



AquiStar[®] T1 & T1R

Temperature Sensor



True data, measure by measure



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Introduction

What is the T1/T1R?

The T1 and T1R are highly accurate, submersible temperature sensors. They are available in both a recording and a non-recording version. Communicating either via Modbus® RTU or SDI-12, these temperature sensors are versatile and easy to use.

The T1 and T1R temperature sensors are designed to provide trouble-free submersible operation when properly installed. Both the T1 and T1R are compatible with INW's WaveData® VZCOM wireless data collection technology, making them excellent for remote monitoring.

The T1 (non-recording version) operates on an external (9 to 16 VDC) power supply and is ideal for use with many data loggers and SCADA systems.

The T1R (recording version) operates on either two internal AA batteries or an external (6 to 15 VDC) power supply. The unit is programmed using INW's easy-to-use Aqua4Plus control software. Once programmed it will measure and collect data on a variety of time intervals. The T1R can be used as a stand-alone unit or network with other INW Aquistar® Smart Sensors, as well as with many data loggers and SCADA systems using Modbus® RTU or SDI-12.

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 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.

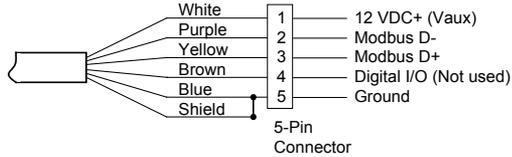
Don't allow the device to free-fall down as well as impact damage can occur.

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

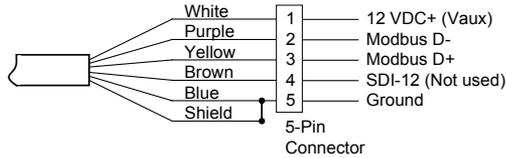
General Information

Wiring Information

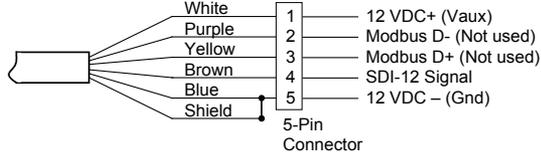
For Modbus® with
firmware lower than 2.0
— with 5-pin connector



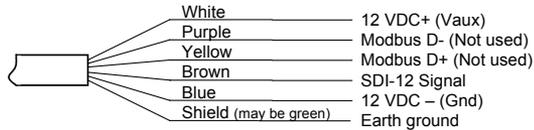
For Modbus® with
firmware 2.0 or higher
— with 5-pin connector



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



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



Installation

Lower the sensor to the desired depth. Fasten the cable to the well head using tie wraps or a weather proof strain-relief system.

If your sensor comes with a connector, be sure the supplied cap is securely placed on the weather-resistant connector at the top of the cable when not connected to a computer or logger. 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.

The sensor can be installed in any position. Strapping the sensor body with tie wraps or tape will not hurt it. 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.

Maintenance

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

Cable: Cable can be damaged by abrasion, sharp objects, twisting, crimping or crushing and 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.

Connectors (if used): 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 damaged sensor, damaged cable, poor connections or improper operation of readout equipment. In most cases, erratic readings are due to moisture getting into the system. Assuming that the readout equipment is working

correctly, the first thing to check is the connection. Look for moisture between contacts or a loose or broken wire.

Erratic and erroneous readings can also occur due to improper grounding. See Grounding Issues.

Zero Readings

Continuous zero readings are caused by an open circuit which usually indicates broken cable, a bad connection, or possibly a damaged sensor. Check the connector to see if a wire has become loose, or if the cable has been cut. If neither of these appears to cause the problem, the sensor needs factory 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 the following: (1) the sensor cable shield (the wrapped shield inside the cable) be attached to the power ground on the datalogger and (2) the grounding lug be connected via a 12 AWG or larger wire, to a grounding rod driven into the earth. It is also recommended that if you are using an external power supply to power the datalogger that it be tied to the same earth ground.

