PT12

Manual

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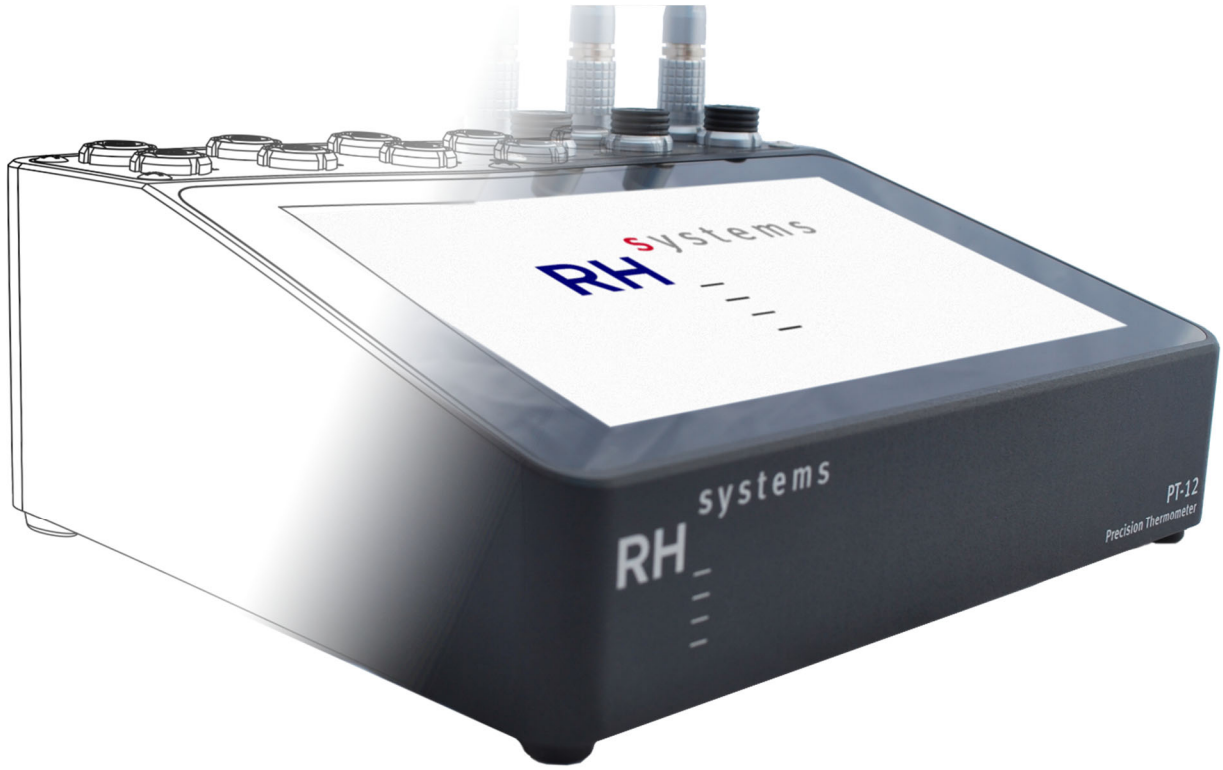
FOR SUPPORT, PLEASE EMAIL SUPPORT@RHS.COM OR CALL (480) 926-1955 WITH TECHNICAL OR CALIBRATION QUESTIONS.

1 INTRODUCTION

The PT12 is a highly precise and stable platinum resistance thermometer (PRT) based multi-channel temperature measurement system. Using a custom designed high precision measurement circuit with full current reversal and multiplexed sampling, the PT12 provides 12 channels of low uncertainty temperature data for validation and calibration.

Using one of three automatic or user selectable currents, the PT12 repeatedly scans all 12 channels. Employing a full reversal current source, the PT12 eliminates polarity sensitive errors normally inherent to DC measuring techniques. Accuracy is further enhanced by referencing all measurements to a series of high accuracy, temperature stable internal reference resistors.

The integrated firmware allows each channel to be individually programmed with ITS-90 or Callendar-Van Dusen (CVD) coefficients for direct conversion of resistance measurements to temperature. It incorporates a full color, pinch zoom touch screen as the user interface. Although not required for operation, the PT12 may also be connected to a PC over an RS-232 or USB interface.

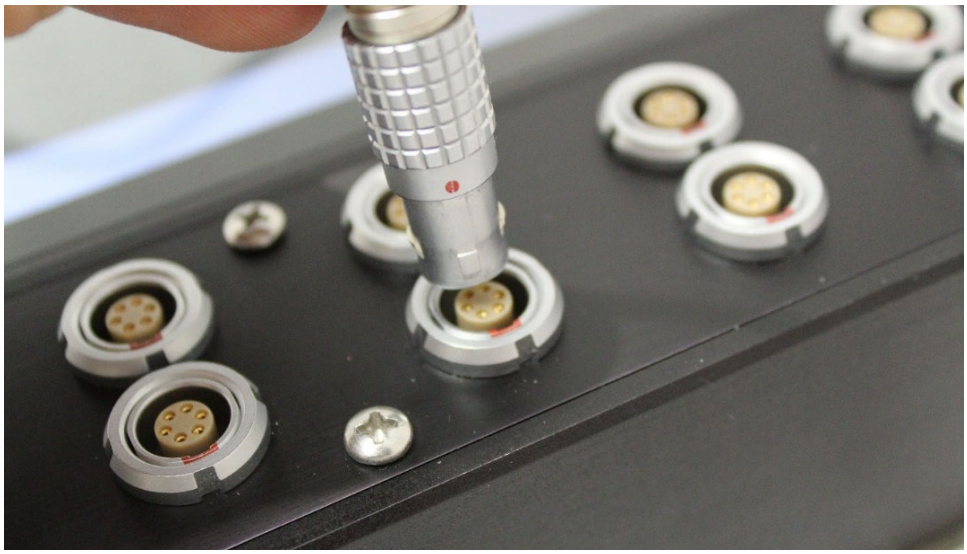


2 QUICK START / INITIAL SETUP

The quick start is intended to get you up and running quickly. For additional information see section 4 Operation.

2.1 CONNECTING A TEMPERATURE PROBE

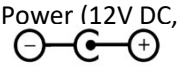
Select any of the supplied probes and connect it to any desired channel (the remainder of this section will assume channel 5). When inserting the plug, ensure the red dots line up.



3 STARTING UP THE PT12

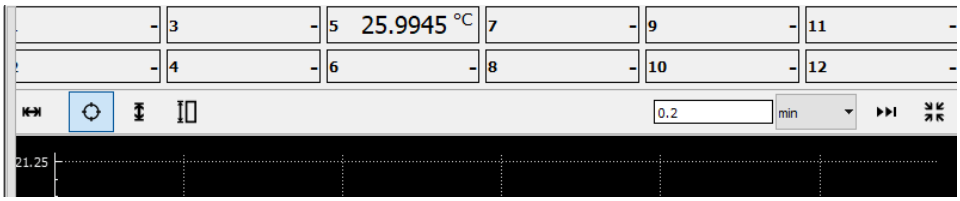
Plug in the included AC power adapter to a 110-240VAC outlet. Plug the round connector of the power adapter into the back of the PT12. A splash screen should appear in about 15 seconds and the machine will fully boot within about 30 seconds.

Power (12V DC, 3A) USB Flash Drive USB Serial RS-232

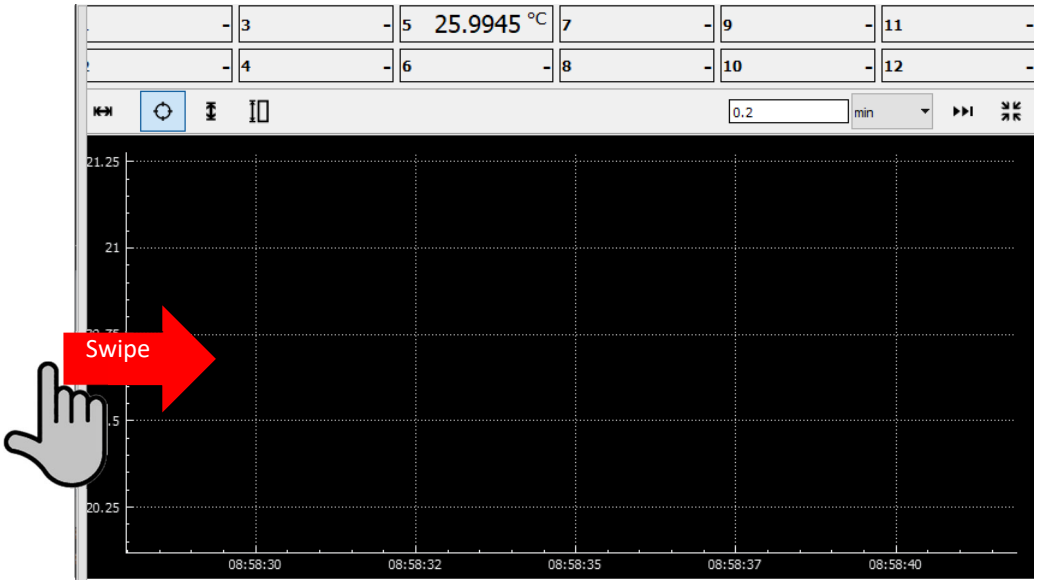


3.1 OBTAINING A READING

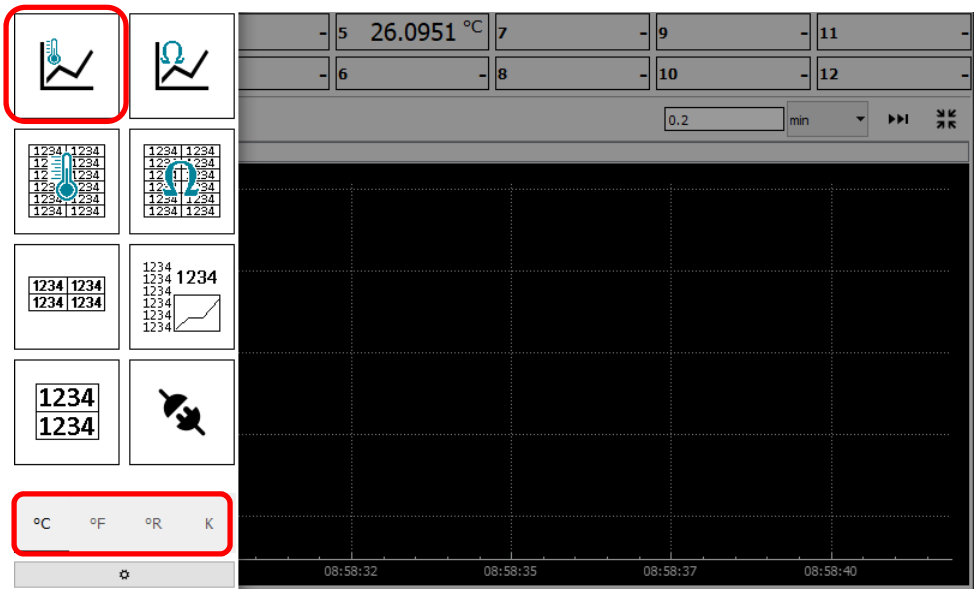
Once the system fully boots and the user interface is present, probe 5 should indicate a reasonable temperature value. All probe coefficients (if a smart probe) are automatically read from the probe and applied to channel 5.



The PT12 has several different display modes. It will power up in the previous mode that was displayed on shut down. To change display modes, swipe with a finger from the left-hand side to bring up the menu.



From this menu, units may be changed, or a new display format may be selected.

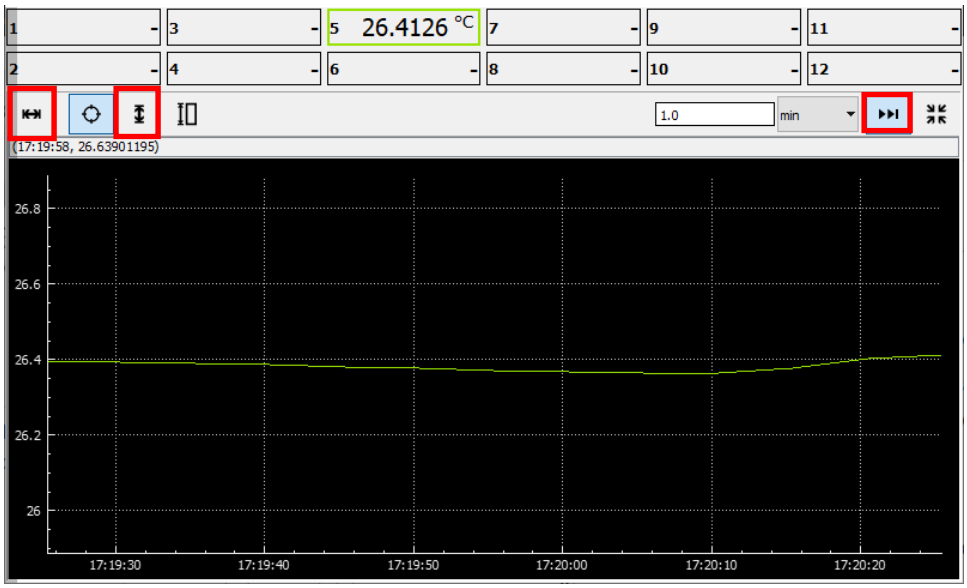


To select a display mode, tap the desired icon. The menu will hide, and the new display mode will appear. For this quick start example, select the top left display mode icon (this is the temperature graph display mode).

