



AquiStar[®] PT2X

Pressure/Temperature Smart Sensor and Datalogger



True data, measure by measure

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Introduction

What is the PT2X?

INW's Aquistar® PT2X Smart Sensor is an integrated datalogger and pressure/temperature sensor and is ideal for monitoring groundwater, well, tank and tidal levels, as well as for pump testing and flow monitoring. This sensor networks with all of the INW Aquistar® Smart Sensor family. Its compatibility with INW's WaveData® Wireless Data Collection technology makes it ideal for remote monitoring.

This industry standard digital RS485 interface device records up to 520,000 records of pressure, temperature and time data, operates with low power, and features easy-to-use software with powerful features. Constructed with 316 stainless steel or titanium, Viton® and Teflon®, this sensor provides high-accuracy readings in rugged and corrosive field conditions.

Two internal AA batteries power the PT2X. (Auxiliary power supplies are available for data intensive applications.) The unit is programmed using INW's easy-to-use Aqua4Plus control software. Once programmed the unit will measure and collect data on a variety of time intervals.

Replace your analog sensor / datalogger with the Aquistar® PT2X as a stand-alone unit or network with other INW Aquistar® Smart Sensors. Most users will use the PT2X with INW's Aqua4Plus software. However, the PT2X is quite versatile, communicating via either Modbus® or SDI-12 interfaces, allowing you to do the following:

- Read a PT2X via the Modbus® protocol using your own software.
- Read a PT2X via SDI-12 protocol.
- Display readings from a PT2X on a panel meter.

If you want to use one of these methods, please contact INW for further details.

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.

Check the etched label on the sensor to be sure that the proper range and type were provided. Also check the label attached to the cable at the connector end for the proper cable length.

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 if using a gauge sensor.

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.

How Pressure Sensors Work

Liquids and gasses do not retain a fixed shape. Both have the ability to flow and are often referred to as fluids. One fundamental law for a fluid is that the fluid exerts an equal pressure in all directions at a given level. Further, this pressure increases with an increasing depth of “submergence”. If the density of a fluid remains constant (noncompressible...a generally good assumption for water at “normal” pressures and temperatures), this pressure increases linearly with the depth of “submergence”.

We are all “submerged” in the atmosphere. As we increase our elevation, the pressure exerted on our bodies decreases as there is less of this fluid above us. It should be noted that atmospheric pressure at a given level does vary with changes in the weather. One standard atmosphere (pressure at sea level at 20° C) is defined to be 14.7 PSI (pounds per square inch).

There are several methods to reference a pressure measurement. Absolute pressure is measured with respect to an ideal vacuum (no pressure). Gauge pressure is the most common way we express pressure in every day life and is the pressure exerted over and above atmospheric pressure. With this in mind, gauge pressure (P_g) can be expressed as the difference between the absolute pressure (P_a) and atmospheric pressure (P_{atm}):

$$P_g = P_a - P_{atm}.$$

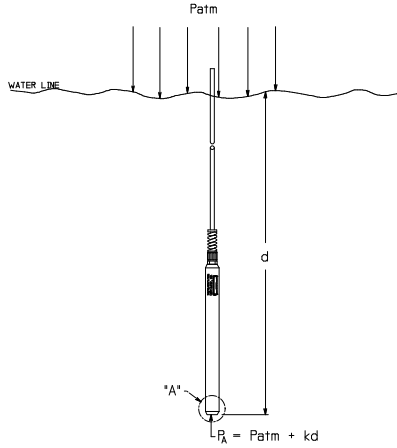
To measure gauge pressure, atmospheric pressure is subjected to one side of the system and the pressure to be measured is subjected to the other. The result is that the differential (gauge pressure) is measured. A tire pressure gauge is a common example of this type of device.

Recall that as the level of submergence increases (in a noncompressible fluid), the pressure increases linearly. Also, recall that changes in weather cause the absolute atmospheric pressure to change. In water, the absolute pressure (P_a) at some level of depth (d) is given as follows:

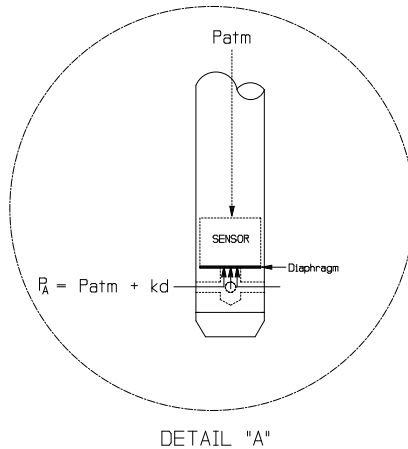
$$P_a = P_{atm} + kd$$

where k is simply a constant (i.e.: 2.307 feet of water = 1 PSI)

INW's standard gauge submersible pressure devices utilize a vent tube in the cable to allow the device to reference atmospheric pressure. The resulting gauge pressure measurement reflects only the depth of submergence. That is, the net pressure on the diaphragm is due entirely to the depth of submergence.



