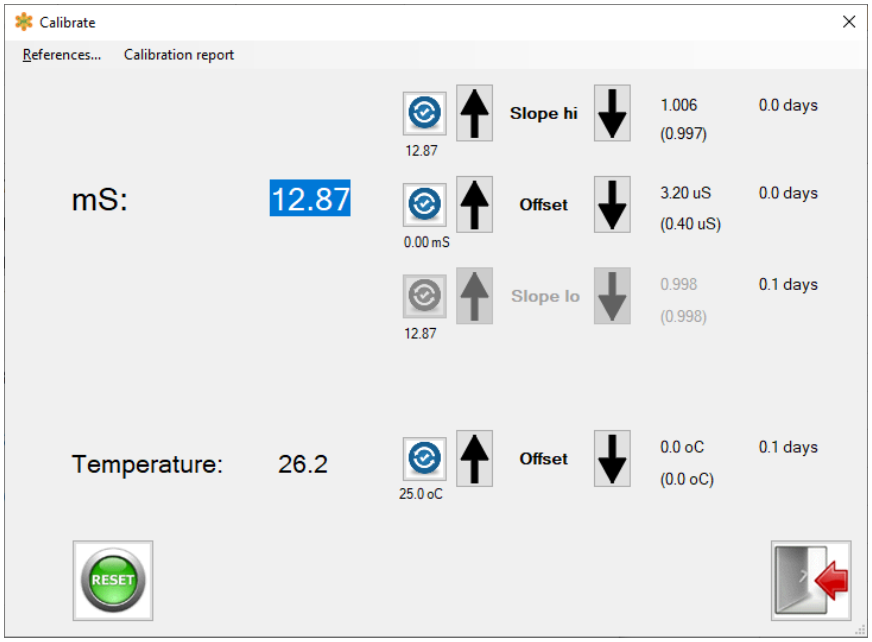


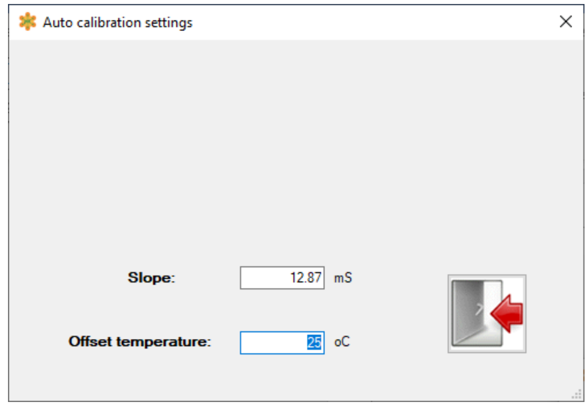
A 0.1mV change in the ISE sensor always produces a systematic corresponding response in pION units. In contrast, the same 0.1mV change in the ion selective sensor reading produces a non-linear response in ppm.

NOTE:

Actual linear measurement range for your particular ISE sensor will vary based upon a variety of factors. Examples shown here are only meant to illustrate how mV changes manifest in pION & ppm units.

HiQDT-CON Standard & High Range "Calibrate" Menu – Overview of Fields & Options





The autocalibration condutivity values are used when performing the slope lo and slope hi calibrations and are defined by clicking on the "References" and entering the mS values in the screen as shown directly above. Click on the "Exit" icon to save the entered values before calibrating.

Clicking on "Calibrate" menu loads the screen shown above when a HiQDT-CON sensor is connected. The temperature compensated conductivity reading as well as the temperature reading is displayed based upon the current calibrations for the connected sensor. Before performing a calibration click on "References" menu to configure the autocalibration vaues to be used for your connected smart digital HiQDT MODBUS RTU standard or high range mode conductivity sensor.

Overview of Display Fields:
Displayed **mS:** 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 (parentheses).

Offset Auto Calibration:
The HiQDT conductivity should read exactly zero when it is in the dry in air state. If your conductivity is clean and dry in air and does not read zero then you should perform the zero autocalibration until it does. Minor deviations are normal.