For more information see section 4.3 Navigating the User Interface.

3.2 PLOTTING TEMPERATURE

To add a probe's value to the graph, tap the appropriate probe (probe 5 in this case) on the top portion of the screen. The probe's recent data will be plotted on the graph. To ensure that the data is visible, tap the Show All graph buttons, and the Continuous Update button to enable them. When enabled, they are highlighted in light blue.



Drag a single finger on the graph to scroll in any direction. Use two fingers for pinch-zoom operation. For additional information on graph functions, see section 4.3.1 Temperature Graph Display Mode

Note: The graph only retains the last 48 hours of data, while the log file holds all the data since the last power cycle or when logging was last toggled on. See sections 4.5 File Manager and 4.6 System Info.

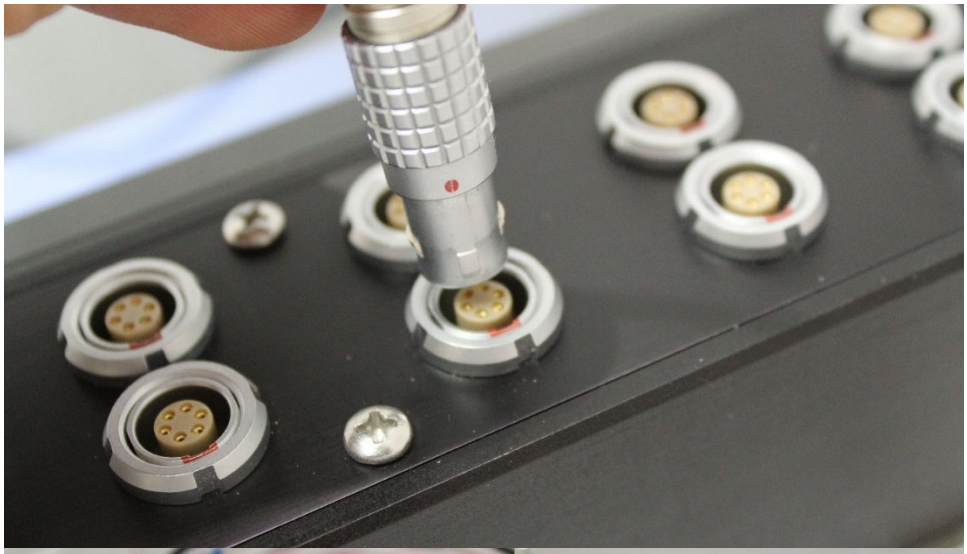
4 OPERATION

The PT12 measures temperature by ratiometric comparison of the unknown resistance of a temperature probe to a series of temperature stable precision reference resistors.

Through custom selection of the four reference resistors, the PT12 operating range and precision can be tuned for either 25 Ω PRTs or 100 Ω PRTs. Alternatively, it can be customized to cover both ranges with slightly less overall precision. (For more information on customization, contact RH Systems). The PT12 supports three distinct current modes which can be manually or automatically selected. The three current modes available are approximately 0.3 mA, 0.6 mA, and 1 mA. The PT12 will attempt to get the most accurate reading possible when utilizing auto current mode.

4.1 CONNECTING TEMPERATURE PROBES

There are 12 LEMO connectors (one per probe) on the PT12 and any number of probes (between 1 and 12) may be connected in any order at any given time. To connect a probe, ensure the red dots between the plug and receptacle are aligned, then push to connect. Pulling up on the body of the plug releases the catch, allowing the probe to be removed. Once inserted, the PT12 will automatically detect the probe and determine if it is a smart probe (with internal configuration memory) or a basic probe (without any memory).



4.1.1 BASIC PROBES

Basic probes do not have internal memory and use the channel's configuration for coefficients. If you move a basic probe from one channel to another, you will have to manually reenter the probe coefficients. Pins 1 and 6 are jumpered together inside the LEMO plug to indicate a basic probe.

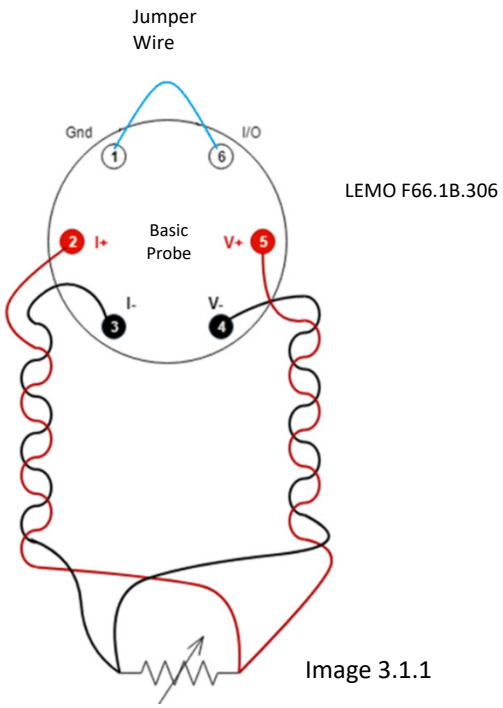


Image 3.1.1

4.1.2 SMART PROBES

The LEMO connector of each smart probe is embedded with a Maxim Integrated DS28EC20 - 20Kb 1-Wire EEPROM chip. This memory chip holds the probe's coefficients, serial number, and calibration date. When a smart probe is plugged in, the PT12 automatically detects it and extracts configuration information from the chip. Manual entry of coefficients is not required as the configuration information travels with the probe regardless of which channel it's plugged in to.

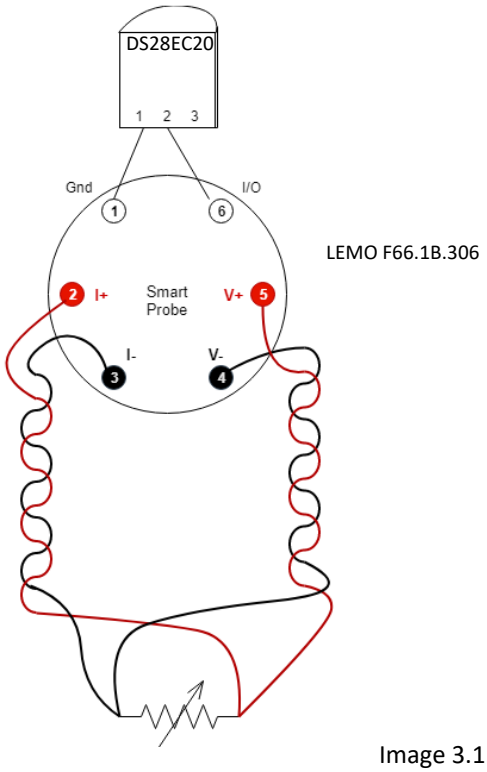


Image 3.1.2

4.1.3 USER-SUPPLIED PROBES

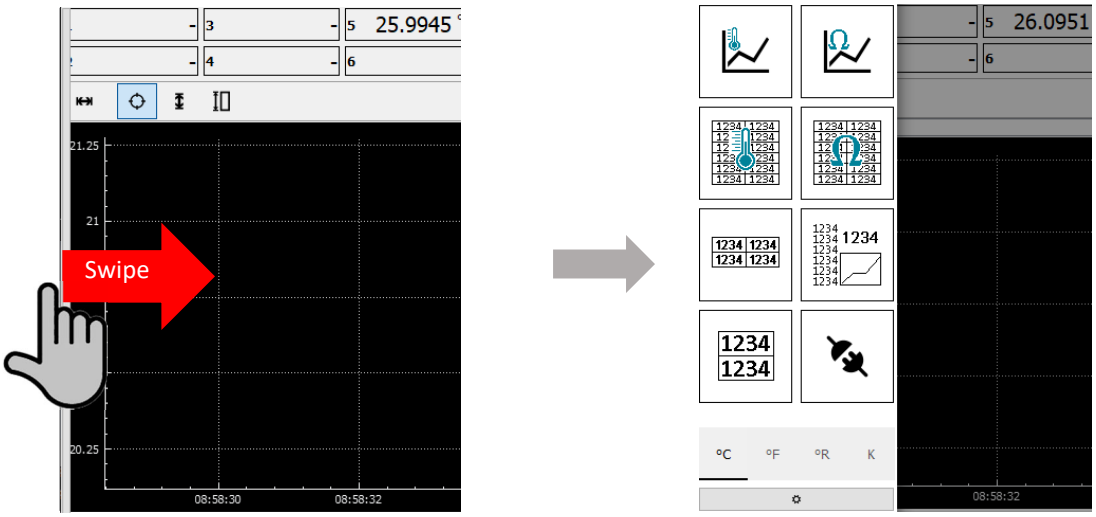
User supplied probes may be utilized by wiring them to a LEMO connector (part #FGG.1B.306). To create a basic probe, short pin 1 to pin 6. To create a smart probe, insert a Maxim Integrated DS28EC20 with pin 1 of the chip to pin 1 of the LEMO and pin 2 of the chip to pin 6 of the LEMO. Pin 3 of the chip is unused and should be cut off. See Image 3.1.2 above. Both smart and basic probes will require an initial entry of coefficients. Upon saving, the smart probe coefficients will travel with the probe. Basic probe coefficients will be retained in the PT12 channel.

4.2 CHANNEL MEASUREMENT RATE

It takes approximately 90 msec per reading for each of the attached probes and each of the four internal reference resistors. Meaning, if twelve probes are attached, the total measurement time to update all twelve channels and the four reference resistors is just under 1.5 seconds. If fewer probes are plugged in, unused channels are automatically skipped, increasing measurement frequency. For example, with only one attached probe, the approximate update rate would be less than 0.5 seconds.

4.3 NAVIGATING THE USER INTERFACE

The PT12 has a touch screen interface that supports tap, pinch/zoom, swipe, and long press. They each have different functions and are supported on various display modes.
The PT12 has several different display modes. It will power up in the previous mode that was displayed on shut down. To change display modes swipe with a finger from the left-hand side. This brings up a menu of available display modes.



To select a display mode, tap the desired icon. The menu will hide, and the new display mode will appear.

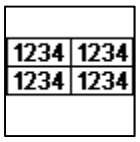
The display mode icons and descriptions:

Temperature Graph: Majority of the screen is filled with a temperature graph with 12 small temperature values listed above.

Resistance Graph: Majority of the screen is filled with a resistance graph with 12 small resistance values listed above.

All Temperatures: Shows a 2x6 grid with the temperatures of all twelve probes.

All Resistances: Shows a 2x6 grid with the resistances of all twelve probes.



4x Numeric: Shows a 2x2 grid with the temperatures and resistances of any four selected probes.

2x Numeric: Shows temperatures and resistances in a large font for any two selected probes.

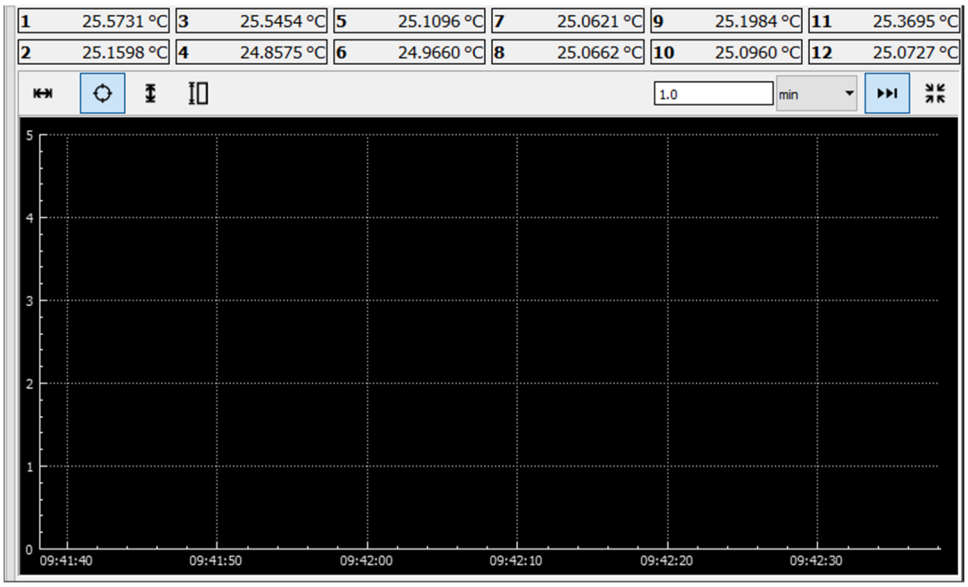
Combo: Shows up to twelve connected probe temperatures on one side, a mini graph, and a large numeric value (temperature and resistance) for any single probe selected.