Pressure Diagram: See detail A on next page.



Absolute pressure is given as $P_a = P_{atm} + kd$ (where k is 2.307 feet of water)

Installation and Operation

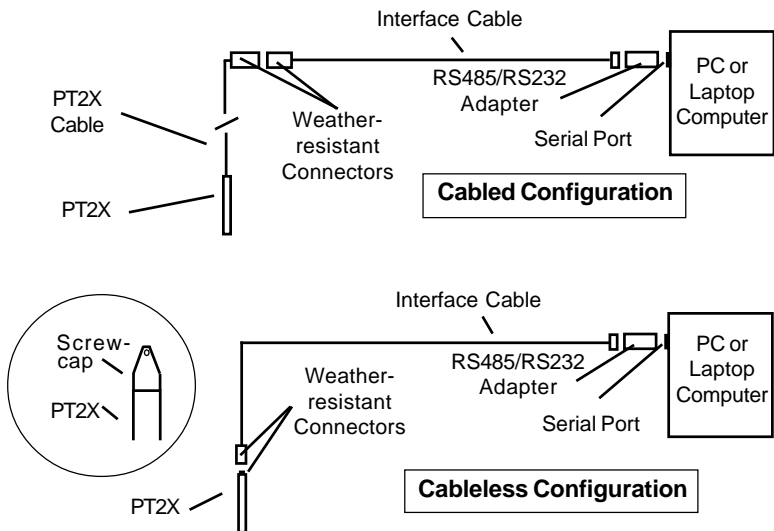
Connecting External Power

The PT2X 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 PT2X to a Computer

In its cabled configuration, the Smart Sensor cable is terminated with a weather-resistant connector. In its cableless configuration, the PT2X is terminated with a weather-resistant connector inside a screw-cap. Connect the weather-resistant connector to your PC or laptop serial port via the interface cable and an RS485/RS232 adapter, as shown below. For USB connections, see Appendix D.



Connect the sensor to your computer using the interface cable and an RS485/RS232 adapter. See Appendix D for details on connecting using a USB Port.

Installing the Aqua4Plus Software

The PT2X 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 PT2X Without Aqua4Plus

Most users will use the PT2X with INW's Aqua4Plus software. However, the PT2X is quite versatile, communicating via either Modbus® or SDI-12 interfaces, allowing you to do the following:

- Read a PT2X via the Modbus® protocol using your own software.
- Read a PT2X via SDI-12 protocol.
- Display readings from a PT2X on a panel meter.

If you want to use one of these methods, please contact INW for further details.

Installing the Sensor

The PT2X measures pressure. The most common application is measuring liquid levels in wells and tanks. In order to do this, the sensor must be installed below the water level at a fixed depth. The installation depth depends on the range of the sensor. One (1) PSI is equal to approximately 2.31 feet of water. If you have a 5 PSI sensor, the range is 11.55 feet of water and the sensor should not be installed at a depth below 11.55 feet. If the sensor is installed below its maximum range, damage may result to the sensor and the output reading will not be correct.

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.

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.

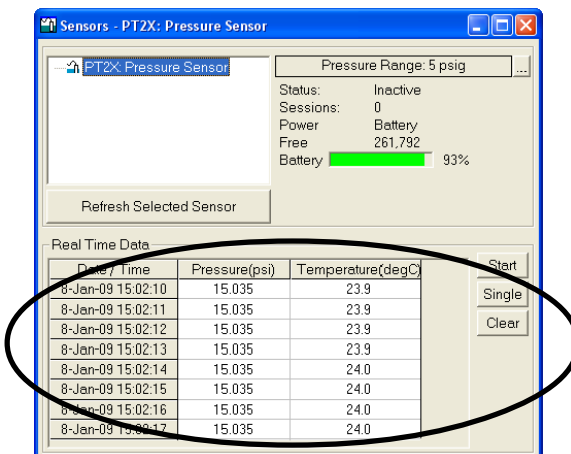
Real Time Monitor

Click Single to get a single reading.

Click Start to get a reading once a second.


Click Stop to stop the reading.

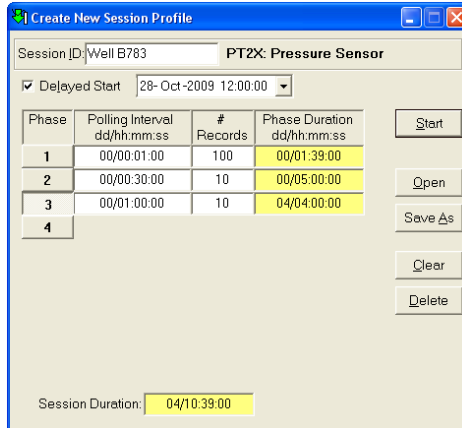
Note: These are snapshot readings and are not recorded on the sensor. On sensors with firmware versions lower than 2.0, the pressure is displayed in the first column and temperature in the second. On sensors with firmware versions 2.0 and higher, the temperature is displayed in the first column and pressure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