Notes:

- **Proper grounding is very important!** If your sensor does not come with a connector, INW recommends the following:
(1) the sensor cable shield (the wrapped shield inside the cable) be attached to the power ground on the datalogger and (2) the grounding lug be connected via a 12 AWG or larger wire, to a grounding rod driven into the earth. It is also recommended that your power supply be tied to the same earth ground.

T1 - Non-Recording Sensor

Technical Specifications

Dimensions and Specifications

GENERAL

Length	6.85" (17.4 cm)
Diameter	0.75" (1.9 cm)
Weight	0.8 lb (0.4 kg)
Body Material	316 stainless steel or titanium
Wire Seal Material	Fluoropolymer and PTFE
Submersible Cable	Polyurethane, polyethylene, FEP, or ETFE available
Terminating Connector	Available
Communication	RS485 Modbus® RTU SDI-12 (ver. 1.3)
Direct Modbus Read Output	32-bit IEEE floating point
SDI-12 Output	ASCII
Internal Math	32-bit floating point
Operating Temperature Range¹	-5° C to 70° C
Storage Temperature Range	-40° C to 80° C

POWER

Operating Voltage	9 - 16 VDC
Over Voltage Protection	24 VDC
Power Supply Current	Active 3mA avg./10mA peak Sleep 150 µA
Electromagnetic & Transient Protection	IEC-61000 — 4-3, 4-4, 4-5, 4-6

TEMPERATURE

Element Type	Digital IC on board
Accuracy	± 0.2° C
Resolution	0.06° C
Units	Celsius, Fahrenheit, Kelvin

Contact factory for extended temperature ranges.

¹ Requires freeze protection kit if in water below freezing.

Reading via Modbus RTU

Register Definitions

Modbus® Functions

Read the values in the registers using function 03-Read Holding Registers.

Parameter Data

32-bit ieee floating point values, read-only

These registers must be read as pairs

40003-4	Temperature (degrees C)
40005-6	Power supply voltage (volts)

Statistical Data Values

40013-14	Averaged temperature
----------	----------------------

Calibration and Conversion Constants

32-bit ieee floating point values, read/write

Register	Mnemonic	Description		
40223-24	mT	Field calibration	-	Temperature slope
40225-26	bT	Field calibration	-	Temperature offset
40227-28	T_Alpha	Factory calibration	-	Temperature alpha
40229-30	T_Offset	Factory calibration	-	Temperature offset
40231-32	T_ZeroSlope	Factory calibration	-	Temperature slope
40237-38	T_mUnits	Temperature Units	-	Conversion slope
40239-40	T_bUnits	Temperature Units	-	Conversion offset

Factory calibration values are set at the factory.

Writing to Factory Calibration registers will void calibration!!

Field calibration values can be set by user. If set, these values will be applied to readings before values are returned.

Sensor Configuration/Control

40301=n Set **averaging**: This enables sensor for n seconds (Read/Write). Each second, the statistical data registers will be update to contain new averages, max and min. At the completion of n seconds, the final statistical values will be left in the registers, and the sensor will be put to sleep. n = 0..10,800. If n = 0, the sensor is put to sleep, and the statistical data values are not updated.

40401=a Set **sensor address** = a (Write Only)

- 40501=b Set **baud rate** according to b (Write Only)
b=0:38400 b=1:19200 b=2:9600 b=3:4800 b=4:2400 b=5:1200
- 40601=w Set **auto-enable**. Causes sensor to be enabled automatically for w seconds after a read of any parameter data register. W=0 disables auto-enable. (This is normally set to 10 seconds at the factory.)

For lowest power usage, set this to zero. For fastest readings while still retaining as much power savings as possible, set slightly longer than your read frequency. See section on next page for information on how this setting affects your readings.

