UT-ONE

3-Channel Thermometer Readout

User manual

Version 2.04.xx

Table of Contents

1 Introductions

UT-ONE is an accurate and versatile thermometer readout. UT-ONE is capable of measuring platinum resistance thermometers, thermistors and thermocouples. Optionally, an external combined probe may be used for the measurement of ambient conditions (air temperature and relative humidity). UT-ONE features a colour touch screen which presents measured data in graphical and numerical format. UT-ONE can be operated in a stand-alone mode or connected to the computer via the serial or USB interface. UT-ONE can be battery-operated from the internal LiPo battery, which provides up to eight hours of standalone operation.

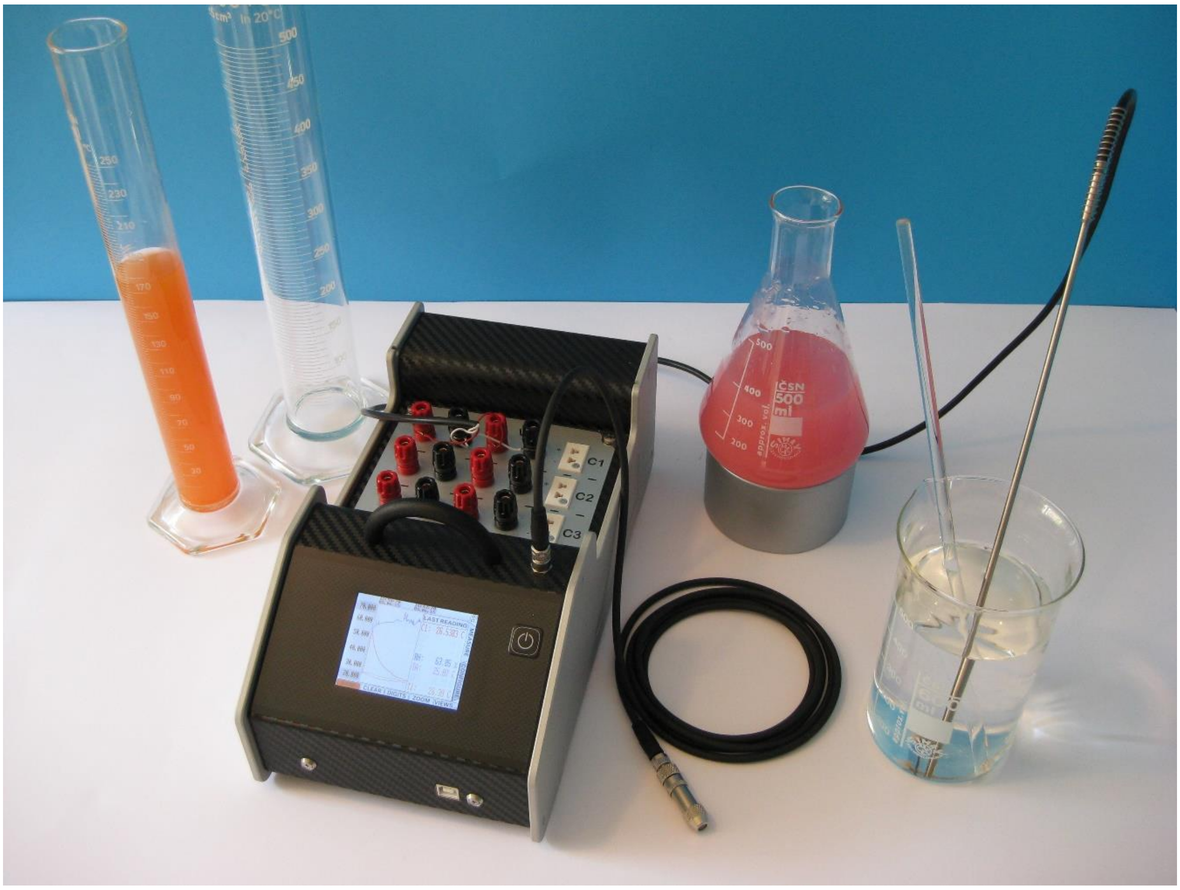

Figure 1: UT-ONE

2 Getting Started

2.1 Warning and cautions

Use the instrument only as specified in this manual. Keep a copy of this manual for future reference. Besides the general good practice for handling electronic equipment, follow these particular warnings and cautions:

- Read this manual carefully before starting the UT-ONE operation!
- UT-ONE is designed for indoor use only. Prevent the use of instrument in wet or damp conditions, prolonged direct sunshine, vibrations, dust, water vapor, fumes and chemical residues.
- Use and store UT-ONE according to environmental conditions as listed in Specifications.
- When moving the unit from a cold to warm and humid ambient, take measures to prevent condensation on and inside the instrument. If condensation occurs, do not start the instrument. Condensation may damage the instrument or cause drift of calibration values.
- Do not connect any of the connectors to electric potential, which is lower than -0.3 V or higher than 3 V referred to system ground. Higher voltages may damage the instrument or cause personal injury.
- Avoid using the instrument in environments prone to electrostatic discharges (ESD). ESD may disturb the normal operation of the instrument, and may cause permanent damage to electronic components, which may in long term cause instrument failure.
- Prevent electric contact between probes, cable leads and cable shields and the conductors which are electrically energized. This may result in severe shock, personal injury or death, fire hazard and damage to instruments.
- Connect probes only in floating configuration.
- Use only a CE certified external power adaptor with low voltage ripple and low leakage current. External adaptor voltage and current rating must be within instrument electrical specifications. Use the power adaptor only with mains power supply as specified on its rating plate.
- The instrument may be used to measure extremely high or low temperatures. Extreme care must be taken when handling thermometer probes, otherwise personal injury, and damage to equipment or fire may occur. Always allow the thermometer probe to reach ambient temperature in a controlled and supervised manner.
- If instrument or external power adaptor is damaged, do not use it. Secure the instrument and contact support for further instructions.
- Clean only with a damp cloth. Do not wet or allow water to penetrate the instrument. Do not use chemical solvents to clean the instrument. If the display becomes stained, use a mild soap solution.
- Do not use sharp objects to manipulate the touch screen. Touch screen may be operated with fingers or (preferably) with a stylus pen. Touching the screen with dirty or greasy objects may cause permanent stains. Do not use excessive force while manipulating the touch screen.
- Do not place objects, liquid containers or other instrumentation on top of the UT-ONE. Handle the instrument carefully to prevent mechanical damage.
- When ambient probe is disconnected, always attach the plastic protective plug in order to protect the interface from dirt and ESD damage.

2.2 Power supply

UT-ONE can be operated from three power sources:

- External power adaptor. Use only the CE certified external adaptor with 6 V DC ± 0.5 V, 0.5 A to 1 A output rating. External power adaptor must have low voltage ripple and low leakage current. Use of non-compliant external adaptors may degrade performance or cause personal injury and instrument damage, which is not covered by warranty.
- USB interface. UT-ONE can be powered directly from the USB cable, connected to the computer or USB hub. Note that UT-ONE may draw up to 500 mA DC. This current may not be available on some portable devices or USB hubs, so consult the documentation of the USB host device before connecting it to UT-ONE.
- LiPo battery. Internal LiPo battery with 2000 mAh (7.4 Wh) is sufficient for approximately 8 hours of standalone operation. If running on LiPo battery, UT-ONE will automatically shut down when only 5% capacity is remaining. LiPo battery will automatically recharge when the external adapter or USB interface is connected.

Using both the external power adaptor and USB interface at the same time is acceptable. Power supplies may be connected or disconnected during operation (UT-ONE performs automating switching to LiPo battery). LiPo battery has a typical endurance of 500 charging cycles, during which capacity will slowly decrease. UT-ONE has a built-in counter of charging cycles.

2.3 Starting and stopping the UT-ONE

UT-ONE can be started by pressing the ON/OFF button, located on the right side of the UT-ONE front panel. Press and hold the ON/OFF button, until the screen lights up. Note that UT-ONE cannot be started from the communication interface or touch screen.

UT-ONE can be stopped by pressing the ON/OFF button. The screen will display a "shutting down..." warning, store the current configuration, release the resources and shutdown.

In case the UT-ONE becomes unresponsive, a hard shutdown may be employed by pressing and holding the ON/OFF button for more than 10 seconds. This will turn off the power supplies without storing the current configuration and without releasing the resources, so this procedure should be avoided. After a hard shutdown, wait at least 30 seconds before restarting the UT-ONE.

UT-ONE can also be stopped from the communication interface by issuing the stop command. Note that after stopping, UT-ONE cannot be restarted using the communication interface, so manual intervention is required.

2.4 Connection of thermometer probes

UT-ONE has three independent channels for the connection of thermometer probes. Channels are acquired sequentially in ascending order (C1, C2, C3, C1, C2,…). Each channel can be enabled or disabled individually. Disabled channels are removed from the acquisition sequence. Connection of different probe types on different channels is acceptable. Probes can be connected with the UT-ONE switched on, however it is recommended that the acquisition sequence is stopped during connection in order to avoid out-of-range readings.

Figure 2: Connectors for the connection of thermometer probes on main channels

Connectors for one channel (Cx) consist of four banana-style connectors and one miniature thermocouple connector. Banana-style connectors accept bare wires, spade lugs and banana connectors. Note that voltage connectors and thermocouple connector are internally connected. Simultaneous connection of a PRT on banana connectors and a thermocouple on miniature thermocouple connector is not allowed and will result in erroneous readings.

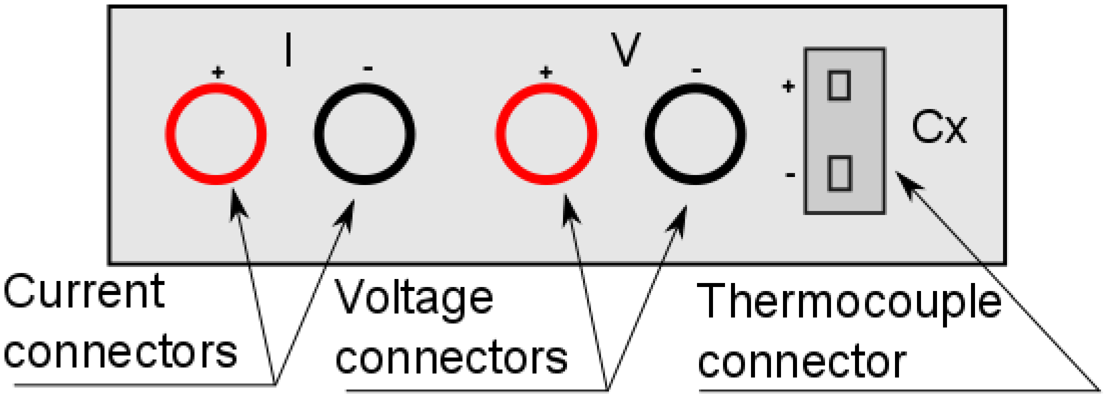

Figure 3: Connectors for one channel

2.4.1 Connection of platinum resistance thermometers and thermistors

Platinum resistance thermometers and thermistors (RTDs) are connected using the four-wire (Kelvin) connection. RTD is connected using a pair of current wires and a pair of voltage wires. If the RTD has only two connecting wires, connect it to voltage connector and use two separate wires to short the voltage and current connectors. Note that in this case, the resistance of connecting wires represents a measurement error, so this connection is not recommended. Note that in all cases, thermocouple connector must be disconnected. RTD lead wires must be connected in floating configuration, with no electrical connection to system ground or any other electrical potential.

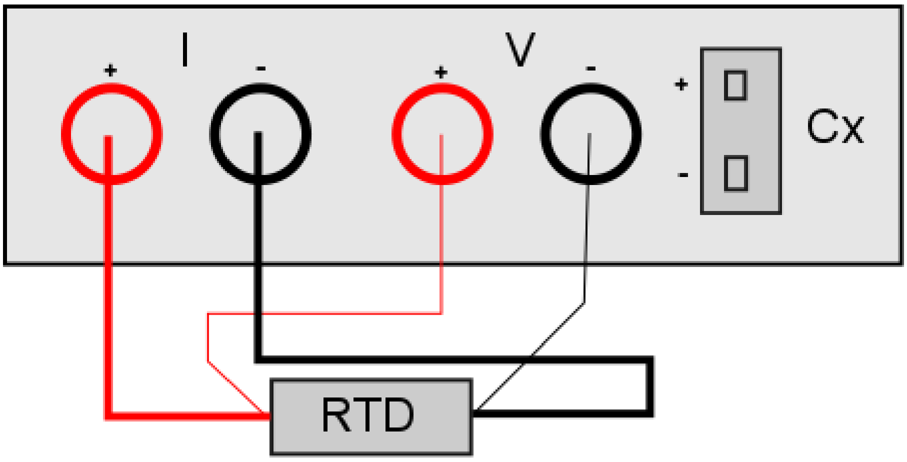

Figure 4: Four-wire connection of a RTD

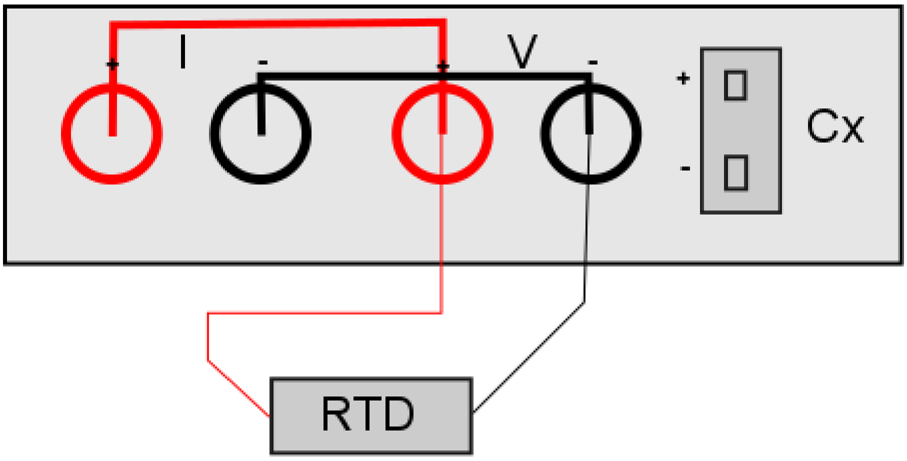

Figure 5: Two-wire connection of a RTD

2.4.2 Connection of thermocouples

Thermocouples are normally connected using a miniature thermocouple connector. Note that the thermocouple connector is white (neutral), which means that it has copper wires on both connections, so any thermocouple type can be connected. The thermometer for the measurement of cold junction temperature is located directly under the thermocouple connector, thus minimizing the error due to temperature gradients.

Alternatively, the thermocouple can be connected also directly to voltage connector, which is internally connected to the thermocouple connector. This connection is recommended for thermocouples with external cold junction (with cold junction compensation in ice point). Note that red connector is the positive and black connector is the negative pole.

Thermocouple wires must be connected in a floating configuration (not electrically connected to system ground or any other electrical potential). In order to provide optimum measurement conditions, one of the leads is internally connected to voltage bias of 2 V.

