



AquiStar[®] CT2X

Conductivity Smart Sensor
(With Pressure Option)

For PSIG
sensors, refer
to page 11
regarding
desiccant
use!



True data, measure by measure



Table of Contents

Introduction	3
What is the CT2X with Pressure Option?.....	3
Initial Inspection and Handling	3
Do's and Don'ts	3
Installation and Operation.....	4
Connecting to External Power	4
Connecting the CT2X to a Computer	4
Installing the Aqua4Plus Software.....	4
Selecting Linear or Non-Linear Mode.....	5
Installing the Sensor	6
Collecting Data	7
Maintenance.....	10
Changing Batteries.....	10
Removing Debris from End Cone on Pressure Units	10
Desiccant Tubes on Vented Pressure Units.....	11
Miscellaneous	11
Trouble Shooting.....	12
Erratic Readings.....	12
Oscillating Readings Over Time.....	12
Zero Readings When Pressurized.....	12
Grounding Issues	12
Appendix A: Technical Specifications	14
Wiring Information	14
Dimensions and Specifications	15
Appendix B: Field Calibration.....	17
Preparing for Calibration	17
Field Calibration — Conductivity	17
Field Calibration — Pressure.....	19
Appendix C: Measuring Elevation or Depth-to-Water	20
Groundwater Elevation Calibration	21
Appendix D: Alternate Connection Options	22
Connecting via RS232 Serial Port	22
Connecting with a USB/Serial Adapter	22
Appendix E: Reading the CT2X via Direct Read.....	24
Setting Units for Direct Read	24
Reading Via Modbus® RTU	25
Reading Via SDI-12.....	27
Appendix F: Reading Salinity.....	30
Appendix G: Battery Changing Details	31
Reordering Information	35
Limited Warranty/Disclaimer - AquiStar® CT2X SENSORS.....	36

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Introduction

What is the CT2X with Pressure Option?

The AquiStar® CT2X is a submersible conductivity/temperature sensor with built-in datalogging. This device stores thousands of records of conductivity, temperature, and time data. The CT2X is also available with a pressure option based on INW's popular CT2X Smart Sensor, giving added functionality in the same sensor housing. The conductivity channel can also be used to measure salinity. See Appendix F for details.

The CT2X incorporates 4-pole electrode cell measurement technology. This technology reduces fringe field interference errors, lessens inaccuracy caused by polarization effects, and lowers contact resistance problems. Four-pole electrode technology also allows users to work with one electrode over a wide range of conductivity.

The conductivity probe is constructed of epoxy/graphite, making it extremely durable for use in rugged field conditions. To clean, simply scrub with a small brush.

The CT2X is powered internally with 2 AA batteries or with an external auxiliary power supply for data intensive applications.

Most users will use the CT2X with INW's Aqua4Plus software. However, the CT2X is quite versatile, communicating via either Modbus® or SDI-12 interfaces, allowing you to do the following:

- Read a CT2X via the Modbus® protocol using your own software.
- Read a CT2X via SDI-12 protocol.
- Display readings from a CT2X on a panel meter.

If you want to use one of these methods, please see Appendix E.

Initial Inspection and Handling

Upon receipt of your smart sensor, inspect the shipping package for damage. If any damage is apparent, note the signs of damage on the appropriate shipping form. After opening the carton, look for concealed damage, such as a cut cable. If concealed damage is found, immediately file a claim with the carrier.

Do's and Don'ts

Do handle the device with care.

Do store the device in a dry, inside area when not in use.

Do install a desiccant tube (pressure version only) if you are doing long-term outdoor monitoring with a gauge unit.

Do install the device so that the connector end is kept dry.

Don't support the device with the connector. Use a strain relief device to take the tension off the connectors.

Don't allow the device to free-fall down as well as impact damage can occur.

Don't bang or drop the device on hard objects.

Installation and Operation

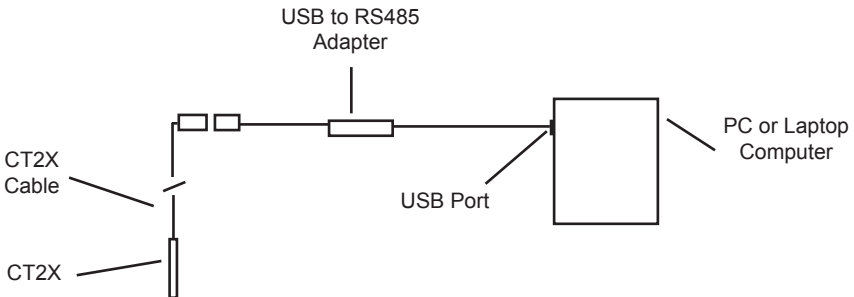
Connecting to External Power

The CT2X comes with two AA internal batteries. This provides enough power for at least one year of operation at the rate of four measurements per hour. (See Battery Life Calculation section in Appendix A for further details.)

If auxiliary power is desired, you can use a 6 - 13 VDC supply that can provide 15 mA. Connect to Vaux++ (pin 1 - white) and Ground (pin 5 - blue) or contact INW for auxiliary power supplies.

Connecting the CT2X to a Computer

Connect the CT2X to your computer's USB port, as shown below. Drivers and installation instructions come with the adapter. (For alternate connection options, see Appendix D.)



*Connect the CT2X to your PC using a USB to RS485 adapter.
(See Appendix D for alternate connection options.)*

Installing the Aqua4Plus Software

The CT2X comes with the Aqua4Plus host software that is installed on your PC or laptop. Use this software to program the datalogger, to retrieve data from the logger, to view collected data, and to export data to external files for use with spreadsheets or databases.

Refer to the Aqua4Plus software manual for details on installing and using Aqua4Plus.

Using the CT2X Without Aqua4Plus

Most users will use the CT2X with INW's Aqua4Plus software. However, the CT2X is quite versatile, communicating via either Modbus® or SDI-12 interfaces, allowing you to do the following:

- Read a CT2X via the Modbus® protocol using your own software.
- Read a CT2X via SDI-12 protocol.
- Display readings from a CT2X on a panel meter.

If you want to use one of these methods, see Appendix E.

Selecting Linear or Non-Linear Mode

All conductivity measurements are sensitive to temperature change. The CT2X has built-in temperature compensation to correct for changes in temperature. As a user, you can select either a linear temperature compensation method or a non-linear (nLFn) compensation method.

In the linear mode, a constant temperature coefficient is applied to the readings. This defaults to 2.1% per degree C, which works well for a wide range of applications. If you want to use the linear method with a different coefficient, then enter that coefficient in the Temp Coef box on the Field Calibration window.

Natural waters, such as ground water, streams, and rivers, often have a very low conductivity and do not respond to temperature in a linear fashion. For this situation, the CT2X provides a non-linear mode, which uses a complex formula to calculate and apply temperature compensation to the readings. This method meets the DIN EN 27888 standards. If you want to use the non-linear method, checkmark the Non-Linear box on the Field Calibration window. The temperature coefficient box will disappear.

Channels	Channel Label: Conductivity
1: Temperature	Cal Date: 20-Jan-12 08:33
2: Conductivity	Ref. Temp.: 25 °C
3: Pressure	<input type="checkbox"/> Non-Linear
	Temp Coef: 2.10 %/°C
	TDS FCTR: 0.49

Enter a temperature coefficient for linear mode, if not using default.