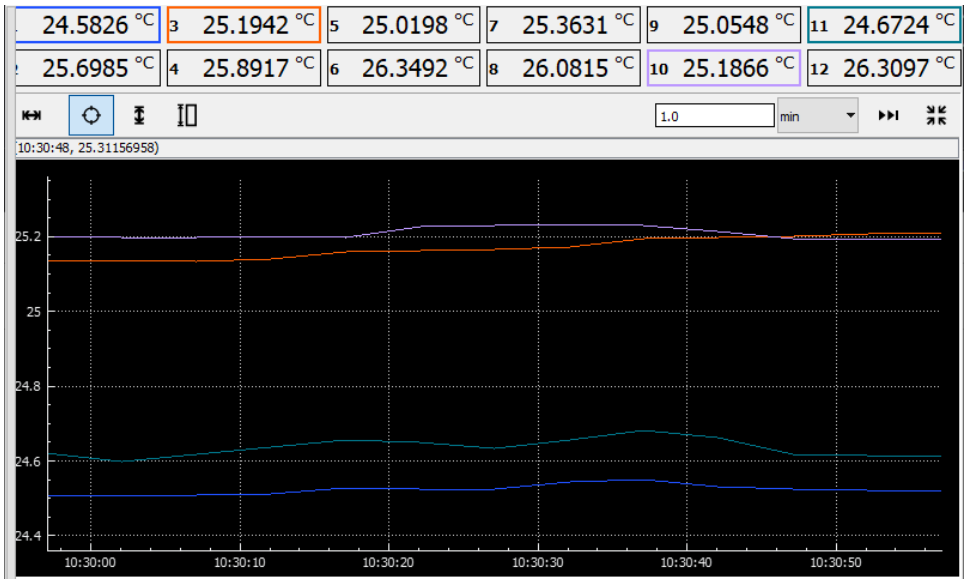
Probe Status: Shows the probe connection status of each channel of the PT12.

4.3.1 TEMPERATURE GRAPH DISPLAY MODE

To add a probe to the graph, tap on its numeric value. The numeric value will be outlined in a unique color, and the temperature plot will appear on the graph in that same color.

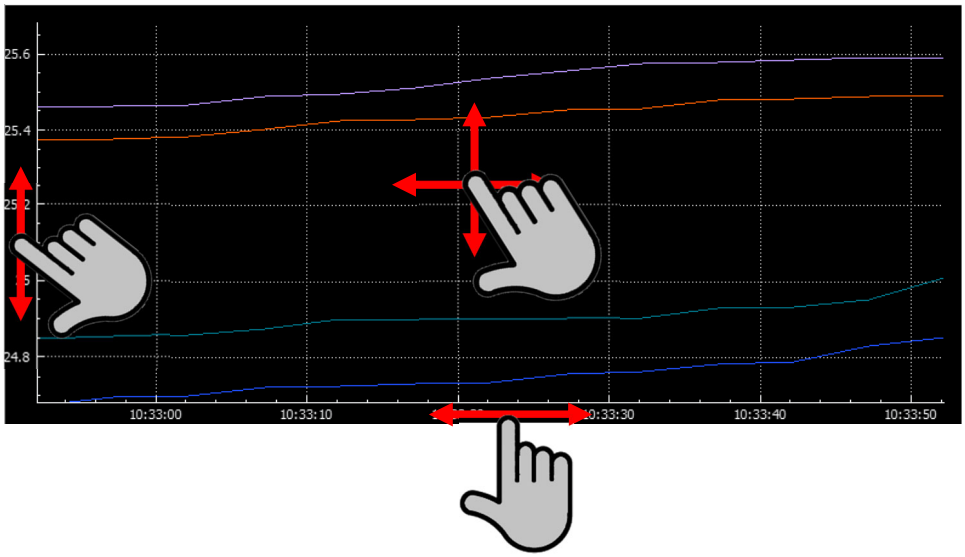
NOTE: The graph only retains the last 48 hours' worth of data, while the log holds all the data since the last power cycle or when logging was last toggled on.





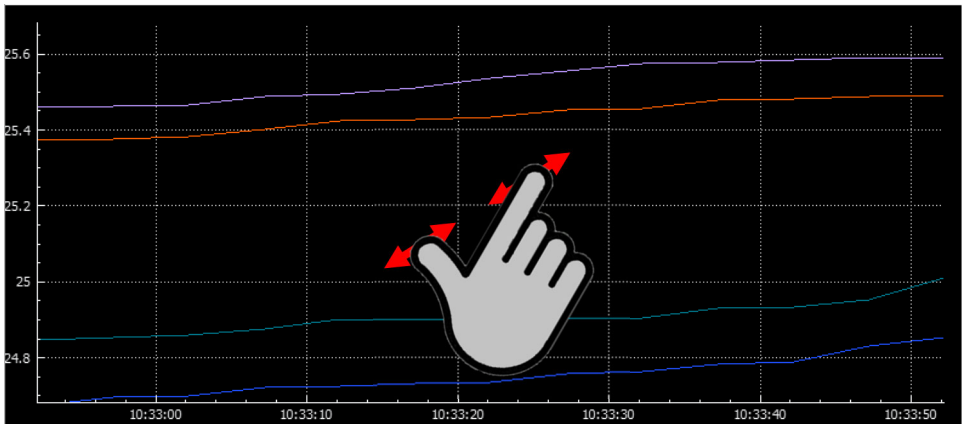
4.3.1.1 SCROLLING THE GRAPH

To scroll the graph, drag a finger in any direction. Alternatively, to scroll a single axis, drag within the axis area.



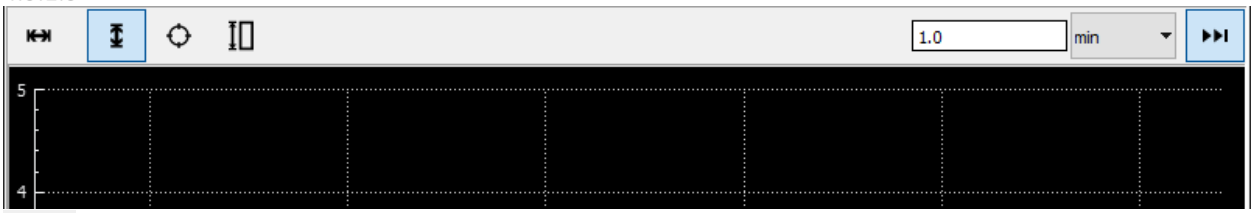
4.3.1.2 ZOOMING THE GRAPH

Pinch in/out with two fingers to zoom the graph in/out.



Alternatively, to zoom a single axis, long press on the axis area then drag. For y-axis, drag up or down to zoom in or out. For x-axis, drag right or left to zoom in or out.

4.3.1.3 AXIS CONTROL

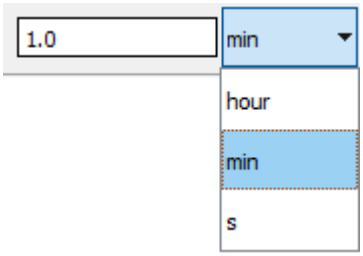



Show All (x-axis): While the button is selected the x-axis will be scaled to show all data.


Show All (y-axis): While the button is selected the y-axis will be scaled to show all data.


Fixed y-axis (semi-auto): While the button is selected the y-axis is fixed. If the data goes out of bounds the y-axis automatically adjusts to fit the data.


Locked y-axis: While the button is selected the y-axis remains exactly as shown without any auto adjustment.

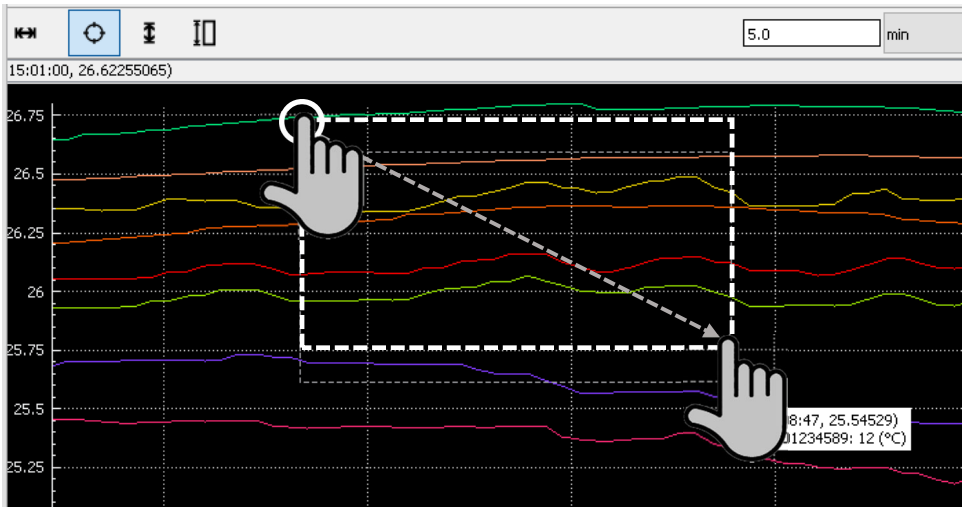


X-axis Width: Fixes the width of the x-axis to the specified period of time. Scrolling does not affect this value however, zooming overrides this value. The numeric value displays in hours, minutes, or seconds based on its associated drop-down menu.

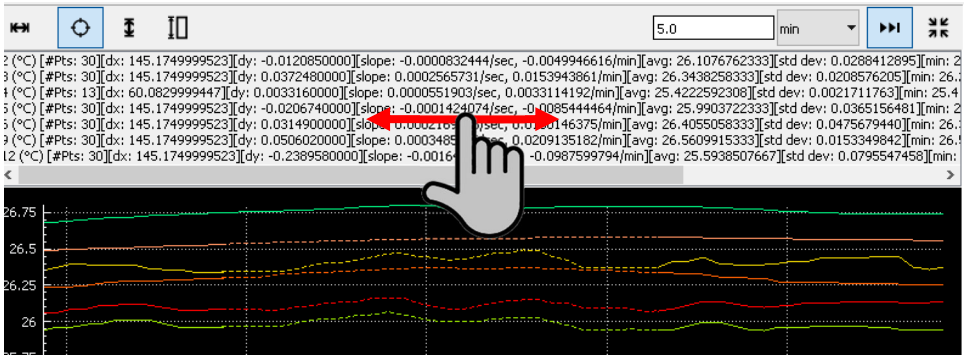

Continuous Update: While the button is selected, the graph will always display the most recent values, scrolling the time axis as required. Manually scrolling or zooming will disable this button.

4.3.1.4 GRAPH STATISTICS

To display numerical statistics of any currently graphed data, long press and drag the box to highlight the graph data you wish to analyze. After releasing, the statistics will be shown above the graph.



Scroll the statistical data left or right to display more information.



4.3.2 RESISTANCE GRAPH

The resistance display graph is identical to the temperature graph of section 4.3.1 Temperature Graph Display Mode, with the exception that values shown and graphed are probe resistances rather than temperatures.

4.3.3 ALL TEMPERATURE DISPLAY MODE

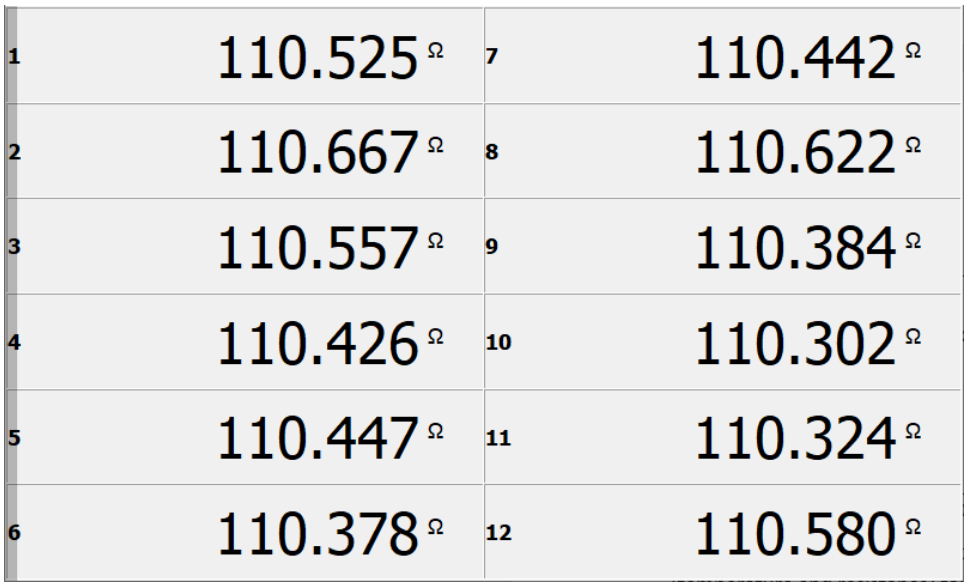
The All Temperature Display Mode simultaneously shows all twelve temperatures in the largest font possible.

1	27.0121 °C	7	26.8003 °C
2	27.3805 °C	8	27.2632 °C
3	27.0887 °C	9	26.6685 °C
4	26.7313 °C	10	26.4257 °C
5	26.8041 °C	11	26.4506 °C
6	26.5906 °C	12	27.1581 °C

Unconnected channels appear with blank values.