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


Setting up a Data Recording Session

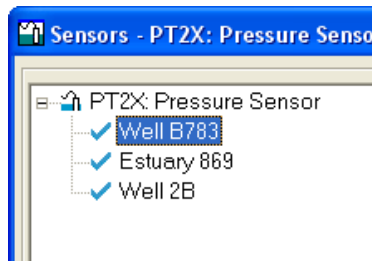
Click the  tool button. A Session Profile Window will open. Refer to the *Aqua4Plus Instruction Manual* for details in describing your session profile. Click the Start button to save the session to the sensor and begin recording.



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



Retrieving Data from the Sensor/Datalogger

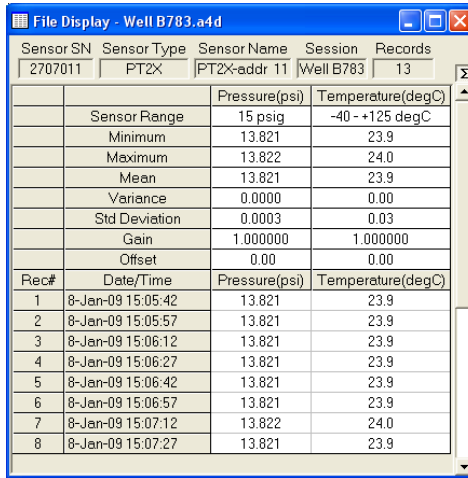
- Click on the session you want to upload.
- Click the  tool button.
- Select a file location.
- Click Save.
- Click Start.



Select the data session you are ready to upload.

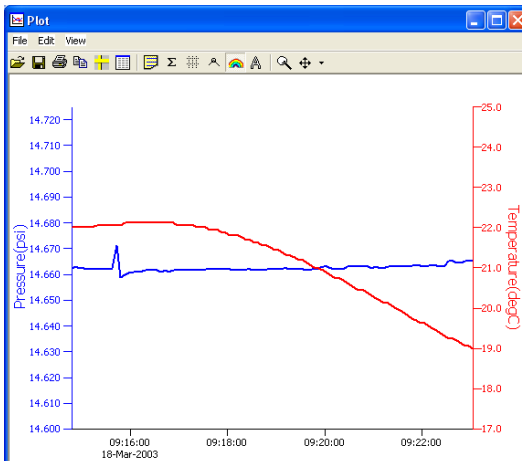
Viewing Data

- 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.)




Sensor SN	Sensor Type	Sensor Name	Session	Records
2707011	PT2X	PT2X-addr 11	Well B783	13
		Pressure(psi)	Temperature(degC)	
Sensor Range		15 psig	-40 - +125 degC	
Minimum		13.821	23.9	
Maximum		13.822	24.0	
Mean		13.821	23.9	
Variance		0.0000	0.00	
Std Deviation		0.0003	0.03	
Gain		1.000000	1.000000	
Offset		0.00	0.00	
Rec#	Date/Time	Pressure(psi)	Temperature(degC)	
1	8-Jan-09 15:05:42	13.821	23.9	
2	8-Jan-09 15:05:57	13.821	23.9	
3	8-Jan-09 15:06:12	13.821	23.9	
4	8-Jan-09 15:06:27	13.821	23.9	
5	8-Jan-09 15:06:42	13.821	23.9	
6	8-Jan-09 15:06:57	13.821	23.9	
7	8-Jan-09 15:07:12	13.822	24.0	
8	8-Jan-09 15:07:27	13.821	23.9	

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 PT2X 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

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.**

PT2X Smart Sensors come in two housing styles - a twist open version and a set screw version. Directions follow for each type separately.

The PT2X uses two standard AA Alkaline batteries. A fresh set of batteries should last up to one year when taking four samples per hour. For details in calculating battery life, see Appendix A.

Twist Open Housing

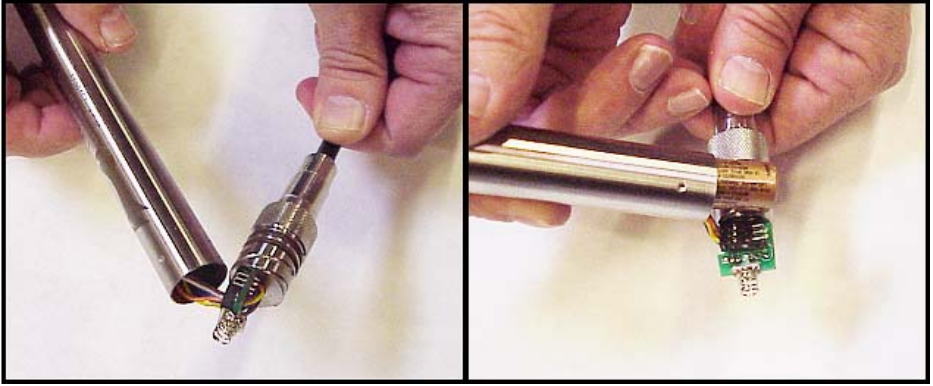
Opening the Housing

Open the housing by removing the top-cap, as outlined below. The top-cap is the connector between the tube housing the sensor and the cable.