Channels	Channel_Label: <input type="text" value="Conductivity"/>
1: Temperature	Cal Date: <input type="text" value="20-Jan-12 08:37"/>
2: Conductivity	Ref. Temp.: <input type="text" value="25"/> °C
3: Pressure	<input checked="" type="checkbox"/> Non-Linear
	TDS FCTR: <input type="text" value="0.49"/>

To use Non-Linear temperature compensation, checkmark this box.

Installing the Sensor

Lower the sensor to the desired depth. Fasten the cable to the well head using tie wraps or a weather proof strain-relief system. When securing a vented cable, make sure not to pinch the cable too tightly or the vent tube inside the cable jacket may be sealed off. Take a measurement to insure the sensor is not installed below its maximum range.

Be sure the supplied cap is securely placed on the weather-resistant connector at the top of the cable. Do not install such that the connector might become submerged with changing weather conditions. The connector can withstand incidental splashing but is not designed to be submerged.

For vented sensors, if at all possible, install the sensor so that the desiccant tube will not flood or lie in water. (Note: Though the hydrophobic filter will prevent water intrusion via the desiccant tube at one to two feet of submergence, care must still be taken to keep the cable connector from being submerged.)

The sensor can be installed in any position; however, when it leaves the factory it is tested in the vertical position. Strapping the sensor body with tie wraps or tape will not hurt it. INW can provide an optional 1/4" NPT input adapter which is interchangeable with the standard end cone for those applications where it is necessary to directly attach the sensor to a pipe, tank or other pipe port. If the sensor is being installed in a fluid environment other than water, be sure to check the compatibility of the fluid with the wetted parts of the sensor. INW can provide a variety of seal materials if you are planning to install the sensor in an environment other than water.

Collecting Data

Following is a brief overview on using Aqua4Plus to collect data. Please refer to the *Aqua4Plus Instruction Manual* for further details on configuring and using Aqua4Plus.

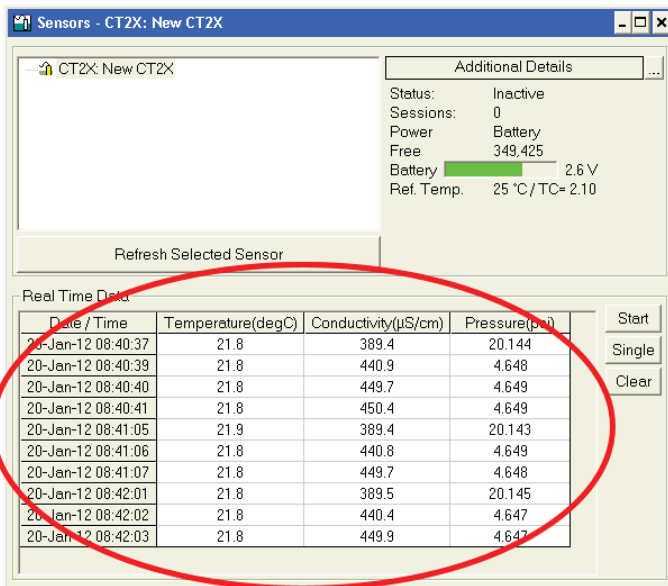
Real Time Monitor

Click Single to get a single reading.

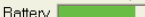
Click Start to get a reading once a second.

Click Stop to stop the reading.

Note: These are snapshot readings and are not recorded on the sensor. On sensors with firmware versions lower than 2.0, the pressure is displayed in the first column and temperature in the second. On sensors with firmware versions 2.0 and higher, the temperature is displayed in the first column and pressure in the second.



The screenshot shows a software window titled "Sensors - CT2X: New CT2X". The window is divided into several sections:

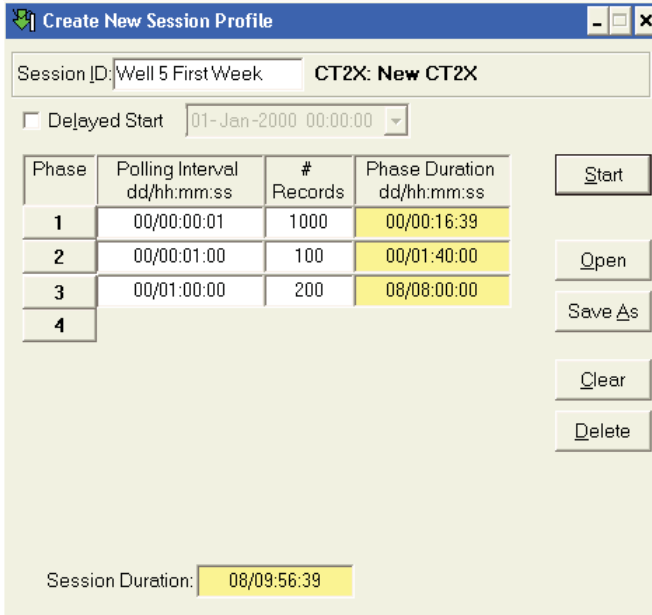
- Header:** "CT2X: New CT2X" with a refresh button.
- Additional Details:**
 - Status: Inactive
 - Sessions: 0
 - Power: Battery
 - Free: 349,425
 - Battery:  2.6 V
 - Ref. Temp: 25 °C / TC= 2.10
- Real Time Data:** A table with columns for Date / Time, Temperature(degC), Conductivity(µS/cm), and Pressure(psi). The table contains 10 rows of data. A red circle highlights this table.
- Buttons:** "Start", "Single", and "Clear" buttons are located to the right of the table.

Date / Time	Temperature(degC)	Conductivity(µS/cm)	Pressure(psi)
20-Jan-12 08:40:37	21.8	389.4	20.144
20-Jan-12 08:40:39	21.8	440.9	4.648
20-Jan-12 08:40:40	21.8	449.7	4.649
20-Jan-12 08:40:41	21.8	450.4	4.649
20-Jan-12 08:41:05	21.9	389.4	20.143
20-Jan-12 08:41:06	21.8	440.8	4.649
20-Jan-12 08:41:07	21.8	449.7	4.648
20-Jan-12 08:42:01	21.8	389.5	20.145
20-Jan-12 08:42:02	21.8	440.4	4.647
20-Jan-12 08:42:03	21.8	449.9	4.647

The Real Time Monitor gives a snapshot of the current readings on the sensor.

Setting up a Data Recording Session

Click the  tool button. A Session Profile Window will open. Refer to the *Aqua4Plus Instruction Manual* for details in describing your session profile. Click the Start button to save the session to the sensor and begin recording.




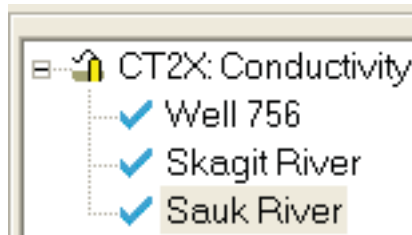
Phase	Polling Interval dd/hh:mm:ss	# Records	Phase Duration dd/hh:mm:ss
1	00/00:00:01	1000	00/00:16:39
2	00/00:01:00	100	00/01:40:00
3	00/01:00:00	200	08/08:00:00
4			

Session Duration: 08/09:56:39

Using the Session Profile Window, describe the test steps for your particular test.



Retrieving Data from the Sensor/Datalogger

- Click on the session you want to upload.
- Click the  tool button.
- Select a file location.
- Click Save.
- Click Start.



