What is the T1/T1R?

The Seametrics 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.

The T1 (non-recording version) operates on an external (9 to 15 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 (9 to 15 VDC) power supply. The unit is programmed using our 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 Seametrics 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.

_Do_ support the device with the connector.  
_Do_ use a strain relief device to take the tension off the connectors.  
_Do_ allow the device to free-fall down a well as impact damage can occur.  
_Do_ bang or drop the object on hard objects.
**Sensor:** There are no user-serviceable parts. If problems develop with sensor stability or accuracy, contact Seametrics. 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.

**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 Seametrics are not submersible, but are designed to be splash-resistant.

---

**Wiring Diagram**

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.
### Dimensions and Specifications

**GENERAL**

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

**POWER**

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Voltage</td>
<td>9 - 15 VDC</td>
</tr>
<tr>
<td>Over Voltage Protection</td>
<td>24 VDC</td>
</tr>
<tr>
<td>Power Supply Current</td>
<td>Active 3mA avg./10mA peak</td>
</tr>
<tr>
<td></td>
<td>Sleep 150 µA</td>
</tr>
<tr>
<td>Electromagnetic &amp; Transient Protection</td>
<td>IEC-61000 — 4-3, 4-4, 4-5, 4-6</td>
</tr>
</tbody>
</table>

**TEMPERATURE**

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Element Type</td>
<td>Digital IC on board</td>
</tr>
<tr>
<td>Accuracy</td>
<td>± 0.2° C</td>
</tr>
<tr>
<td>Resolution</td>
<td>0.06° C</td>
</tr>
<tr>
<td>Units</td>
<td>Celsius, Fahrenheit, Kelvin</td>
</tr>
</tbody>
</table>

*Contact factory for extended temperature ranges.*

1 *Requires freeze protection kit if in water below freezing.*
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

<table>
<thead>
<tr>
<th>Register</th>
<th>Mnemonic</th>
<th>Description</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>40223-24</td>
<td>mT</td>
<td>Field calibration</td>
<td>Temperature slope</td>
</tr>
<tr>
<td>40225-26</td>
<td>bT</td>
<td>Field calibration</td>
<td>Temperature offset</td>
</tr>
<tr>
<td>40227-28</td>
<td>T_Alpha</td>
<td>Factory calibration</td>
<td>Temperature alpha</td>
</tr>
<tr>
<td>40229-30</td>
<td>T_Offset</td>
<td>Factory calibration</td>
<td>Temperature offset</td>
</tr>
<tr>
<td>40231-32</td>
<td>T_ZeroSlope</td>
<td>Factory calibration</td>
<td>Temperature slope</td>
</tr>
<tr>
<td>40237-38</td>
<td>T_mUnits</td>
<td>Temperature Units</td>
<td>Conversion slope</td>
</tr>
<tr>
<td>40239-40</td>
<td>T_bUnits</td>
<td>Temperature Units</td>
<td>Conversion offset</td>
</tr>
</tbody>
</table>

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 updated 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

0x0000000 .. 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:

\[ cmd \quad response \quad // \quad comments \]
SDI-12 Commands

Sensor Identification

\(<a>! <a>13 INWUSA PT12 20.7ssssssssss\cr<lf>

Note: 0.7 will change to reflect current firmware version.
ssssssssss = device serial number

Acknowledge Active, Address Query

a! a\cr<lf>
?! 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)
T1/T1R INSTRUCTIONS

Concurrent Measurement with CRC

aMC4! a0ttt4<cr><lf>
Request averaged data. ttt depends on programmed average duration.

aD0! a+0+0+0+25.0000{crc}<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 on programmed average duration

aD0! a+0+0+0+25.0000{crc}<cr><lf>
Read null, null, null, average temperature

Extended Commands

Set duration for averaging reading

aXAttt! attt<cr><lf>
Set duration of averaged data for M4 ttt = 1-997 seconds

Read/Modify Calibration Values

aXCnn{= <value>!}
Read (modify) calibration value nn

Examples:
axC00! a+1.591600e-5<cr><lf>
Read value from calibration register 00

axC00=1.704e-4! a+1.704000e-4<cr><lf>
Set value of calibration register 00

Set number of significant digits

aXS! at<cr><lf>
Set number of significant digits for SDI-12 report data t = 1–7
# Calibration Register Definitions

All calibration registers contain floating point values.