1. Twisting gently, unscrew the top-cap.
2. Gently separate the top-cap from the body of the sensor. Top-cap remains attached to body via several colored wires.

Caution! Pulling forcefully on the top-cap can pull the insides out of the sensor or snap the connections inside. Removing the circuit board or pushing on the surface of the pressure element **may void your warranty.**

Note: O-rings provide a water-tight seal for the sensor housing. Take care not to nick or otherwise damage these O-rings.



On the twist open housing, gently remove the top cap and slide batteries out.

Replacing Batteries

3. Tip housing over and gently slide batteries out.
4. Insert new batteries - **positive terminals towards the top-cap.**
5. Replace and retighten top-cap.

Set Screw Housing

Open the housing by removing the top-cap, as outlined below. The top-cap is the connector between the tube housing the PT2X and the cable.

Opening the Housing

1. Remove the two set screws at the top of the housing tube, using a 1/16" allen wrench.
2. Very gently work the top cap loose. Note, two O-rings provide a water-tight seal for the PT2X housing and often seal tightly. Inserting the blade of a flat screw-driver between the top-cap and the housing and twisting gently can help to release the O-rings' seal. Then rock the top-cap back and forth, while applying steady, but controlled, upward pressure.

Caution! Pulling forcefully on the top-cap can cause the O-rings to release suddenly and the top-cap to disengage with enough force to pull the insides out of the sensor or snap the connections inside. Removing the circuit board or pushing on the surface of the pressure element **may void your warranty.**

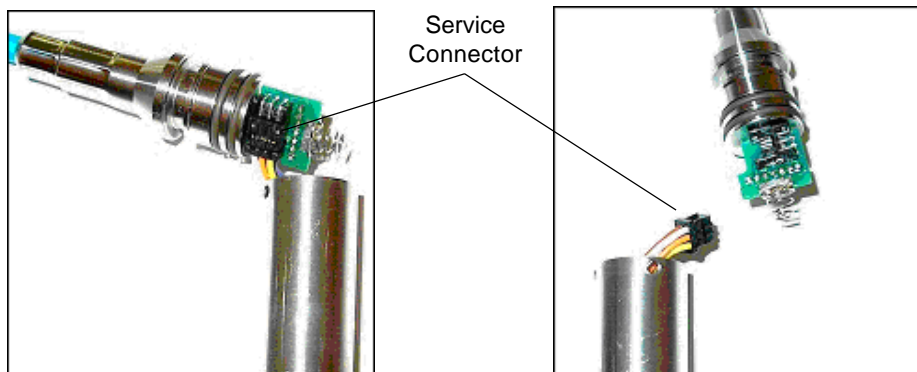
Note: O-rings provide a water-tight seal for the sensor housing. Take care not to nick or otherwise damage these O-rings.

Replacing the Batteries

3. Remove the black service connector.
4. Tip housing over and gently slide batteries out.
5. Insert new batteries - **positive terminals towards the top-cap.**

Re-sealing the Housing

6. Replace service connector. Note: this connector is keyed and can only be connected in one direction.
7. Carefully wrap the cable around the slot in the connector board.
8. Replace top-cap and secure with set screws.



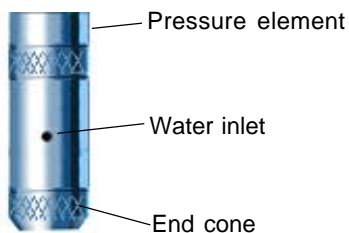
On the set screw housing, gently remove the service connector before replacing batteries. Carefully replace the connector once batteries have been replaced.

Removing Debris from End Cone

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.

Twist Open Housing

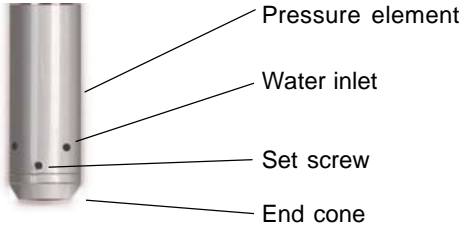
1. Gently twist off end cone portion only - do not twist off pressure element!
2. Remove debris. **Take care not to poke anything into the sensor.** This can damage the sensor element and void the warranty.
3. Replace and retighten the end cone.



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

Set Screw Housing

1. Remove the two set screws at the bottom of the housing tube, using a 1/16" allen wrench.
2. Gently remove the end cone.
3. Remove debris. **Take care not to poke anything into the sensor.** This can damage the sensor element and void the warranty.
4. Replace the end cone and secure with set screws.