- 40701=L Set **serial number**. L= unsigned longword value
0x00000000 .. 0xFFFFFFFF (0 .. 4,294,967,295)
- 40801 Read sensor firmware revision. Word MSB = Major revision,
LSB = minor revision. E.g., 0011 = revision 0.11

Readings and the Auto-Enable Setting

When a reading is requested, four things happen:

1. The sensor wakes up.
2. The current value in the register is returned.
3. The sensor turns on the analog portion, begins sampling, and begins putting the new values in the registers.
- 4a. If auto-enable is set to a positive value w, the sensor stays awake for w seconds, sampling and moving values into the registers all the while, and then goes to sleep.
- 4b. If auto-enable is set to zero, the sensor immediately goes to sleep after putting the reading in the register.

If your read frequency is less than the auto-enable value, the sensor will stay on continuously, and your readings will always be fresh, with the exception of the very first reading.

If your read frequency is greater than the auto-enable value, the following reading sequence is recommended:

1. Request a reading. This begins the wakeup process on the sensor and returns the value currently in the register, which will be old data. Throw this value away.
2. Wait one second, and then take another reading. This reading will have fresh data. Record this reading.

Note: This sequence applies only to Modbus® direct read. If reading the sensor via SDI-12, the warmup timing is automatically taken care of.

Reading via SDI-12

SDI-12 Command Nomenclature

a = Sensor address

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

<cr> = ASCII carriage return character

<lf> = ASCII line feed character

Following commands are shown in the format of:

cmd response // comments

SDI-12 Commands

Query and Setup Commands

/** Sensor Identification

a! a13 INWUSA PT120.7ssssssss<cr><lf> // note: 0.7 will change to reflect
current firmware revision
ssssssss = device serial #

/** Acknowledge Active

a! a<cr><lf>

/** Address Query

?! a<cr><lf>

/** Change Address

aAb! b<cr><lf> // change address from a to b

Request measurement

aM! a0023<cr><lf> // request temperature/voltage
measurement

aD0! a+0+25.0000+12.0512<cr><lf> // read null, temperature (°C), voltage (V)

aM2! a0021<cr><lf> // request temperature measurement

aD0! a+25.0000<cr><lf> // read temperature (°C)

aM3! a0021<cr><lf> // request power supply voltage
measurement

aD0! a+12.0512<cr><lf> // read power supply voltage (V)

aM4! a0ttt4<cr><lf> // request averaged data. ttt depends upon
programmed average duration

aD0! a+0+0+0+25.0000<cr><lf> // read null, null, null, average temperature

Request measurement with CRC

aMC! a0023<cr><lf> // request temperature/voltage measurement

aD0! a+0+25.0000+12.0512{crc}<cr><lf> // read null, temperature (°C), voltage (V)

aMC2! a0021<cr><lf> // request temperature measurement

aD0! a+25.0000{crc}<cr><lf> // read temperature (°C)

```

aMC3! a0021<cr><lf> // request power supply voltage measurement
aD0! a+12.0512{crc}<cr><lf> // read power supply voltage (V)

aMC4! a0ttt4<cr><lf> // request averaged data. ttt depends upon
// programmed average duration
aD0! a+0+0+0+25.0000{crc}<cr><lf> // read null, null, null, average temperature

```

Concurrent measurement

```

aC! a00203<cr><lf> // request temperature/voltage measurement
aD0! a+0+25.0000+12.0512<cr><lf> // read null, temperature (°C), voltage (V)

aC2! a00201<cr><lf> // request temperature measurement
aD0! a+25.0000<cr><lf> // read temperature (°C)

aC3! a00201<cr><lf> // request power supply voltage measurement
aD0! a+12.0512<cr><lf> // read power supply voltage (V)

aC4! a0ttt04<cr><lf> // request averaged data. ttt depends upon
// programmed average duration
aD0! a+0+0+0+25.0000<cr><lf> // read null, null, null, average temperature