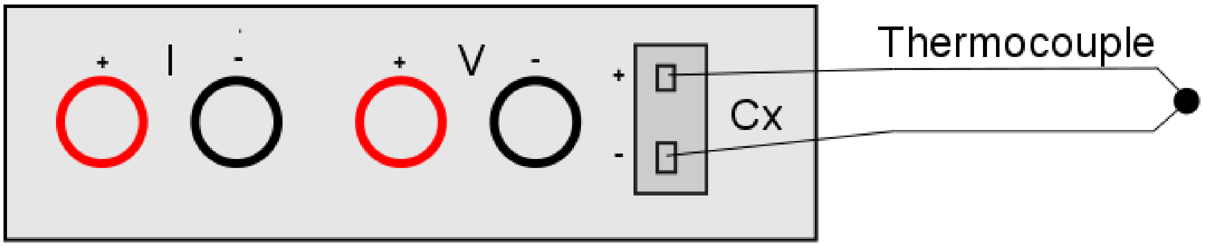

Figure 6: Thermocouple connection using the thermocouple connector

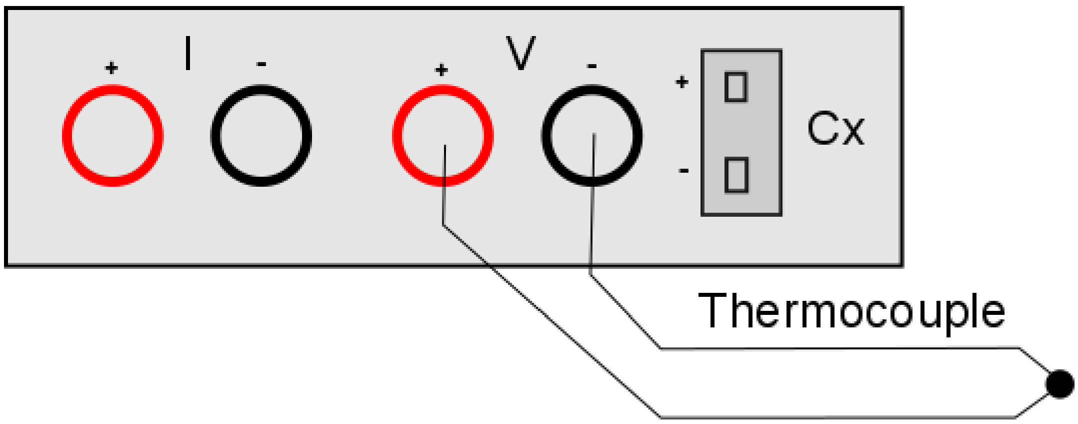

Figure 7: Thermocouple connection using the voltage connectors

2.4.3 Internal cold-junction compensation

UT-ONE has an additional internal digital thermometer probe, which can be used as cold junction compensation for thermocouple measurements. This thermometer probe is located directly under the thermocouple connectors. The probe is located inside the housing with significant thermal inertia and implements extensive digital filtering, so the response to rapid changes in ambient temperature is slow, possibly resulting in significant dynamic errors. To obtain best accuracy, always use UT-ONE in ambient with constant temperature and wait at least 30 minutes after a significant change in ambient conditions. Current value of the internal thermometer, as well as temperature trends, can be observed in channel TJ.

2.4.4 Connection of ambient probe

Ambient probe is used for the measurement of ambient conditions (air temperature and relative humidity).

Ambient probe is connected to the 4-pole circular connector located above the touch screen. If connector is protected by the plastic protective plug, unscrew it first. Then, gently push the probe into the connector and screw it in until it is firmly attached. Ambient probe can be used with or without the extension cable. To use it without the extension cable, unscrew the probe from the cable and connect it directly to UT-ONE.

It is recommended that you switch off the UT-ONE while connecting or disconnecting the ambient probe.

When ambient probe is disconnected, always attach the plastic protective plug in order to protect the interface from dirt and ESD damage.

Figure 8: Ambient probe connector with plastic protective plug removed

Figure 9: Direct connection of ambient probe

Figure 10: Connection of ambient probe with 2 m extension cable

2.5 Channels

UT-ONE measurement system consists of several measurement channels. The main channels are C1, C2 and C3, which correspond to three channels for the connection of three thermometer probes. RH channel displays the relative humidity of the optionally connected combined probe. TA channel displays the ambient temperature of the optionally connected combined probe. TD displays the dewpoint temperature, which is **calculated** from the relative humidity RH and ambient temperature TA. TJ is the temperature of the internal thermometer, which is used for the internal compensation of the cold junction of thermocouples.

Table 1: List of channel names

Channel	Description
RT	Real time clock
C1	Corrected temperature reading from temperature probe on channel C1
C2	Corrected temperature reading from temperature probe on channel C2
C3	Corrected temperature reading from temperature probe on channel C3
RH	Corrected reading of relative humidity from external ambient-conditions probe
TA	Corrected reading of air temperature from external ambient-conditions probe
TD	Corrected reading of dew-point temperature from external ambient-conditions probe. This reading is calculated from values in channels RH and TA
TJ	Corrected temperature reading of internal thermometer for cold-junction compensation
TI	Corrected temperature of the A/D converter. Used for internal correction of temperature coefficients
B1	Raw reading (resistance or emf) of the temperature probe on channel C1
B2	Raw reading (resistance or emf) of the temperature probe on channel C2
B3	Raw reading (resistance or emf) of the temperature probe on channel C3
BH	Uncorrected reading of relative humidity from external ambient-conditions probe
BA	Uncorrected reading of air temperature from external ambient-conditions probe
BD	Uncorrected reading of dew-point temperature from external ambient-conditions probe. This reading is calculated from values in channels BH and BA
BJ	Uncorrected temperature reading of internal thermometer for cold-junction compensation
BI	Uncorrected temperature of A/D converter

3 User Interface

UT-ONE has a touch-screen user interface. The only exception is the start key, which is located on the right side of the screen and is used for starting and stopping the UT-ONE.

Touch screen is a resistive type of touch screen, which unlike the capacitive type touch screens (common in smart phones) requires a press and not just a touch. There is also no support for multi-touch operations.

Touch can be performed with fingers or stylus pens. If using fingers, make sure you do not introduce grease or sweat on the screen surface, as this may result in stains that cannot be removed. Never use sharp or abrasive objects to manipulate the screen, as this may result in permanently damaged screen.

Every touch is accepted with both visual and sound feedback.

There are two types of a touch. Short touch is confirmed with as single click sound and the user must release the screen immediately. Long touch is confirmed with first click sound and the user must hold the touch for another second, until a second click sound signals that the long touch was accepted. Note that short and long touch may have different functionality associated to them.

3.1 User Interface Structure

User interface structure is composed of a set of windows, which are organized on two pages. Pages are selectable using the page selector located on the right-hand side of the screen. Each page has several windows, which can be accessed sequentially by repeatedly pressing the page selector. Measurement page is used to control and display measurements in different formats, while the Configuration page is used to view and change instrument configuration and parameters.

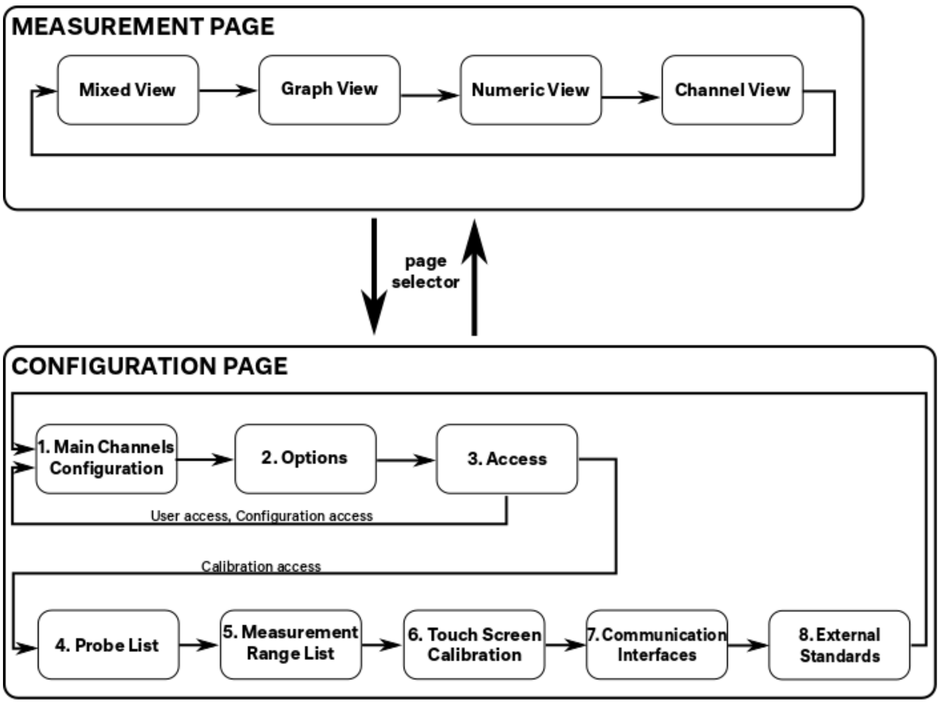

Figure 11: User Interface Structure

3.2 User Interface Elements

Each window on the user interface is composed of several common elements, which are common to windows on both pages.

The main frame presents data specific to currently selected window and will be described in details for each window in the following chapters.

The menu consists of up to five menu buttons, which dynamically change according to window content and instrument state. Note that some menu buttons have a different function for the short and long touch.

The page selector consists of two page tabs, which are labelled MEASURE and CONFIGURE. The currently selected page is displayed in front and with brighter background. You may repeatedly press the page selector to scroll through all windows in the selected page. Using the long touch on the page selector will select the first window in the window sequence. Changing pages and windows will not affect measurements, but changes to configuration that were not explicitly saved will be lost after changing the window or page.

The acquisition status indicator displays the current status of the acquisition sequence. If several main channels are enabled, the acquisition status indicator will scroll through each channel as it is being acquired. If all main channels are disabled, but the acquisition is started, acquisition status indicator will display AP, which indicates that only ambient probes are being acquired. If acquisition is stopped, acquisition status indicator will display STOP.

The battery status indicator displays the current status of the battery. Each bar in the battery status indicator represents approximately 20% of the battery capacity. If UT-ONE is connected to external power supply, the background of the battery status indicator will turn blue. If UT-ONE is running on batteries and battery capacity is below 20%, the background of the battery status indicator will turn red. You can get more information about battery status in the Power options in the Configure page.

Figure 12: User Interface Elements

3.3 Measurement page

Measurement page consists of four windows, which are used for viewing and controlling the measurements on configured channels. Each window presents measurements in a different view, such as graphic and/or numeric format. Windows with different views in the Measure page can be selected by repeatedly pressing the MEASURE page selector or the VIEW… menu button.

Acquisition sequence can be started by touching the green START menu button and stopped by touching the red STOP menu button. Note that the menu button functionality and appearance is automatically adjusted according to current acquisition state.

IMPORTANT!
If acquisition sequence is stopped, displayed readings will not be refreshed!

3.3.1 Mixed view

Mixed measurement view is the basic measurement view, which presents the measurement data in both numerical and graphical format, as well as some measurement statistics and uncorrected raw data.

Mixed measurement view is divided in two sections. The left-hand side of the main frame presents the data in the graph, while the right-hand side of the main frame displays the data in numerical format.

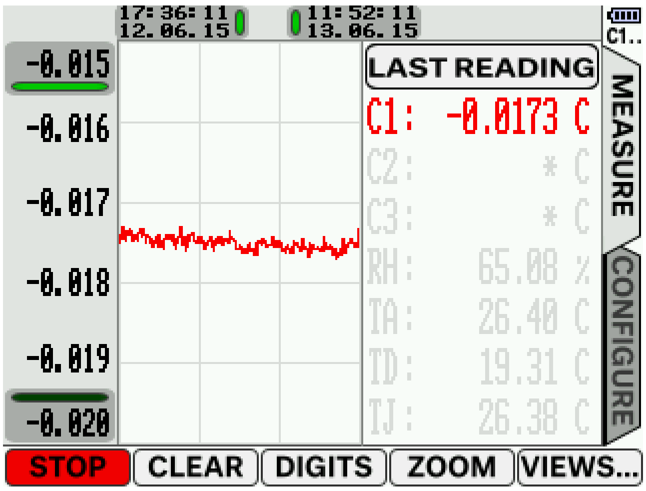

Figure 13: Mixed view

The left-hand side of the main frame displays the graph. Graph can display up to seven channels. Displayed graphs can be selected by pressing the numeric representation of the channel value (in the right side of the screen). Unselected channels are displayed in gray color.

Graph can use auto scaling or manual scaling. Scale limits can be adjusted manually by pressing the first or last label (scale limit) in the graph scale. A dialog will appear and a new value can be entered. Entering a manual scale limit automatically disables auto scaling for the particular scale limit. Auto scaling can be enabled by performing a long touch on the selected scale limit.

Auto scaling indicator is the small green indicator, located on the inner side of the scale limit label. If auto scaling is enabled for the particular scale, the auto scaling indicator will turn bright green.

Graph scale can be adjusted directly on the graph using the ZOOM menu button. The user must select two corner points within the graph and the graph will be zoomed between the nearest possible points, as determined by graph resolution. The exact zooming area is indicated by region which is not painted with red border. You may choose not to zoom for a particular scale limit, in this case you must select the corner point outside the graph area.

Auto scaling for all four scale limits can be enabled by applying a long touch to the ZOOM menu command. This is particularly useful for graph initialization, as the measurements may be initially displayed outside of the screen area.

Graph can be configured in the rolling display mode. In this mode, a fixed time span is presented in the graph and each new acquired readings shifts the graph data to the left, so the oldest readings fall of the graph. To configure the rolling display mode, first enable the auto scale for the upper limit of the time scale. Then adjust the lower limit of the time scale, so that a suitable time span is presented on the graph. This can be achieved either manually or by using the ZOOM function. Then use a long touch on the lower limit of the time scale. The auto scaling indicator will turn blue in order to indicate rolling display mode.

All graph readings can be cleared using the CLEAR menu button. Note that this operation will clear the readings on the graph and reinitialize the measurement statistics and graph auto scale limits, but readings will remain stored in the UT-ONE nonvolatile memory.

Graph can display up to 3 months of readings at the same time. If you try to adjust the scale limits beyond this limitation, the scale adjustment will be truncated.

Displaying very large data sets on the graph will result in slower response/redraw time.

The right-hand side of the main frame displays the data in numeric format. Data is presented for each of the seven measurement channels. Numeric display can present the last measured value, as well as some statistics and uncorrected raw measured value. The header button above the numeric data can be used to change the type of displayed numeric values:

- LAST READING displays the last acquired reading for each channel
- MIN READING displays the smallest acquired reading for each enabled channel
- MAX READING displays the largest acquired reading for each enabled channel
- MAX - MIN displays the difference between the largest and smallest acquired reading for each enabled channel
- RAW READING displays the uncorrected raw value for the last acquired reading for each enabled channel. Note that for main channels, raw reading is presented in ohms for resistance thermometers and microvolts for thermocouples, while for the ambient channels it is presented in °C or %.

If a channel is disabled, the numeric display will display a " * " character. Note that main channels are enabled manually in the Main Channels Configuration window on the Configure page, while ambient probes are enabled automatically after the probe is detected. Disabled channels do not affect the statistics and graph presentation.

If a channel is enabled, but the reading is erroneous due to wrong connection, wrong configuration or out-of-range condition, the numeric display will display " ERROR! " message. Check your probe, connection and configuration to correct this condition. Erroneous readings do not affect the statistics and graph presentation.

Using a short touch on the numeric value of the particular channel will enable the display of the particular channel on the graph. Note that disabling the display on the graph has no effect on measurement of the particular channel. Channels with the enabled display are drawn in color, while the channels with disabled display are drawn in gray.