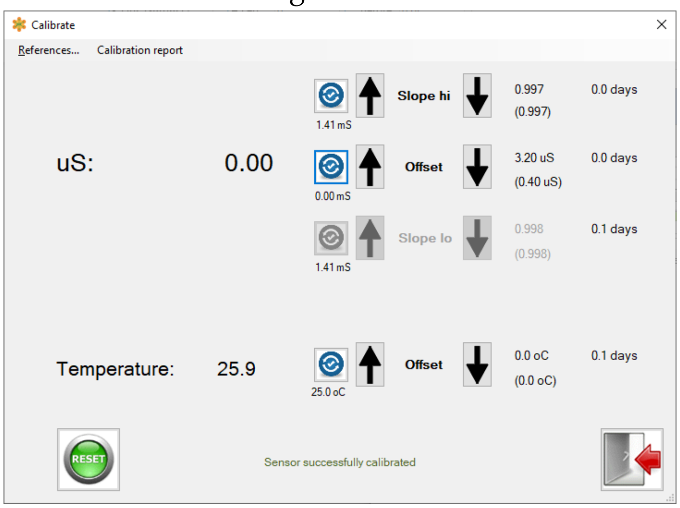
Slope Lo & Slope Hi Auto Calibration:
When the sensor is in the standard range mode then the "Slope lo" autocalibration will be engage and available. When the sensor is in the high range mode then the "Slope Hi" autocalibration will engage and become available. The reference value entered must be within the boundary limits for the range mode of the cell constant selected for the connected sensor in the setup screen. Please see page 14 for details for each available range mode for each cell contant to ensure that a valid reference value is entered before performin slope calibration. If no commercially available conductivity standard is present then it is possible to use precisely prepared potassium chloride (KCl) or sodium chloride (NaCl) solutions as the basis for conductivity standard solutions (contact factory for assistance). Alternatively the 'Up' or 'Down' buttons can be used to perform manual slope calibration adjustment to any value without first entering the reference value instead.

"Grab Sample" Calibration:
The wet slope calibrations on the conductivity sensors can be made based upon a conductivity standard solution or else to force agreement to a grab sample which has been analyzed in a timely manner (typically analyzed with a precalibrated 4-electrode portable or laboratory cell). In addition to this Windows software the offset and slope calibrations can also be performed by means of the handheld communicator or the touchscreen controller (either locally or remotely).

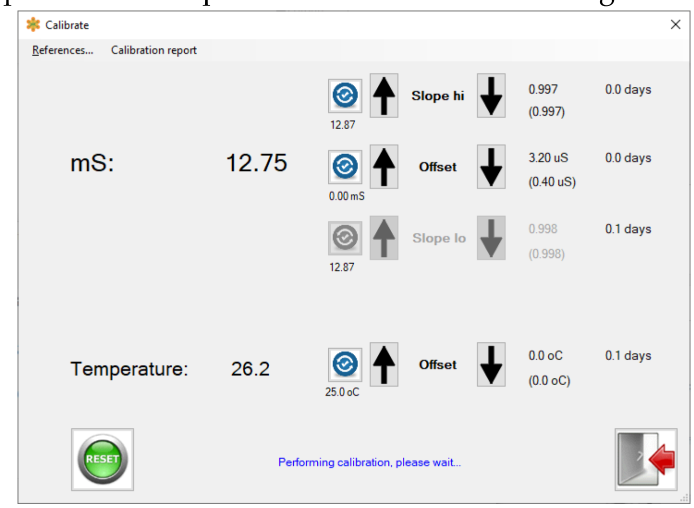
HiQDT-CON Std/Hi "Calibrate" Menu – Perform Temperature & Conductivity Calibrations