Remove end cone by removing set screws. Gently clean out debris.

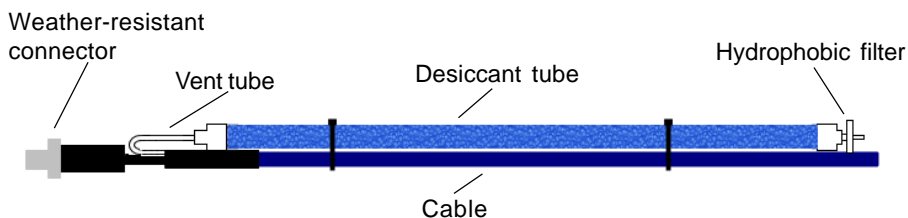
Desiccant Tubes

On vented 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. This filter also prevents water intrusion should the desiccant tube be submerged under one to two feet of water.

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, care must still be taken to keep the cable connector from being submerged.)

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 cyclic 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

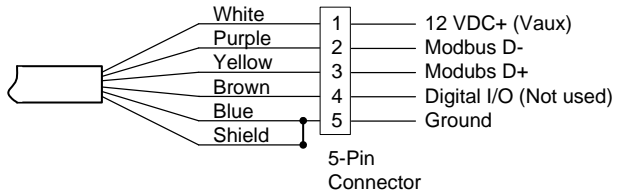
General Specification

The Aquistar® PT2X is a microprocessor based digital intelligent sensor designed to measure and record pressure, temperature and time, utilizing state-of-the-art low power, battery operated circuitry.

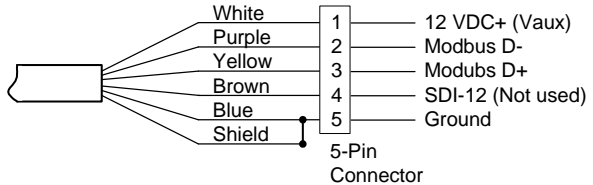
Pressure is measured with an extremely rugged and stable piezo-electric media-isolated pressure element combined with a 16-bit delta/sigma analog-to-digital converter. This provides extremely accurate and stable pressure input into the microprocessor on the circuit board. Temperature is measured with a digital temperature chip. The data is stored in non-volatile memory. A serial communication link (RS485) provides communication to the host computer.

Wiring and Component Information

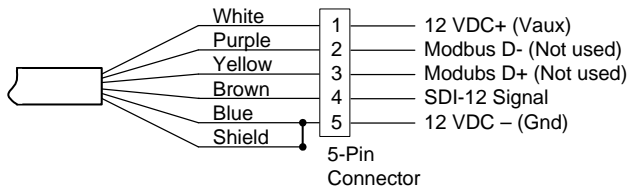
For Modbus® with
firmware lower than 2.0
— with 5-pin connector



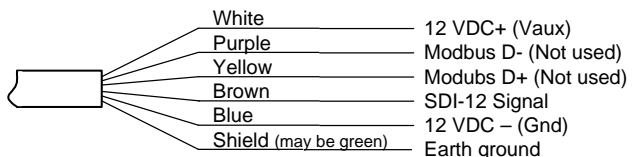
For Modbus® with
firmware 2.0 or higher
— with 5-pin connector



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



For SDI-12 with
firmware 2.0 or higher
— without connector



Mechanical:*Transmitter*

Dimensions	11.875" x 0.75" - cabled twist open housing
	10.75" x 0.84" - cabled set screw housing
	11.625" x 0.75" - cableless twist open housing
	10.6" x 0.84" - cableless set screw housing

Body Material	316 stainless steel or titanium
Wire Seal Materials	Viton® and Teflon®
Desiccant	High- and standard- capacity packs
Terminating Connector	Available
Weight	.80 lbs.