```

Concurrent measurement with CRC

```

aCC! a00203<cr><lf> // request temperature/voltage measurement
aD0! a+0+25.0000+12.0512{crc}<cr><lf> // read null, temperature (°C), voltage (V)

aCC2! a00201<cr><lf> // request temperature measurement
aD0! a+25.0000{crc}<cr><lf> // read temperature (°C)

aCC3! a00201<cr><lf> // request power supply voltage measurement
aD0! a+12.0512{crc}<cr><lf> // read power supply voltage (V)

aCC4! a0ttt04<cr><lf> // request averaged data. ttt depends upon
// programmed average duration
aD0! a+0+0+0+25.0000{crc}<cr><lf> // readnull, null, null, average temperature

```

Extended Commands

```

/** Set duration for averaging reading
aXAttt! attt<cr><lf> // set duration of averaged data for M4 command

// ttt = 1..997 seconds

/** Read/Modify Calibration Values
aXCnn{=<value>}! a<value><cr><lf> // read{modify} calibration value nn

```

examples:

```

aXC00! a+1.591600e-5<CR><LF> // read value of calibration register 00
aXC00=1.704e-4! a+1.704000e-4<CR><LF> // set value of calibration register 00

```

```

/** Set number of significant digits
aXSt! at<cr><lf> // set # of significant digits for SDI-12 report data
// t = 1..7 Calibration Register Definitions

```

Calibration Register Definitions

All calibration registers contain floating point values.

SDI-12 REG ID	Mnemonic	Description	Default Value
11	mT	Field temperature cal-slope	1.000000E+00
12	bT	Field temperature cal-offset	0.000000E+00
13	T_Alpha	Factory Temperature Cal-Alpha	0.000000E+00
14	T_Offset	Factory Temperature Cal-Offset	0.000000E+00
15	T_ZeroSlope	Factory Temperature Cal-ZeroSlope	0.000000E+00
18	T_mUnits	Temperature units conversion slope	1.000000E+00
19	T_bUnits	Temperature units conversion offset	0.000000E+00

Factory calibration values are set at the factory.
Writing to Factory Calibration registers will void calibration!!

Field calibration values can be set by user. If set, these values will be applied to readings before values are returned.

T1R - Recording Sensor

Operation

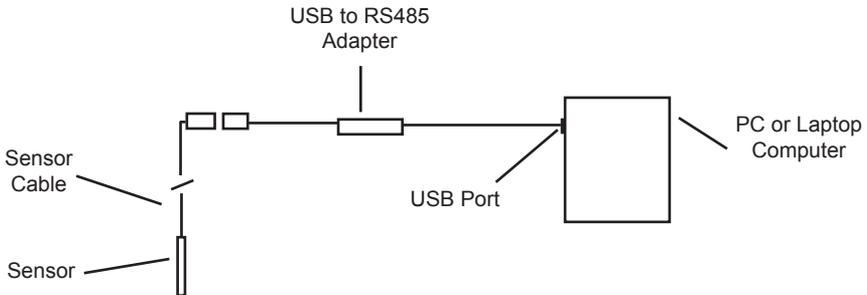
Connecting External Power

The T1R 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.

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 T1R to a Computer

Connect the T1R to your computer's USB port, as shown below. Drivers and instructions come with the adapter. (For alternate connection options, see Alternate Connection Options Section.)



*Connect the sensor to your PC using INW's USB to RS485 adapter.
(See Appendix C for alternate connections.)*

Installing the Aqua4Plus Software

The T1R 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 T1R Without Aqua4Plus

Most users will use the T1R with INW's Aqua4Plus software. However, the T1R is quite versatile, communicating via either Modbus® or SDI-12 interfaces, allowing you to do the following:

- Read a T1R via the Modbus® protocol using your own software.
- Read a T1R via SDI-12 protocol.
- Display readings from a T1R on a panel meter.

If you want to use one of these methods, please see Direct Read Section or contact INW for more details.

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.