SUMMARY OF CORRECT SEQUENCE FOR CALIBRATION OF HiQDT ISE SENSORS

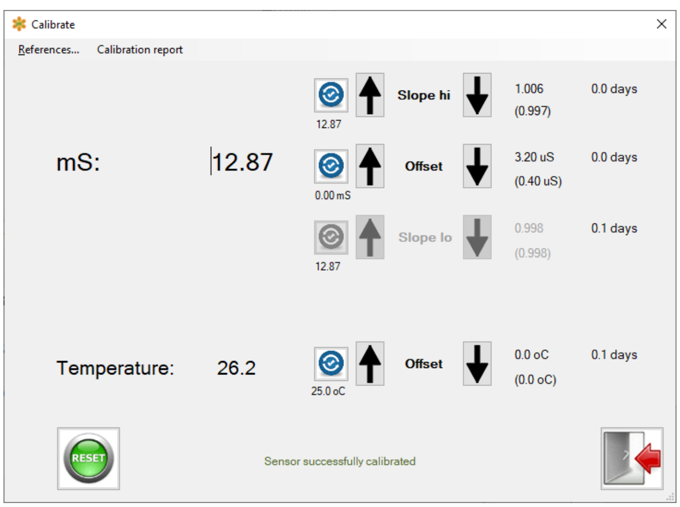
1. **Select the conductivity values to be used for the slope autocalibration in "References"**
2. Perform '**Zero Dry in Air Offset'** Calibration (Autoread or Manual)
3. Perform **'Slope'** Calibration (Autoread or Manual)
   - **a.** Best results are typically obtained by using conductivity standard solutions near 50% of the full range for the given cell constant and range mode. **It is critical to ensure that the entire measuring cell is completely full with the standard solution and no air is present.**
   - b. If it is planned to operate in both the standard range mode and the high range mode with the sensor then a separate slope calibration should be performed for each range mode. You must first go back to the 'Setup' screen to toggle between the standard and high range mode before returning back to the Calibrate screen to perform the slope calibration for the other range mode.



Step 1 *- Perform the Zero Dry in Air Offset Calibration*



Step 2 *- Perform Slope calibration in range mode to be used*

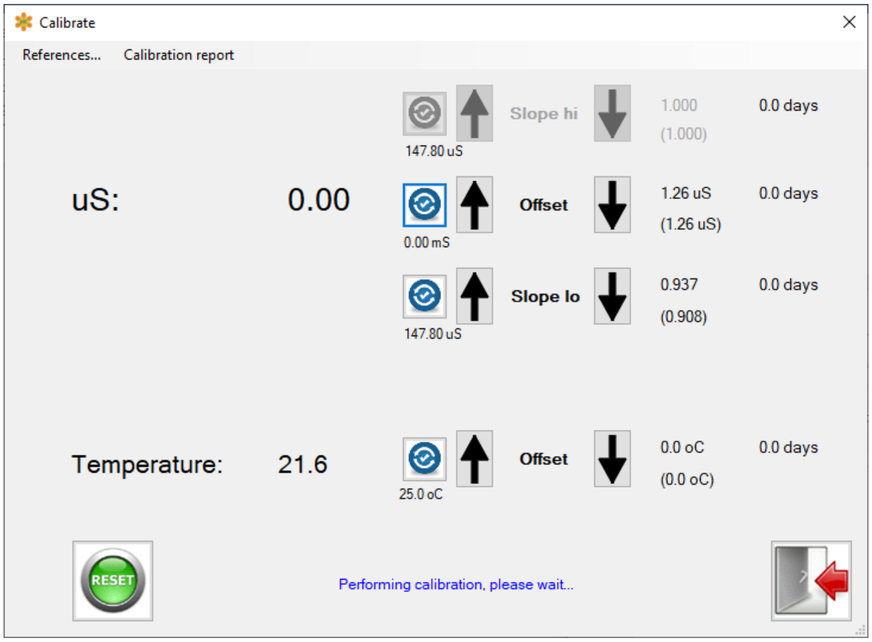


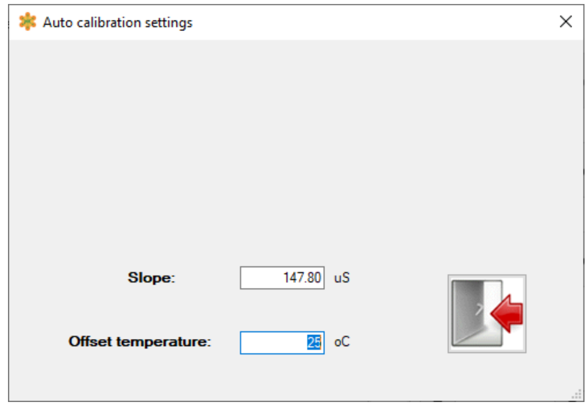
Step 3 *– Perform slope for alternate range mode (optional)*

<u>GENERAL NOTE:</u>
User adjustable dampener is always on. Wait until the reading is stable before proceeding to the next calibration step. Lag between when "Sensor successfully calibrated" is displayed & reading shows expected value based upon autocal reference will be equal to the dampener setting.