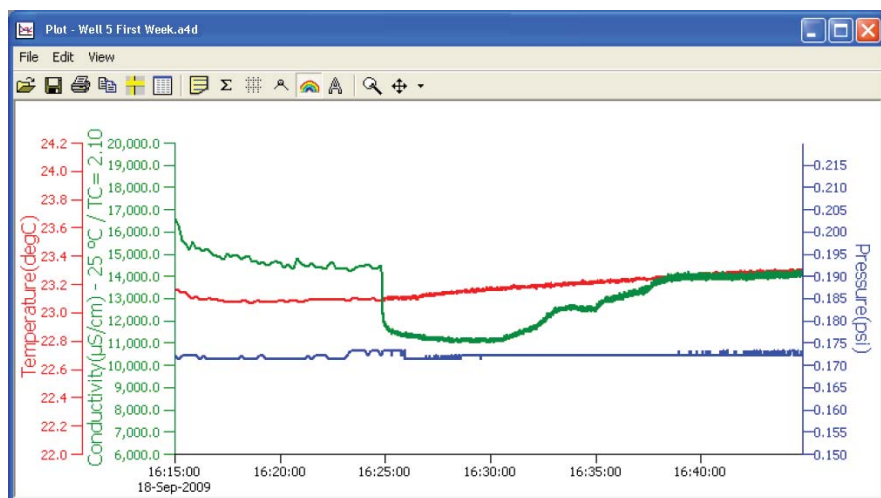
Select the data session you are ready to upload.

Viewing Data

- Click the  tool button to view data as a table.
- Click the  tool button to view data as a graph.
- Navigate to the desired file, then click the Open button. (If the File Open box does not appear, click the File Menu, then select Open.)


File Display - Well 5 First Week.a4d				
Sensor SN	Sensor Type	Sensor Name	Session	Records
21123456	CT2X	New CT2X	Well 5 FirstWeek	80
	Sensor Range	150K ohm	0-100 mS/cm	100 psia
	Minimum	22.1	445.5	4.622
	Maximum	22.1	450.6	4.628
	Mean	22.1	449.1	4.625
	Variance	0.00	0.57	0.0000
	Std Deviation	0.00	0.76	0.0019
	Element/Ref Temp	30K5A-5 to 100	25 °C / TC= 2.10	
	Field Cal Date	19-Jan-12 15:36	20-Jan-12 08:33	14-Dec-11 14:40
Rec#	Date/Time	Temperature(degC)	Conductivity(µS/cm)	Pressure(psi)
1	20-Jan-12 09:55:07	22.1	447.0	4.627
2	20-Jan-12 09:55:08	22.1	448.0	4.623
3	20-Jan-12 09:55:09	22.1	447.7	4.625
4	20-Jan-12 09:55:10	22.1	448.5	4.624
5	20-Jan-12 09:55:11	22.1	449.0	4.627
6	20-Jan-12 09:55:12	22.1	449.4	4.624
7	20-Jan-12 09:55:13	22.1	449.2	4.628
8	20-Jan-12 09:55:14	22.1	449.1	4.627
9	20-Jan-12 09:55:15	22.1	449.1	4.627
10	20-Jan-12 09:55:16	22.1	448.0	4.626
11	20-Jan-12 09:55:17	22.1	448.1	4.628
12	20-Jan-12 09:55:18	22.1	449.7	4.626
13	20-Jan-12 09:55:19	22.1	447.5	4.625
14	20-Jan-12 09:55:20	22.1	445.5	4.623

The File Display Window displays your data in a tabular format.



The Graph Window displays your data on an X Y coordinate graph.

Exporting Data to .csv or .xls Files

- Using the File Display window, open the file you want to export.
- Click on the  tool button.
- Select a file location and enter a name for the file.
- Select a file type.
- Click Save.

A Word About Units

Readings from the CT2X Smart Sensor can be displayed in various units, such as PSI, Ft. H₂O, or mm H₂O for pressure, or degrees Celsius or degrees Fahrenheit for temperature. Select the units you want from the Options | Units menu.

Maintenance

Changing Batteries

Battery Type: Two standard AA Alkaline batteries.

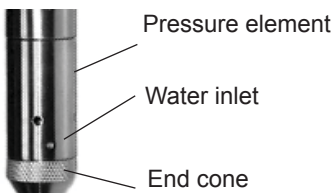
Because changing the batteries involves opening the water-tight seal, **this must be done in a clean, dry environment to avoid contamination or moisture damage to the circuitry.**

Refer to Appendix G for details on opening the housing and replacing the batteries.

Removing Debris from End Cone on Pressure Units

At times mud, silt, or other debris may foul the water inlets to the pressure element. The end cone can be removed to clean out the debris.

1. Gently twist off end cone portion only - do not twist off pressure element!
2. Remove debris. **Take care not to poke anything into the sensor.** This can damage the sensor element and void the warranty.
3. Replace and retighten the end cone.



Gently twist off the end cone, and then carefully remove debris.

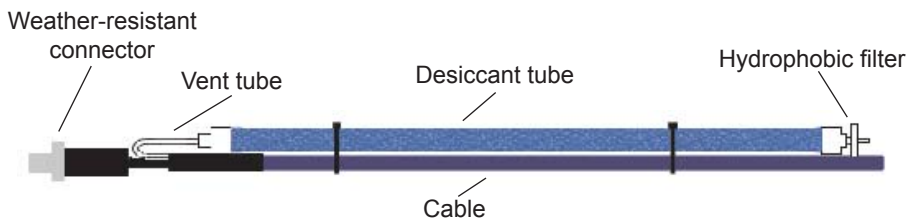
Desiccant Tubes on Vented Pressure Units

On vented pressure sensors, inspect the desiccant tube at least once every two months. The desiccant tube prevents moisture in the air from being sucked into the vent tube, which can cause erratic readings and sensor damage.

The desiccant tube is filled with blue silica gel beads. A locking barb and a hydrophobic water filter are attached to the end of the desiccant tube. This filter prolongs the life of the desiccant as much as three times over a desiccant tube without the filter.

Install the sensor so that the desiccant tube will not flood or lie in water.

The desiccant is a bright blue color when active and dry. As moisture is absorbed the color will begin to fade, becoming a light pink, which indicates full saturation and time to replace. Replacement desiccant and hydrophobic filters can be purchased from INW; please contact an INW sales engineer at 1-800-776-9355 for more information.



The desiccant tube prevents water intrusion through the vent tube. Be sure to replace the desiccant when it turns pink, as that indicates it is saturated.

Miscellaneous

Sensor: There are no user-serviceable parts, other than the batteries. If problems develop with sensor stability or accuracy, contact INW. If the transducers have been exposed to hazardous materials, do not return them without notification and authorization.

Cable: Cable can be damaged by abrasion, sharp objects, twisting, crimping, crushing, or pulling. Take care during installation and use to avoid cable damage. If a section of cable is damaged, it is recommended that you send your sensor back to replace the cable harness assembly.

End Connections: The contact areas (pins & sockets) of the connectors will wear out with extensive use. If your application requires repeated connections other types of connectors can be provided. The connectors used by INW are not submersible, but are designed to be splash-resistant.

Trouble Shooting

Erratic Readings

Erratic readings can be caused by a poor connection, damaged cable, moisture in the unit, or a damaged transmitter. In most cases, erratic readings are due to moisture getting into the system. The first thing to check is the connection. Look for moisture between contacts or a loose or broken wire. Next, check the cable for cracking or fraying. If the connections and cable appear OK, but the readings are still erratic, the transmitter may be damaged. Contact INW for evaluation and repair. Erratic and erroneous readings can also occur due to improper grounding. See Grounding Issues, below.