Using a long touch on the numeric value of the particular main channel acts as a shortcut to the configuration window for the selected main channel.

The resolution of the numeric display can be adjusted using the DIGITS menu button. A short touch on the DIGITS menu button will cycle through resolution from 0 to 4 decimal places. Reduced resolution is useful for measurements with unstable or fast-changing readings, were last digits are irrelevant and only distract the user. Note that for ambient probes, full resolution is limited to 2 decimal places.

A long touch on the DIGITS buttons will display the alternative color scheme, which has a black background. Alternative color scheme is functionally identical to basic color scheme and is simply a matter of user preference.

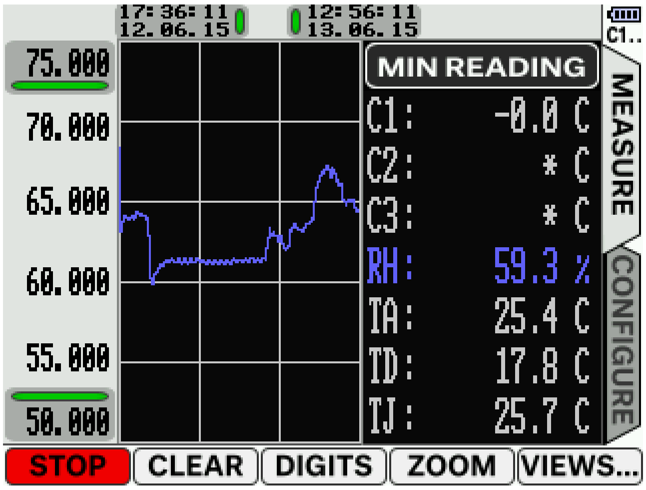

Figure 14: Alternative colour scheme (reduced numeric resolution)

3.3.2 Graph view

Graph measurement view presents the data in graphic format only, using the entire main frame. Functionality is very similar to functionality of graph presentation in mixed measurement view. Note that some functions, such as the enabling of the display of graphs for individual channels can only be made in mixed view and applies identically to both views.

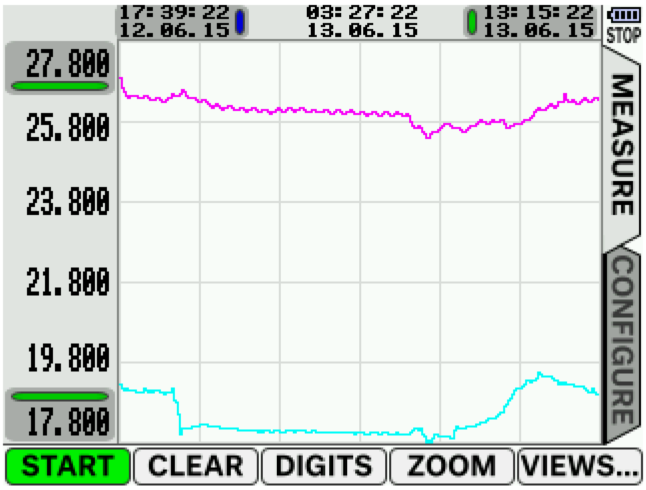

Figure 15: Graph view

3.3.3 Numeric view

Numeric measurement view presents the data in numeric format using large font, which is clearly visible from larger distance. This view can show either temperatures from main channels C1, C2 and C3, or readings from the external ambient probe (channels RH, TA and TD). The displayed set of channels can be selected using the MAIN / AMBIENT menu button.

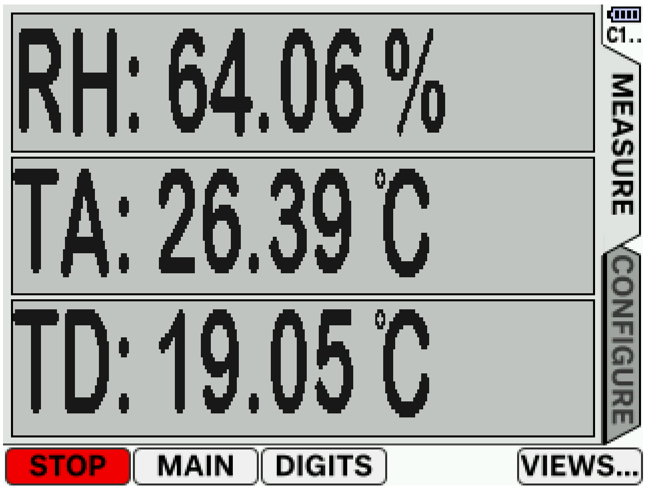

Figure 16: Numeric view

3.3.4 Channel view

Channel measurement view displays the extended information for the measurements on the selected channel. Available channels C1, C2, C3, RH, TA, TD and TJ can be selected using the tabs in the main frame of the window. This view displays a large indicator with the temperature or relative humidity for the selected channel. Under the large indicator, there are four smaller indicators displaying minimum reading, maximum reading, difference between maximum and minimum reading and uncorrected raw reading for the selected channel. This is similar to statistics in the mixed view window.

In the bottom of the main frame, the name of the currently used probe is displayed. Using a long touch on the probe name or on the large indicator will display configuration window for the selected main channel.

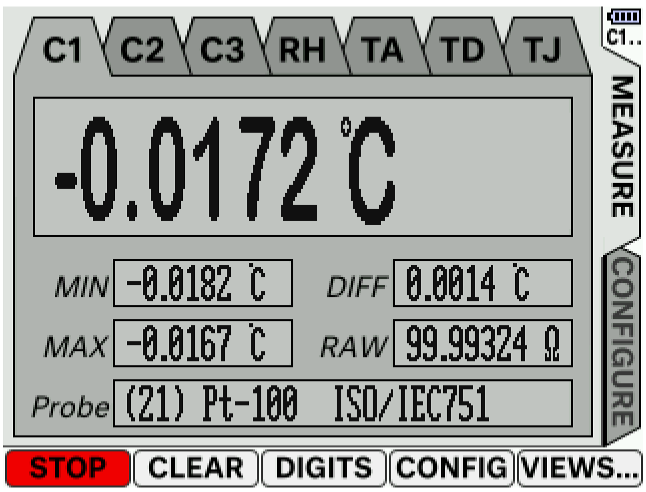

Figure 17: Channel view

3.4 Configuration page

Configuration page consists of eight windows, which are used for viewing and changing UT-ONE configuration and parameters. Configuration can be selected using the CONFIGURE page selector. Individual windows can be scrolled by repeatedly pressing the CONFIGURE page selector or MORE… menu button. Long touch on the CONFIGURE page selector or MORE… menu button will select the first configuration window (Main Channels Configuration).

Configuration page supports three levels of access, which enables the user to lock some of the features of the UT-ONE configuration from unauthorized/accidental modification. Change of access levels is password protected and can be performed in the Access Level configuration window.

3.4.1 Main Channels Configuration

Main channels of the UT-ONE thermometer are channels C1, C2 and C3 and are used for measurement of resistance probes and thermocouples. Each of the main channels can be configured independently in the Main Channels Configuration window on the Configuration page.

Changing channel configuration requires Configuration or Calibration access level. If you are currently in User access level, input boxes are gray and disabled. Use the ACCESS menu button to enter password for the configuration access level to unlock channel configuration.

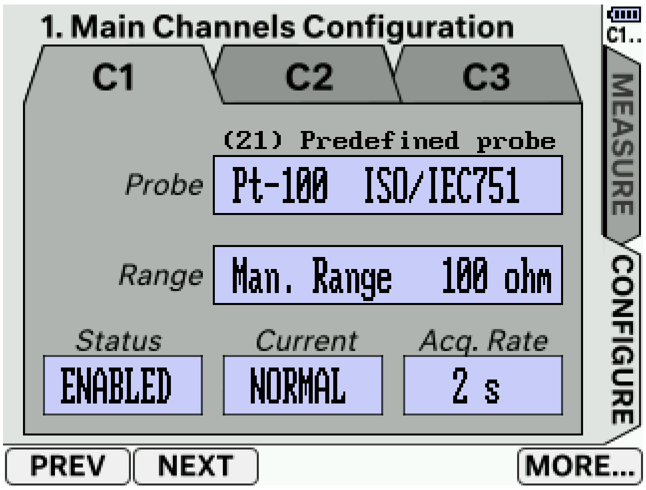

Figure 18: Main Channels Configuration

Main channel configuration window consists of five parameters:

- *Probe* parameter determines the resistance probe/thermocouple that is connected to the specified channel. Note that you may use a predefined set of probe using standard parameters, as well as user defined probes with particular parameters, which were obtained during probe calibration. Probe parameter determines the equation type and coefficients, which are used to transform measured resistance/emf to probe temperature. To change probe, touch the probe input box to select (input box background turns white) and use PREV and NEXT menu buttons to scroll through probe list. Long touch will select the first user or predefined probe. The same functionality can be achieved by touching the left-hand side or right-hand side of the probe input box.
- *Range* parameter determines the resistance/emf measurement range for the selected channel. After the probe is selected/changed, UT-ONE automatically selects the optimum measurement range for the given probe type, as well as limits the manual selection to resistance or emf ranges. In most practical cases, use of auto range is recommended, however you can also set the range manually.

- *Status* parameter determines if the channel is enabled and therefore included in the acquisition sequence. If channel is not used or probe is not connected to channel connectors, you should disable it to prevent erroneous readings and to speed up the acquisition sequence.
- *Current* parameter determines the value of the measurement current for the measurement of resistance probes (for thermocouples, this parameter is not applicable). You may choose between two values of measurement current: NORMAL value is 1 mA for PRT ranges and 20 μA for thermistor ranges, while REDUCED value is 0.707 mA for PRT ranges and 14.1 μA for thermistor ranges. You should always use NORMAL current to achieve best measurement result, while REDUCED current is used only for determining the self-heating error.
- *Acquisition Rate* determined the time for the acquisition of a single reading on the selected channel. Acquisition rate can be set in the range from 2 seconds to 240 seconds with 2 second resolution. Using larger values for acquisition rate will perform averaging of internal readings and therefore reduce the scatter of readings (improve effective resolution), but it will decrease the refresh rate of the displayed measurements.

When you change any of the channel parameters, changes are not applied immediately, but a green SAVE menu button and red CANCEL menu button are displayed. Changes are committed to the acquisition sequence only if you touch the SAVE menu button. If you touch the CANCEL button, original channel parameters are restored. If you leave the channel configuration window, changes are not committed and are permanently lost.

If acquisition is running during the channel parameters change, the acquisition may be stopped and automatically restarted with new parameters. In this case, results from the interrupted measurement are discarded. Note that changing channel parameters during acquisition is allowed, but may result in a larger gap between acquired measurements.

3.4.2 Options

Options configuration windows is used to view/set various options and parameters of the UT-ONE thermometer. Options are grouped in three tabbed pages, which include Power options, Time option and Info options. Use tabs to select each of the tabbed pages.

Power options display the information about the internal rechargeable LiPo battery, power source and power saving options.

Battery Voltage and *Battery State of Charge* determine the available capacity of the LiPo battery. Note that battery state of charge is a more accurate (numeric) representation of the battery indicator. Note that battery voltage and state of charge for a fully charged battery may be slightly higher than nominal 4,2V (100%) for a fully charged LiPo battery. This is within the 1% accuracy of the charger and battery monitor. Voltages higher than 4.25 V are not acceptable and require a service intervention.

Battery Charge Cycle displays the count of discharge and recharge cycles of the LiPo battery. One cycle is defined as discharge and recharge for at least 40% of full capacity. Note that the battery is rated for 500 charge cycles, but this number is very dependable on operating conditions. Note also that battery full capacity slowly decreases with increasing number of charge cycles.

Source parameter determines the current power source, which can be either EXTERNAL (external adapter or USB bus) or BATTERY.

Screensaver parameter determines the timeout before the display starts displaying the UT-ONE screensaver. Timeout is set in minutes, use 0 to disable the screensaver feature. Timeout is reset with any touch activity. Use of screensaver is recommended for applications where display is displaying a constant image for prolonged time periods, as this may result in permanently burned-in image. Note that using a screensaver will not decrease power consumption. You can enter the screensaver mode immediately by touching the SCRSVR menu button.

Sleep parameter is similar to screensaver, but in this case UT-ONE enters sleep mode, in which display enters a low power mode, reducing the total power consumption by over 60%. Measurements can be normally acquired and logged in sleep mode.

To exit screensaver and sleep mode touch screen. In sleep mode, screen touch is sampled in 5 second intervals, so a longer constant touch may be required.

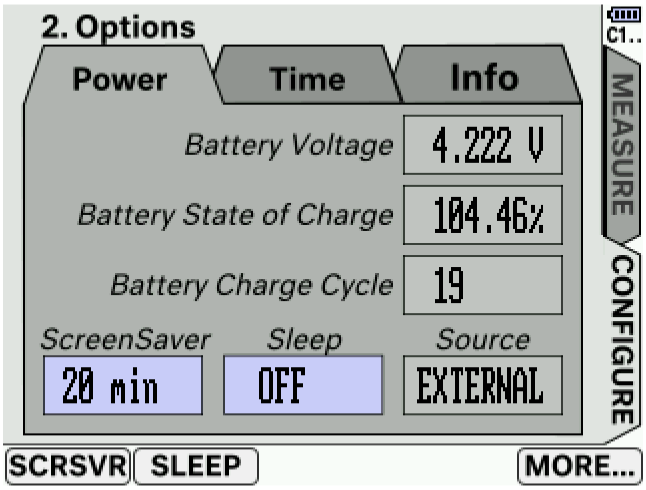

Figure 19: Power options

Figure 20: Screensaver

Time options displays the current time and date of the UT-ONE real time clock. User can touch the SET menu button to correct the current time.

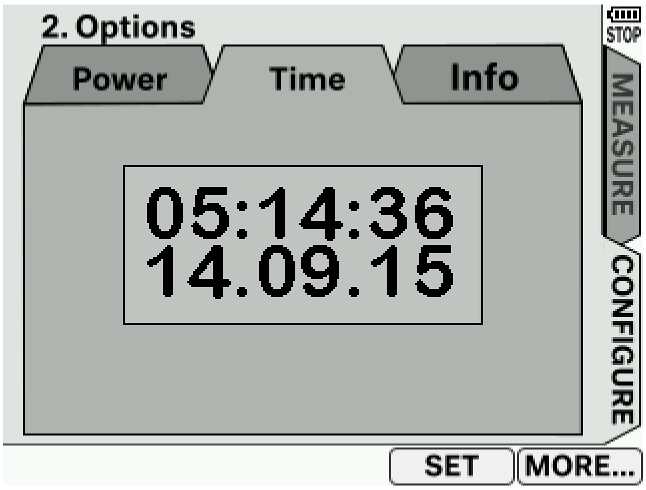

Figure 21: Time options

Info options display the serial, production and measurement modul number, as well as firmware version and CRC coded calculated from main processor firmware. This information is useful for traceability and support.

Figure 22: Info options

3.4.3 Access Level

UT-ONE has three access levels, which are used to secure the configuration, calibration and internal data from accidental or unauthorized access. Access level can be changed by selecting the corresponding tabbed page. Increasing the access levels require that you enter a password. There are three access levels:

- *User Access* is used for normal operation (measurements of temperature). User cannot change configuration and calibration parameters. No password is required.
- *Configuration Access* is used for configuring the UT-ONE channels with particular thermometer probes and measurement ranges. Password is **207**. This access level is retained after the UT-ONE is restarted. If required, changed to User access manually after the configuration is complete.
- *Calibration Access* is used for changing calibration parameters, such as user probe data and reference values for measurement ranges. Password is **42849**. After the UT-ONE is restarted, the access level is automatically decreased to Configuration level.