- Temperature stability of both the sensor & measured solution is required for good calibration of EC 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 slope 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 adjustable % per 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 occuring.
- 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 conductivity value.

HiQDT-CON-L Ultralow High Range "Calibrate" Menu – Overview of Fields & Options





The autocalibration condutivity values are used when performing the slope lo and slope hi calibrations and are defined by clicking on the "References" and entering the mS values in the screen as shown directly above. Click on the "Exit" icon to save the entered values before calibrating.

Clicking on "Calibrate" menu loads screen shown above when a HiQDT-CON-L sensor is connected. The temperature compensated conductivity reading as well as the temperature reading is displayed based upon the current calibrations for the connected sensor. Before performing a calibration click on "References" menu to configure the autocalibration vaues to be used for your connected smart digital HiQDT MODBUS RTU standard or high range mode conductivity sensor.

Overview of Display Fields:
Displayed **µS:** 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 (parentheses).

Offset Auto Calibration:
The HiQDT conductivity should read exactly zero when it is in the dry in air state. If your conductivity is clean and dry in air and does not read zero then you should perform the zero autocalibration until it does. Minor deviations are normal.

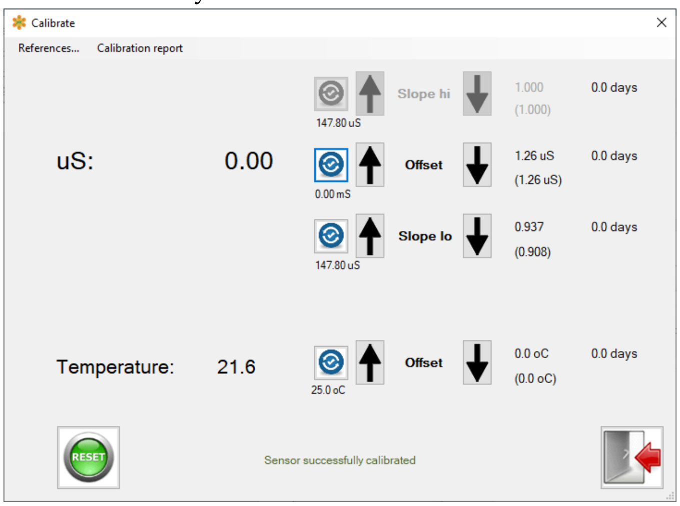
Slope Auto Calibration:
The ultralow range mode conductivivty sensors always use the "Slope lo" autocalibration. The "Slope hi" autocalibration is not available for the ultralow range mode conductivity sensors. The reference value entered must be within boundary limits for the range of the cell constant selected for the connected sensor in the setup screen. Please see page 15 for details for the range associated for each cell contant in the ultralow range mode sensors to ensure that a valid reference value is entered before performin slope calibration. Alternatively the 'Up' or 'Down' buttons can be used to perform manual slope calibration adjustment to any value without first entering the reference value instead.

"Grab Sample" Calibration:
The wet slope calibrations on the conductivity sensors can be made based upon a conductivity standard solution or else to force agreement to a grab sample which has been analyzed in a timely manner (typically analyzed with a precalibrated 4-electrode portable or laboratory cell). In addition to this Windows software the offset and slope calibrations can also be performed by means of the handheld communicator or the touchscreen controller (either locally or remotely).