Oscillating Readings Over Time

If, after time, your transmitter is functioning normally but your data is showing a clic effect in the absence of water level changes, you are probably seeing barometric changes. The amount is usually .5 to 1.5 feet of water. This can be caused by a plugged vent tube in the cable or actual water level changes in the aquifer itself in response to barometric pressure changes. This effect can occur in tight formations where the transmitter will immediately pick up barometric changes but the aquifer will not. If you think you are having this type of problem you will have to record the barometric pressure as well as the water level pressure and compensate the data. If it appears that the vent tube is plugged, consult the factory.

If a desiccant tube is not installed in line with the cable, water may have condensed in your vent tube causing it to plug. After you are finished installing the desiccant tube you can test the vent tube by applying a small amount of pressure to the end of the desiccant tube and seeing if this affects the transmitter reading.

Zero Readings When Pressurized

Continuous zero readings are usually caused by an open circuit which may indicate a broken cable, a bad connection, or possibly a damaged transmitter. Check the connector to see if a wire has become loose or if the cable has been cut. If damage is not readily apparent, contact INW for evaluation and repair.

Grounding Issues

It is commonly known that when using electronic equipment, both personnel and equipment need to be protected from high power spikes that may be caused by lightning, power line surges, or faulty equipment. Without a proper grounding system,

a power spike will find the path of least resistance to earth ground – whether that path is through sensitive electronic equipment or the person operating the equipment. In order to ensure safety and prevent equipment damage, a grounding system must be used to provide a low resistance path to ground.

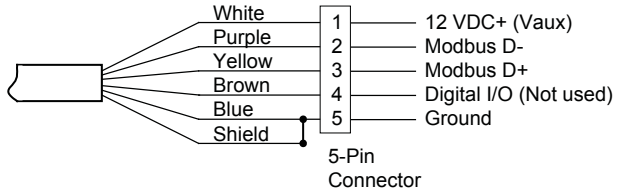
When using several pieces of interconnected equipment, each of which may have its own ground, problems with noise, signal interference, and erroneous readings may be noted. This is caused by a condition known as a *Ground Loop*. Because of natural resistance in the earth between the grounding points, current can flow between the points, creating an unexpected voltage difference and resulting erroneous readings.

The single most important step in minimizing a ground loop is to tie all equipment (sensors, dataloggers, external power sources and any other associated equipment) to a **single common grounding point**. INW recommends connecting the shield to ground at the connector end.

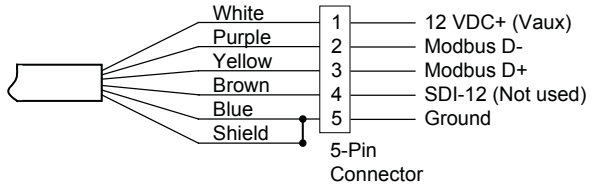
Appendix A: Technical Specifications

Wiring Information

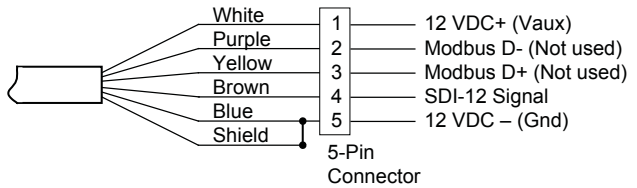
For Modbus® with firm-
ware lower than 2.0 —
with 5-pin connector



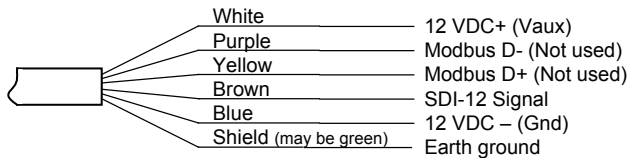
For Modbus® with
firmware 2.0 or higher —
with 5-pin connector



For SDI-12 with firm-
ware 2.0 or higher —
with 5-pin connector



For SDI-12 with firm-
ware 2.0 or higher —
without connector



Dimensions and Specifications

GENERAL

Length	12.745"(32.37cm)/16.395"(41.641cm) <i>w/pressure</i>
Diameter	0.75" (1.9 cm)
Weight	1.0 lb (0.5 kg)
Body Materials	Acetal & 316 stainless steel <i>or</i> titanium
Wire Seal Materials	Fluopolymer and PTFE
Submersible Cable	Polyurethane, polyethylene, or FEP
OD	0.28" (0.71 cm) maximum
Break Strength	138 lbs (62.6 kg)
Maximum Length	2000 feet (609.6 m)
Cable Weight	4 lbs/100 ft (1.8 kg/30 m)
Protection Rating	IP68, NEMA 6P
Desiccant	1-3mm indicating silica gel (<i>high or standard capacity</i>)
Termination Connector	Available
Communication	RS485 Modbus® RTU / SDI-12 (ver. 1.3)
Operating Temperature Range³	-15° C to 55° C
Storage Temperature Range¹	-40° C to 80° C

LOGGING

Memory	4MB – 349,000 records
Log Types	Variable, user-defined, logarithmic, profiled
Programmable Baud Rate	9600, 19200, 38400
Logging Rate	4x/sec maximum
Software	Complimentary Aqua4Plus or Aqua4Push
Networking	32 available addresses per junction w/ batching capabilities (up to 255)
File Formats	.xls / .csv / .a4d

POWER

Internal Battery	2x1.5V AA Alkaline ²
Auxiliary Power	12 VDC – Nominal / 6-15VDC – Range
Exp. Battery Life	12 months at 15m polling interval ⁷

TEMPERATURE

Element Type	30K ohm thermistor
Element Material	Epoxy bead/external housing
Accuracy	± 0.2° C
Resolution	0.1° C
Range	-5° C to 60° C
Units	Celsius, Fahrenheit, Kelvin

DEPTH / LEVEL

Transducer Type	Silicon strain gauge
Transducer Material	316 stainless steel or titanium
Units	PSI, FtH ₂ O, inH ₂ O, cmH ₂ O, mmH ₂ O, mH ₂ O, inHg, cmHg, mmHg, Bars, mBars, kPa
Static Accuracy	± 0.05% FSO (Typical)
<i>(B.F.S.L. 20°C)</i>	± 0.1% FSO (maximum) (±0.25% FSO for 0-5 PSI, 0-12 FtH ₂ O, 0-3.5 mH ₂ O)
Resolution	0.0034% (typical)
Maximum Operating	1.1 x FS
Burst Pressure⁴	3.0 x FS
Compensated Range	0° C to 40° C

Pressure Ranges⁵**Gauge**

fH₂O 2.3, 5.8, 12, 35, 69, 115, 231, 692

mH₂O 0.7, 1.75, 3.5, 10.5, 21, 35, 70, 210

Absolute⁸

fH₂O 12, 35, 81, 196, 658

mH₂O 3.5, 10, 24, 59, 200

CONDUCTIVITY

Probe Material	Epoxy/Graphite
Electrode	4-pole
Static Accuracy	± 0.5% of measured value
Resolution	32 bit
Ranges	
<i>Conductivity⁶</i>	0-100,000 or 0-200,000 or 0-300,000 µS/cm
<i>TDS</i>	4.9-49,000 or 4.9-98,000 or 4.9-147,000 mg/L
<i>Salinity</i>	2-42 PSU
Units	µS/cm, mS/cm, mg/L, PSU
Resolution	0.1 µS/cm / 0.001 mS/cm / 0.1 mg/L (TDS) / 0.001 PSU
Warm-Up Time	200 msec
Thermal Compensation	None, linear, of nLFn

¹ Storage without batteries

² Lithium available upon request

³ Requires freeze protection kit if using option in water below freezing

⁴ Burst reduced at PSI>300 (692 fH₂O & 210 mH₂O Gauge, 658 fH₂O & 200 mH₂O Absolute)

⁵ Higher pressure ratings available upon request

⁶ Accuracy reduced at levels <10 µS/cm

⁷ May vary due to environmental factors

⁸ Depth range for absolute sensors has 14.7 PSI subtracted to give actual depth allowed

Appendix B: Field Calibration

Preparing for Calibration

- Click on the sensor on the sensor tree.
- Erase any sessions on the sensor. (Be sure to upload any data you want to save first.)
- Select the Field Calibration option from the Configure menu.
- Click on the channel you want to calibrate.