Cable

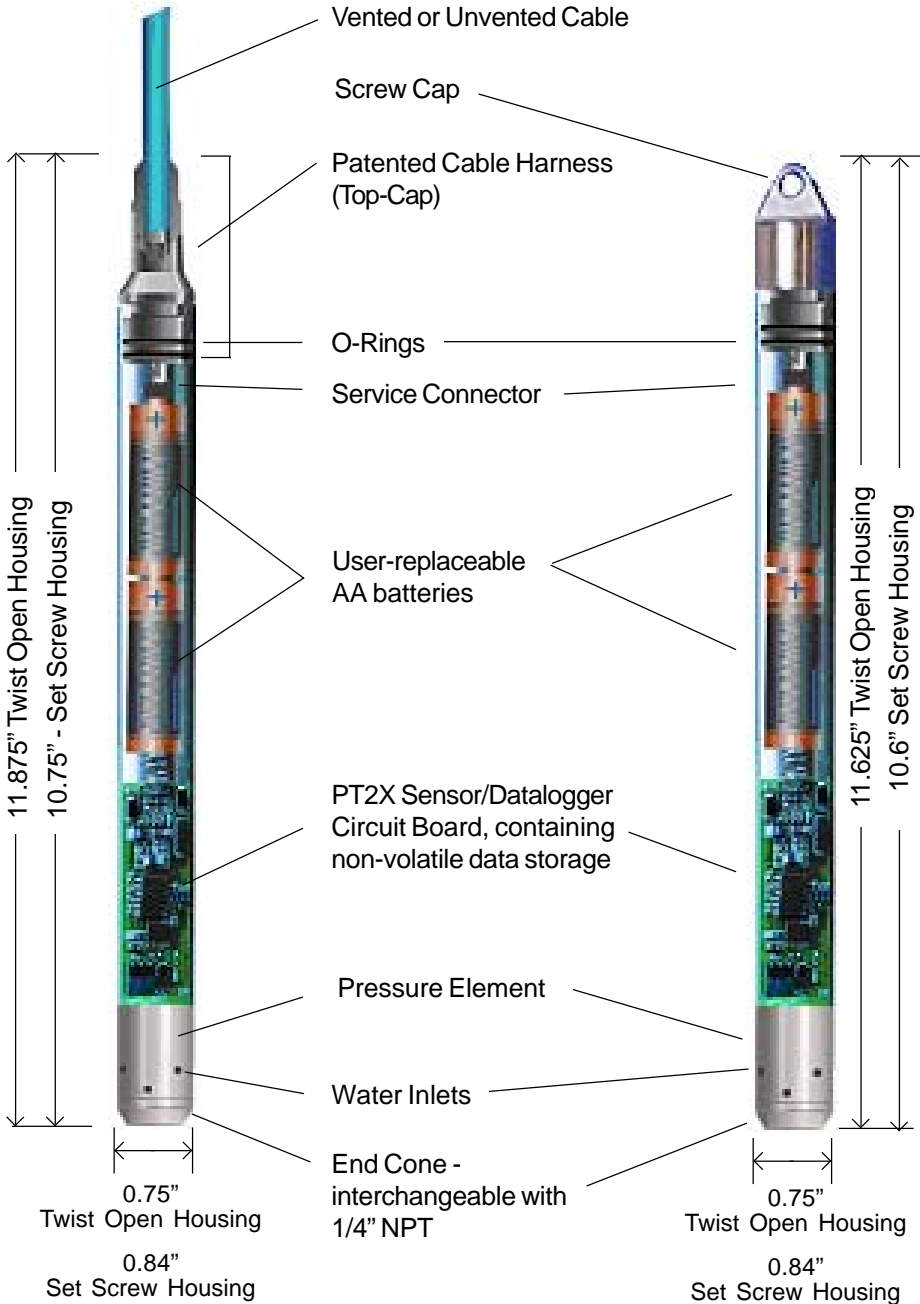
OD	0.28" maximum
Break Strength	138 lbs.
Maximum Length	2000 feet
Weight	4 lbs. per 100 feet

Electrical:*Pressure*

Static Accuracy (B.F.S.L. 25° C)	±0.1% FSO (maximum) ±0.06% FSO (typical) <i>0.06% available on request.</i>
Maximum Zero Offset at 25° C	±0.25% FSO
Resolution	16 bit
Ranges Available	1 PSI to 500 PSI <i>(contact INW for higher ranges)</i>
Over Range Protection	2x (except 300 PSI and higher)
Compensated Temperature Range	0° C to 40° C
Operating Temperature Range	-5° C to 70° C
Storage Temperature Range	-20° C to 100° C
<i>Contact factory for extended temperature ranges.</i>	

Cabled Version

Cableless Version



Sensor Components

Continuous Rate and Filter Settings

Continuous Rate:

The PT2X can take readings more often than once per second. This is known as a “continuous rate.” Set the continuous rate for the PT2X from the Configure Menu | Sensor Continuous Rate.

Firmware Version	Available settings
1.0 and above	Exactly 2, 4, or 8 readings per second
0.22, 0.23, 0.24	Approximately 2, 3, 4, 5, 6, or 10 readings per second
0.18	Approximately 10 readings per second

To use the continuous rate during a session, enter a “c” in the Polling Interval.

Filter Settings:

The PT2X has the ability to apply some filtering to incoming data in order to smooth out minor variations in readings. This filter can be from 1 (no filtering) to 8 (maximum filtering.) Different versions of firmware have different filtering options as shown below. For further information on PT2X data filtering, see INW application note *Filter Response on PT2X Smart Sensor* (9C0530).

Firmware Version	Filtering
1.3 and above	Can be set from 1 (no filtering) to 8 (maximum filtering) from the Advanced option on the Configure menu.
1.0 - 1.2	Filter is set to 1 (no filtering). Adjustable filtering can be obtained by upgrading to a higher firmware version.
0.24	Filter is permanently set to 1 (no filtering).
0.23 and lower	Filter is permanently set to 8 (maximum filtering).