4.3.4 ALL RESISTANCE DISPLAY MODE

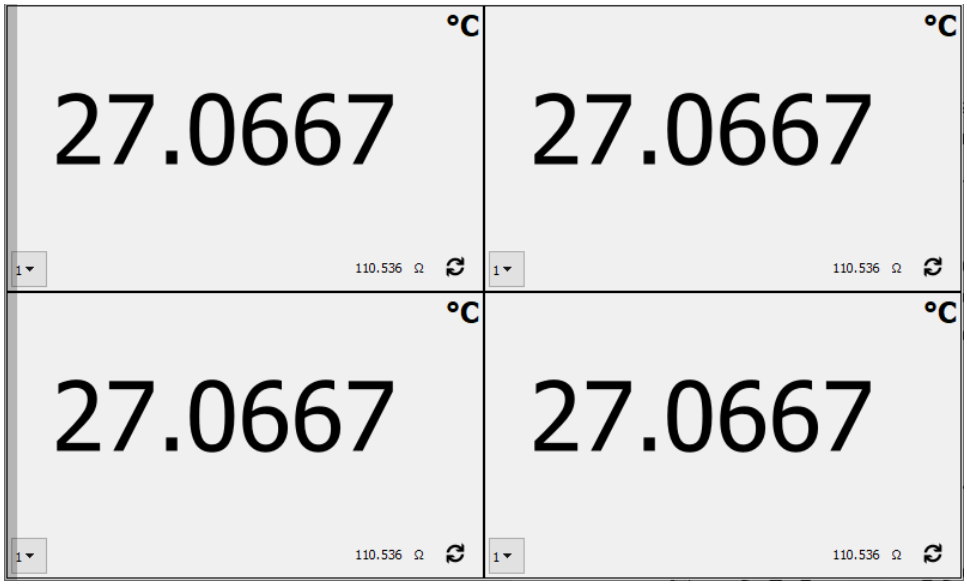
The All Resistance Display Mode simultaneously shows all twelve resistances in the largest font possible.



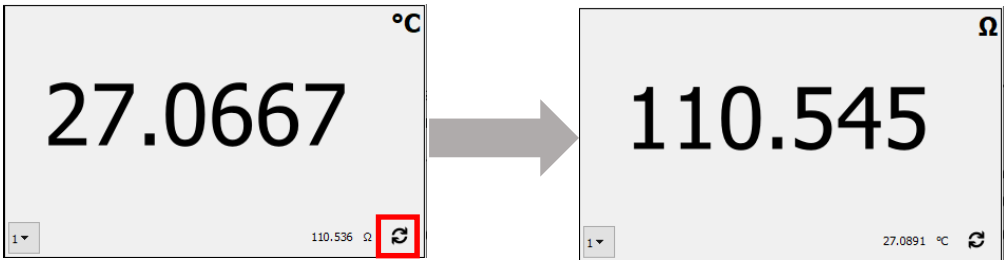
Unconnected channels appear with blank values.

4.3.5 NUMERIC 4X DISPLAY MODE

The Numeric 4x Display Mode shows any combination of four individually selectable channels. Each of the four channels may be selected to show temperature or resistance in a large font while showing the opposite in a smaller font.

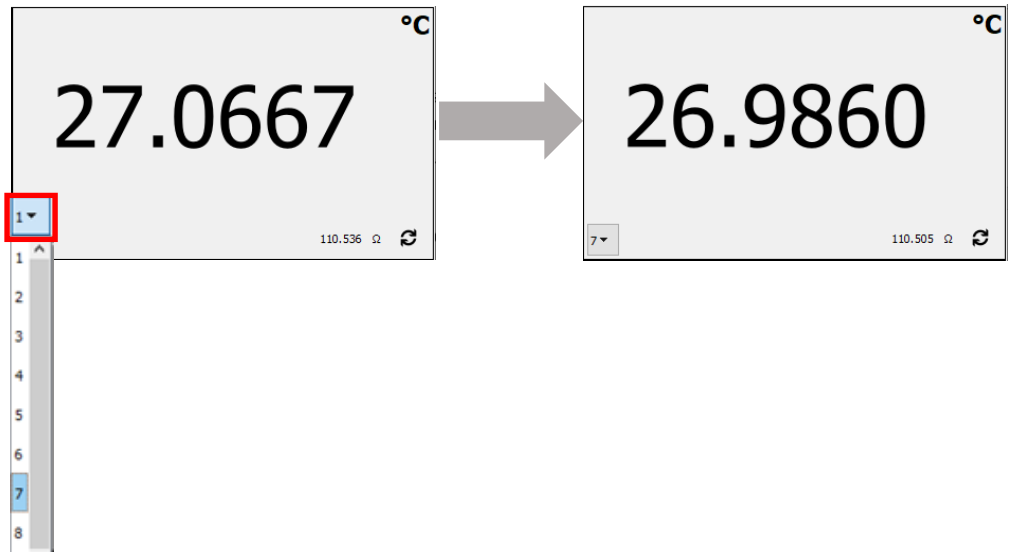


To swap a probe's indication from temperature to resistance, tap its bottom right button: 



The temperature and resistance value for that probe swap places. To toggle resistance back to temperature, tap the button again.

Tap the drop-down menu on any of the four channels to select a different channel:



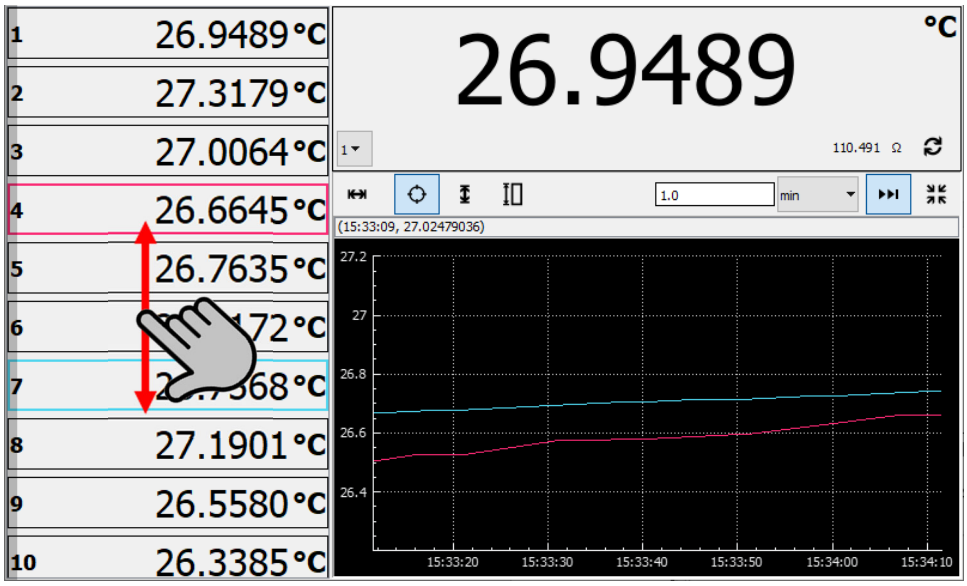
4.3.6 NUMERIC 2X DISPLAY MODE

The 2x Numeric Display Mode shows any combination of two individually selectable channels. Each of the two channels may be selected to show temperature or resistance in the largest possible font. Operation is identical to section 4.3.5 Numeric 4x Display Mode.

4.3.7 COMBO DISPLAY MODE

The Combo Display Mode shows up to 12 connected probe's temperatures on one side, a mini graph, and a large numeric value (temperature and resistance) for any single probe selected. The functions of the mini graph operate identical to the graph in section 4.3.1 Temperature Graph Display Mode. Although the graph is physically smaller, it is the same graph as on the other display modes. To add a channel to the graph, tap the channel value.

The large numeric value above the graph operates identical to a single item from section 4.3.5 Numeric 4x Display Mode.



This display only shows up to 10 of the connected probes simultaneously. Scroll the numeric data section to see others.

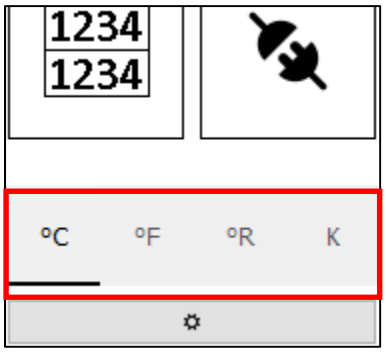
4.3.8 PROBE STATUS DISPLAY MODE

The Probe Status Display Mode shows the current probe status of each of the twelve channels.

1	Smart Probe	7	Smart Probe
2	Basic Probe	8	Basic Probe
3	Disconnected	9	Smart Probe
4	Smart Probe	10	Basic Probe
5	Smart Probe	11	Smart Probe
6	Smart Probe	12	Smart Probe

4.3.9 CHANGING DISPLAYED UNITS OF MEASUREMENT

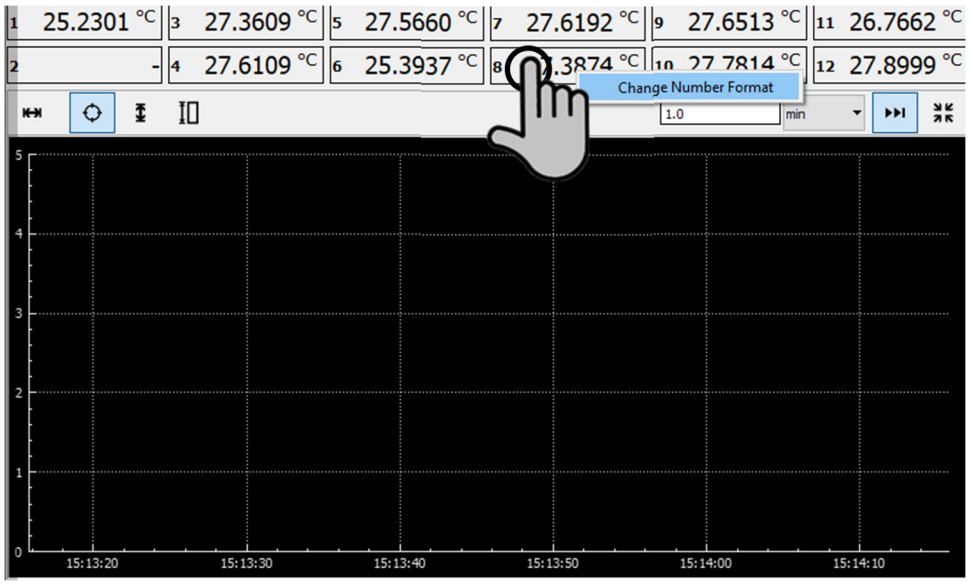
The available temperature display units are °C, °F, °R , and K. To change the displayed units of measurement, swipe in from the left on any display mode and tap the desired unit on the bottom of the menu.



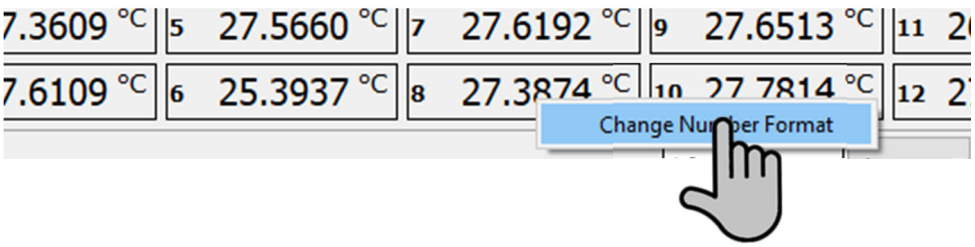
Changing units is common to all probes, meaning all temperatures will be displayed in the new units. However, for uniformity and consistency, temperature is always logged to file in °C and the serial port interface will always respond in °C regardless of displayed unit selection. Resistance is always in Ω.

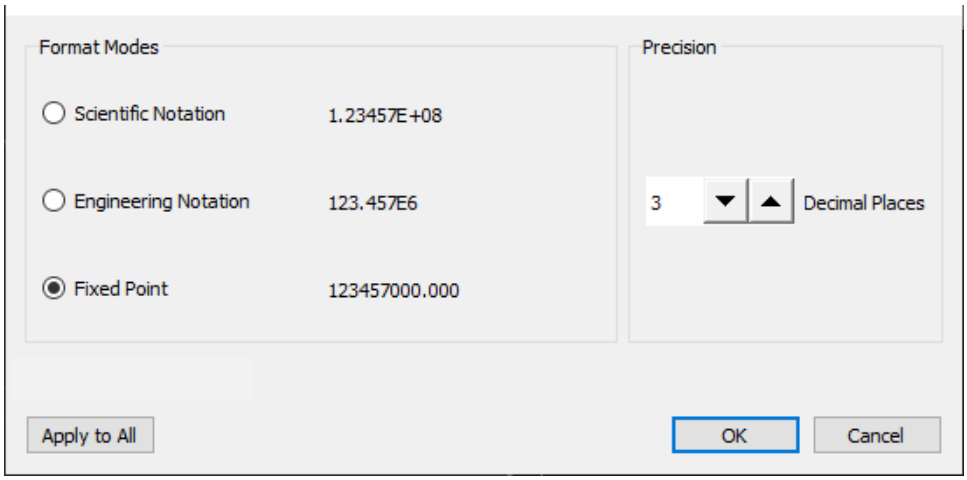
4.3.10 CHANGING NUMBER FORMAT

To change the number format of displayed values, long press on a numeric value to bring up the Change Number Format button.