Field Calibration — Conductivity

To get the most accurate readings, you should calibrate the conductivity channel using a standard or reference close to the expected conductivity of your samples. If you will be using the nLFn mode for your measurements, you must use a standard that has a reference temperature of 25 degrees C.

One-Point Calibration:

— Preparing —

- Select a standard that is close to the expected conductivity of your samples.
- Note the reference temperature on the standard's packaging.
- Select that reference temperature on the calibration window.
- Make sure the Non-Linear box is not checked, unless using a non-linear calibration standard.
- Enter the Temperature Coefficient (2.1 works for a wide variety of fluids). (Not needed if using a non-linear calibration standard.)
- If measuring TDS, enter TDS factor, if other than default of .49.

— Computing Calibration Value —

- Rinse sensor first with distilled water and then with a small amount of the standard.
- Dry with clean paper towel and cotton swab.
- Place sensor in standard.
- Make sure there are no bubbles in the conductivity slot.
- Allow time for sensor to stabilize.
- In the Ref box for the first point, enter the reference conductivity, as specified on the bottle.
- Click first Measure button.
- When readings have stabilized to your satisfaction, click the OK button in the pop-up box.

— Applying Calibration Value —

- Click the Apply button to apply calibration value.
- The computed b value will be transferred to the calibration field.
- Click OK to save the value to the sensor.

Two-Point Calibration:

— Preparing —

- Select two standards that bracket the expected conductivity of your samples.
- Note the reference temperature on the standards' packaging. (Must both be the same!)
- Select that reference temperature on the calibration window.
- Make sure the Non-Linear box is not checked, unless using non-linear calibration standards.
- Enter the Temperature Coefficient (2.1 works for a wide variety of fluids). (Not needed if using a non-linear calibration standard.)
- If measuring TDS, enter TDS factor, if other than default of .49.

— Compute First Calibration Point —

- Rinse sensor first with distilled water and then with a small amount of the lower standard.
- Dry with clean paper towel and cotton swab.
- Place sensor in lower standard.
- Make sure there are no bubbles in the conductivity slot.
- Allow time for sensor to stabilize.
- In the Ref box for the first point, enter the reference conductivity, as specified on the bottle.
- Click first Measure button.
- When readings have stabilized to your satisfaction, click the OK button in the pop-up box.

— Compute Second Calibration Point —

- Rinse sensor first with distilled water and then with a small amount of the higher standard.
- Dry with clean paper towel and cotton swab.
- Place sensor in higher standard.
- Make sure there are no bubbles in the conductivity slot.
- Allow time for sensor to stabilize.
- In the Ref box for the second point, enter the reference conductivity, as specified on the bottle.
- Click second Measure button.
- When readings have stabilized to your satisfaction, click the OK button in the pop-up box.

— Applying Calibration Values —

- Click the Apply button to apply calibration values.
- The computed m and b values will be transferred to the calibration fields.
- Click OK to save the values to the sensor.

Field Calibration — Pressure

Before shipping, the pressure channel has been calibrated using sophisticated environmental chambers and deadweight testers. As the sensor can drift slightly over time, it may occasionally need field calibration. If the pressure needs to be calibrated, one- and two-point calibration can be performed from the Field Calibration window as follows:

One-Point Calibration:

— Computing Calibration Value —

- Place sensor in the fluid you are measuring at a precise known level.
- In the Ref box for the first point, enter this level or pressure.
- Click first Measure button.
- When readings have stabilized to your satisfaction, click the OK button in the pop-up box.

— Applying Calibration Value —

- Click the Apply button to apply calibration value.
- The computed b value will be transferred to the calibration field.
- Click OK to save the value to the sensor.

Two-Point Calibration:

— Compute First Calibration Point —

- Place sensor in the fluid you are measuring at a precise known level.
- In the Ref box for the first point, enter this level or pressure.
- Click first Measure button.
- When readings have stabilized to your satisfaction, click the OK button in the pop-up box.

— Compute Second Calibration Point —

- Place sensor in the fluid you are measuring at a second precise known level.
- In the Ref box for the second point, enter this level or pressure.
- Click second Measure button.
- When readings have stabilized to your satisfaction, click the OK button in the pop-up box.

— Applying Calibration Values —

- Click the Apply button to apply calibration values.
- The computed m and b values will be transferred to the calibration fields.
- Click OK to save the values to the sensor.

Appendix C: Measuring Elevation or Depth-to-Water

The purpose of this appendix is to provide a simple description for configuring a CT2X Smart Sensor for monitoring depth-to-water or groundwater elevation, using the Aqua4Plus Control Software.

In normal configuration, the CT2X returns a pressure measurement relative to the water above the sensor. This can be expressed in psi, feet of water, inches of mercury, or a number of other units - however, it is always relative to the water above the sensor.

Often an engineer will need to know the depth-to-water or the elevation of the water. Using Aqua4Plus' field calibration abilities, the CT2X can be configured to display depth-to-water or elevation.

Depth-to-Water Calibration

NOTE: When using Depth-To-Water, you may want to change the channel label at the top of the Field Calibration window to read "Depth".

— Computing Offset —

Checkmark the box labeled *Compute pressure as depth to water*.

- If you are using a gauge (PSIG) sensor:
 1. Using a water level indicator or other measuring device, determine the depth to water.
 2. Enter this level in the *Ref* box.
- If you are using an absolute (PSIA) sensor * :
(See also important note on next page)
 1. Using a water level indicator or other measuring device, determine the depth to water.
 2. Obtain the current barometric reading from another device. (Note: be sure to use the same units as you are using in Aqua4Plus, e.g., if you are using Ft H₂O in Aqua4Plus, use Ft H₂O on the barometric reading.)
 3. Subtract the barometric reading from the value you read from the water level indicator.
 4. Enter this level in the *Ref* box.
- Click the *Measure* button.
- When readings have stabilized to your satisfaction, click the *OK* button in the pop-up box.

— Applying Calibration Values —

- Click the *Apply* button to apply calibration values.
- The computed m and b values will be transferred to the calibration fields.
- Click *OK* to save the values to the sensor.

Groundwater Elevation Calibration

— Computing Offset —

- Place sensor in well
- If you are using a gauge (PSIG) sensor:
 1. Using a water level indicator or other measuring device, determine the depth to water.
 2. Subtract this from the elevation at the top of the casing.
 3. Enter this value in the *Ref* box for the first point.
- If you are using an absolute (PSIA) sensor * :
(See also important note below)
 1. Using a water level indicator or other measuring device, determine the depth to water.
 2. Obtain the current barometric reading from another device. (Note: be sure to use the same units as you are using in Aqua4Plus, e.g., if you are using Ft H2O in Aqua4Plus, use Ft H2O on the barometric reading.)
 3. Subtract the water level reading (from step 1) from the elevation at the top of the casing.
 4. Add the barometric reading from step 2 to the result of step 3.
 5. Enter this level in the *Ref* box for the first point.
- Click first *Measure* button.
- When readings have stabilized to your satisfaction, click the *OK* button in the pop-up box.