Battery Life Calculation

The PT2X has been designed for very low power consumption. When not in active use, the unit goes into a “sleep” mode, waking only to take readings or communicate with the host computer.

It is difficult to know how fresh particular batteries are. Just sitting on a shelf, especially in a warm environment, will cause the batteries to lose energy. If the batteries are stored in a cold environment, the self-discharge will be less, but the batteries won't provide as much energy output when they're cold. Under optimum conditions, two fresh AA alkaline batteries should provide 15,000 Joules of energy. To give yourself some margin, INW recommends that you assume approximately 12,000 Joules.

When sleeping, the PT2X consumes approximately 150 Joules per week. Each reading consumes approximately .075 Joules. Communicating with the sensor for one minute, to upload data or take real-time readings, for instance, consumes approximately two Joules.

Use the following formulas to calculate your battery life:

Compute Weekly usage:

Readings usage = number of readings per hour * 24 hours * 7 days * .075 Joules

Communications usage = minutes of communication per week * 2 Joules

Sleep time usage = 150 Joules

Total weekly usage = reading + communication + sleep usage

Compute life of batteries:

Life of batteries in weeks = 12,000 Joules / Total weekly usage

Example:

4 readings per hour, 1 minute of communication per week

Readings usage = $4 * 24 \text{ hours} * 7 \text{ days} * .075 \text{ Joules} = 50 \text{ Joules}$

Communication usage = $1 * 2 \text{ Joules} = 2 \text{ Joules}$

Sleep time usage = 150 Joules

Total weekly usage = $50 + 2 + 150 = 202 \text{ Joules}$

Life of battery = $12,000 / 202 = 59 \text{ weeks (approximate)}$

Appendix B: Field Calibration (Pressure)

Calibration can only be done when there are no sessions stored on the sensor. If there are any sessions stored on the sensor, upload any data you want and then erase the session before continuing.

Before leaving the factory, your PT2X has been calibrated using precision pressure sources and thermal chambers. However, you may wish to run a field calibration from time to time for one or more of the following reasons.

- You want to set a specific zero reference point - use a 1- or 2-point calibration.
- You suspect you may have some zero drift on your sensor - use a 1- or 2- point calibration.
- You suspect you may have some gain drift on your sensor (rare) - use a 2-point calibration.
- You are measuring in a fluid with a density other than that of fairly pure fresh water - use a 2-point calibration.

Preparation:

- Run Aqua4Plus and scan for sensors.
- On the Sensor Map, click the sensor you want to calibrate.
- From the Options Menu, select the units you want to use to measure pressure, i.e., psi, feet of water, inches of mercury, etc.
- From the Configure Menu, select Field Calibration.
- Click on Pressure in the left panel.

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.

— Verifying Calibration Value —

- Using the Real Time Monitor, take a few readings while the sensor is still at the precise known level. Readings should be very close to that level.

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.

— Verifying Calibration Values —

- Using the Real Time Monitor, take a few readings while the sensor is still at the second precise known level. Readings should be very close to that level.

Appendix C: Measuring Elevation or Depth-to-Water

The purpose of this appendix is to provide a simple description for configuring a PT2X Smart Sensor for monitoring depth-to-water or groundwater elevation, using the Aqua4Plus Control Software.

In normal configuration, the PT2X 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 PT2X 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". (Label not available on PT2X version 1.5 or earlier.)

— 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 * :
 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 * :
 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.

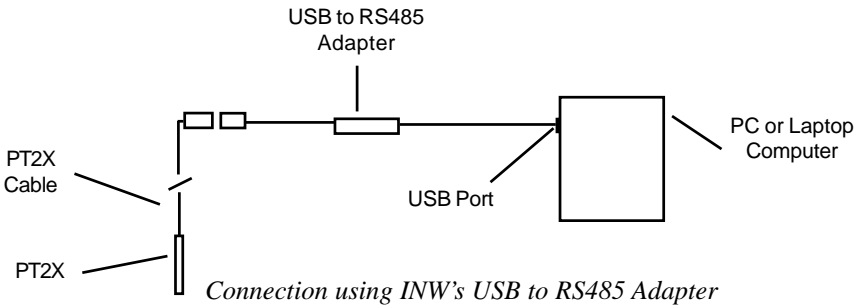
* When taking readings on an absolute sensor, you will need to adjust the sensor readings by the current barometric pressure to get depth-to-water or elevation. See the Barometric Compensation Utility Application Note (9C0275) for information on how the Barometric Utility can help automate this process.

Appendix D: Using a USB Port

If you do not have or do not want to use a 9-pin serial port for connecting your sensor to your PC, you can connect to your sensor using a USB port.