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

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.
## Dimensions and Specifications

### GENERAL

<table>
<thead>
<tr>
<th>Specification</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Length</strong></td>
<td>10.725” (27.24 cm) cabled</td>
</tr>
<tr>
<td></td>
<td>10.475” (26.61 cm) cableless</td>
</tr>
<tr>
<td><strong>Diameter</strong></td>
<td>0.75” (1.9 cm)</td>
</tr>
<tr>
<td><strong>Weight</strong></td>
<td>0.8 lb. (0.4 kg)</td>
</tr>
<tr>
<td><strong>Body Material</strong></td>
<td>Acetal &amp; 316 stainless steel or titanium</td>
</tr>
<tr>
<td><strong>Wire Seal Material</strong></td>
<td>Fluoropolymer and PTFE</td>
</tr>
<tr>
<td><strong>Submersible Cable</strong></td>
<td>Polyurethane, polyethylene, or ETFE</td>
</tr>
<tr>
<td><strong>Protection Rating</strong></td>
<td>IP68, NEMA 6P</td>
</tr>
<tr>
<td><strong>Terminating Connector</strong></td>
<td>Available</td>
</tr>
<tr>
<td><strong>Communication</strong></td>
<td>RS485 Modbus® RTU</td>
</tr>
<tr>
<td></td>
<td>SDI-12 (ver.1.3)</td>
</tr>
<tr>
<td><strong>Direct Modbus Read Output</strong></td>
<td>32-bit IEEE floating point</td>
</tr>
<tr>
<td><strong>SDI-12 Output</strong></td>
<td>ASCII</td>
</tr>
<tr>
<td><strong>Internal Math</strong></td>
<td>32-bit floating point</td>
</tr>
</tbody>
</table>

### LOGGING

<table>
<thead>
<tr>
<th>Specification</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Memory</strong></td>
<td>4MB - 520,000 records</td>
</tr>
<tr>
<td><strong>Log Types</strong></td>
<td>Variable, user-defined, logarithmic, profiled</td>
</tr>
<tr>
<td><strong>Programmable Baud Rate</strong></td>
<td>9600, 19200, 38400</td>
</tr>
<tr>
<td><strong>Logging Rate</strong></td>
<td>8x/sec maximum</td>
</tr>
<tr>
<td><strong>Software</strong></td>
<td>Complimentary Aqua4Plus</td>
</tr>
<tr>
<td><strong>Networking</strong></td>
<td>32 available addresses per junction w/ batching</td>
</tr>
<tr>
<td></td>
<td>capabilities (up to 255)</td>
</tr>
<tr>
<td><strong>File Formats</strong></td>
<td>.xls / .csv / .a4d</td>
</tr>
</tbody>
</table>

### TEMPERATURE

<table>
<thead>
<tr>
<th>Specification</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Element Type</strong></td>
<td>Digital IC on board</td>
</tr>
<tr>
<td><strong>Accuracy</strong></td>
<td>± 0.2° C</td>
</tr>
<tr>
<td><strong>Resolution</strong></td>
<td>0.06° C</td>
</tr>
<tr>
<td><strong>Operating Temperature Range</strong></td>
<td>-5° C to 70° C</td>
</tr>
<tr>
<td><strong>Storage Temperature Range</strong></td>
<td>-20° C to 80° C</td>
</tr>
<tr>
<td><strong>Units</strong></td>
<td>Celsius, Fahrenheit, Kelvin</td>
</tr>
</tbody>
</table>