— Applying Offset —

- Click the *Apply* button to apply the offset.
- The computed *b* value will be transferred to the calibration field.
- Click *OK* to save the value to the sensor.

IMPORTANT NOTE!

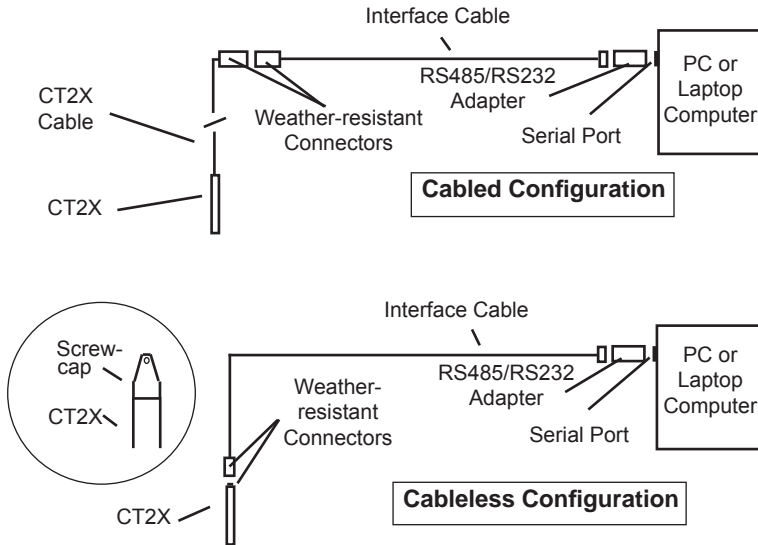
When taking readings with an absolute sensor:

- You will need to **ADD** the current barometric pressure to the sensor reading to get depth-to-water.
- You will need to **SUBTRACT** the current barometric pressure from the sensor reading to get elevation.

Appendix D: Alternate Connection Options

Connecting via RS232 Serial Port

In its cabled configuration, the CT2X cable is terminated with a weather-resistant connector. In its cableless configuration, the CT2X is terminated with a weather-resistant connector inside a screw-cap. Connect the weather-resistant connector to your computer's serial port as shown below.




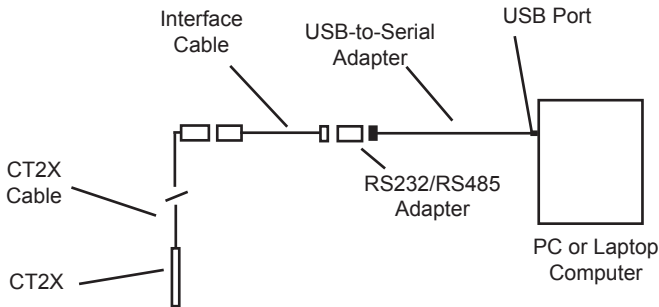
Connect the CT2X to your computer using an RS485/RS232 adapter and an interface cable.

Connecting with a USB/Serial Adapter

USB-to-Serial cables are readily available from many electronics and computer stores, as well as numerous sites on the Internet. INW has tested and recommends the Keyspan USA-19HS. It is available from INW as well as from many sites on the Internet. Install as follows:

- Plug into USB port.
- Install the drivers provided with the particular unit.
- Determine the port number to which the adapter is assigned.
 - Right-click on My Computer.
 - From the popup menu, select Manage to open the Computer Management window.

- On left panel, click on Device Manager.
- On right panel, double-click on Ports.
- A list of active COM ports will be displayed. Note the COM number assigned to the adapter you just installed.
For example:  Keyspan USB Serial Port (COM4)
- Close Manager.
- Connect to the sensor.
- On the Aqua4Plus software, select the COM port noted above. (If you do not see your new COM port in the dropdown box, open the Communications dialog box from the Options menu. Increase the Highest COM port number, up to a maximum of 15.)



Connection using a USB to Serial Adapter

Appendix E: Reading the CT2X via Direct Read

While the CT2X comes with INW's easy to use Aqua4Plus software, you can also use standard Modbus® RTU or SDI-12 equipment to easily take readings, so as to tie into your existing equipment or networks.

You may need to use Aqua4Plus to make a few settings, prior to directly reading the CT2X with your equipment. For one thing, you may want to change the units for returned values. If reading via Modbus, you may also need to set the baud rate. (You do not need to set the baud rate for SDI-12). These are described in the following sections.

For Modbus you must have CT2X firmware version 1.5 or higher. For SDI-12 you must have version 2.0 or higher.

Setting Units for Direct Read

The CT2X by default uses the following units:

Temperature	Degrees Celsius
Conductivity	uS/cm
Pressure	PSI
Salinity	PSU*
TDS	mg/L*

*Firmware version 2.8 or higher

If you have firmware 2.2 or later, you can select from a variety of units. If you want to change to different units, for example, degrees Fahrenheit for temperature or meters of water for pressure, set these units using Aqua4Plus, as shown below. Note: conductivity is always returned in uS/cm

- Connect your sensor to your computer.
- Run Aqua4Plus (Be sure that you have Aqua4Plus version 1.8.5 or later. Also, be sure you have the correct sensor firmware version, as described above.)
- Scan for and click on your sensor.
- Click on the Configure menu, and then select Advanced.
- From the flyout menu, select Direct Read Units. If you do not see this option, be sure your sensor is running the correct firmware.
- On the popup box, click the down-arrows next to the channel type you want to change, and then select the units you want to. (Note, this does not affect the units used on the Aqua4Plus display. Refer to the Aqua4Plus software manual for details on using Aqua4Plus.)
- Click OK

Once set, these units are saved on the sensor and direct readings, either via Modbus or via SDI-12, will return values using these units. (Note: These settings do not affect the units used on the Aqua4Plus display. Refer to the Aqua4Plus software manual for details on using Aqua4Plus.)

Reading Via Modbus® RTU

Setting Baud Rate

Your CT2X comes configured to communicate at 38,400 baud, with 8 data bits, one stop bit, and no parity. The sensor can also be set to 19,200 or 9600 baud, if needed for your application.

If needed, set your CT2X to the desired baud rate as follows:

- Connect your sensor to your computer. (Refer to the Aqua4Plus or CT2X Instruction manual for information on connecting your sensor to your computer.)
- Run Aqua4Plus version 1.9.2 or later.
- Scan for and click on your sensor.
- If your sensor contains any data you want to keep, upload that data now.
- Erase all sessions.
- Click on the Configure menu, and then select Advanced.
- From the flyout menu, select Sensor Baud Rate. (You may be asked for a password. The password is admin.) If you do not see the baud rate option, be sure your sensor is running version 1.5 or later firmware – see previous section.
- On the popup box, click the down-arrow and select the baud rate you need, and then click OK.

Once you have changed the baud rate on the sensor, you will not be able to talk to it with Aqua4Plus until you change the baud rate for Aqua4Plus, as follows:

- Click the Options menu, and then select Baud Rate.
- On the popup box, click the down-arrow, select the baud rate you need, and then click OK.

The current Aqua4Plus baud rate is displayed in the lower right corner of the main Aqua4Plus window.

Taking Measurements

Reading Registers

Read measurements using Modbus function 03 – Read Holding Registers.

Readings are located in two registers each, starting at address 62592. (CT2X register addressing is zero based, i.e., starts at zero. Check with your program and/or equipment documentation to determine what style of register addressing is required.)