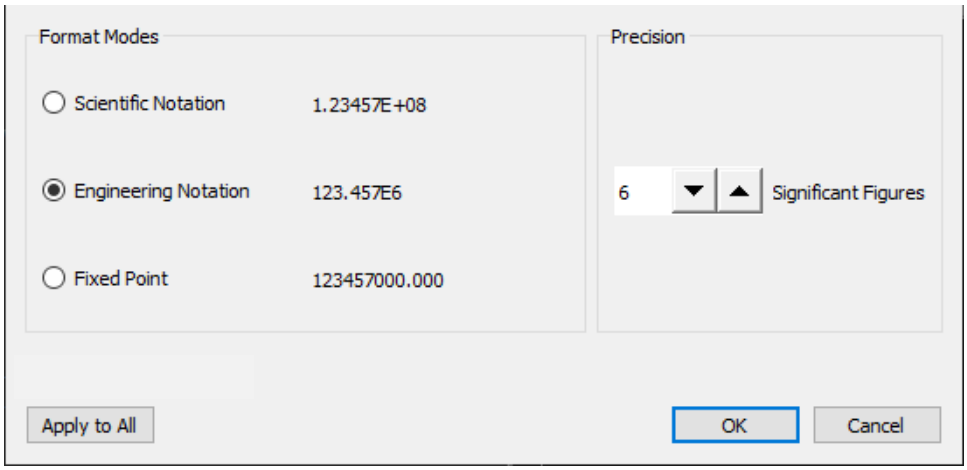


Tap the change number format button which brings up the number format screen:





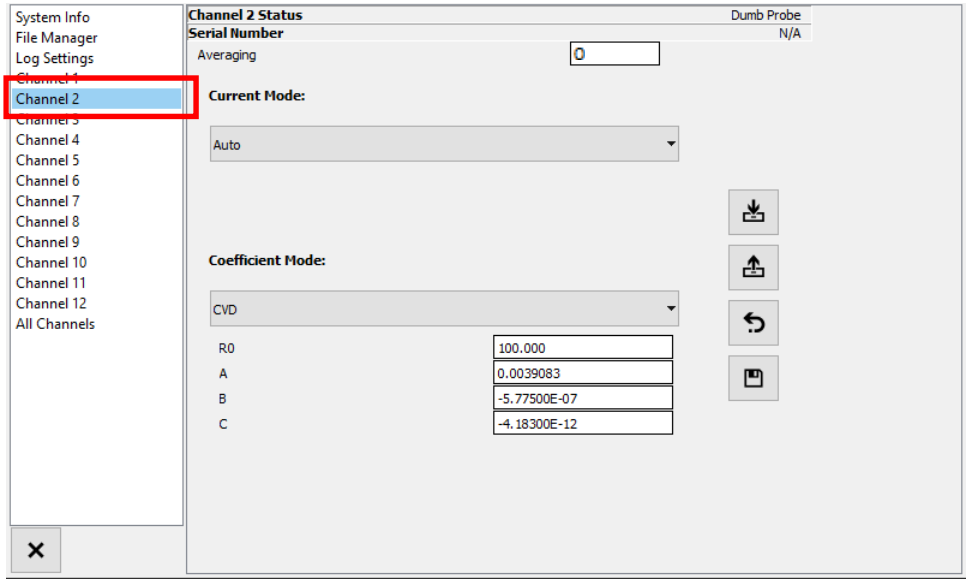
Choose a desired number format and tap **OK** for the single item, or **Apply to All** to apply the format to all PT12 displayed values.



4.4 CONFIGURING THE PROBES

To configure the probes, open the settings menu by swiping in from the left, then tap the settings button on the lower section of the menu.

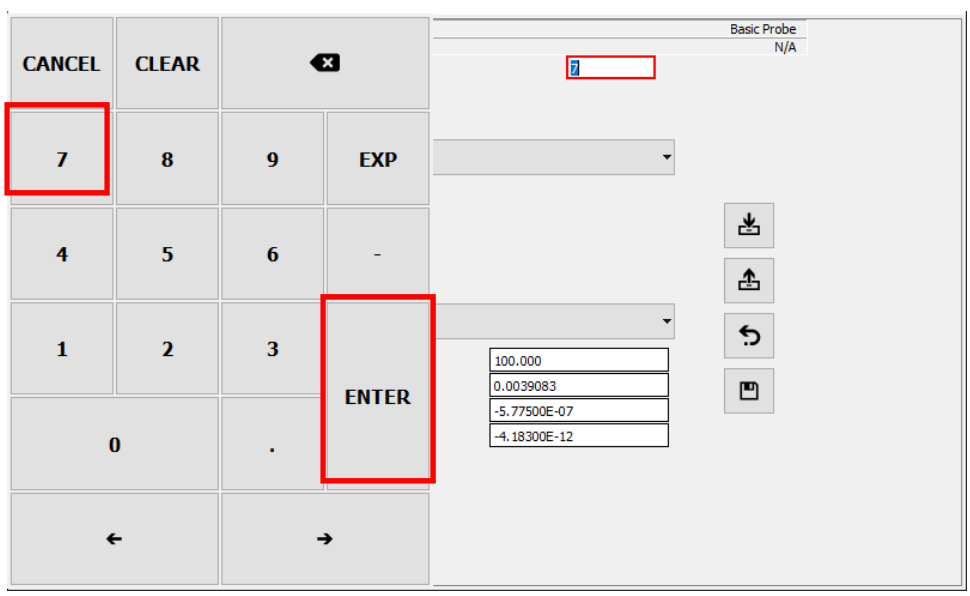
In the settings menu that appears, select the appropriate channel for the probe you wish to configure.



NOTE: Each probe has its own set of coefficients, averaging, current mode, etc. and each of them need to be saved individually.

4.4.1 AVERAGING

Probe averaging uses a weighted response low pass filter. To change averaging, tap on the text box. The on-screen keyboard will appear and allow entry of a new value. You must press enter to confirm the change. Reasonable averaging range is 0 to 100. 0=no averaging, every reading is new. 100=slower reaction, longer stabilization time but with significant noise reduction.




Tap the save button to ensure the values persist after a power cycle.

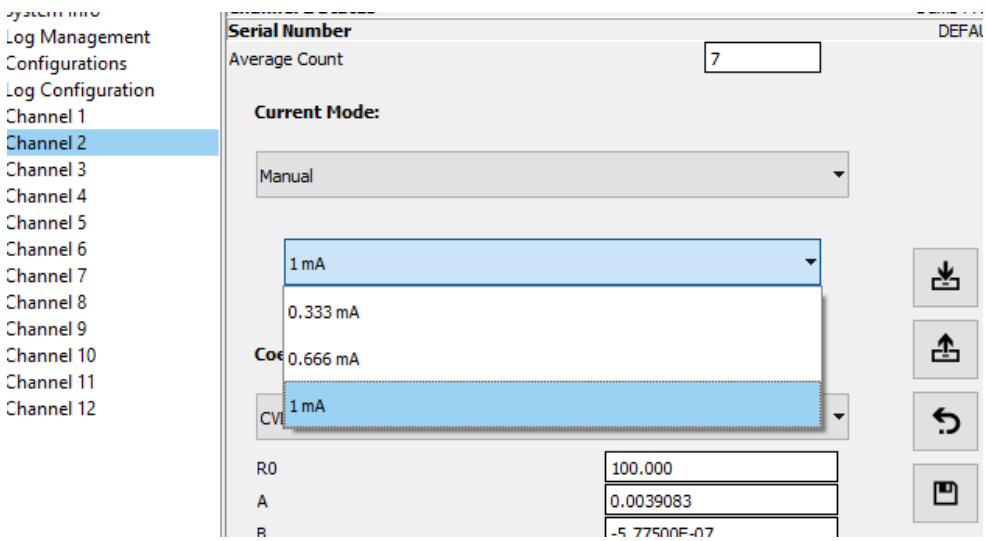
4.4.2 CURRENT MODE

For each probe, the PT12 supports three independently selectable current modes, 1mA, 0.66mA, and 0.33mA. The approximate maximum measurable resistance for each current mode is listed in the table below:

Current Mode (mA)	Absolute Maximum Resistance (Ω)
1	128
0.66	192
0.33	384

The PT12 will attempt to get the most accurate reading possible with auto current mode enabled. It attempts to use the most suitable current depending on the probe's resistance and the range of the reference resistors while preventing over/under range of the A/D converter. When in manual current mode, it is possible to over range the A/D converter if the probes exceed the resistances identified in the table above. This causes no harm to the system other than temporary errant readings. If the resistance of the probe is outside the range of the PT12 internal reference resistors, the probe readings may be less accurate.

Tap the current mode drop-down to switch between auto and manual current modes. If manual mode is selected, a secondary drop-down appears allowing for selection of 1 mA, 0.66 mA, and 0.33 mA.



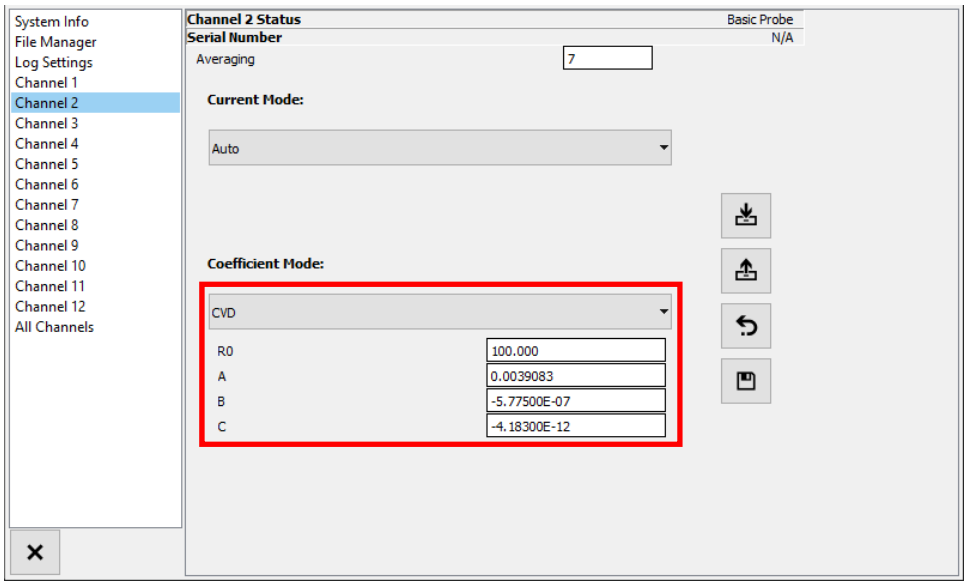

Tap the save button to ensure the values persist after a power cycle. Current mode is saved to the channel only, regardless of the probe type (smart or basic).

4.4.3 COEFFICIENT MODE

The PT12 currently supports both Callendar-Van Dusen (CVD) and ITS-90 for calculating temperature. Each probe may be configured independently. If using a smart probe, the coefficients may be stored on the probe itself. Only one coefficient type may be used at a time to measure temperature, but both coefficient types may be stored on the probe (if a smart probe) or in the system (if a basic probe).

4.4.3.1 CALLENDAR-VAN DUSEN (CVD)

To select CVD mode, tap the coefficient mode drop down and select CVD.



In CVD mode, the PT12 calculates temperature from resistance by solving the following CVD equation for temperature *(T)*:

When $T < 0$ °C (or $R < R_o$)

$$R = Ro * (1 + A(T) + B(T)^2 + C(T - 100)T^3) \quad [1]$$

When $T \geq 0$ °C (or $R \geq R_o$)

$$R = R * (1 + A(T) + B(T)^2) \quad [2]$$

Default (uncalibrated) Temperature Coefficients and Acceptable Ranges

Coefficient	Default	Acceptable Range
R0	100	99 < R0 < 101
A	0.0039083	0.0037 < A < 0.0041
B	-5.775E-7	-4.0E-7 > B > -7.5E-7
C	-4.183E-12	Exponent of coefficient C should be no larger than E-10. For example, coefficients of E-10, E-11, E-12 and so on, are acceptable, but E-9 would be outside of the acceptable range.

Enter the probe's specific values for *R0*, *A*, *B*, and *C*.

There are two common forms of the CVD equation. The PT12 uses the *A*, *B*, *C* form. If the probe's coefficients are given in the other form as α, δ, β (alpha, delta, beta), the following may be used to convert to the *A*, *B*, and *C* coefficients needed by the PT12.

$$A = \alpha(100 + \delta)/100$$
$$B = -\alpha\delta/100^2$$
$$C = -\alpha\beta/100^4$$

It is also possible to convert A, B, and C to α, δ, β (alpha, delta, beta) that may be required by other temperature measurement systems.

$$\alpha = A + 100B$$
$$\delta = -B(100^2) / (A + 100B)$$
$$\beta = -C(100^4) / (A + 100B)$$

Note that C=0 and β=0 when T≥0 °C.

Tap the save button to ensure the values persist after a power cycle.