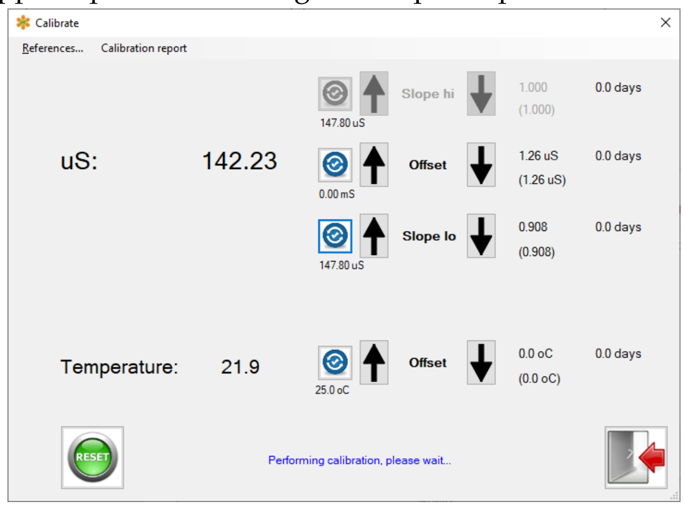
HiQDT-CON-L Ultralow "Calibrate" Menu – Perform Temp & Conductivity Calibrations

SUMMARY OF CORRECT SEQUENCE FOR CALIBRATION OF HiQDT ISE SENSORS

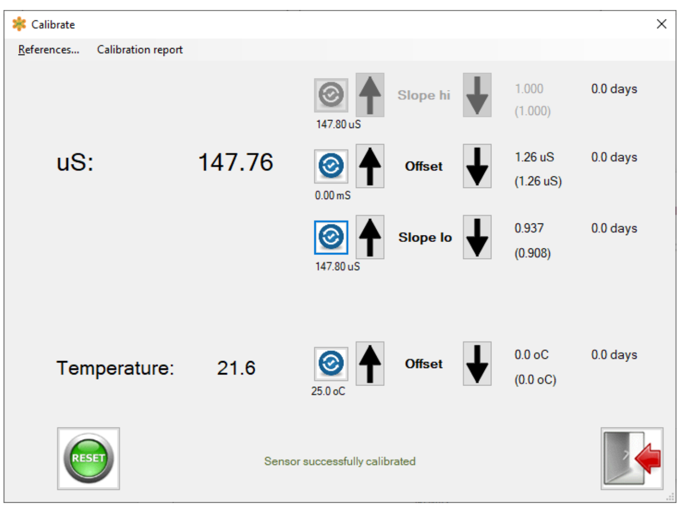
1. **Select the conductivity values to be used for the slope autocalibration in "References"**
2. Perform '**Zero Dry in Air Offset'** Calibration (Autoread or Manual)
3. Perform **'Slope'** Calibration (Autoread or Manual)
   - **a.** Best results are typically obtained by using conductivity standard solutions near 50% of the full range for the given cell constant and range mode. **It is critical to ensure that the entire measuring cell is completely full with the standard solution and no air is present.**
   - b. For best results it is recommended to also perform an in-situ slope calibration when the sensor is installed into process service and the temperature and conductivity value is well stabilized. This can be done either with this Windows software or else the handheld communicator for all systems. Touchscreen controllers also supports perform in-situ grab sample slope calibration.



Step 1 - *Perform the Zero Dry in Air Offset Calibration*



Step 2 - *Perform Slope calibration within range of cell used*



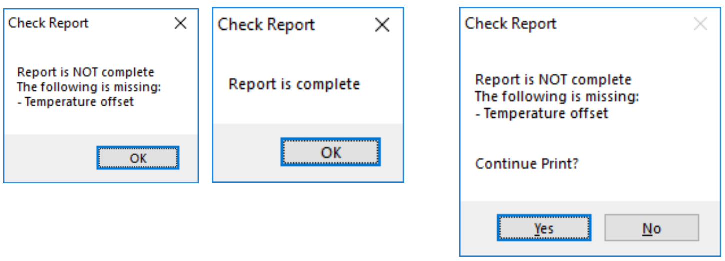
Step 3 – *Perform grab sample slope calibration in-situ if needed*

GENERAL NOTE:
User adjustable dampener is always on. Wait until the reading is stable before proceeding to the next calibration step. Lag between when "Sensor successfully calibrated" is displayed & reading shows expected value based upon autocal reference will be equal to the dampener setting.

- Temperature stability of both the sensor & measured solution is required for good calibration of EC 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 slope 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 adjustable % per 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 occuring.
- 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 conductivity value.

pH, ORP, Dissolved Oxygen, Ion Selective & Conductivity "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 printer 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 calibrate 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:

<u>SENSOR DESCRIPTION & ANALYTICS:</u>

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

<u>SENSOR CALIBRATIONS:</u>

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, DO, ISE & EC Only (Factory, Previous and Current Values)
Time Since Last Temperature Offset Calibration was Performed

Slope for Alkaline Measurements Calibration – pH & EC Std/Hi Range 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 US Letter or A4 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 (https://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.