Register Addresses for the TempHion

To Read:	Specified Address	+ 1	+ 400,000	+ 400,001
Temperature	62592	62593	462592	462593
Conductivity (Linear)	62594	62595	462594	462595
Conductivity (nLFn)	62596	62597	462596	462597
Pressure	62598	62599	462598	462599
Salinity*	62600	62601	462600	462601
TDS*	62602	62603	462602	462603
Sample Programs or Equipment	Visual Basic, Modbus Poll	Modpol		Precision Digital meters

*Firmware version 2.8 or higher

Measurement Timing

When you request a reading via Modbus, the sensor wakes up, returns the current values in the registers, and then starts taking new readings and updating the registers. After approximately 10 seconds, if no more readings have been requested, the sensor goes back to sleep.

Because of this, the first reading you get will be old. If you are taking readings at intervals of less than 10 seconds, simply ignore the first reading — all remaining readings will be current. On the other hand, if you are taking readings at intervals of greater than 10 seconds, take a reading, ignore it, wait one second, take another reading. Record this second reading.

Data Format

The data is returned as 32-bit IEEE floating-point values, high word first, also referred to as big-endian or float inverse.

For further information and detailed Modbus examples, see INW application note, “*Modbus Direct Read on AquiStar Smart Sensors*” available from our web site at www.inwusa.com/technical-library/application-notes.

Reading Via SDI-12

Addressing

Default SDI-12 Address: 0

SDI-12 Command Nomenclature

<a> = Sensor address

{crc} = SDI-12 compatible 3-character CRC

<cr> = ASCII carriage return character

<lf> = ASCII line feed character

highlighted values indicate variable data

SDI-12 Commands

/** Sensor Identification

<a>I! <a>13 INWUSA CT2X**2.0**ssssssss<cr><lf>

// note: **2.0** will change to reflect current

// firmware revision

// sssssssss = device serial #

/** Acknowledge Active, Address Query

<a>! <a><cr><lf>

?! <a><cr><lf>

/** Change Address

<a>A! <cr><lf>

// change address from <a> to

/** Request measurement

<a>M! <a>**0024**<cr><lf>

// request all measurements

<a>D0! <a>**+22.0512+155.0127+155.2155+12.0512**<cr><lf>

// read: temperature, conductivity (linear–

// uS/cm), conductivity (non-linear–uS/cm),

// pressure (psi)

<a>M1! <a>**0021**<cr><lf>

// request temperature measurement

<a>D0! <a>**+22.0512**<cr><lf>

// read temperature

<a>M2! <a>**0021**<cr><lf>

// request linear conductivity measurement

<a>D0! <a>**+155.0127**<cr><lf>

// read conductivity (uS/cm)

<a>M3! <a>**0021**<cr><lf>

// request non-linear conductivity measurement

<a>D0! <a>**+155.2155**<cr><lf>

// read conductivity (uS/cm)

<a>M4! <a>**0021**<cr><lf>

// request pressure measurement

<a>D0! <a>**+12.0512**<cr><lf>

// read pressure (psi)

<a>M5! <a>**0021**<cr><lf>

// request salinity measurement

<a>D0! <a>**20.7862**<cr><lf>

// read salinity (psu)

<a>M6! <a>**0021**<cr><lf>

// request TDS measurement

<a>D0! <a>**14700.9**<cr><lf>

// read TDS (mg/L)

```

/** Request measurement with CRC
<a>MC! <a>0024<cr><lf> // request all measurements with CRC
<a>D0! <a>+22.0512+155.0127+155.2155+12.0512{crc}<cr><lf> // read: temperature, conductivity (linear–
// uS/cm), conductivity (non-linear–uS/cm),
// pressure (psi)

<a>MC1! <a>0021<cr><lf> // request temperature measurement with CRC
<a>D0! <a>+22.0512<cr><lf> // read temperature

<a>MC2! <a>0021<cr><lf> // request linear conductivity with CRC
<a>D0! <a>+155.0127<cr><lf> // read conductivity (uS/cm)

<a>MC3! <a>0021<cr><lf> // request non-linear conductivity with CRC
<a>D0! <a>+155.2155<cr><lf> // read conductivity (uS/cm)

<a>MC4! <a>0021<cr><lf> // request pressure measurement with CRC
<a>D0! <a>+12.0512<cr><lf> // read pressure (psi)

<a>MC5! <a>0021<cr><lf> // request salinity measurement with CRC
<a>D0! <a>20.7862<cr><lf> // read salinity (psu)

<a>MC6! <a>0021<cr><lf> // request TDS measurement with CRC
<a>D0! <a>14700.9<cr><lf> // read TDS (mg/L)

/** Concurrent measurement
<a>C! <a>0024<cr><lf> // request all measurements
<a>D0! <a>+22.0512+155.0127+155.2155+12.0512<cr><lf> // read: temperature, conductivity (linear–
// uS/cm), conductivity (non-linear–uS/cm),
// pressure (psi)

<a>C1! <a>0021<cr><lf> // request temperature measurement
<a>D0! <a>+22.0512<cr><lf> // read temperature

<a>C2! <a>0021<cr><lf> // request linear conductivity measurement
<a>D0! <a>+155.0127<cr><lf> // read conductivity (uS/cm)

<a>C3! <a>0021<cr><lf> // request non-linear conductivity measurement
<a>D0! <a>+155.2155<cr><lf> // read conductivity (uS/cm)

<a>C4! <a>0021<cr><lf> // request pressure measurement
<a>D0! <a>+12.0512<cr><lf> // read pressure (psi)

<a>C5! <a>0021<cr><lf> // request salinity measurement
<a>D0! <a>20.7862<cr><lf> // read salinity (psu)

<a>C6! <a>0021<cr><lf> // request TDS measurement
<a>D0! <a>14700.9<cr><lf> // read TDS (mg/L)

```

/** Concurrent measurement with CRC

```

<a>CC! <a>0024<cr><lf> // request all measurements with CRC
<a>D0! <a>+22.0512+155.0127+155.2155+12.0512{crc}<cr><lf>
// read: temperature, conductivity (linear-
// uS/cm), conductivity (non-linear-uS/cm),
// pressure (psi)

<a>CC1! <a>0021<cr><lf> // request temperature measurement with CRC
<a>D0! <a>+22.0512<cr><lf> // read temperature

<a>CC2! <a>0021<cr><lf> // request linear conductivity with CRC
<a>D0! <a>+155.0127<cr><lf> // read conductivity (uS/cm)

<a>CC3! <a>0021<cr><lf> // request non-linear conductivity with CRC
<a>D0! <a>+155.2155<cr><lf> // read conductivity (uS/cm)

<a>CC4! <a>0021<cr><lf> // request pressure measurement with CRC
<a>D0! <a>+12.0512<cr><lf> // read pressure (psi)

<a>CC5! <a>0021<cr><lf> // request salinity measurement with CRC
<a>D0! <a>20.7862<cr><lf> // read salinity (psu)

<a>CC6! <a>0021<cr><lf> // request TDS measurement with CRC
<a>D0! <a>14700.9<cr><lf> // read TDS (mg/L)

```

For further information and SDI-12 examples, see the INW application note, “*CT2X Interface Specification (SDI-12)*” available from our web site at www.inwusa.com/technical-library.

Appendix F: Reading Salinity



NOTE: For greatest salinity accuracy, your CT2X should have the pressure option installed. If you do not have the pressure option, contact INW for further details.