4.4.3.2 ITS90

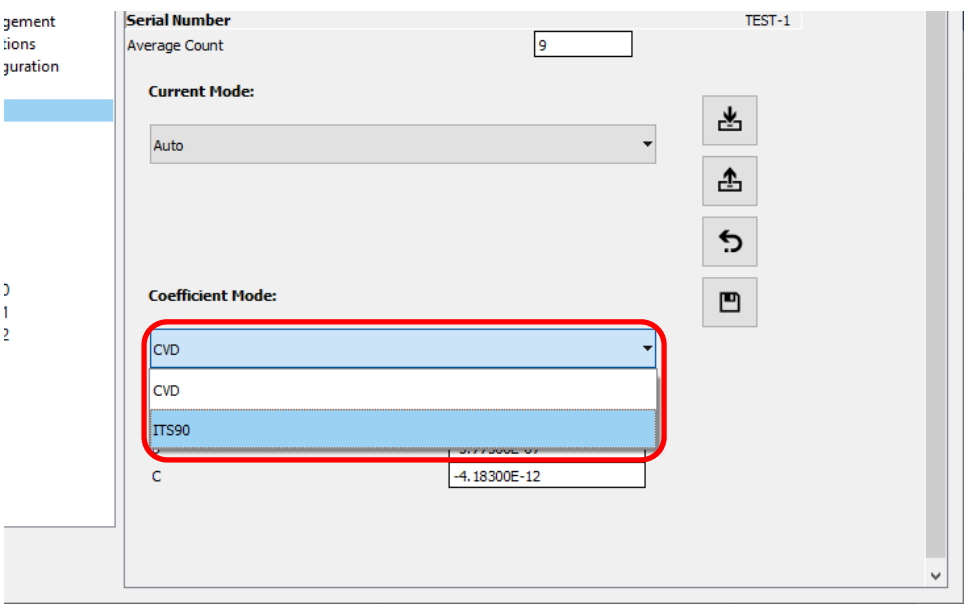
The PT12 supports three different modes of ITS90.

1. **ITS90 mode** – Subrange 4 below T_{TPW} (where *T*<273.16 K) and subranges 7-11 above T_{TPW} (where *T*≥273.16 K).
2. **SR5** – Subrange 5 only. Anything data outside subrange 5 is extrapolated.
3. **ITS90 & SR5** – Subrange 5 is used when within subrange 5. Subrange 4 is used below subrange 5. Subrange 7-11 is used above subrange 5.

Coefficients	Description
RTPW	Resistance of probe at triple point of water
A, B, C	Sub range 7-11 coefficients
A4, B4	Sub Range 4 coefficients
A5, B5	Sub Range 5 coefficients

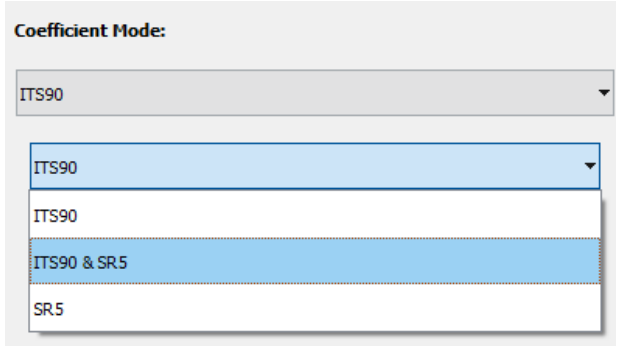
Sub Range	Min (°C)	Max (°C)	Coefficients	Notes
4	-189.3442	0.01	A4, B4	Below zero
5	-38.8344	29.7646	A5, B5	Subrange 5 only
7	0.01	660.323	A7, B7, C7	A=A7, B=B7, C=C7
8	0.01	419.527	A8, B8	A=A8, B=B8, C=0
9	0.01	231.928	A9, B9	A=A9, B=B9, C=0
10	0.01	156.5985	A10	A=A10, B=0, C=0
11	0.01	29.7646	A11	A=A11, B=0, C=0

To select ITS90 mode, tap the coefficient mode drop down and select ITS90.

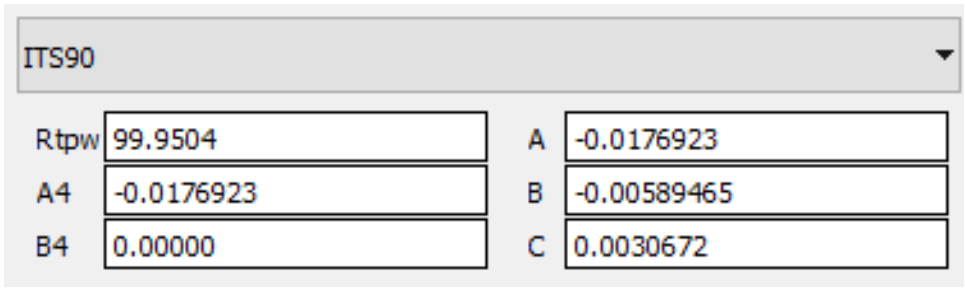


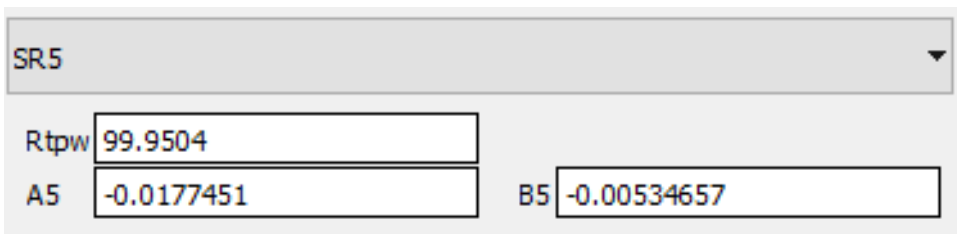
Depending on the sub range selected, the appropriate coefficients will appear.

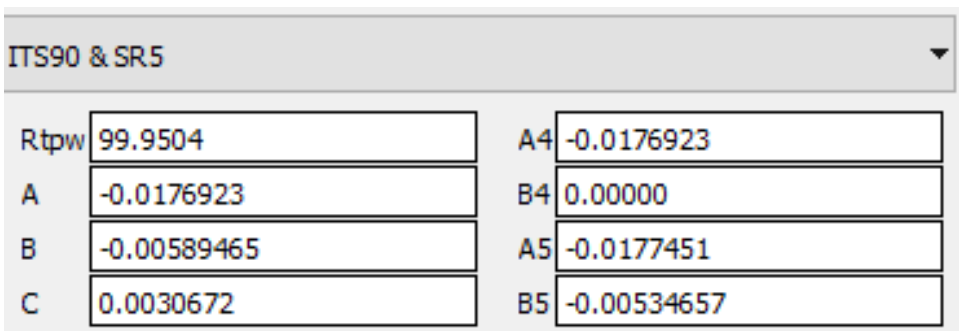
Select the desired subrange from the second drop down menu.



One of three different coefficient sets will be shown depending on the subrange selection.







Enter the probe's specific coefficients based on the sub range selection.


Tap the save button to ensure the values persist after a power cycle. If using a smart probe, coefficients are stored on the probe. If using a basic probe, coefficients are stored on the PT12 channel.

In the PT12, temperatures are determined per ITS90 in terms of the ratio (W) of the resistance of a probe (R) at a given temperature, and the resistance of that same probe at the triple point of water, R_{TPW} (where the temperature T_{TPW} is defined as 273.16K):

$$W = \frac{R}{R_{TPW}} \qquad [3]$$

ITS-90 defines two reference equations for an ideal probe. One equation defines resistance ratio, W_r, as a function of temperature in a range below the triple point of water, the other equation is for temperatures above the triple point. Both reference equations are i^{th} order polynomials defined as W_r.
The reference equation below the triple point of water (where W_r<1 and T<273.16K) is:

$$\ln(W_r) = A_0 + \sum_{i=1}^{12} A_i \left[\frac{\ln\left(\frac{T}{273.16K}\right) + 1.5}{1.5}\right]^i \qquad [4]$$

While the reference equation above the triple point of water (where $W_r \geq 1$ and $T \geq 273.16$K) is:

$$W_r = C_0 + \sum_{i=1}^{9} C_i \left[\frac{T - 754.15}{481}\right]^i \qquad [5]$$

Since the goal is to calculate temperature from resistance, both reference equations have inverses.
The inverse temperature reference equation below the triple point of water (where $W_r \geq 1$ and $T \geq 273.16$K) is:

$$T = 273.16 * \left(B_0 + \sum_{i=1}^{15} B_i \left[\frac{{W_r}^{1/6} - 0.65}{0.35}\right]^i\right) \qquad [6]$$

The inverse temperature reference equation above the tripe point of water (where $W_r \geq 1$ and $T \geq 273.16$K) is:

$$T = D_0 + \sum_{i=1}^{9} D_i \left[\frac{W_r - 2.64}{1.64}\right]^i + 273.15 \qquad [7]$$

where T is the temperature in Kelvin, W_r is the reference resistance ratio, and A_i and C_i are constants given in the ITS-90 standard. See the ITS-90 standard for a more complete definition, as well as the full table of constants for A_i, B_i, C_i, and D_i.

No probe is ideal of course. Each exhibit small deviations that make their temperature vs. resistance characteristics unique. To account for this, ITS-90 provides “deviation functions” for various temperature subranges, each with their own equation and probe specific coefficients. These deviation functions provide unique probe correction to the reference resistor ratio equation. The deviation functions utilized by the PT12 are listed below.

ITS-90 mode below triple point of water using *A4*, *B4*:

$$W_r = W - A4[W - 1] - B4[W - 1] * \ln(W) \qquad [8]$$

ITS-90 mode above triple point of water using *A, B, C*:

$$W_r = W - A[W - 1] - B[W - 1]^2 - C[W - 1]^3 \qquad [9]$$

For the ITS-90 mode above the triple point of water, the coefficients for A, B, and C are:
A7-11, B7-11, and C7-11.

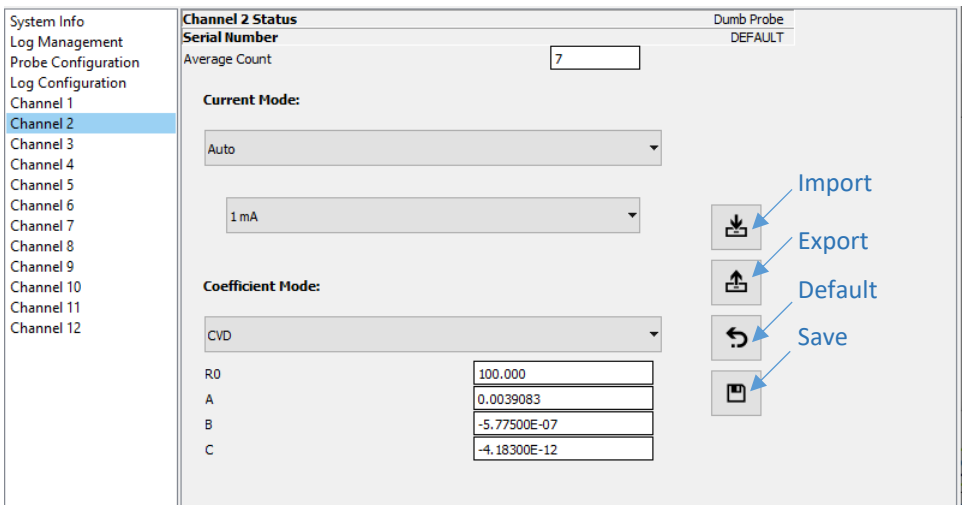
Subrange 5 (SR5, spans triple point of water) using *A5, B5*:

$$W_r = W - A5[W - 1] - B5[W - 1]^2 \qquad [10]$$

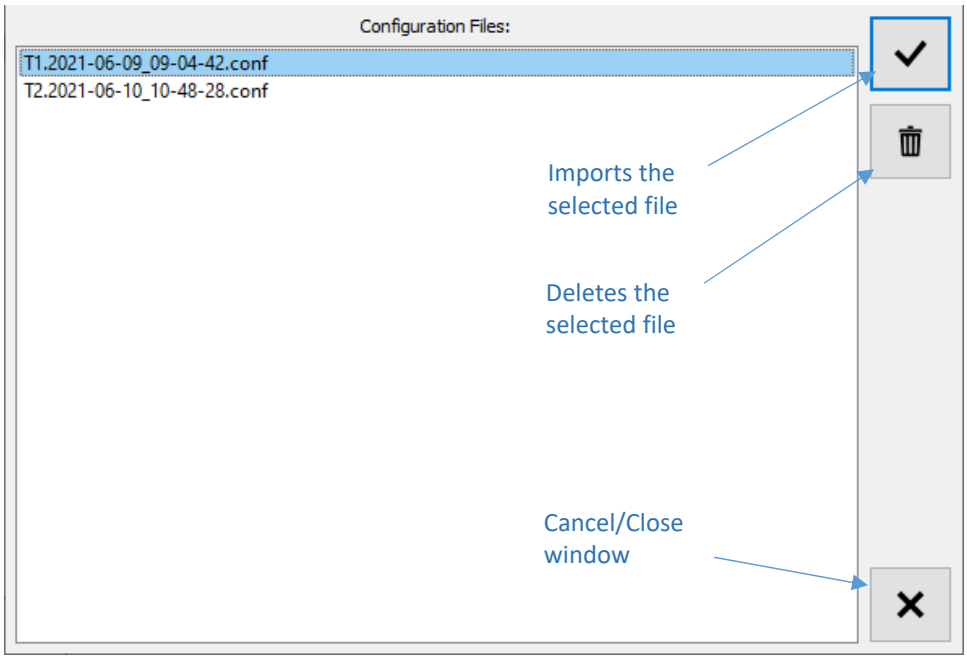
Given W and the coefficients A, B, C, A4, B4, A5, B5 and the corresponding deviation equation, W_r is calculated for the probe's unique non-idealities for the specific sub range of interest. W_r is then used with the corresponding inverse reference equation (equation [4] or [5] depending on value of W_r) to compute the actual temperature in Kelvin.