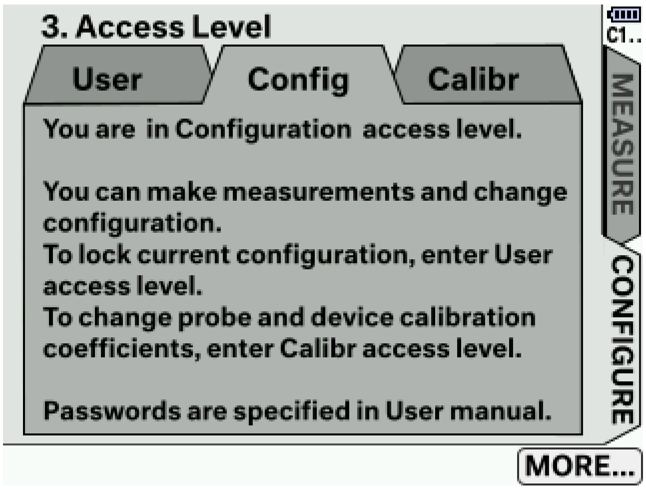

Figure 23: Access Level

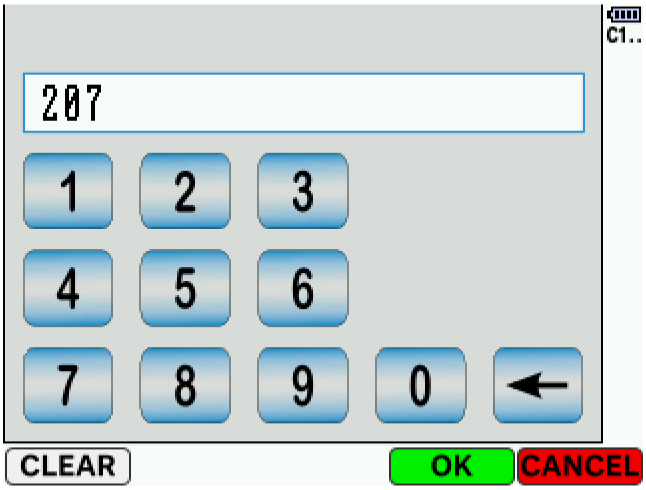

Figure 24: Entering a password using the numeric keyboard

3.4.4 Probe List

Probes List configuration window allows the reviewing and configuration of user-defined, predefined and ambient probes. Note that in order to enter Probe List window, access level must be set to calibration.

User-defined probe list consists of 20 locations, where user can enter its own probes with particular coefficients, which can be later selected in the Main Channels Configuration window. Use the scrollbar on the right-hand side to scroll through all 20 locations. Touch a location to select it, selected location will be displayed with white background. Use DELETE menu button to permanently delete the selected user-defined probe. Use the EDIT menu button to view/change probe parameters.

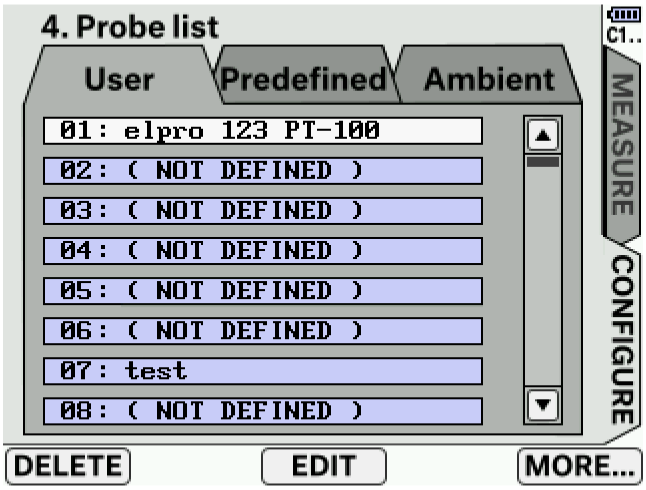

Figure 25: User-defined probe list

Predefined probe list is similar to user-defined list, but for predefined probes you can only view parameters, you can't change or delete them.

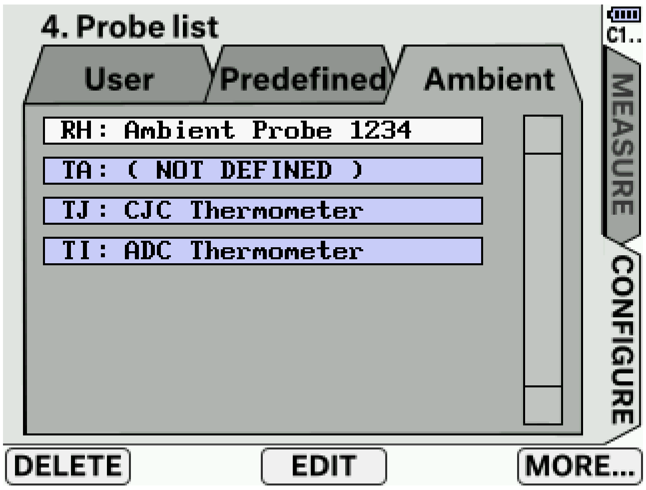

Figure 26: Ambient probe list

Ambient probe list displays probes for ambient channels, which include external ambient probe (relative humidity RH and air temperature TA), internal cold-junction thermometer TJ and internal ADC thermometer TI. Note that each ambient channel has exactly one linked probe, which cannot be selected from a list of probes, as in the case of main channels.

Note that temperature measured with ADC thermometer (TI) is used for internal temperature compensation of main channels, so using wrong ADC thermometer coefficients may result in erroneous readings of main channels.

Probe data is viewed/changed in Edit Probe Data dialog. Touch the parameter input box to select it and touch CHANGE menu button to change. Changes are made in a text or numeric data editor.

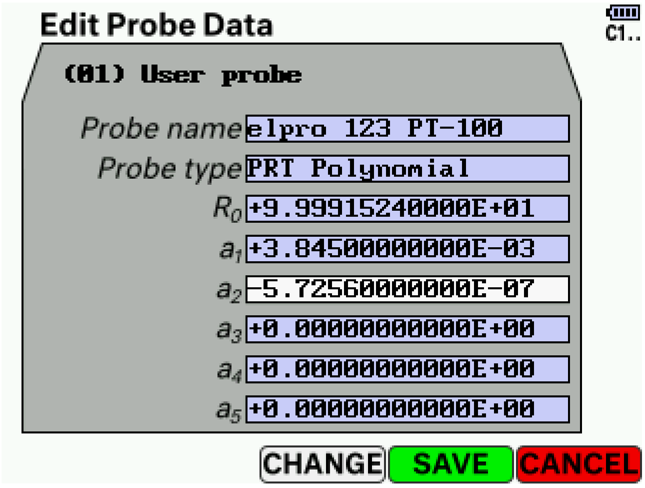

Figure 27: Edit Probe Data dialog

Editing the probe name will open the text data editor. Probe name can be up to 20 characters long and may consist of any available character.

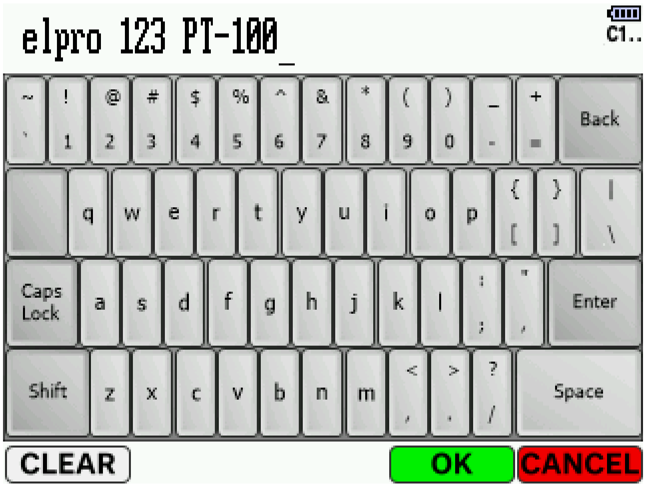

Figure 28: Text data editor

Editing the probe type will display the Probe type label and the associated conversion function. You may use the PREV and NEXT menu buttons to scroll through available probe types. Note that after a new probe type is selected, the labels of the probe coefficients are automatically adapted.

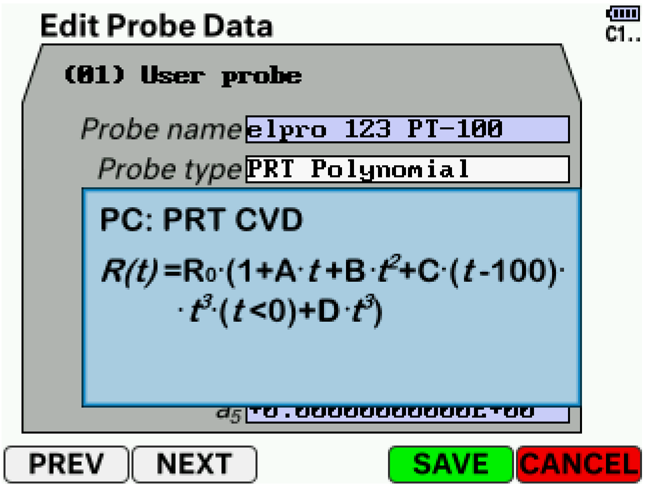

Figure 29: Probe type selection

Editing probe numeric coefficients will display a numeric keyboard, which allows the entry of numbers in floating point format with 12 decimal digits and exponent in range from -99 to 99.

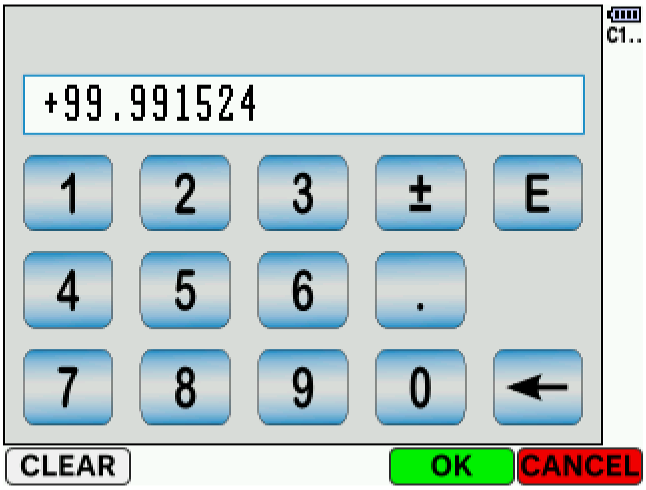

Figure 30: Numeric data editor

3.4.5 Measurement Range List

Measurement range list window is used for reviewing and configuring calibration coefficients for measurement ranges. UT-ONE features 35 measurement subranges:

- RA: Auto Range Pt-100, Normal current (virtual range, no coefficients)
- R1: Manual range 25 Ω, Normal current
- R2: Manual range 50 Ω, Normal current
- R3: Manual range 100 Ω, Normal current
- R4: Manual range 200 Ω, Normal current
- R5: Manual range 400 Ω, Normal current
- R6: Manual range 800 Ω, Normal current
- HA: Auto Range Thermistor, Normal current (virtual range, no coefficients)
- H1: Manual range 1.25 kΩ, Normal current
- H2: Manual range 2.5 kΩ, Normal current
- H3: Manual range 5 kΩ, Normal current
- H4: Manual range 10 kΩ, Normal current
- H5: Manual range 20 kΩ, Normal current
- H6: Manual range 40 kΩ, Normal current
- EA: Auto Range Thermocouple (virtual range, no coefficients)
- E1: Manual range 15 mV
- E2: Manual range 30 mV
- E3: Manual range 60 mV
- E4: Manual range 125 mV
- E5: Manual range 250 mV
- E6: Manual range 500 mV
- rA: Auto Range Pt-100, Normal current (virtual range, no coefficients)
- r1: Manual range 25 Ω, Reduced current
- r2: Manual range 50 Ω, Reduced current
- r3: Manual range 100 Ω, Reduced current
- r4: Manual range 200 Ω, Reduced current
- r5: Manual range 400 Ω, Reduced current
- r6: Manual range 800 Ω, Reduced current
- hA: Auto Range Thermistor, Reduced current (virtual range, no coefficients)
- h1: Manual range 1.25 kΩ, Reduced current
- h2: Manual range 2.5 kΩ, Reduced current
- h3: Manual range 5 kΩ, Reduced current
- h4: Manual range 10 kΩ, Reduced current
- h5: Manual range 20 kΩ, Reduced current
- h6: Manual range 40 kΩ, Reduced current

Auto ranges are virtual ranges which instruct the UT-ONE to select one of the possible six associated manual subranges. Auto ranges have no coefficients associated to them.

Each manual subrange is associated with three parameters:

- Reference value is obtained in UT-ONE calibration and user may adjust it to compensate instrument drift. This value also indicates the exact value of instrument overrange.
- Linearity correction compensates the linearity error for the particular range. Measurement of this parameter requires dedicated equipment and procedures and may not be performed by the user.

- Temperature coefficient compensates the temperature drift for the particular range. Measurement of this parameter requires dedicated equipment and procedures and may not be performed by the user.

IMPORTANT!
Changing the reference value directly affects measurement accuracy and traceability of the instrument!

Use PREV and NEXT menu button to scroll through the list of manual measurement ranges. Use CHANGE menu button to change the reference value for the currently selected measurement range.

Note that reference value is immediately stored in the volatile memory of the UT-ONE and measurements are immediately using the new value. This feature is useful for verifying the new reference value before committing changes to UT-ONE nonvolatile memory. Switching to other windows will not discard changes to reference value. Values in volatile memory are lost after UT-ONE power down.

Use red CANCEL menu button to discard all changes to reference value and reload existing values from nonvolatile memory. Use green SAVE button to commit changes to nonvolatile memory.

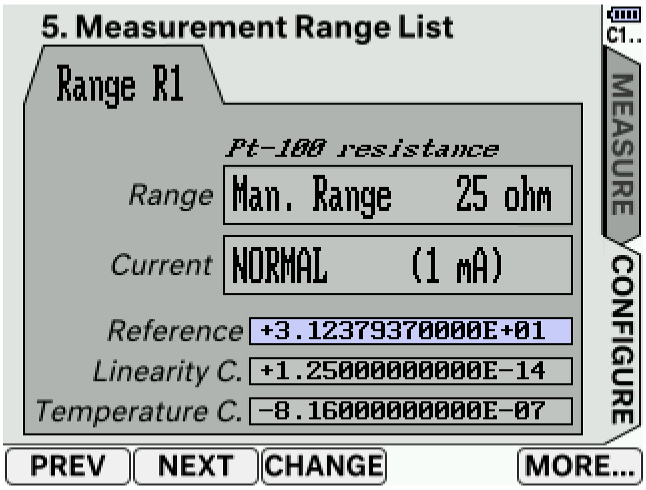

Figure 31: Measurement Range List

3.4.6 TouchScreen Calibration

Touch screen resistive element may drift with time, so user may have to perform a recalibration of the touch screen. Touch the TEST menu button to test the accuracy of the current touch screen calibration. It is recommended that you use a stylus pen to perform testing and calibration of the touch screen.