Aqua4Plus

If you are only reading with Aqua4Plus:

- Any firmware version higher than 2.0 will work.
 - We recommend Aqua4Plus version 1.9.2 or higher.
 - You will need to set the Temperature coefficient in the field calibration window to zero (0) – it defaults to 2.1.
 - From Options Menu => Display Units, set Conductivity to PSU.
 - Salinity will now read on the Conductivity channel.
-

Via Modbus® or SDI-12

Firmware Compatibility

- Firmware version 2.8 or higher and a sensor serial number higher than 2113500.
 - This is fully compatible.
- Firmware version 2.8 and a sensor serial number lower than 2113501:
 - You will need to get a factory version of Aqua4Plus. (Contact INW.) We recommend using 1.9.2 or higher.
 - Using this factory version, scan for your sensor. Open Configure => Factory settings => Sensor Range, and then click OK. (This will automatically set some internal values that are needed in the salinity calculations.) You will only have to do this once on a particular sensor.
- Firmware 2.0 or above but less than 2.8:
 - You will need return the sensor to INW for a firmware update. (While we can usually update firmware in the field, in this instance it must be flashed at the factory.)
- Firmware lower than 2.0:
 - The firmware cannot be updated; the board will have to be replaced with a new generation board.

Setting Temperature Coefficient

You will need to set the Temperature coefficient in the field calibration window to zero (0) – it defaults to 2.1.

Taking Readings

Refer to Appendix E for details in using Modbus® or SDI-12 to take readings from the CT2X sensor.

Appendix G: Battery Changing Details

Battery Type: Two standard AA Alkaline batteries.

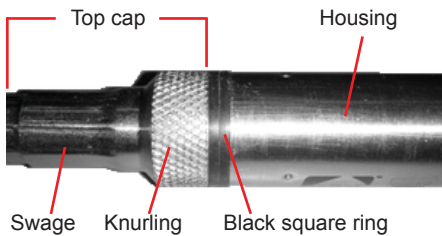
Because changing the batteries involves opening the water-tight seal, **this must be done in a clean, dry environment to avoid contamination or moisture damage to the circuitry.**

Tips

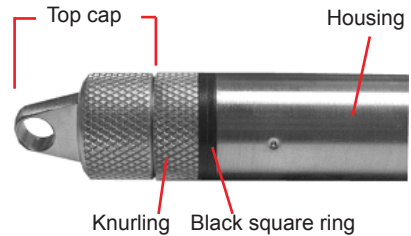
- Never place a tool on the sensor body, it is very thin and will deform causing leaks at o-ring seals and potentially crushing the circuit board!
- Always twist the sensor body off the top cap assembly rather than twisting the top cap assembly off of the sensor body.
- For cabled sensors, always clamp the sensor on the swaged area when applicable, the shoulder above it will allow you to press down without the worry of the sensor slipping out of the clamping device.
- If the sensor body is slippery or you are unable to grip it hard enough to twist, try a piece of rubber cabinet liner for additional friction.

Opening the Housing

There is a black, compressible square ring near the top of the sensor. This ring acts as a spring to lock the cable in. This needs to be compressed in order to allow removal of the top cap. Once this ring is compressed, a gentle counterclockwise twist is all that is needed to remove the cable from the sensor body. Compressing the black square ring does take force, **twisting does not**.



Cabled Sensor



Cableless Sensor

Care must be taken to compress the black square ring before attempting to twist the housing. **Forceful twisting of the housing can permanently damage the sensor.**

Securing the sensor

In order to compress the black square ring, the sensor must be secured so that you can apply downward pressure to compress the ring. This can be done by holding in your hand, using a vise, or using pliers, as detailed below.

By Hand - cabled version only

1. Tightly grasp the top cap in one hand.
2. Brace your hand against something such as a table or the ground. (Do not allow the cable to be pinched against the brace.)

Continue to **Removing the Housing** on the next page.

With Vise - recommended method

Cabled Sensor

1. If possible, use a set of soft jaws as shown to prevent marring the surfaces of the top cap assembly.
2. Place the sensor in a vise clamping gently on the swaged area. You do not need to clamp the vise very hard.

Continue to **Removing the Housing** on the next page.

Cableless Sensor

1. If possible, use a set of soft jaws as shown to prevent marring the surfaces of the top cap assembly.
2. Remove the cableless top cap.
3. Place the sensor in a vise clamping gently on the knurled area. You do not need to clamp the vise very hard.

Continue to **Removing the Housing** on the next page.



Cabled Sensor - gripping on swage



Cableless Sensor - gripping on knurled area

With Pliers or Vise Grips - good for field use

Cabled Sensor

1. Grasp the pliers on the swaged area (do not grab the knurled diameter).
2. Find a hard edge and place the tips of the jaws of the pliers onto this edge as shown. This will allow you to press down with your weight to compress the square ring.

Continue to **Removing the Housing** below.

Cableless Sensor

1. Leave the cableless cap on in order to protect the pins inside.
2. Grasp the pliers on the knurled area tightly being careful to avoid grabbing the knurled cap.
3. Find a hard surface and place the cableless cap down onto it. This will allow you to press down with your weight to compress the square ring.

Continue to **Removing the Housing** below.



Cabled Sensor



Cableless Sensor

Removing the Housing

1. With your free hand, grasp the sensor body. Press down to compress the square ring. Twist gently. Once the body begins to twist, you can stop the compression action.
2. Finish gently twisting until the sensor body is removed.
3. Carefully disconnect the wiring connector inside from the circuit board in the top cap.

Replacing Batteries and Resealing Sensor

1. Gently pull wiring to one side in order to allow batteries to fall out. Shake gently if needed.
2. Replace batteries with button (+) facing open end.
3. Reinstall wiring connector — it only goes in one way, so make sure not to force it.



Pull wires gently to the side to allow battery removal.



Connector connected properly

4. Hold the top cap assembly at 90° to the housing opening as shown. Depress the spring with your fingertip and tuck the wiring into the cutaway on the circuit board with your thumb to protect it while being installed back into the housing.
5. Rotate the top cap assembly into the opening in the housing being very careful not to nick or pinch any wires.
6. Gently press down until the assembly stops and then twist it into place. It will click in and decompress the gasket when it is fully engaged.



Wires tucked into slot and spring tucked into housing.



Push top cap in before twisting and locking.



Properly completed — black ring uncompressed

Reordering Information

For sales & service offices, please contact:

INW
www.inwusa.com
800-776-9355

LIMITED WARRANTY/DISCLAIMER - *AquiStar*[®] CT2X CONDUCTIVITY SENSORS

A. Seller warrants that products manufactured by Seller when properly installed, used and maintained **with a properly installed desiccant tube**, shall be free from defects in material and workmanship. Seller's obligation under this warranty shall be limited to replacing or repairing the part or parts or, at Seller's option, the products which prove defective in material or workmanship within ONE (1) year from the date of delivery, provided that Buyer gives Seller prompt notice of any defect or failure and satisfactory proof thereof. Any defective part or parts must be returned to Seller's factory or to an authorized service center for inspection. Buyer will prepay all freight charges to return any products to Seller's factory, or any other repair facility designated by Seller. Seller will deliver replacements for defective products to Buyer (ground freight prepaid) to the destination provided in the original order. Products returned to Seller for which Seller provides replacement under this warranty shall become the property of Seller.

This limited warranty does not apply to lack of performance caused by abrasive materials, corrosion due to aggressive fluids, mishandling or misapplication. Seller's obligations under this warranty shall not apply to any product which (a) is normally consumed in operation, or (b) has a normal life inherently shorter than the warranty period stated herein.

In the event that equipment is altered or repaired by the Buyer without prior written approval by the Seller, all warranties are void. Equipment and accessories not manufactured by the Seller are warranted only to the extent of and by the original manufacturer's warranty.

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