Last Modified December 2020

CALIBRATION REPORT & CERTIFICATE FOR SMART DIGITAL RS-485 MODBUS RTU SENSOR

Time & Date New Calibrations Performed: Friday, June 28, 2019 10:24 AM

SENSOR DESCRIPTION & ANALYTICS

Sensor Type:	pH r.8
Sensor Item Number:	1418
Serial Number:	18.11-D.00
Build Date:	11/1/2018
Modbus Node Address:	1
Baudrate:	19200 baud
Total Days in Use:	155.0 days
Min. Temp. in Use:	18.1 oC
Max. Temp. in Use:	31.4 oC

SENSOR CALIBRATIONS

Temperature Offset Calibrations:

Factory:	-0.1 oC
Last Calibration:	0.0 oC
Time since Last Calibration:	155.8 days
New Calibration:	N/A

mV Offset Calibrations (Asymmetric Potential Calibration for pH):

Factory:	54.6 mV
Last Calibration:	0.0 mV
Time since Last Calibration:	155.8 days
New Calibration:	54.6 mV

Slope for Acidic Measurements Calibration (pH Only):

Factory:	60.45 mV/pH
Last Calibration:	59.15 mV/pH
Time since Last Calibration:	155.8 days
New Calibration:	60.45 mV/pH

Slope for Alkaline (Base) Measurements Calibration (pH Only):

Factory:	56.15 mV/pH
Last Calibration:	59.15 mV/pH
Time since Last Calibration:	155.8 days
New Calibration:	56.15 mV/pH

Operator Signature for Calibrations: ______________________________

CALIBRATION REPORT & CERTIFICATE FOR SMART DIGITAL RS-485 MODBUS RTU SENSOR

Time & Date New Calibrations Performed: Friday, June 28, 2019 10:26 AM

SENSOR DESCRIPTION & ANALYTICS

Sensor Type:	DO r.5
Sensor Item Number:	18017
Serial Number:	19.06-D.00
Build Date:	6/4/2019
Modbus Node Address:	4
Baudrate:	19200 baud
Total Days in Use:	8.0 days
Min. Temp. in Use:	23.0 oC
Max. Temp. in Use:	54.0 oC

SENSOR CALIBRATIONS

Temperature Offset Calibrations:

Factory:	0.0 oC
Last Calibration:	0.0 oC
Time since Last Calibration:	8.9 days
New Calibration:	N/A

Slope for dissolved Oxygen Measurements Calibration (DO Only):

Factory:	1.79 mV/ppm
Last Calibration:	1.70 mV/ppm
Time since Last Calibration:	8.9 days
New Calibration:	1.79 mV/ppm

Operator Signature for Calibrations: ______________________________

CALIBRATION REPORT & CERTIFICATE FOR SMART DIGITAL RS-485 MODBUS RTU SENSOR

Time & Date New Calibrations Performed: Saturday, June 20, 2020 2:34 PM

SENSOR DESCRIPTION & ANALYTICS

Sensor Type:	ISE r.0 Cation 18.04
Sensor Item Number:	1587
Serial Number:	20.06-E.42
Build Date:	6/20/2020
Modbus Node Address:	5
Baudrate:	19200 baud
Total Days in Use:	0.0 days
Min. Temp. in Use:	25.6 oC
Max. Temp. in Use:	25.6 oC

SENSOR CALIBRATIONS

Temperature Offset Calibrations:

Factory:	0.0 oC
Last Calibration:	0.0 oC
Time since Last Calibration:	0.0 days
New Calibration:	N/A

mV Offset Calibrations (Asymmetric Potential Calibration for pH):

Factory:	0.0 mV
Last Calibration:	0.0 mV
Time since Last Calibration:	0.0 days
New Calibration:	-7.5 mV

Slope for Acidic Measurements Calibration (pH Only):

Factory:	57.20 mV/pH
Last Calibration:	57.20 mV/pH
Time since Last Calibration:	0.0 days
New Calibration:	57.40 mV/pH