If calibration is required, touch the CALIBR menu button. A circular target will be displayed in the lower left corner of the screen. Touch and hold the center of the target until OK is displayed. Repeat the procedure for the target in upper right corner. Calibration is now complete, but the coefficients are not yet permanently stored. You may use the TEST function to verify that calibration was successful. If calibration is correct, touch the SAVE menu button to permanently store the touch calibration coefficients. You will have to verify the calibration by repeating the touching of two corner targets. If verification is successful new touchscreen calibration is stored in nonvolatile memory.

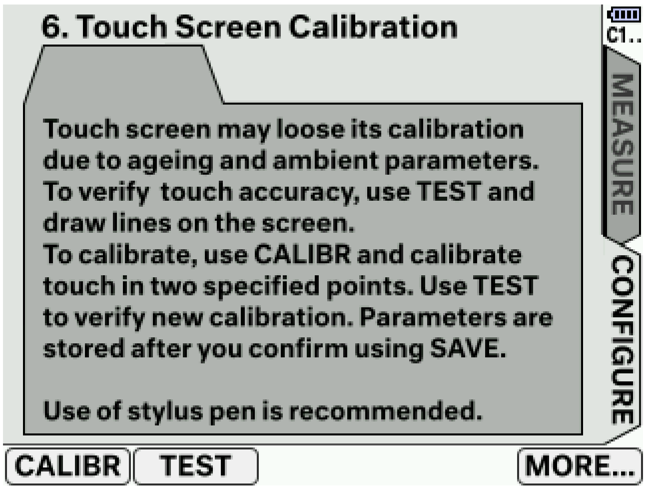

Figure 32: Touch screen calibration window

3.4.7 Communication Interfaces

Communication Interfaces window displays the information about the installed communication interfaces for communication with a computer. UT-ONE has two communication interfaces:

- Serial (RS232) interface is a simple and reliable interface for slow communication over longer communication cables. Communication parameters are displayed in this view. Parity is fixed to odd parity, each character has 8 bits and you can use one or two stop bits. Default baud rate is 38400 bauds. You can touch the baud rate input box to change the baud rate and use green SAVE button to save to nonvolatile memory. The new baud rate will become effective after the UT-ONE is restarted. Available data rates are 300, 600, 1200, 2400, 4800, 9600, 19200 and 38400 bauds. Use lower baud rates if you are using long communication cables in a noisy environment and the communication is not reliable.
- USB interface is the most commonly used interface in modern computers and provides fast communication over a limited cable length. Note that UT-ONE can also be powered from the USB interface. Basic communication parameters are displayed in this view. Communication is compliant with USB 2.0 full speed at 12 Mbps. VISA resource name is the default name that is used in the LabVIEW drivers for USB RAW communication.

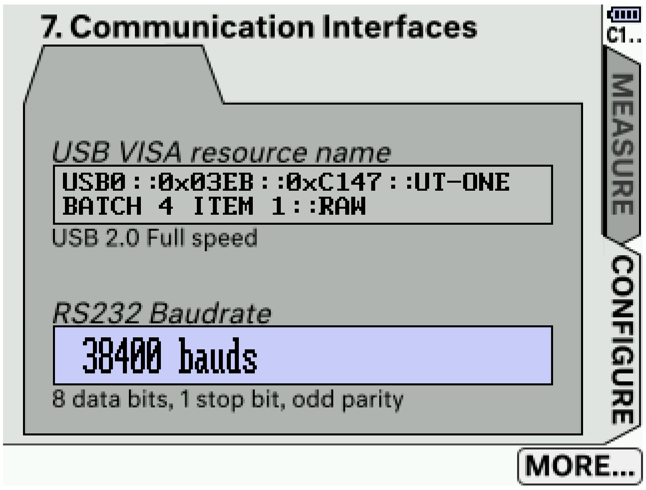

Figure 33: Communication interfaces

3.4.8 External Standards

UT-ONE supports the use of external standards, which can be used to eliminate internal short-term and long-term drifts and therefore improves accuracy of the measurement. Note that external standards are only applicable with single reading measurements, initiated over communication interface.

To set-up external-standard parameters, first select the page for the channel, on which the external standard will be connected. Then touch the parameter input box to select and touch CHANGE menu button to modify it.

- *Name* input box contains a user-defined label for the external standard. Name is limited to 20 characters.
- *Range* input box specifies the type of external references. Valid options are "Pt-100 ranges", "Thermistor ranges", "Thermocouple ranges" and "Not defined". The last option effectively disables the external reference on selected channel. Note that external-standard range must much the range specified in a single reading measurement, otherwise single reading measurement will return E2 error.
- *Reference* input box specifies the exact value of the external standard, as obtained in its calibration certificate.

- *Temperature C.* input box specifies the temperature coefficient of the external reference. UT-ONE internally measures ambient temperatures and automatically corrects the reference value of the external standard. This correction is only applicable, if the external standard is placed near the UT-ONE unit at approximately the same ambient temperature. If external standard is stabilized at constant temperature, enter zero for temperature coefficient. This will effectively disable temperature correction of the external standard. Temperature coefficient is specified relatively per °C. For example 2.8E-7 is equal to 0.28 ppm/°C.

After you set all parameters, touch the green SAVE button to store external-standard configuration to nonvolatile memory. Touching red CANCEL button or changing the page/window will discard all changes.

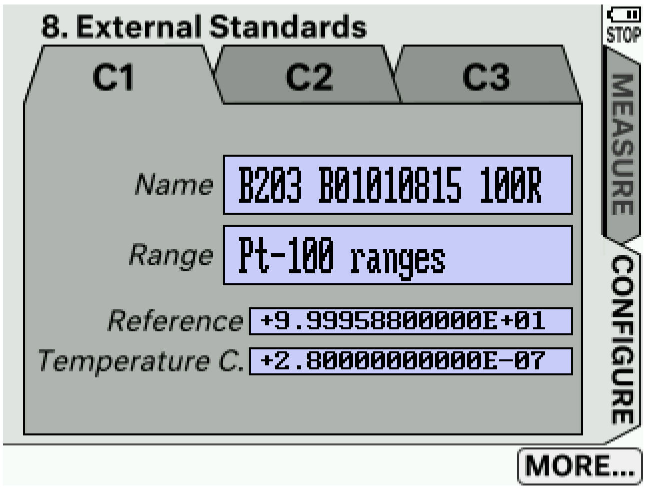

Figure 34: External Standards

4 Probe Characterization

UT-ONE provides all commonly used coefficients and equations to convert measured resistance or emf to temperature. UT-ONE has internal non-volatile memory for storage of coefficients for up to twenty user-defined probes and has 29 predefined coefficients for standard probe types.

User-defined probes and their coefficients can be reviewed and changed in the Probes List configuration window in the UT-ONE user interface. Alternatively, user-defined probes can be managed using the remote interface commands.

Alternatively, user may choose to ignore the internal conversion functions and use retrieve the raw values of resistance or emf via the remote interface. In this case, conversion to temperature is performed in dedicated software on a computer, independently of the UT-ONE.

4.1 Data structure

Probe characterization for both user-defined and predefined probe coefficients are stored in a data structure in binary format. Size of the data structure is 128 bytes. Data structure for probe coefficients consists of:

- *Probe name* (20 bytes)
  Probe name describes the probe in unique and user-friendly manner. Probe name may consist of probe model, manufacturer, serial number, certificate number, or it can be a functional description of the probe. If probe name is less than 20 characters long, append space characters up to the size of 20. There is no terminating zero character.
- *Probe type* (2 bytes)
  Probe type describes the type of the conversion equation used for calculation of the true temperature. Available probe types are PP, PC, PI, NS, NE, TK, TJ, TT, TE, TN, TS, TR and TB.
- *Coefficients* (6 * 8 bytes)
  Coefficients are the numeric parameters of the conversion equation for the particular probe type. Data structure supports up to six numeric parameters, but some of them may be fixed to zero and ignored, depending on the selected probe type. Coefficients are stored as floating-point numbers in packed binary-coded-decimal format (BCD format). Each BCD number consists of a mantissa with 12 decimal digits, a sign character and an exponent in the range from -99 to 99.
- *Reserved* (56 bytes)
  This section is reserved for future upgrades.
- *Cyclic redundancy code CRC* (2 bytes)
  This is an error checking signature, which ensures data integrity of the entire data structure.

4.2 Probe types

UT-ONE supports the measurement with platinum resistance thermometers, thermistors and thermocouples by measuring their resistance or emf. The conversion of resistance/emf to temperature is performed using the conversion equation. Note that there can be several different types of conversion equation available for a particular probe and the users may choose which fits their purpose.

4.2.1 PP: PRT polynomial

PRT polynomial is a simple polynomial equation that converts the resistance of a platinum resistance thermometer to temperature. This type of conversion equation is commonly used for industrial-grade PRTs. R_0 coefficient is also known as the resistance of a PRT at ice point (0 °C) and can be used as a measure of PRT stability between the successive calibrations. Conversion equation supports polynomials up to fifth order, but often the coefficients of up to second or third order are sufficient. In this case, set the rest of the coefficients to 0.

PP: PRT Polynomial

$$R(t) = R_0 \cdot (1 + a_1 \cdot t + a_2 \cdot t^2 + a_3 \cdot t^3 + a_4 \cdot t^4 + a_5 \cdot t^5)$$

Figure 35: Conversion equation for PP probe type

4.2.2 PC: PRT CVD

PRT CVD is a Callendar-Van Dusen equation that converts the resistance of a platinum resistance thermometer to temperature. This type of conversion equation is commonly used for industrial-grade PRTs. This equation is similar to PRT polynomial equation, but it has an additional conditional parameter for temperatures below 0 °C. If thermometer is calibrated only at temperature above 0 °C, set the coefficient C to 0. R_0 coefficient is also known as the resistance of a PRT at ice point (0 °C) and can be used as a measure of PRT stability between the successive calibrations. Coefficient D is rarely used, but it improves the accuracy at high temperatures. If D is not used, set it to 0.

PC: PRT CVD

$$R(t) = R_0 \cdot (1 + A \cdot t + B \cdot t^2 + C \cdot (t - 100) \cdot t^3 \cdot (t < 0) + D \cdot t^5)$$

Figure 36: Conversion equation for PC probe type

4.2.3 PI: SPRT ITS-90

SPRT ITS-90 is a set of equations, defined by the International Temperature Scale of 1990 (ITS-90), which converts the resistance of a standard platinum resistance thermometer (SPRT) to temperature. Consult the ITS-90 definition for applicability and usage of this equation type. ITS-90 defines several conversion equations for particular temperature ranges, but UT-ONE supports only two of the most commonly used temperature ranges. The low temperature range is used for temperatures from the triple point of argon (-189.3442 °C) up to the triple point of water (0.01 °C). The high temperature range is used for temperatures from triple point of water (0.01 °C) up to freezing point of aluminum (660.323 °C). Note that the thermometer can also be calibrated in a narrower range, in this case set the appropriate coefficients to zero. R_{TPW} coefficient is the resistance of the SPRT in the triple point of water and can be used as a measure of SPRT stability between the successive calibrations.

UT-ONE does not perform any internal self-heating correction procedure. It is recommended, that during calibration coefficients are calculated for resistance at 1 mA current (and not for 0 mA current). If coefficients are available only for 0 mA current, a reasonable approximation is to add the value of self-heating for 1 mA at triple point of water to the R_{TPW} coefficient.

PI: SPRT ITS-90

$$W=R(t)/R_{TPW}$$
$$W-W_R=a_4\cdot(W-1)+b_4\cdot(W-1)\cdot\ln(W)$$
$$W-W_R=a_8\cdot(W-1)+b_8\cdot(W-1)^2+c_8\cdot(W-1)^3$$

Figure 37: Conversion equations for PI probe type

4.2.4 NS: NTC Steinhart-Hart

NTC Steinhart-Hart is a standard conversion equation for negative-temperature-coefficients thermistors. Note that temperature T in the equation has the unit kelvin.

NS: NTC SH

$$1/T=A+B\cdot\ln(R)+C\cdot\ln(R)^3$$

Figure 38: Conversion equation for NS probe type

4.2.5 NE: NTC exponential

This is the simplified version of the Steinhart-Hart equation, where coefficient C is equal to zero. This equation is useful only for relatively narrow temperature ranges, otherwise the conversion error may become too large.

NE: NTC exponential

$$R=alpha\cdot\exp(beta/T)$$

Figure 39: Conversion equation for NE probe type

4.2.6 TK: Thermocouple Type K

TK is a deviation function for the thermocouple of type K. Deviation function is given as the difference between the measured emf and the emf reference function according to IEC 60584-1 for the particular thermocouple type. Cold junction of measured and reference emf is at 0 °C. If cold junction of the measured thermocouple is not at 0 °C, measured emf is corrected for the difference between 0 °C and cold junction temperature. Conversion is valid in the temperature range from -200 °C to 1370 °C.

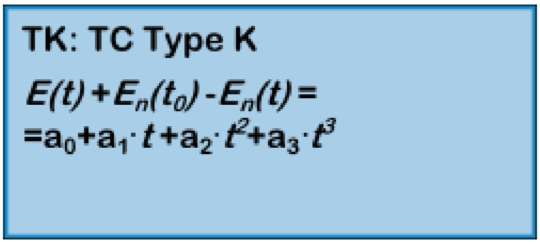

Figure 40: Conversion equation for TK probe type

4.2.7 TJ: Thermocouple Type J

TJ is a deviation function for the thermocouple of type J. Deviation function is given as the difference between the measured emf and the emf reference function according to IEC 60584-1 for the particular thermocouple type. Cold junction of measured and reference emf is at 0 °C. If cold junction of the measured thermocouple is not at 0 °C, measured emf is corrected for the difference between 0 °C and cold junction temperature. Conversion is valid in the temperature range from -200 °C to 1200 °C.

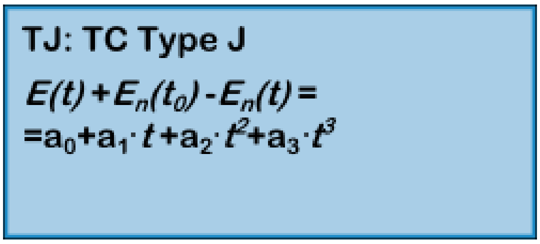

Figure 41: Conversion equation for TJ probe type

4.2.8 TT: Thermocouple Type T

TT is a deviation function for the thermocouple of type T. Deviation function is given as the difference between the measured emf and the emf reference function according to IEC 60584-1 for the particular thermocouple type. Cold junction of measured and reference emf is at 0 °C. If cold junction of the measured thermocouple is not at 0 °C, measured emf is corrected for the difference between 0 °C and cold junction temperature. Conversion is valid in the temperature range from -200 °C to 400 °C.

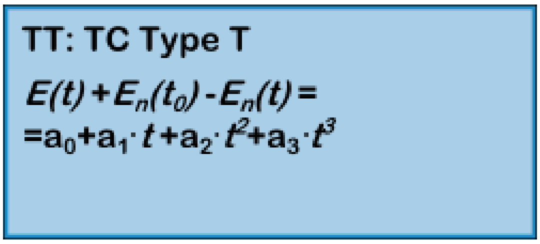

Figure 42: Conversion equation for TK probe type

4.2.9 TE: Thermocouple Type E

TE is a deviation function for the thermocouple of type E. Deviation function is given as the difference between the measured emf and the emf reference function according to IEC 60584-1 for the particular thermocouple type. Cold junction of measured and reference emf is at 0 °C. If cold junction of the measured thermocouple is not at 0 °C, measured emf is corrected for the difference between 0 °C and cold junction temperature. Conversion is valid in the temperature range from -200 °C to 1000 °C.