4.4.4 PROBE CONFIGURATION MANAGEMENT

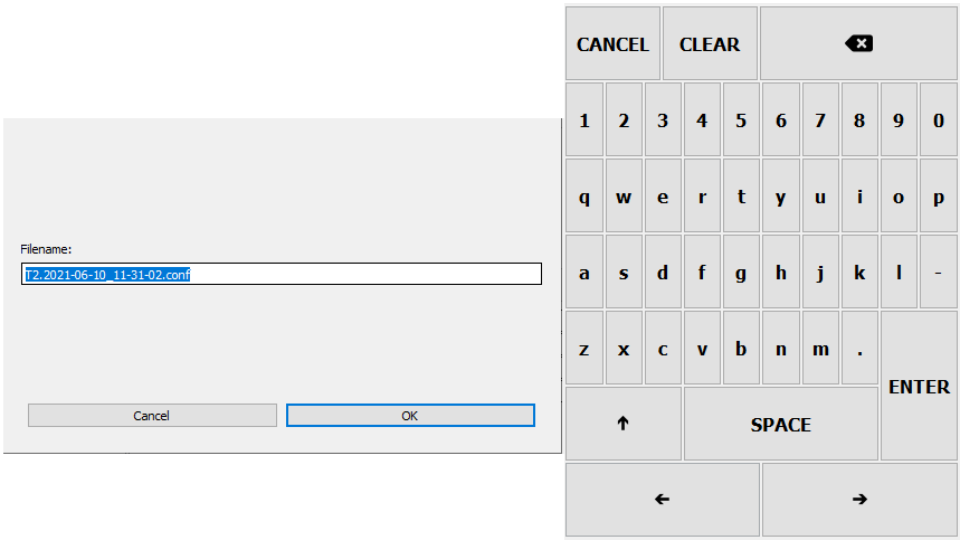
Each probe's configuration may be imported, exported, defaulted, and saved. The averaging and current mode selection are always saved to the channel. If using a basic probe, the coefficients will also be saved to the channel. However, if using a smart probe, the coefficients will be saved to the memory chip within the probe.




Import Configuration: Imports a previously stored configuration file from the system to a probe or channel. This is especially useful when moving a basic probe from one channel to another. Click the import button and then select the desired configuration file.



Export: Export a probe's current configuration to a file. This is useful when moving a basic probe from one channel to another. On export, the keyboard will display for entry of a filename. The default filename is the channel appended by the current date.



Default: Return a probe's configuration to default. This sets the coefficient mode to CVD with default coefficients. See section 4.4.3.1 Callendar-Van Dusen (CVD) for more information on defaults.

Save: Save the probe's configuration. For a smart probe, the configuration is stored within the probe itself. For a basic probe, the configuration is stored on the channel. Averaging and current mode are stored only on the channel, never on a smart probe.

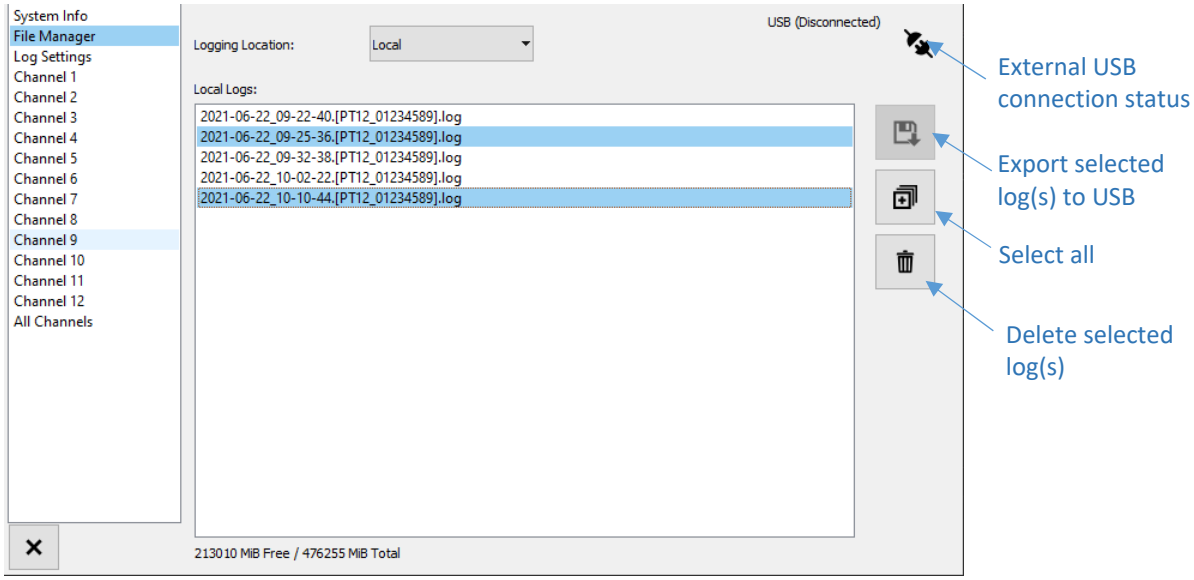
Note: Do not unplug probes while saving is in progress. Unplugging a probe during a save could corrupt the memory chip.

4.5 FILE MANAGER

The file manager page is used for copying logs to a USB drive, deleting old logs from the system, and setting the preferred logging location.

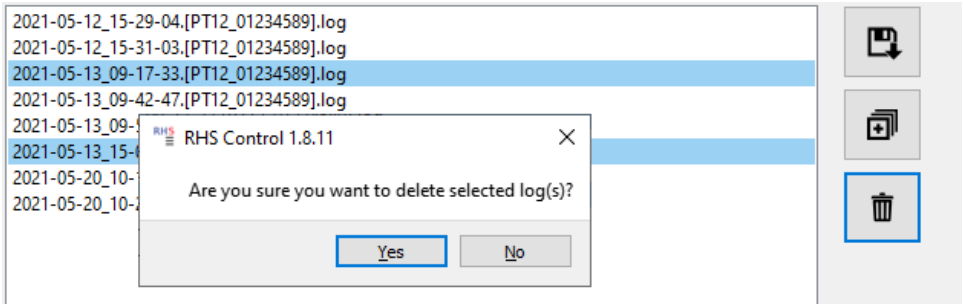
4.5.1 COPYING LOG FILES TO USB DRIVE

Attach a USB flash drive (must be pre-formatted to FAT-32, EXFAT, NTFS, or EXT4) and select which logs you would like to copy to your USB drive.



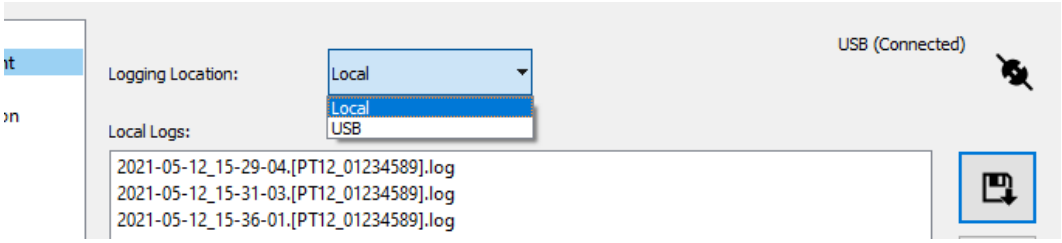
4.5.2 DELETING LOG FILES

Delete old log files from this menu by selecting the unwanted files and tapping the delete button:



4.5.3 SET PREFERRED LOGGING LOCATION

To log directly to a USB drive, ensure a USD drive is attached, then select USB from the 'logging location' drop down menu. This will create a new log file on the attached USB drive and start logging directly to that drive. The files do not appear on the system, only on the USB drive. If the USB drive is removed, logging will automatically revert back to the local system.



To log to the PT12 local internal memory, select 'Local' from the logging location drop down menu. Files will not log to the USB drive.

4.6 SYSTEM INFO

The system info page contains the software and firmware versions, serial number of the system, and a few generic settings.

Logging active: To start a new log file, toggle this off then on. Leave it off to stop logging.

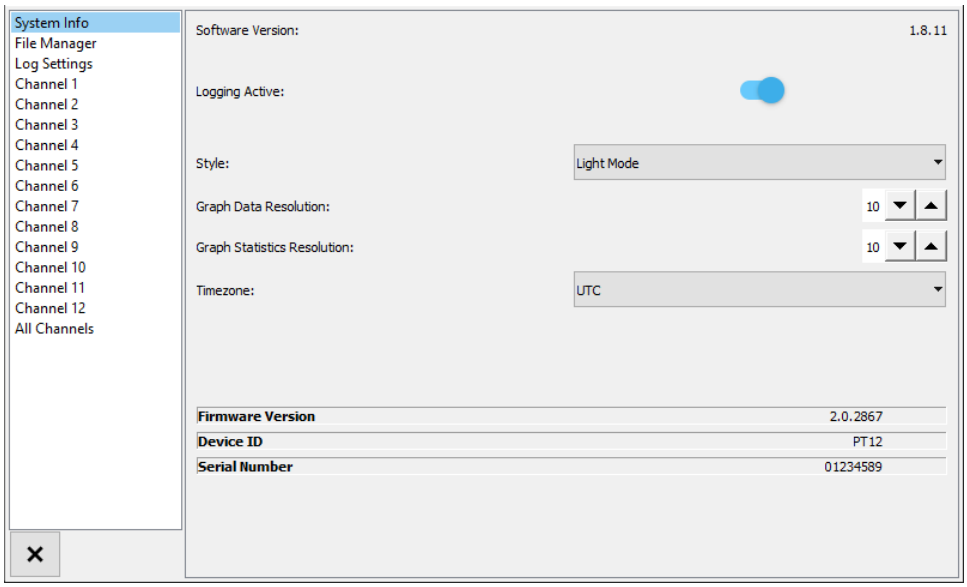
Style: Dark or Light mode theming. After selection, the change requires several seconds to complete, during which time the screen remains locked.

Graph data resolution: The number of digits displayed when clicking on plotted points.

Graph statistics resolution: The number of digits to display in the graph statistics.

System unit control: Another location to change system units. Serial communication and logged data always occur in °C and ohms regardless of the units selected for display.

Time zone: UTC time zone set for log file or graph. If the time zone is changed while logging, the graph will update properly but the log file will have a time discontinuity forwards or backwards depending on which time zone is selected. After changing time zones, it is recommended to toggle logging off and on to create a new log file.



5 SERIAL COMMUNICATIONS

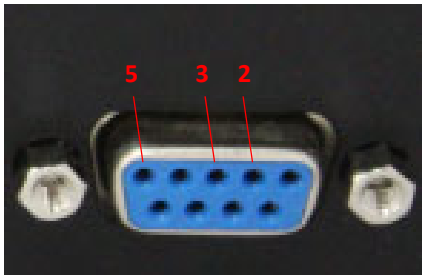
The PT12 may be connected to a PC for continuous communication. All communication is managed in a polled format. The PT12 never sends information without being queried.

5.1 SERIAL CONNECTIONS

5.1.1 ELECTRICAL WIRING TO THE RS-232 PORTS

Connect the RS-232/USB converter to the PC's USB port, then connect the other end to the PT12 using a standard RS-232 9-pin extender cable. The extender cable has a male connector on one end and a female connector on the other end. It is wired straight through with pins 1 through 9 on one end wired to pins 1 through 9 on the other end. The PT12 ignores the DSR and CTS handshaking signals. While there is no harm in connecting all 9 pins, the PT12 only requires connection of three of the pins (TxD, RxD, Gnd). For your reference, the complete connector pin-out is listed in the following table. Note that those signals identified by * are required, while the others are completely optional.

5.1.1.1 RS232 PIN OUT



Signal	PT12 (9pin)	Direction	Computer (9pin)
	1		1
***TxD**	2	→	2
***RxD**	3	←	3
DSR	4	←	4
***GND**	5	--	5
DTR	6	→	6
CTS	7	←	7
RTS	8	→	8
	9		9

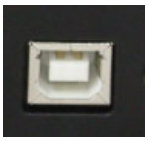
* Denotes a required connection. All others are optional.

5.1.1.2 SERIAL CONFIGURATION

To communicate with the PT12, the computer should be set to the following parameters.

Baud Rate	115200
Data Bits	8
Stop Bits	1
Handshaking	None

5.1.2 USB TO SERIAL PORT



The USB type B host port is used for connecting the PT12 to a PC without the need of an external RS-232 to USB converter. The device will show up on a PC as a serial port and will need to be configured with the same serial settings as the RS-232 connection (above).

5.2 PROTOCOL

5.2.1 COMMUNICATION SEQUENCE AND TERMINATION CHARACTERS

All commands sent to the PT12 must be terminated with either a carriage return $^{C}{}_{R}$ or a carriage return linefeed combination $^{C}{}_{R}{}^{L}{}_{F}$. Both $^{C}{}_{R}$ and $^{C}{}_{R}{}^{L}{}_{F}$ terminators are identical in action as the PT12 simply ignores the $^{L}{}_{F}$ character. For those writing communication programs to communicate with the PT12, note that $^{C}{}_{R}$ and $^{C}{}_{R}{}^{L}{}_{F}$ are represented by the following values:

Symbol	Decimal	Hex
$^{C}{}_{R}$	13	0D
$^{C}{}_{R}{}^{L}{}_{F}$	13,10	0D 0A

When using a terminal emulator such as Hyper-terminal or Putty, note that pressing the **Enter** key is equivalent to sending $^{C}{}_{R}$.