Connecting with INW's USB to RS485 Adapter

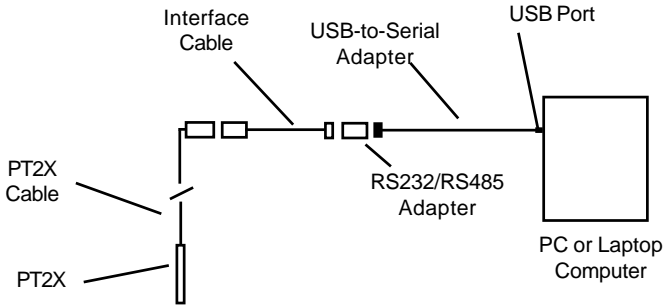
If using INW's USB to RS485 adapter, connect as shown in figure below. Drivers and installation instructions come with the adapter.



Connecting with a USB to 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 PT2X via Direct Read

While the PT2X 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 PT2X 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 direct read, you must have PT2X firmware 1.5 or higher. For SDI-12, you must have firmware 2.0 or higher.

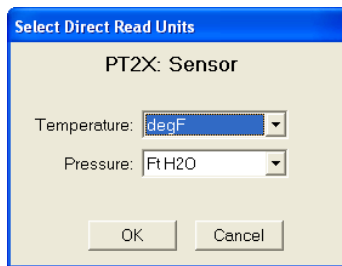
Setting Units for Direct Read

By default, the PT2X uses the following units:

Temperature	Degrees Celsius
Pressure	PSI

However, you can select from a variety of units for direct read measurements. If you want to change to different units, for example, degrees Fahrenheit for temperature or feet of water for pressure, set these units using Aqua4Plus.

- Click on the Configure menu, and then select Advanced.
- From the flyout menu, select Direct Read Units.
- On the popup box, click the down-arrows next to the channel types you want to change, and then select the units you want.
- Click OK



Use Aqua4Plus to select the units for your direct read measurements, whether Modbus or SDI-12.

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 PT2X 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 PT2X to the desired baud rate as follows:

- Click on the Configure menu, and then select Advanced.
- From the flyout menu, select Sensor Baud Rate. (You may be asked for a password. Enter admin.)
- 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 PT2X, 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. (PT2X register addressing is zero based, i.e., starts at zero. If your equipment uses one based addressing, you will need to add one to the register addresses.)

Register addresses for PT2X		
<u>Addresses for PT2Xs with firmware lower than 2.0</u>		
	Zero Based	One Based
Pressure	62592	62593
Temperature	62594	62595
<u>Addresses for PT2Xs with firmware 2.0 or higher</u>		
	Zero Based	One Based
Temperature	62592	62593
Pressure	62594	62595

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 <http://www.inwusa.com/apnotes.htm>.

Reading Via SDI-12

Note: The default units setting for pressure is PSI. The default units setting for temperature is Celsius. To change these, use the Direct Read Units option under the Configure | Advanced menu in the Aqua4Plus Control Software.

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 PT2X**2.1**sssssssss<cr><lf>

// note: **2.1** will change to reflect current

// firmware revision

// ssssssssss = device serial #

/** Acknowledge Active, Address Query

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

?! <a><cr><lf>

/** Change Address

<a>A! <cr><lf>

// change address to

/** Request measurement

<a>M! <a>0022<cr><lf>

// request all measurements

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

// read temperature

// pressure

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

// request temperature measurement only

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

// read temperature

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

// request pressure measurement only

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

// read pressure

```

//*** Request measurement with CRC
<a>MC! <a>0022<cr><lf> // request all measurements with CRC
<a>D0! <a>+22.0512+12.0512{crc}<cr><lf> // read temperature
// pressure

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

<a>MC2! <a>0021<cr><lf> // request pressure measurement only
// with CRC
<a>D0! <a>12.0512{crc}<cr><lf> // read pressure

//*** Concurrent measurement
<a>C! <a>00202<cr><lf> // request all measurements
<a>D0! <a>+22.0512+12.0512<cr><lf> // read temperature
// pressure

<a>C1! <a>00201<cr><lf> // request temperature measurement only
<a>D0! <a>+22.0512<cr><lf> // read temperature

<a>C2! <a>00201<cr><lf> // request pressure measurement only
<a>D0! <a>12.0512<cr><lf> // read pressure

//*** Concurrent measurement with CRC
<a>CC! <a>00202<cr><lf> // request all measurements with CRC
<a>D0! <a>+22.0512+12.0512{crc}<cr><lf> // read temperature
// pressure

<a>CC1! <a>00201<cr><lf> // request temperature measurement only
// with CRC
<a>D0! <a>+22.0512{crc}<cr><lf> // read temperature

<a>CC2! <a>00201<cr><lf> // request pressure measurement only
// with CRC
<a>D0! <a>12.0512{crc}<cr><lf> // read pressure

```

For further information and SDI-12 examples, see INW application note, “*PT2X SDI-12 Interface Specification*” available from our web site at www.inwusa.com/pdfs/pt2x_sdi12_spec.pdf

Reordering Information

For sales & service offices, please contact:

Instrumentation Northwest, Inc.

www.inwusa.com

800-776-9355

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