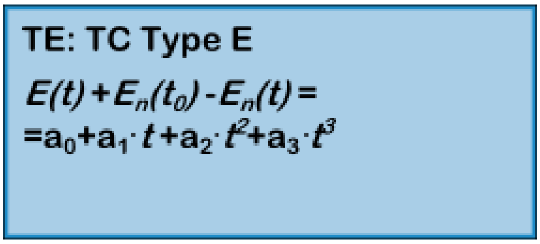

Figure 43: Conversion equation for TE probe type

4.2.10 TN: Thermocouple Type N

TN is a deviation function for the thermocouple of type N. Deviation function is given as the difference between the measured emf and the emf reference function according to IEC 60584-1 for the particular thermocouple type. Cold junction of measured and reference emf is at 0 °C. If cold junction of the measured thermocouple is not at 0 °C, measured emf is corrected for the difference between 0 °C and cold junction temperature. Conversion is valid in the temperature range from -200 °C to 1300 °C.

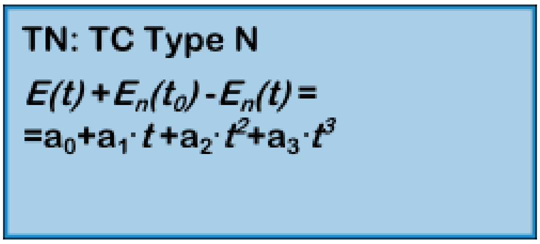

Figure 44: Conversion equation for TN probe type

4.2.11 TS: Thermocouple Type S

TS is a deviation function for the thermocouple of type S. Deviation function is given as the difference between the measured emf and the emf reference function according to IEC 60584-1 for the particular thermocouple type. Cold junction of measured and reference emf is at 0 °C. If cold junction of the measured thermocouple is not at 0 °C, measured emf is corrected for the difference between 0 °C and cold junction temperature. Conversion is valid in the temperature range from -50 °C to 1768 °C.

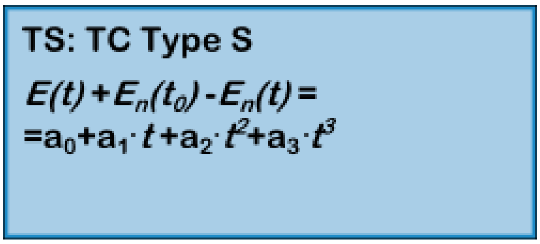

Figure 45: Conversion equation for TS probe type

4.2.12 TR: Thermocouple Type R

TR is a deviation function for the thermocouple of type R. Deviation function is given as the difference between the measured emf and the emf reference function according to IEC 60584-1 for the particular thermocouple type. Cold junction of measured and reference emf is at 0 °C. If cold junction of the measured thermocouple is not at 0 °C, measured emf is corrected for the difference between 0 °C and cold junction temperature. Conversion is valid in the temperature range from -50 °C to 1768 °C.

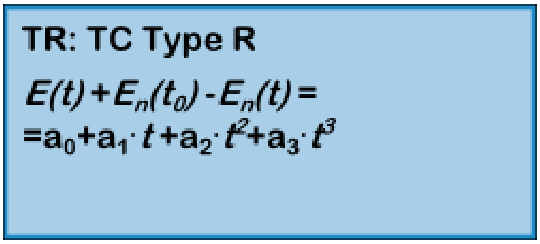

Figure 46: Conversion equation for TS probe type

4.2.13 TB: Thermocouple Type B

TB is a deviation function for the thermocouple of type B. Deviation function is given as the difference between the measured emf and the emf reference function according to IEC 60584-1 for the particular thermocouple type. Cold junction of measured and reference emf is at 0 °C. If cold junction of the measured thermocouple is not at 0 °C, measured emf is corrected for the difference between 0 °C and cold junction temperature. Conversion is valid in the temperature range from 300 °C to 1820 °C.

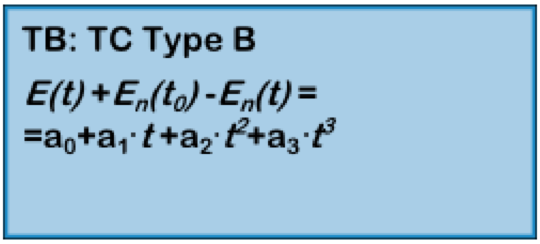

Figure 47: Conversion equation for TB probe type

4.3 Ambient probes

UT-ONE features three additional ambient probes. The internal thermometer on channel TJ is used for the cold-junction compensation for thermocouple measurements. The internal thermometer on channel TI is used for the temperature compensation of resistance and emf readings. The optional external combined probe for relative humidity and air temperature on channels RH and TA is used primarily for monitoring ambient conditions. All ambient probes have a direct indication in temperature or relative humidity, but to improve the accuracy, a deviation function obtained in calibration can be entered in UT-ONE.

4.3.1 Relative humidity deviation function

Relative humidity deviation function is applicable to channel RH of the external combined probe. UT-ONE implements the relative humidity function with up to six coefficients, which can provide excellent accuracy over wide temperature and relative humidity range. In most applications, especially if the combined probe is used only for monitoring ambient conditions in a laboratory, a linear deviation function with coefficients a_0 and a_1 is sufficient. In this case, set the unused coefficients to zero.

$$RH - RH_{RAW} = a_0 + a_1 \cdot RH + a_2 \cdot RH^2 + a_3 \cdot t + a_4 \cdot t \cdot RH + a_5 \cdot t \cdot RH^2$$

4.3.2 Temperature deviation function

Temperature deviation function is applicable to channels TA of the external combined probe, TJ of the internal CJC thermometer and TI of the internal ADC thermometer. UT-ONE implements the temperature deviation function with up to four coefficients, which can provide excellent accuracy over wide temperature range. In most applications, especially for monitoring ambient conditions in a laboratory or for cold junction compensation, a linear deviation function with coefficients a_0 and a_1 is sufficient. In this case, set the unused coefficients to zero.

$$t - t_{RAW} = a_0 + a_1 \cdot t + a_2 \cdot t^2 + a_3 \cdot t^3$$

5 Remote Communication Interface

Remote communication interface can be used to control the device from a computer using the RS232 or USB interface. Remote interface operation has no effect on the device measurement capabilities and both interfaces can be accessed independently at maximum supported speed.

5.1 RS232 interface

RS232 is a low-speed serial communication interface, popular in measurement devices due to its simplicity, robustness and reliability. Although RS232 interface is becoming less common on personal computers and especially laptops, low-cost USB-RS232 adapters are available.

RS232 inteface settings:

- Odd parity
- 8 data bits
- 1 or 2 stop bit
- Baud rate is software selectable (300, 600, 1200, 4800, 9600, 19200 or 38400)

Connection cable is a straight cable (not crossed or null-modem cable), also known as extension cable. Note that only pins 2, 3 and 5 are internally connected. Note that GND connection effectively connects the computer ground and the device digital ground. Use of dedicated cable with proper shielding and reasonable length is recommended. If a long cable is required, only three lines (2, 3 and 5) are mandatory.

RS232 connector is located on the back side of UT-ONE, just under the power supply connector. Connector is the standard DB-9 female connector. Computers and most USB-RS232 adapters have a standard DB-9 male connector. The connection cable must therefore have one male and one female DB-9 connector. It is possible to connect several connection cables in series. Alternatively, a compatible USB-RS232 adapter may be connected directly to UT-ONE without the use of additional connection cable.

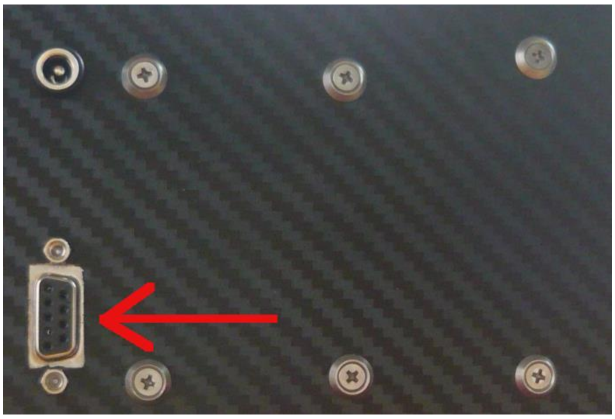

Figure 48: RS232 connector on the back-side of UT-ONE

Figure 49: RS232 connection cable

Figure 50: USB-RS232 adapter

5.2 USB interface

USB interface is a fast and reliable communication protocol, readily available on most personal computers. USB interface is compatible with USB 2.0 standard and implements Full speed communication (12 Mbits/s).

For the USB interface it is recommended to use the LabVIEW drivers provided by Batemika. These drivers internally implement the USB protocol, so the user can directly write and read message from the device.

In case the user chooses to implement the USB driver in another programming language, use the following protocol parameters:

- Vendor ID: 0x03EB
- Product ID: 0xC147
- Manufacturer name: Batemika
- Model name: UT-ONE
- Serial number: unique for each device
- Transfer type: bulk transfer on endpoint 1

USB connector is located in the front side of the UT-ONE. Connector is a standard 'B' receptacle.

Connection cable must be a dedicated double screened USB 2.0 compatible cable with standard 'A' plug on computer side and standard 'B' plug on device side. Use of ferrite cores on the connection cable is recommended. Never use unshielded USB 1.1 compatible cables or cables exceeding 3 meters in length.

USB remote interface requires device driver installation after the device is connected to the computer for the first time. Use the *.inf file provided by the manufacturer to install support for LabVIEW drivers.

USB interface can also be used to power UT-ONE. Note that UT-ONE can require up to 500 mA of supply current, which is the standard limit for a single USB port. Note that some USB ports (especially on economy laptop computers) may not be able to provide sufficient power. In this case, use an external USB hub with a separate power supply. Use of external hubs without separate power supply (bus powered) is not recommended.

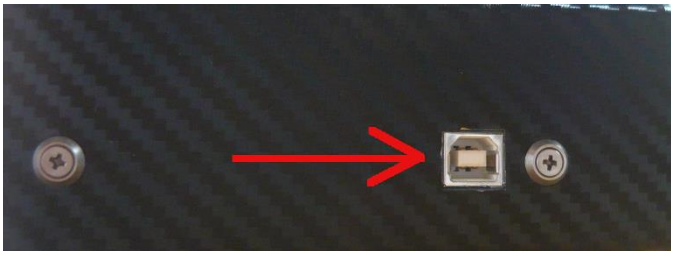

Figure 51: USB connector on the front side of UT-ONE

Figure 52: USB cable with two ferrite cores

5.3 Command syntax

Command set is identical for both the RS232 and USB communication interfaces. However, RS232 is considerably slower, so commands involving transfer of large blocks of data are more suitable for USB communication interface.

Communication protocol is based strictly on the client-server architecture. The computer starts the command by sending the command message and the device always replies with the response message. Each message is terminated with the line feed character (hexadecimal value 0x0A).

Input and output communication buffers are 255 bytes long, so messages exciding 255 characters will result in a communication error.

Commands can be sent at any rate without affecting the device operation or accuracy of measurements. Commands can be sent by both RS232 and USB interfaces simultaneously. Always read the response message before starting the next command. Sending several concatenated command messages together is not allowed. When using USB interface, always send the entire message in a single data block.

Commands never wait for some operation to complete, they always return the current status or data. The turnaround time is typically around 2 ms and always bellow 100 ms. Note that this does not include the data transfer time, which may be considerable for long message and low baud rates with RS232 interface.

Response message is constructed of obligatory status message and optional data message. Status message is defined by the first two characters of the response message. Status message are:

- *OK* signals that the command was correctly executed
- *E1* signals a syntax error in the command message
- *E2* signals invalid parameter value or format
- *E3* signals invalid CRC value in a data block
- *E4* signals communication error on the interface level
- *E5* signals that the communication buffer for data transfer to display is full
- *E6* signals that command is valid, but cannot be accepted at this time
- *E7* to *E9* are reserved values

Command and response messages are constructed exclusively of printable ASCII characters. Messages are case sensitive, so use only capital letters. In addition to this, binary data of any value can be sent using a binary block structure. Binary block is always placed in the beginning of the command message and after status in the response message. Binary block syntax is:

#ddd{ *binary data of size ddd*}

The hash character # marks the beginning of the binary block. Three decimal digits ddd specify the length of binary data. This length does not include the #ddd{ and }, it includes only the net length of binary data. The opening braces character { marks the beginning of the binary data and the closing braces character marks the end of the binary data. Binary data consists of ddd characters of any value, including line feed, zero character and braces. Note that the end of binary data is defined by the length ddd, the closing braces is just a syntax element. A closing braces character within the binary data will not signal the end of binary block.

Numeric constants must follow exact syntax without any flexibility. For integer constants, observe the specified number of digits and if necessary, prepend the required number of zeros. Use – character as sign for negative numbers, any other character is accepted for positive sign (for example space character or +). For floating point numbers used a signed BCD format with 12 digits and exponent in range from -99 to 99:

±d.dddddddddddE±ee

Examples of valid BCD numbers are -1.23456789012E-34, +3.14159265359E+00 and 0.00000000000E+00. If the first digit of mantissa is equal to zero, the whole number is treated as zero. Adjust the exponent so that the first digit of mantissa is not equal to zero.

Numeric values in binary format are stored in little-endian format (least significant byte first).

Packed BCD format stores one floating-point BCD in 8 eight bytes of memory. 6 bytes are used for decimal digits dd (two digits in each byte), one is used for sign ss (0x0C for positive sign and 0x0D for negative sign). Exponent ee in range from -99 to 99 is stored in signed two's complement binary format (one byte).

dd dd dd dd dd dd ss ee

5.4 Command set

UT-ONE command set consists of the following commands:

5.4.1 B?

Return the binary block with binary values directly from analog to digital converter (ADC). Each block contains 15 ADC readings, which correspond to one second of measurements. This command is useful only for troubleshooting and advanced applications.

Command message: B?
Response message: OK#055{<*binary block data*>}

Binary block data consists of:

- ADC buffer index (0x00 or 0x80) (1 byte)
- Channel index (0x00 = C0, 0x01 = C1 and 0x02 = C2) (1 byte)
- Real time clock in binary format, expressed as number of seconds since 1.1.2000 (4 bytes)
- Cold junction temperature in displaced binary format (4 bytes)
- 15 uncorrected ADC readings in displaced binary format (15 * 3 bytes)

Example:
Command message: `B?`
Response message: `OK#055{` *`8000 AB88 451B F6F4 7C01 B7D6 4CB9 D64C B3D6 4CB4 D64C B1D6 4CAE D64C BBD6 4CB6 D64C B5D6 4CBF D64C BED6 4CB8 D64C B5D6 4CB3 D64C A8D6 4C`* `}`

5.4.2 CPCx?

Return the currently selected probe index for channel Cx. Cx can be either C1, C2 or C3. Probe index can be any probe index according to probe list from 0 to 44.

Command message: CPCx?
Response message: OK<*Probe index*>

Example:
Command message: `CPC1?`
Response message: `OK21`

5.4.3 CPCx <Probe index>

Set the new probe index for channel Cx. Cx can be either C1, C2 or C3. Probe index can be any probe index according to probe list from 0 to 44.