Regardless of the command sent, the PT12 will reply with a carriage return linefeed $^{C}{}_{R}{}^{L}{}_{F}$ terminator at the end of the response, provided the command was recognized as valid. Here is an example:

T1?$^{C}{}_{R}{}^{L}{}_{F}$	(sent by the computer to the PT12)
-10.015$^{C}{}_{R}{}^{L}{}_{F}$	(sent by the T1 back to the computer)
T1?$^{C}{}_{R}$	(sent by the computer to the PT12)
-10.015$^{C}{}_{R}{}^{L}{}_{F}$	(sent by the T1 back to the computer)
I=1$^{C}{}_{R}$	(sent by the computer to the PT12)
$^{C}{}_{R}{}^{L}{}_{F}$	(sent by the T1 back to the computer)

NOTE: Even if the command is not a request for data, but rather is a command to change a parameter, the PT12 still responds with a carriage return line feed combination.

5.2.2 CASE SENSITIVITY

All commands are insensitive to case. In other words, it does not matter if the command is sent in upper case letters, lower case letters, or as some combination of the two. For example, the commands **T1?** and **t1?** appear identical to the PT12. However, with two commands (**save=RHS** and **default=RHS**) the **RHS** needs to be capitalized. This is to prevent an accidental overwrite of a probe's configuration.

5.2.3 NUMERIC VALUES

All numeric data sent to or received from the PT12 is done so in either standard or scientific notation. Sending a number as **12.34** is the same as sending it as **1234e-2** or as **1.234e1**.

Depending on the value of numeric responses the PT12 sends out, it may send the numbers in either standard or scientific notation. Temperatures and resistances will be sent in standard notation, but some coefficients will be sent in scientific notation due to their values. Numeric data is never appended with text of any kind. In other words, if requesting a temperature related value, only the numeric portion of the value is sent. The units are assumed but never sent. The device will always respond in °C for temperatures and Ω for resistances, regardless of the display units setting. Some values simply require integer numbers such as 1 and 0 for On and Off, while others might expect real numbers with a decimal point. The PT12 recognizes both types of numbers and will attempt to convert the values received to the correct format it expects.

5.3 COMMAND LIST

5.3.1 SYSTEM LEVEL COMMANDS

System level commands have nothing prepended. A few examples of system commands are:

I?$^{C}_{R}$ (sent by the computer to the PT12 to query the system current mode)
3$^{C}_{R}$$^{L}_{F}$ (sent by the T1 back to the computer)
ID?$^{C}_{R}$ (sent by the computer to the PT12)
PT12$^{C}_{R}$$^{L}_{F}$ (sent by the T1 back to the computer)

Command	Typical Response (Read Command) or Input Values (Write Command)	Notes
ID?	PT12	
IDN?	PT12	
SN?	T21X123	10-digit Alpha Numeric SN
I? I=	0	Read/set global current mode. 0=0.333 mA 1=0.666 mA 2=1 mA Setting global current mode disables probe specific current mode for each channel and sets the manual current
R?		Comma separated list of each resistance in Ω. If a probe is not connected, it will appear as NaN (not a number).
T?	25.38095, 25.26928, 25.53783, 25.27834, 25.38860, 25.23795, NaN, 25.41134, 25.48914, NaN, 25.34643, 25.37140	Comma separated list of each connected temperature in °C. If a probe is not connected it will appear as NaN (not a
CONNECTED?	1, 2, 3, 4, 5, 6, 8, 9, 11, 12	Comma separated list indicating which channels have probes connected.
SAVE=RHS		Saves all probes. Takes approximately one minute.
VERSION?	2.0.2728	Firmware version number.

5.3.2 CHANNEL COMMANDS

Each channel command can be run to query for temperature in °C. Each channel command has associated sub commands that pertain to that individual channel or probe's configuration. The channel commands are T1 through T12. For example:

T3?$^{C}_{R}$ (sent by the computer to the PT12 to query probe 3 temp)
24.1234$^{C}_{R}{}^{L}_{F}$ (sent by the PT12 back to the computer temp in °C)

Command	Typical Response (Read Command)	Notes
T1[.][?]	25.123	See sub command list below.
T2[.][?]	25.123	See sub command list below.
T3[.][?]	25.123	See sub command list below.
T4[.][?]	25.123	See sub command list below.
T5[.][?]	25.123	See sub command list below.
T6[.][?]	25.123	See sub command list below.
T7[.][?]	25.123	See sub command list below.
T8[.][?]	25.123	See sub command list below.
T9[.][?]	25.123	See sub command list below.
T10[.][?]	25.123	See sub command list below.
T11[.][?]	25.123	See sub command list below.
T12[.][?]	25.123	See sub command list below.

5.3.2.1 CHANNEL SUB COMMANDS

These are associated with T1 through T12 only. Each channel has a list of sub commands associated with it.

Example of a channel sub command:

T1.I?$^{C}_{R}$ (sent by the computer to the PT12)
1 $^{C}_{R}{}^{L}_{F}$ (sent by the PT12 back to the computer)
T1.I=2$^{C}_{R}$ (sent by the computer to the PT12)
$^{C}_{R}{}^{L}_{F}$ (sent by the PT12 back to the computer)
T1.I?$^{C}_{R}$ (sent by the computer to the PT12)
2 $^{C}_{R}{}^{L}_{F}$ (sent by the PT12 back to the computer)

Channel Commands	Typical Response (Read Command) or Input Values (Write Command)	Notes
T1?	25.12345	Temperature in °C for channel 1
T1.I? T1.I=	0	Probe's current mode. 0=0.33 mA 1=0.66 mA 2=1 mA Will be ignored if AUTO_CURRENT_DISABLE is not 1.
T1.AUTO_CURRENT_DISABLE? T1.AUTO_CURRENT_DISABLE=	0	1=Auto current mode disabled 0=Auto current mode enabled
T1.CONNECTED?	1	0= Probe Disconnected 1= Probe Connected
T1.OHMS?	99.123	Resistance of probe in ohms
T1.AVGCOUNT? T1.AVGCOUNT=	8	Number of measurements to include in average of value. Typical range 0-100
T1.SAVE=RHS	N/A	SAVE=RHS to save the config. RHS must be uppercase.
T1.DEFAULT=RHS	N/A	DEFAULT=RHS to set the channel config to default. Does not save without running a save command. RHS must be uppercase.

Note: All of the channel commands for T2-T12 are identical to the commands above. Just replace T1 with T2-T12 for the desired channel.

5.3.3 PROBE COMMANDS

Each probe command must be proceeded by the channel and probe # (i.e., T1). The probe commands are used mainly for setting coefficients. **Note**: None of the probe commands will persist without calling the SAVE command(above). Some examples of a probe command are:

T1. PROBE.CVDR0?$^{C}_{R}$ (sent by the computer to the PT12)
100.0 $^{C}_{R}L_{F}$ (sent by the PT12 back to the computer)
T1.PROBE.CVDR0=99.99$^{C}_{R}$ (sent by the computer to the PT12)
$^{C}_{R}L_{F}$ (sent by the PT12 back to the computer)
T1.PROBE.CVDR0?$^{C}_{R}$ (sent by the computer to the PT12)
99.99 $^{C}_{R}L_{F}$ (sent by the PT12 back to the computer)

Probe Sub Commands	Typical Response (Read Command) or Input Values (Write Command)	Notes
T1.PROBE.SN? T1.PROBE.SN=	0123456789	Read/set probe's ten digit alpha-numeric serial number.
T1.PROBE.CALDATE? T1.PROBE.CALDATE=	210525	Read/set probe's calibration date. Format is YYMMDD
T1.PROBE.CORTYPE? T1.PROBE.CORTYPE=	10	Read/set the probe's coefficient type. 10=CVD 9=ITS90
T1.PROBE.CVDR0? T1.PROBE.CVDR0=	100.0	Read/set the probe's CVD R0 coefficient. 99 < R0 < 101
T1.PROBE.CVDA? T1.PROBE.CVDA=	0.0039083	Read/set the probe's CVD A coefficient. 0.0037 < A < 0.0041
T1.PROBE.CVDB? T1.PROBE.CVDB=	-5.775E-7	Read/set the probe's CVD B coefficient. -4.0E-7 > b > -7.5E-7
T1.PROBE.CVDC? T1.PROBE.CVDC=	-4.183E-12	Read/set the probe's CVD C coefficient. Exponent of coefficient c should be no larger than E-10.

T1.PROBE.ITS90MODE? T1.PROBE.ITS90MODE=	0	Read/set the probe's ITS90 mode 0=ITS90 1=ITS90&SR5 2=SR5 Only
T1.PROBE.RTPW? T1.PROBE.RTPW=	99.99	Read/set the probe's RTPW coefficient. 99 < RTPW < 101 for 100Ω PRT 24 < RTPW < 26 for 25Ω PRT
T1.PROBE.A? T1.PROBE.A=	-0.001	Read/set the probe's ITS90 A7 Coefficient -1≤A7≤1
T1.PROBE.B? T1.PROBE.B=	-0.001	Read/set the probe's ITS90 B7 Coefficient -1≤B7≤1
T1.PROBE.C? T1.PROBE.C=	0.001	Read the probe's ITS90 C7 Coefficient -1≤C7≤1
T1.PROBE.A4? T1.PROBE.A4=	-0.001	Read the probe's ITS90 A4 Coefficient -1≤A4≤1
T1.PROBE.B4? T1.PROBE.B4=	-0.001	Read the probe's ITS90 B4 Coefficient -1≤B4≤1
T1.PROBE.A5? T1.PROBE.A5=	-0.001	Read the probe's ITS90 A5 Coefficient -1≤A5≤1
T1.PROBE.B5? T1.PROBE.B5=	-0.001	Read the probe's ITS90 B5 Coefficient -1≤B5≤1

Note: All of the channel commands for T2-T12 are identical to the commands above. Just replace T1 with T2-T12 for the desired channel.

6 CALIBRATION

Contact RH Systems for calibration options. Contact information is located at the end of the table of contents.

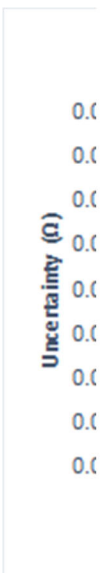
7 UNCERTAINTY

The PT12 is a versatile 12 probe PRT temperature measurement device accurate to within ± 0.0003 Ω over a customizable range. In a Characterization with a PT12 optimized for 100 Ω PRTs, the maximum observed uncertainty was within ± 0.0003 Ω for values under 180 Ω. The PT12 was characterized using calibrated precision resistors, and uncertainty was calculated for each channel using the following equation:

$$Uncertainty = \sqrt{\Delta^2 + (2\sigma)^2 + R_u{}^2}$$

Where Δ is the deviation of the average indicated value from the characterized reference value applied, σ is the standard deviation of the indicated values, and R_u is the uncertainty of the reference resistances applied during the characterization.

The following table contains the mean and maximum channel uncertainties observed:



Resistance (Ω)	Maximum Channel Uncertainty (Ω)	Average Channel Uncertainty (Ω)
5.00015752	0.000316876	0.0002589
25.001911	0.000363353	0.0002798
60.0049527	0.000189909	0.0001655
100.005241	0.000342708	0.0002393
140.004765	0.000358613	0.0003045
180.007329	0.000576929	0.0004342
230.009409	0.001355477	0.0009165
280.006798	0.001577576	0.0011847
340.024239	0.002671505	0.0015240
400.022006	0.003768707	0.0022801

8 SPECIFICATIONS

Specifications:	Thermometer PT12
Measurement Ranges	
Temperature	-200-660°C
Resistance	1-380 Ω
Measurement Performance	**For the range of -200...+250 °C**
Resolution	0.1 mK
Accuracy	≤ ± 2 mK @ 23 °C (95% confidence level, 1 year)
Temperature coefficient	0.1 mK / °C
Standard Features	
Available inputs	12 Channels
Input type	Pt-100 and Pt-25 Platinum Resistance Thermometer (PRT), 4-wire, Supports Smart 4-wire PRTs
Supported coefficients	ITS-90, Callendar-Van Dusen
Excitation current	0.33, 0.66 and 1mA resistance, DC polarity reversing
Reference resistors	4 internal Ultra High Precision
Data I/O	RS-232, USB (serial port)
Control and data acquisition	RHS Control
Logging intervals	User programmable from 5 seconds to 60 minutes
Sampling rate	<1.5 seconds per channel
Enclosure type	Aluminum
Power supply	External 12VDC power supply with 1.5 m cable (indoor use only)
Operating instructions	English
Factory calibration certificate	Resistance Calibration
Accessories	
Probes	Calibrated and uncalibrated PRT's available
Connectors	Lemo plug FGG.1B.306
Additional Information	
Digital I/O	Bi-directional RS-232 and USB.
AC Power	Power supply: 110-230V, 50/60 Hz, 0.3 A
Maximum operating conditions	10-30°C, < 98 %RH, non-condensing
Storage temperature	-20...+40°C
Weight and Dimensions	**Instrument**
Dimension (W X H X D)	200 X 72 X 164 mm
Weight	1.87 kg

9 DOCUMENT HISTORY

REVISION HISTORY

Version	Revision Date	Summary of Changes	Author
A	June 21, 2021		Bob Hardy
B	June 29, 2021		Bre Lee