Operator Signature for Calibrations: ______________________________

CALIBRATION REPORT & CERTIFICATE FOR SMART DIGITAL RS-485 MODBUS RTU SENSOR

Time & Date New Calibrations Performed: Saturday, June 20, 2020 2:53 PM

SENSOR DESCRIPTION & ANALYTICS

Sensor Type:	ISE r.0 Anion 19.00
Sensor Item Number:	1586
Serial Number:	20.06-E.13
Build Date:	6/18/2020
Modbus Node Address:	5
Baudrate:	19200 baud
Total Days in Use:	0.0 days
Min. Temp. in Use:	26.0 oC
Max. Temp. in Use:	26.0 oC

SENSOR CALIBRATIONS

Temperature Offset Calibrations:

Factory:	0.0 oC
Last Calibration:	0.0 oC
Time since Last Calibration:	0.0 days
New Calibration:	N/A

mV Offset Calibrations (Asymmetric Potential Calibration for pH):

Factory:	-7.9 mV
Last Calibration:	0.0 mV
Time since Last Calibration:	0.0 days
New Calibration:	-25.5 mV

Slope for Acidic Measurements Calibration (pH Only):

Factory:	53.50 mV/pH
Last Calibration:	57.20 mV/pH
Time since Last Calibration:	0.0 days
New Calibration:	59.10 mV/pH

Operator Signature for Calibrations: ______________________________

CALIBRATION REPORT & CERTIFICATE FOR SMART DIGITAL RS-485 MODBUS RTU SENSOR

Time & Date New Calibrations Performed: Tuesday, November 24, 2020 8:28 AM

SENSOR DESCRIPTION & ANALYTICS

```
Sensor Type:            Con r.0 Ck=0.10, high range
Sensor Item Number:     23002
Serial Number:          20.11-C.00
Build Date:             11/4/2020
Modbus Node Address:    6
Baudrate:               19200 baud
Total Days in Use:      0.0 days
Min. Temp. in Use:      25.7 oC
Max. Temp. in Use:      26.2 oC
```

SENSOR CALIBRATIONS

Temperature Offset Calibrations:

```
Factory:                        0.0 oC
Last Calibration:               0.0 oC
Time since Last Calibration:    0.1 days
New Calibration:                N/A
```

Offset Calibrations (Dry in air):

```
Factory:                        0.000 mS
Last Calibration:               0.000 mS
Time since Last Calibration:    0.1 days
New Calibration:                0.003 mS
```

Slope Calibrations (Standard range):

```
Factory:                        0.998
Last Calibration:               0.998
Time since Last Calibration:    0.1 days
New Calibration:                N/A
```

Slope Calibrations (High range):

```
Factory:                        0.997
Last Calibration:               0.997
Time since Last Calibration:    0.0 days
New Calibration:                1.006
```

Operator Signature for Calibrations: ______________________________

CALIBRATION REPORT & CERTIFICATE FOR SMART DIGITAL RS-485 MODBUS RTU SENSOR

Time & Date New Calibrations Performed: Tuesday, November 24, 2020 9:26 AM

SENSOR DESCRIPTION & ANALYTICS

Sensor Type:	Con-L r.0 Ck=1.00
Sensor Item Number:	23009
Serial Number:	20.11-C.142
Build Date:	11/24/2020
Modbus Node Address:	6
Baudrate:	19200 baud
Total Days in Use:	0.0 days
Min. Temp. in Use:	21.6 oC
Max. Temp. in Use:	21.6 oC

SENSOR CALIBRATIONS

Temperature Offset Calibrations:

Factory:	0.0 oC
Last Calibration:	0.0 oC
Time since Last Calibration:	0.0 days
New Calibration:	N/A

Offset Calibrations (Dry in air):

Factory:	1.256 uS
Last Calibration:	1.260 uS
Time since Last Calibration:	0.0 days
New Calibration:	1.296 uS

Slope Calibrations (Standard range):

Factory:	0.908
Last Calibration:	0.937
Time since Last Calibration:	0.0 days
New Calibration:	0.937

Operator Signature for Calibrations: ______________________________

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Version 1.0 September 2018

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