Command message: CPCx <*Probe index*>
Response message: OK

Example:
Command message: `CPC1 23`
Response message: `OK`

5.4.4 CRCx?

Return the currently selected measurement range label for channel Cx. Cx can be either C1, C2 or C3. Valid measurement range labels are RA, R1, R2, R3, R4, R5, R6, HA, H1, H2, H3, H4, H5, H6, EA, E1, E2, E3, E4, E5,E6, rA, r1, r2, r3, r4, r5, r6, hA, h1, h2, h3, h4, h5 and h6.

Command message: CRCx?
Response message: OK<*Measurement range label*>

Example:
Command message: `CRC1?`
Response message: `OKR3`

5.4.5 CRCx <Measurement range label>

Set the new measurement range label for channel Cx. Cx can be either C1, C2 or C3. Valid measurement range labels are RA, R1, R2, R3, R4, R5, R6, HA, H1, H2, H3, H4, H5, H6, EA, E1, E2, E3, E4, E5,E6, rA, r1, r2, r3, r4, r5, r6, hA, h1, h2, h3, h4, h5 and h6.

Command message: CRCx <*Measurement range label*>
Response message: OK

Example:
Command message: `CRC2 E1`
Response message: `OK`

5.4.6 CECx?

Return the channel status for channel Cx. Cx can be either C1, C2 or C3. Channel status determines if the channel is included in the acquisition sequence. Channel status can be either ON (enabled channel, included in the acquisition sequence) or OF (disabled channel, excluded from the acquisition sequence).

Command message: CECx?
Response message: OK<*Channel status*>

Example:
Command message: `CEC1?`
Response message: `OKON`

5.4.7 CECx <Channel Status>

Set the new channel status for channel Cx. Cx can be either C1, C2 or C3. Channel status determines if the channel is included in the acquisition sequence. Channel status can be either ON (enabled channel, included in the acquisition sequence) or OF (disabled channel, excluded from the acquisition sequence).

Command message: CSCx <*Channel status*>
Response message: OK

Example:
Command message: `CSC1 OF`
Response message: `OK`

5.4.8 CACx?

Return the averaging time in seconds for channel Cx. Cx can be either C1, C2 or C3. Averaging time is the time it takes to acquire the particular channel in the acquisition sequence. Averaging time can be set in steps of 2 seconds from 2 seconds to 240 seconds. Increasing averaging time will reduce measurement noise and decrease acquisition rate.

Command message: CACx?
Response message: OK<*Averaging time*>

Example:
Command message: `CAC1?`
Response message: `OK010`

5.4.9 CACx <Averaging time>

Set the averaging time for channel Cx. Cx can be either C1, C2 or C3. Averaging time is the time it takes to acquire the particular channel in the acquisition sequence. Averaging time can be set in steps of 2 seconds from 2 seconds to 240 seconds. Increasing averaging time will reduce measurement noise and decrease acquisition rate.

Command message: CACx <*Averaging time*>
Response message: OK

Example:
Command message: `CAC1 012`
Response message: `OK`

5.4.10 CCCx?

Return the measurement current setting for channel Cx. Cx can be either C1, C2 or C3. Measurement current can be set to either NR or RD setting. Normal setting is NR and this setting should be used for all measurements. At RD setting, the measurement current for the selected channel is reduced by √2. Use this feature to estimate the self-heating error.

Command message: CCCx?
Response message: OK<*Measurement current setting*>

Example:
Command message: `CCC1?`
Response message: `OKNR`

5.4.11 CCCx <Measurement current setting>

Set the measurement current for channel Cx. Cx can be either C1, C2 or C3. Measurement current can be set to either NR or RD setting. Normal setting is NR and this setting should be used for all measurements. At RD setting, the measurement current for the selected channel is reduced by √2. Use this feature to estimate the self-heating error.

Command message: CCCx *<Measurement current setting>*
Response message: OK

Example:
Command message: `CCC2 RD`
Response message: `OK`

5.4.12 DS?

Return current acquisition status. If acquisition status is enabled (ON), UT-ONE will sequential measure all enabled channels in the acquisition sequence. If acquisition status is disabled (OF), measurements on channels C1, C2 and C3 will not be performed.

Command message: DS?
Response message: OK*<Acquisition status>*

Example:
Command message: `DS?`
Response message: `OKON`

5.4.13 DS <Acquisition status>

Set new acquisition status. If acquisition status is enabled (ON), UT-ONE will sequential measure all enabled channels in the acquisition sequence. If acquisition status is disabled (OF), measurements on channels C1, C2 and C3 will not be performed. This command is equivalent to touching the START or STOP buttons on UT-ONE user interface.

Command message: DS *<Acquisition status>*
Response message: OK

Example:
Command message: `DS OF`
Response message: `OK`

5.4.14 DB?

Return current baud rate setting for RS232 communication interface. Baud rate settings are:

- B0 = 300 baud
- B1 = 600 baud
- B2 = 1200 baud
- B3 = 2400 baud
- B4 = 4800 baud
- B5 = 9600 baud
- B6 = 19200 baud
- B7 = 38400 baud (default)

Command message: DB?
Response message: OK<*Baud rate setting*>

Example:
Command message: `DB?`
Response message: `OKB7`

5.4.15 DB <Baud rate setting>

Set new baud rate setting for RS232 communication interface. New setting will become active after you restart UT-ONE.

Command message: DB <*Baud rate setting*>
Response message: OK

Example:
Command message: `DB B5`
Response message: `OK`

5.4.16 DX OF

Start the shutdown sequence. UT-ONE will stop acquisition, store non volatile settings, release resources and shut down the power supply. Starting the UT-ONE using the communication interface is not possible.

Command message: DX OF
Response message: OK

Example:
Command message: `DX OF`
Response message: `OK`

5.4.17DDCx < Frequency index >

Start acquisition on channel Cx in fast digitizing mode using specified sampling frequency. Channel name Cx can be either C1, C2 or C3. Fast digitizing mode is available only on USB communication interface. Fast digitizing mode will stop normal acquisition sequence. Acquisition of samples is continuous and there is no current reversal. Acquisition parameters will be set according to the measurement range configuration for the specified channel. Note that absolute accuracy is significantly lower in fast digitizing mode and readings may be subject to interference and drift. Sampling frequency is set according to specified frequency index:

- 1 470 Hz
- 2 242 Hz
- 3 123 Hz
- 4 62 Hz
- 5 50 Hz
- 6 39 Hz
- 7 33.2 Hz
- 8 19.6 Hz (60 Hz line rejection)
- 9 16.7 Hz (50 Hz line rejection)
- A 16.7 Hz (50 Hz and 60 Hz line rejection)
- B 12.5 Hz (50 Hz and 60 Hz line rejection)
- C 10 Hz (50 Hz and 60 Hz line rejection)
- D 8.33 Hz (50 Hz and 60 Hz line rejection)

- E 6.25 Hz (50 Hz and 60 Hz line rejection)
- F 4.17 Hz (50 Hz and 60 Hz line rejection)

Command message: DDCx < *Frequency index* >
Response message: OK

Example:
Command message: `DDC1 A`
Response message: `OK`

After the command is successfully processed, UT-ONE enters in fast digitizing mode and starts automatic sending of data via USB communication interface. Data is sent in blocks of 240 bytes, each containing 80 24bit raw ADC readings. If you write any data to UT-ONE via USB interface, fast digitizing mode will be immediately terminated, but the last block of data may interfere with the command response.

5.4.18 EP<Probe index>?

Return probe data for given probe index. Probe data is stored in a binary structure specified in the *Probe coefficients* chapter. Probe data is 128 bytes long and is terminated with two CRC characters, which ensure data integrity. Probe data is transferred in a binary block.

Command message: EP<*Probe index*>?
Response message: OK#128{ *Probe data* }

Example:
Command message: `EP21?`
Response message:

```
OK#128{ 5074 2D31 3030 2020 4953 4F2F 4945 4337 3531 2020
5043 1000 0000 0000 0C02 3908 3000 0000 0CFD 5775 0000
0000 0DF9 4183 0000 0000 0DF4 0000 0000 0000 0000 0000
0000 0000 0000 0000 0000 3132 3334 3536 3738 3930 3132
3334 3536 3738 3930 3132 3334 3536 3738 3930 3132 3334
3536 3738 3930 3132 3334 3536 3738 3930 3132 4716 }
```

5.4.19 EP<Probe index>

Set new user-defined probe data for given probe index. Note that probe index must be between 1 and 20 in order to store a new user-defined probe data. Probe data is stored in a binary structure specified in the *Probe coefficients* chapter. Probe data is 128 bytes long and is terminated with two CRC characters, which ensure data integrity. Probe data is transferred in a binary block.

Command message: <*Binary block with probe data* >EP<*Probe index*>
Response message: OK

Example:
Command message:

```
#128{ 5074 2D31 3030 2020 4953 4F2F 4945 4337 3531 2020
5043 1000 0000 0000 0C02 3908 3000 0000 0CFD 5775 0000
0000 0DF9 4183 0000 0000 0DF4 0000 0000 0000 0000 0000
0000 0000 0000 0000 0000 3132 3334 3536 3738 3930 3132
3334 3536 3738 3930 3132 3334 3536 3738 3930 3132 3334
3536 3738 3930 3132 3334 3536 3738 3930 3132 4716 }EP14
```

Response message: `OK`

5.4.20 I?

Return identification string from UT-ONE.

Command message: I?
Response message: OK< *identification string* >

Example:
Command message: `I?`
Response message: `OKBatemika, UT-ONE`

5.4.21 IS?

Return serial number from UT-ONE.

Command message: IS?
Response message: OK< serial number >

Example:
Command message: `IS?`
Response message: `OKB01010915`

5.4.22 IP?

Return production number from UT-ONE.

Command message: IP?
Response message: OK< production number >

Example:
Command message: `IP?`
Response message: `OKUTONE 0201250813-04020402`

5.4.23 IM?

Return measurement modul number from UT-ONE.

Command message: IM?
Response message: OK< measurement modul number >

Example:
Command message: `IM?`
Response message: `OKA3010 0003150314-0603010`

5.4.24 IV?

Return firmware version from UT-ONE.

Command message: IV?
Response message: OK< firmware version >

Example:
Command message: `IV?`
Response message: `OK2.03.01r`

5.4.25 L?

Return data sent directly from display. Data is returned within the binary block. If there is no data available, this command returns status OK only and no binary block

Command message: L?
Response message: OK< *binary block with display data*>

Example:
Command message: `L?`
Response message: `OK#040{ 0001 0000 0001 0C00 0000 0000 0000 0C00 0000 0000 0000 0C00 0000 0000 0000 0C00 0000 0000 0000 0C00 }`

5.4.26 LW

Send data sent directly to display. If the buffer for transfer to display is full, command will return error E5. In this case, resend the command.

Command message: < *binary block with display data*>LW
Response message: OK

Example:
Command message: `#040{ 0001 0000 0001 0C00 0000 0000 0000 0C00 0000 0000 0000 0C00 0000 0000 0000 0C00 0000 0000 0000 0C00 }LW`
Response message: `OK`

5.4.27 M< Channel name >?

Return the current measurement for the given channel. Channel name can be any channel name except real time value RT, which is returned by default. Channel values are updated after the end of the acquisition sequence. If acquisition status is OF, channel values are not updated. Real time value is given as unsigned integer, which specifies the number of seconds elapsed since 01.01.2000. Channel value is given as a BCD numeric.

Command message: M< *Channel name* >?
Response message: OKRT:< *Real time value* >,< *Channel name* >:< *Channel value* >

Example:
Command message: `MTA?`
Response message: `OKRT: 0457638877,TA:+2.45400060000E+01`

5.4.28 MT?

Return the current measurements for seven main channels, which are also displayed on the display (C1, C2, C3, RH, TA, TD and TJ). Channel values are updated after the end of the acquisition sequence. If acquisition status is OF, channel values are not updated. Real time value is given as unsigned integer, which specifies the number of seconds elapsed since 01.01.2000. Channel value is given as a BCD numeric. If the channel is disabled, the channel value is returned as "******************".

Command message: MT?

Response message: OKRT:< *Real time value* >,C1:< *Channel C1 value* >,C2:< *Channel C2 value* >,C3:< *Channel C3 value* >,RH:< *Channel RH value* >,TA:< *Channel TA value* >,TD:< *Channel TD value* >,TJ:< *Channel TJ value* >

Example:

Command message: `MT?`

Response message:
```
OKRT:
0457639129,C1:+8.61986654000E+02,C2:*******************,
C3:*******************,RH:+6.03755100000E+01,TA:+2.4540006
0000E+01,TD:+1.63703740000E+01,TJ:+2.50272300000E+01
```

5.4.29 MR?

Return the current measurements for seven raw-data channels (B1, B2, B2, BH, BA, BD and BJ). Channel values are updated after the end of the acquisition sequence. If acquisition status is OF, channel values are not updated. Real time value is given as unsigned integer, which specifies the number of seconds elapsed since 01.01.2000. Channel value is given as a BCD numeric. If the channel is disabled, the channel value is returned as "******************".

Command message: MR?

Response message: OKRT:< *Real time value* >,B1:< *Channel B1 value* >,B2:< *Channel B2 value* >,B3:< *Channel B3 value* >,BH:< *Channel BH value* >,BA:< *Channel BA value* >,BD:< *Channel TD value* >,BJ:< *Channel BJ value* >

Example:

Command message: `MR?`

Response message:
```
OKRT:
0457656074,B1:+9.99297740000E+01,B2:*******************,
B3:*******************,BH:+5.82529820000E+01,BA:+2.4320006
0000E+01,BD:+1.56051900000E+01,BJ:+2.44171180000E+01
```

5.4.30 ML?

Return the value of the last measured channel in the acquisition sequence (channels C1, C2 or C3). Channel values are normally updated simultaneously after the end of the acquisition sequence, but this command allows the reading of channel value immediately after channel acquisition is completed. This allows a smoother adding of values to the graph and assigns the exact time to each channel.

If acquisition status is OF, channel values are not updated. Real time value is given as unsigned integer, which specifies the number of seconds elapsed since 01.01.2000. Channel value is given as a BCD.

Command message: ML?

Response message: OKRT:< *Real time value* >,< *Last channel name* >:< *Last channel value* >

Example:

Command message: `ML?`

Response message: `OKRT: 0457656194,C1:+8.61990734000E+02`

5.4.31 MI?

Returns the immediate measurement values for channels that are not acquired within acquisition sequence (RH, TA, TD, TJ and TI). The values are not synchronized to the end of the acquisition sequence. Values are updated regardless of the acquisition status. Real time value is given as unsigned integer, which specifies the number of seconds elapsed since 01.01.2000. Channel value is given as a BCD numeric.

Command message: MI?

Response message: OKRT:< *Real time value* >,RH:< *Channel RH value* >,TA:< *Channel TA value* >,TD:< *Channel TD value* >,TJ:< *Channel TJ value* >,TI:< *Channel TI value* >

Example:

Command message: `MI?`

Response message:
```
OKRT:
0457656600,RH:+5.80266700000E+01,TA:+2.43900060000E+01,
TD:+1.56097260000E+01,TJ:+2.43244460000E+01,TI:+2.1309854
0000E+01
```

5.4.32 MB?

Returns the current values of LiPo battery monitoring channels (VB, SC and ES). VB monitors battery voltage, SC monitors state of charge in % and ES monitors the presence of external power supply. The values are not synchronized to the end of the acquisition sequence. Values are updated regardless of the acquisition status. Real time value is given as unsigned integer, which specifies the number of seconds elapsed since 01.01.2000. Channel value is given as a BCD numeric.