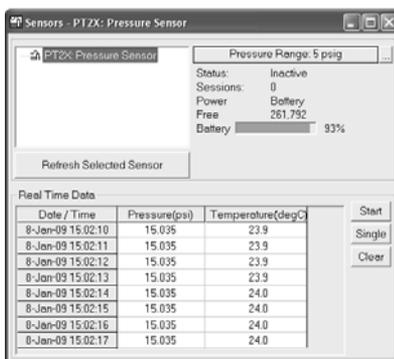
Real Time Monitor

Click Single to get a single reading.

Click Start to get a reading once a second.

Click Stop to stop the reading.

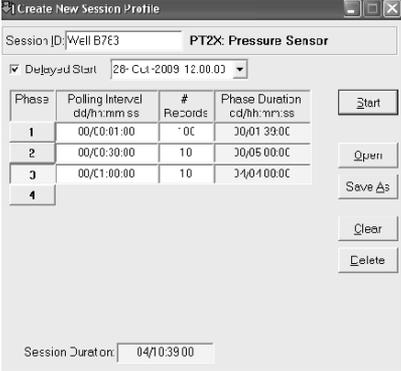
Note: These are snapshot readings and are not recorded on the sensor.



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.



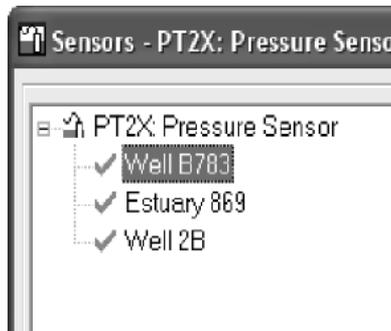
Phase	Polling Interval dd:hh:mm:ss	# Records	Phase Duration dd:hh:mm:ss
1	00:00:01:00	00	00:01:39:00
2	00:00:30:00	10	00:05:00:00
3	00:01:00:00	10	00:04:00:00
4			

Session Duration: 04:10:39:00

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

Retrieving Data from the Sensor/Datalogger

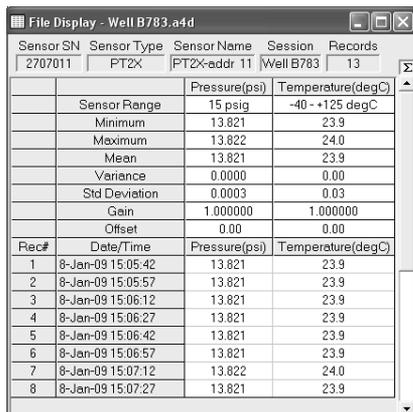
- Click on the session you want to upload.
- Click the  tool button.
- Select a file location.
- Click Save.
- Click Start.



Select the data session you are ready to upload.

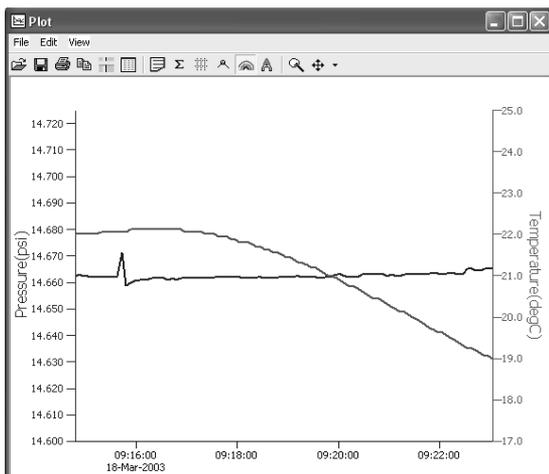
Viewing Data

- 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 T1R Smart Sensor can be displayed in degrees Celsius, or degrees Fahrenheit, or degrees Kelvin. Select the units you want from the Options | Units menu.

Field Calibration

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 T1R has been calibrated. However, you may wish to run a field calibration from time to time.