1 Storage without batteries
OPERATIONS - T1R RECORDING

T1/T1R INSTRUCTIONS

POWER

<table>
<thead>
<tr>
<th>Power Source</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal Battery</td>
<td>2x1.5V AA lithium</td>
</tr>
<tr>
<td>Auxiliary Power</td>
<td>12 VDC - Nominal</td>
</tr>
<tr>
<td></td>
<td>9-15 VDC - Range</td>
</tr>
<tr>
<td>Exp. Alkaline Battery Life</td>
<td>18 months at 15m polling interval</td>
</tr>
</tbody>
</table>

*May vary due to environmental factors*

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 9 - 15 VDC supply that can provide 15 mA. Connect to Vaux++ (pin 1 - white) and Ground (pin 5 - blue) or contact Seametrics 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 Seametrics’ 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 our 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 Seametrics for more details.
Real-time Data

Connect to sensor and select the Real-time data tab.

To start real-time readings click Start, readings default to table view. To switch to Real-time graphing view click the graph icon.

Real-time readings default to a 1 second interval for 1 minute, to adjust enter your desired settings here:

To save this data to the Reports section click the button located next to the Single button in the Real-Time tab. This will permanently save this real-time data set to your Reports database.
Data Logging

Select Set Up Logging from the sensor screen. If there are no files currently on the sensor you’ll see the Set Up Logging button active under the Data Files tab as well as in the upper menu. Once files have been started/logged on the sensor they will be displayed under the Data Files tab.

Set Up Logging Window

Here you will name your data file and set up the recording interval and duration of each logging phase. Select your desired recording interval and duration for each phase, Aqua4Plus 2.0 will display the available memory at the bottom of the window.
Click \( \Rightarrow \) to switch between interval and continuous data recording (PT2X & CT2X only). Select your continuous rate from the drop down box (on the right).

Duration can be set by either number of records or by setting a duration time, as shown on the right.

When set by number of records the time of the recording phase will be displayed detailing how long that phase will run. When set by time, the total number of records for that phase will be displayed.

If you need to check settings or perform a calibration click before proceeding with logging setup to switch to the Settings and Calibration screen.

You may sync the sensor clock with the PC clock when starting logging by clicking the slider shown on the right.

Check the Delayed Start box and enter the desired date/time you would like logging to start. This is useful for syncing data when setting up multiple sensors on a site. Data will start logging at the set date/time rather than immediately when Start is pressed.

Data file name defaults to Test File # and may be re-named here, like on the right.
The 3 previous Logging Schedules that were programmed to a sensor will be listed under the Select Template drop down menu. There you will also find pre-programmed logging schedules such as 24 hour pump test, along with any custom logging schedules saved by the user.

To save a logging schedule as a template enter desired settings and click [This will add your custom schedule to the Select Template menu.]

Once all the desired settings are made simply click Start to begin logging.

This will return you to the Sensor screen and your status will change to Active with the data file displayed under the Data Files tab. Mouse over an active file to pause, terminate, download, or view logging setup details.
Data files already downloaded will show in the Reports column, clicking here will bring you to the reports screen to view the data. See Reports section for details.

You may only have 1 active data file recording on each sensor, however you can store multiple files in memory if desired.

Starting a new file will automatically terminate the active logging and begin the new logging schedule. Real-time data is available during active logging.

To delete files from memory make sure they have all been downloaded to Reports. Files are removed from memory all at once rather than individually.

Once confirmed files are permanently deleted from the sensor memory.
READING THE T1R

Reports

Data downloaded from your sensor is stored in the Reports section of Aqua4Plus 2.0 for viewing and editing. The files will be saved to default data folder on your PC as well. See Program Settings for default data folder location.

In the main view you’ll see a list of reports sorted by date, size, or file name as selected here:

You can also search reports by keyword using the search box

Click on a report to bring up the report details.

Reports are displayed in graphing view by default. You can zoom to specific sections by selecting a section with you mouse or by adjusting the slider below the graph.