One-Point Calibration:

-- Computing Calibration Value --

- Place sensor in water. Allow time for sensor to reach thermal equilibrium.
- Using an accurate alternate measuring device, measure the temperature of the water.
- In the *Ref deg* box for the first point, enter this temperature.
- 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:

-- First Calibration Point --

- Place sensor in water at first temperature. Allow time for sensor to reach thermal equilibrium.
- Using an accurate alternate measuring device, measure the temperature of the water.
- In the *Ref deg* box for the first point, enter this temperature.

- Click first *Measure* button.
- When readings have stabilized to your satisfaction, click the *OK* button in the pop-up box.

-- Second Calibration Point --

- Place sensor in water at second temperature. Allow time for sensor to reach thermal equilibrium.
- Using an accurate alternate measuring device, measure the temperature of the water.
- In the *Ref deg* box for the second point, enter this temperature.
- 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.

Technical Specifications

Dimensions and Specifications

GENERAL

Length	10.725" (27.24 cm) cabled 10.475" (26.61 cm) cableless
Diameter	0.75" (1.9 cm)
Weight	0.8 lb. (0.4 kg)
Body Material	Acetal & 316 stainless steel or titanium
Wire Seal Material	Fluoropolymer and PTFE
Submersible Cable	Polyurethane, polyethylene, or FEP available
Protection Rating	IP68, NEMA 6P
Terminating Connector	Available
Communication	RS485 Modbus® RTU SDI-12 (ver.1.3)
Direct Modbus Read Output	32-bit IEEE floating point
SDI-12 Output	ASCII
Internal Math	32-bit floating point

LOGGING

Memory	4MB - 520,000 records
Log Types	Variable, user-defined, logarithmic, profiled
Programmable Baud Rate	9600, 19200, 38400
Logging Rate	8x/sec maximum
Software	Complimentary Aqua4Plus or Aqua4Push
Networking	32 available addresses per junction w/ batching capabilities (up to 255)
File Formats	.xls / .csv / .a4d

TEMPERATURE

Element Type	Digital IC on board
Accuracy	$\pm 0.2^{\circ}$ C
Resolution	0.06 $^{\circ}$ C
Operating Temperature Range	-5 $^{\circ}$ C to 70 $^{\circ}$ C
Storage Temperature Range¹	-20 $^{\circ}$ C to 80 $^{\circ}$ C
Units	Celsius, Fahrenheit, Kelvin

1 Storage without batteries

POWER

Internal Battery	2x1.5V AA alkaline ²
Auxiliary Power	12 VDC - Nominal 6-15VDC - Range
Exp. Alkaline Battery Life	18 months at 15m polling interval ³

2 Lithium available upon request

3 May vary due to environmental factors

Direct Read

While the T1R 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 T1R 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.

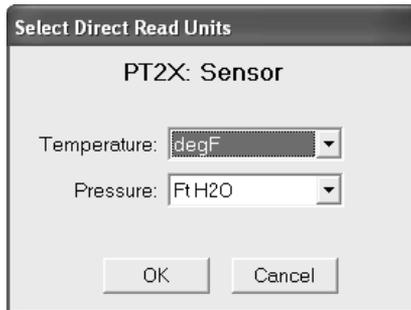
Setting Units for Direct Read

By default, the T1R uses the following units:

Temperature Degrees Celsius

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, 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-arrow next to the Temperature box, and then select the units you want. (Ignore the Pressure box.)
- 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 T1R 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 T1R 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 T1R, 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, starting at address 62594. (T1R 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 T1R

<u>Address for Temperature Channel on T1R</u>		
	Zero Based	One Based
Temperature	62592	62593

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, highword first, also referred to as big-endian or float inverse.