Graph saving and export options are available here
Reading the T1R

Click to switch to full screen graphing view
Click Ξ: to view data as a table
Click Σ to view data statistics

You may change the display units within the graph view by selecting the appropriate channel here:

The Information tab is a new feature allowing users to add metadata to their reports such as site location, field notes, or comments. The Schedule tab will display the logging setup details for the report.
Click Export to export the report as a .csv file or .a4d file for distribution or use in 3rd party software.

Click Delete to delete the report from Aqua4Plus 2.0

You can also import .a4d files from compatible sensors into Aqua4Plus 2.0 by clicking at the top of the Reports screen.

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 Sensor Settings.
Direct Read

While the T1R comes with our 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.

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. See Sensor Settings.

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.)

<table>
<thead>
<tr>
<th>Register addresses for T1R</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address for Temperature Channel on T1R</td>
</tr>
<tr>
<td>Zero Based</td>
</tr>
<tr>
<td>Temperature</td>
</tr>
</tbody>
</table>
READING THE T1R

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>13 \text{ INWUSA T1R2.1ssssssssss<cr><lf>}

Note: 2.1 will change to reflect current firmware version. sssssssssss = device serial number

Acknowledge Active, Address Query

\(<a>\text{?! <cr><lf>}

Change Address

\(<a>A\text{b}<cr><lf>

Change address to b

Request Measurement

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

\(<a>D0!<a>+22.0512<cr><lf>

Request temperature

Read temperature

Request Measurement with CRC

\(<a>MC1! <a>0021<cr><lf>

\(<a>D0! <a>+22.0512<cr><lf>

Request temperature measurements with CRC

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>

\(<a>D0! <a>+22.0512<cr><lf>

Request temperature measurement with CRC

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**

- Swage
- Knurling
- Black square ring

**Cableless Sensor**

- Knurling
- Black square ring

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.
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.

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.
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. Seametrics 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, Seametrics 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.
LIMITED WARRANTY/DISCLAIMER

Seametrics T1 & T1R SUBMERSIBLE PRESSURE /TEMPERATURE SENSOR

A. Seller warrants that products manufactured by Seller when properly installed, used, and maintained, 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.

THE FOREGOING WARRANTIES ARE IN LIEU OF ALL OTHER WARRANTIES, WHETHER ORAL, WRITTEN, EXPRESSED, IMPLIED OR STATUTORY. IMPLIED WARRANTIES OF FITNESS AND MERCHANTABILITY SHALL NOT APPLY. SELLER’S WARRANTY OBLIGATIONS AND BUYER’S REMEDIES THEREUNDER (EXCEPT AS TO TITLE) ARE SOLELY AND EXCLUSIVELY AS STATED HEREIN. IN NO CASE WILL SELLER BE LIABLE FOR CONSEQUENTIAL DAMAGES, LABOR PERFORMED IN CONNECTION WITH REMOVAL AND REPLACEMENT OF THE SENSOR SYSTEM, LOSS OF PRODUCTION OR ANY OTHER LOSS INCURRED BECAUSE OF INTERRUPTION OF SERVICE. A NEW WARRANTY PERIOD SHALL NOT BE ESTABLISHED FOR REPAIRED OR REPLACED MATERIAL, PRODUCTS OR SUPPLIES. SUCH ITEMS SHALL REMAIN UNDER WARRANTY ONLY FOR THE REMAINDER OF THE WARRANTY PERIOD ON THE ORIGINAL MATERIALS, PRODUCTS OR SUPPLIES.

B. With respect to products purchased by consumers in the United States for personal use, the implied warranties including but not limited to the warranties of merchantability and fitness for a particular purpose, are limited to twelve (12) months from the date of delivery.

Some states do not allow limitations on the duration of an implied warranty, so the above limitation may not apply to you. Similarly, some states do not allow the exclusion or limitation of consequential damages, so the above limitation or exclusion may not apply to you. This limited warranty gives you specific legal rights; however, you may also have other rights which may vary from state to state.