Reading Via SDI-12

Note: 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 T1R2.1ssssssss<cr><lf>
// note: 2.1 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<b>! <b><cr><lf>
// change address to <b>

/** Request measurement
<a>M1! <a>0021<cr><lf>
<a>D0! <a>+22.0512<cr><lf>
// request temperature measurement
// read temperature

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

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

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

```

Changing Batteries

Battery Type: Two standard AA Alkaline batteries.

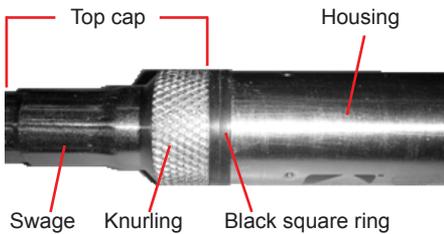
Because changing the batteries involves opening the water-tight seal, **this must be done in a clean, dry environment to avoid contamination or moisture damage to the circuitry.**

Tips

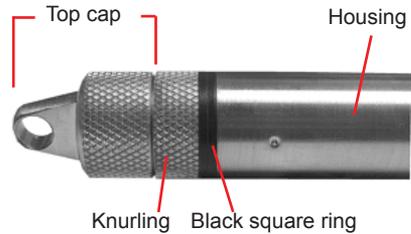
- Never place a tool on the sensor body, it is very thin and will deform causing leaks at o-ring seals and potentially crushing the circuit board!
- Always twist the sensor body off the top cap assembly rather than twisting the top cap assembly off of the sensor body.
- For cabled sensors, always clamp 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 or side 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.

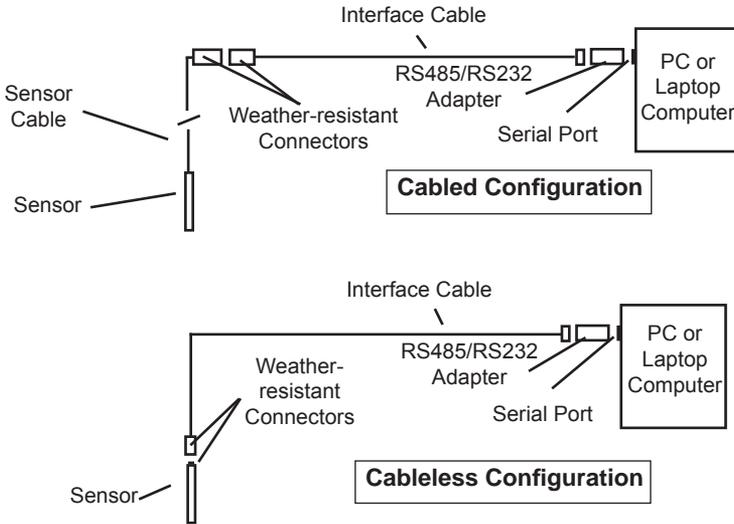


Properly completed — black ring uncompressed

Alternate Connection Options

Connecting via RS232 Serial Port

In its cabled configuration, the sensor cable is terminated with a weather-resistant connector. In its cableless configuration, the sensor 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.



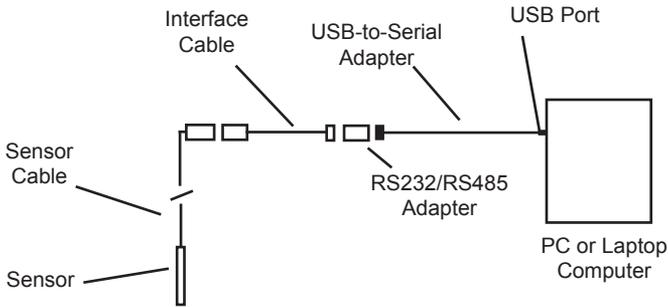
Connect the sensor to your computer using an RS485/RS232 adapter and an interface cable.

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

Reordering Information

For sales & service offices, please contact:

Instrumentation Northwest, Inc.

www.inwusa.com

800-776-9355

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SUBMERSIBLE PRESSURE /TEMPERATURE SENSOR**

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INW

8902 122nd Avenue NE
Kirkland, WA 98033 USA
425-822-4434

FAX 425-822-8384 / info@inwusa.com

1-800-PRO-WELL
WWW.INWUSA.COM