Command message: MB?

Response message: OKRT:< *Real time value* >,VB:< *Channel VB value* >,SC:< *Channel SC value* >,ES:< *Channel ES value* >

Example:

Command message: `MB?`

Response message:
```
OKRT:
0457656981,VB:+3.95500000000E+00,SC:+6.91320000000E+01,
ES:1
```

5.4.33 S<Channel><Reference Channel><Range><Samples>

Starts a single reading with selected settings. *Channel* is the channel name on which reading is acquired (valid channel names are B1, B2 and B3, or equivalently C1, C2 and C3). *Reference Channel* is the channel name on which a compatible external standard is connected (valid reference channel names are 00, B1, B2 and B3, or equivalently 00, C1, C2 and C3). Note that this feature is optional, if external standard is not used, enter 00 for reference channel name. *Range* is the label of the range, which will be used for acquiring the single reading. You may use bot manual and auto ranges (valid range labels are RA, R1, R2, R3, R4, R5, R6, HA, H1, H2, H3, H4, H5, H6, EA, E1, E2, E3, E4, E5,E6, rA, r1, r2, r3, r4, r5, r6, hA, h1, h2, h3, h4, h5 and h6). *Samples* is the number of samples that are acquired during acquisition of a single reading. Increasing the number of samples will increase acquisition time and improve noise levels and effective resolution. Valid number of samples is between 2 and 40. Default number of samples is 15, resulting in the same acquisition sequence as in continuous measurement.

Command returns immediately and does not wait for the single reading to be completed. The result of single reading can be retrieved with the S? command. The response message returns the real time value and channel label of the measurement result, which can be used to synchronize single reading retrieval.

If reference channel is specified, a compatible external standard must be defined using configuration window *8. External standards* and connected to the specified channel, otherwise error E2 will be reported.

If UT-ONE is making continuous measurements, they will be stopped immediately and single reading acquisition will start. Note that continuous measurement will not be automatically restarted after single reading is complete. If UT-ONE is already acquiring a single reading, ongoing single reading operation will not be interrupted and command will return error E6.

Command message: S<Channel><Reference Channel><Range><Samples>
Response message: OKRT:< *Real time value* >,Bx

Example:
Command message: `SB1B3R315?`
Response message: `OKRT: 0457654321,B1`

5.4.34 S?

Returns the result for the last completed single reading. Note that the command returns data immediately and does not wait for any ongoing single-reading measurement to complete. You may compare the timestamp and channel in the command response that started the single reading to avoid reading the older value. Result of single reading is valid until next single reading is completed, so it is possible to start a new reading before the results of previous single reading are read.

This command always returns raw value expressed in ohms for resistance or µV for emf.

Command message: S?
Response message: OKRT:< *Real time value* >,Bx:< *Channel Bx raw value* >

Example:
Command message: `S?`
Response message: `OKRT: 0457654321,B2:+1.08765432100E+02`

5.4.35 S<Probe index>?

Returns the result for the last completed single reading and converts it to temperature using specified probe data. Note that the command returns data immediately and does not wait for any ongoing single-reading measurement to complete. You may compare the timestamp and channel in the command response that started the single reading to avoid reading the older value. Result of single reading is valid until next single reading is completed, so it is possible to start a new reading before the results of previous single reading are read.

This command returns raw value expressed in ohms for resistance or µV for emf and a temperature value in °C, as converted using the specified probe. If you specify invalid or undefined probe, command does not perform any conversion and returns raw data for both Bx and Cx channels. You may specify standard and user-defined probes.

Command message: S< *Probe Index* >?
Response message: OKRT:< *Real time value* >,Bx:< *Channel Bx raw value* >,Cx:< *Channel Cx temperature value* >

Example:
Command message: `S21?`
Response message: `OKRT: 0496406082,B1:+9.99996000000E+01,C1:-1.02346273190E-03`

5.4.36 T?

Returns the current value of real time. Real time value is given as unsigned integer, which specifies the number of seconds elapsed since 01.01.2000.

Command message: T?
Response message: OK< *Real time value* >

Example:
Command message: `T?`
Response message: `OK+0457659060`

5.4.37 T< Real time value >

Sets the new value of real time. Real time value is given as unsigned integer, which specifies the number of seconds elapsed since 01.01.2000.

Command message: T< *Real time value* >
Response message: OK

Example:
Command message: `T+0457659065`
Response message: `OK`

5.4.38 Xx< BCD numeric >

Sets the new value of BCD numeric in BCD buffer Xx. Xx can be X1, X2 or X3. BCD buffers are used for testing of arithmetic and conversion functions.

Command message: Xx< *BCD numeric* >
Response message: OK

Example:
Command message: `X1+1.23456789012E-34`
Response message: `OK`

5.4.39 X< Operation >?

Perform an arithmetic operation or conversion function with arguments in BCD buffers and return the result. This command is used for testing arithmetic operations and conversion functions. Before executing this command, store the argument in the BCD buffers X1 and/or X2. Available operations are:

- M multiplication X3 = X1 * X2
- D division X3 = X1 / X2
- A addition X3 = X1 + X2
- S subtraction X3 = X1 – X2
- R decrement X1 = X1 – 1
- I increment X1 = X1 + 1
- L natural logarithm X3 = ln(X2)
- E exponential function X3 = exp(X2)
- H dew point X3 = Sonntag function(X1, X2)
- K square root X3 = sqrt(X2)
- 1 return X1 X1 = X1
- 2 return X2 X2 = X2
- 3 return X3 X3 = X3

Command message: X< *operation* >
Response message: OK< *BCD result* >

Example:
Command message: `XR?`
Response message: `OK-1.00000000000E+00`

5.4.40 X< Channel name >?

Performs a conversion to corrected temperature or relative humidity for the specified channel. Note that the same probe coefficients and settings are used as for the real conversion in acquisition sequence. Before executing this command, store the raw value (resistance, emf, uncorrected temperature or uncorrected relative humidity) for the channel in the BCD buffer X1. If internal CJC temperature is applicable, store it in the BCD buffer X2. Applicable channel names are C1, C2, C3, RH, TA and TJ.

Command message: X< *Channel name* >?
Response message: OK< *BCD result* >

Example:
Command message: `XC1?`
Response message: `OK-1.02500000000E+01`

5.4.41 X< Probe index >?

Performs a conversion to corrected temperature for specified probe. Note that the same probe coefficients and settings are used as for the real conversion in acquisition sequence. Before executing this command, store the raw value (resistance or emf) in the BCD buffer X1. If internal CJC temperature is applicable, store it in the BCD buffer X2. If probe is invalid or undefined, no conversion is performed and command returns the unchanged raw value.

Command message: X< *Probe index* >?
Response message: OK< *BCD result* >

Example:
Command message: `X21?`
Response message: `OK+1.14500000000E+02`

6 Measurement Modes

UT-ONE is designed to provide the user with greatest possible flexibility, so it provides four different measurement modes for measurement on three main channels. Note that only one measurement mode can be active at any given time. Also, some measurement modes can only be activated using the remote communication interface and computer software.

Ambient channels are continuously acquired in the background, independently of the measurement mode of main channels. TI channel is acquired only in combination with an acquisition of a main channel, so its refresh rate is not guaranteed.

6.1 Continuous measurement mode

Continuous measurement mode is the basic measurement mode, which supports the operation via user interface and remote communication interface. User must first configure the channels using the *1. Main Channels Configuration* window or equivalent remote communication interface commands. Note that you may enable any number of main channels, including none.

The acquisition starts after you touch the green START button in the measurement window. Channels are acquired sequentially from the lowest channel index to the highest channel index. Disabled channels are skipped without any additional delay. If all main channels are disabled, only ambient channels are acquired at 4 second acquisition rate.

Measurement result in continuous measurement mode is assembled after the last main channel in acquisition sequence is completed. Current values of ambient channels are appended and the combined result is displayed in user interface, logged to the internal SD card and is available on remote communication interface.

Continuous measurement mode can be stopped manually using the red STOP button in the measurement window. The ongoing measurement is discarded and UT-ONE enters idle mode immediately. Also, initializing any other measurement mode will stop continuous measurement.

6.2 Single reading mode

Single reading mode is a measurement mode, used primarily for creating computer applications for automation of calibration and test procedures. Single reading mode can only be initialized using the remote communication interface. Single reading will acquire only resistance or emf. There is no direct conversion to temperature within the UT-ONE firmware.

Single reading is initialized remotely using the "S" command. User must specify one of the main channels, the measurement range and the number of samples. Refer to the command description for more details. This command only initializes the single-reading measurement, it does not wait for acquisition to complete. The returned value gives the timestamp and channel label of the incoming single-reading result.

The result of the single reading operation is obtained using the "S?" command. Note that this command returns the last result of a single reading acquisition. Use the timestamp and channel information obtained during the single-reading initialization to synchronize single-reading initialization and result retrieval.

Initializing a single reading will stop the continuous and digitizing measurement mode. However, if there is an ongoing single-reading acquisition, initializing another single-reading acquisition will fail with E6 error. The previously initialized single-reading acquisition will complete normally.

The result of a single reading is valid until the next single reading is completed. This means that initializing a single reading before reading the previous result is valid. This is important in multi-application environment.

After the single reading is completed, UT-ONE returns to idle measurement mode.

Measurement obtained in single-reading mode are not displayed on UT-ONE display and are not logged in the internal UT-ONE SD card.

Single reading measurement mode is particularly useful for creating computer applications that acquire measurements from UT-ONE channels according to any custom measurement procedure. Also, single reading mode can be used to effectively expand the number of input channels using an external multiplexer. In this case, use the following procedure:

- Stop any ongoing measurements or wait for them to complete
- Set the external multiplexer to requested channel and wait for it to settle
- Initialize a single reading
- Wait for the single reading to complete
- Read the result of a single reading
- Release the channel on the external multiplexer

6.3 Single reading mode with external standard

Accuracy of the UT-ONE measurement can be improved using the external standard, which is connected to one of the three main channels. Application of external standard is available only as an option in the single reading measurements. Continuous and digitizing measurements do not support application of external standard.

Single readings with external standard are initialized and read using the same procedure as normal single reading. In the initialization command, you have to specify the channel on which the external reference is connected. A compatible external reference must be defined in the *8. External Standards* configuration window.

Single reading with external standard is performed in three steps:

- A normal single reading on measured channel is performed and result is stored internally.
- Another single reading is performed on specified reference channel and result is stored internally. If applicable, temperature coefficient of the external standard is automatically implemented to correct any temperature drifts.
- The reading of the external standard is compared to its reference value and the difference is used to correct the reading on the measured channel. This removes any short-term and long-term drifts. The resulting reading is on measured channel is made available for reading over communication interface.

The application of external standard requires two internal single readings, so the total acquisition time is doubled. Also, the reading of external standard will introduce additional noise into the combined measurement result, so noisier measurements can be expected. To compensate for this increase in noise, you may choose to increase the number of samples per single reading, thus increasing acquisition time.

Optimal result in measurements with external standard can be achieved when a manual measurement range is specified and the value of the external reference is close to the range nominal limit. For example, when using Pt-25 probes over entire range, it is recommended to use manual measurement range R3 (100 Ω, 1 mA) and an external reference resistor with nominal value of 100 Ω. As another example, for Pt-100 probe up to 250 °C, it is recommended to use measurement range R4 (200 Ω, 1 mA) and external reference resistor with nominal value 200 Ω. Using reference resistors with values that are considerably lower than the nominal limit of measurement range will result in higher increase in measurement noise. Use of reference resistors with value less than 25% of the nominal limit of the measurement range is not recommended.

Alternatively, you may also use auto ranging feature with measurements with external standard. In this case auto ranging is performed independently for measured and reference channel, so optimal range is selected for each reading. This will result in optimal noise performance regardless of the reference resistor value (any value between 25 Ω and 800 Ω is suitable for PRT measurements). However, when different measurement ranges are chosen for the measured and reference channel, this results in only partial elimination of drift errors.

External standard feature is supported for PRT, thermistor and thermocouple measurements, but it is primarily advantageous for PRT measurement, where short-term and long-term drifts are the dominant source of error for the thermometer readout. For thermistors, external standard will reduce the drift error as well, but even without the external resistor, accuracy on the level of 1 mK is achievable, so further reduction is meaningless in most practical cases. For thermocouples, application of external standard may not be straightforward, as parasitic emf may obscure any potential benefits. Although Batemika does not promote the use of external standards for thermocouples, we live this option open for user investigation.

6.4 Digitizing measurement mode

UT-ONE supports a special measurement mode, which allows fast digitizing with a fixed measurement range on one main channel. This mode is applicable only using commands via remote communication interface. In this mode, you can take from 4 to 470 raw samples directly from the ADC output. In this mode, there is no current reversal for resistance measurements, no temperature coefficient correction and no linearity correction. For sampling rates above 50 Hz, there is also no suppression of mains frequency interference. The resulting accuracy is therefore significantly worse than accuracy specified for other measurement modes and this results should never be used to make absolute temperature measurements.

Digitizing measurement mode has two possible applications:

- Observation of very fast temperature phenomena, where general behavior is of interest, while absolute accuracy is not so relevant
- Using high sampling rates, existence of interference signals with mains frequency can be evaluated on probe inputs. This interference is normally filtered out by the UT-ONE algorithms, but it may have some residual effects. This is especially useful for troubleshooting on suspicious measurement results.

Digitizing mode can be programmed with commands described in the UT-ONE command set, but for convenience we recommend the use of digitizing application, available for free download from our website.

7 Batteries

UT-ONE has a built-in LiPo battery, which enables the use of the thermometer in standalone configuration without external power supply. Additionally, UT-ONE has a small button Li-ion battery for keeping track of real time clock.

Figure 53: UT-ONE batteries: extended or standard LiPo battery and button Li-ion battery

7.1 Standard or extended LiPo battery

UT-ONE features two types of LiPo battery. Standard LiPo battery has the capacity of 2000 mAh (7.4 Wh) and optional extended battery has the capacity of 6000 mAh (22.2 Wh). Apart from the triple capacity and therefore approximately triple operational and charging time, there are no differences between the standard and extended LiPo battery.

The current state of charge of the LiPo battery is displayed in the top right corner of the display and can be queried using the MB? communication-interface command. State of charge is expressed in % of full capacity.

LiPo battery is automatically recharged when the external power supply is connected. There is no need to remove the batteries and use the separate external charger.

LiPo batteries are sensitive devices, which are susceptible to overcharging, over discharging, short circuits, thermal shock and mechanical shock. UT-ONE features a double protection circuit to prevent overcharging, over discharging and short circuits. Charging and discharging current is set to approximately 250 mA, which is only 0.125C / 0.042C, so the stress to the battery during charging and discharging is minimal and there is no observable heating of the battery. Avoid using or storing the device outside the 0 °C to 50 °C temperature range in order to prevent permanent damage to the device and particularly to the battery.

UT-ONE has a software over discharge protection feature, which will shut down the device when state of charge falls below 5%. This safety margin allows the UT-ONE to be started for 60 seconds even if the battery is almost discharged. Note that the battery will continue to slowly self-discharge even if the device is switched off, so always recharge the battery before storage.

LiPo battery is designed for typical operational life of 500 charging/discharging cycles. Note that the decrease of battery capacity during operational life is normal. New batteries have a typical tolerance of battery capacity within ±15%. Battery capacity and operational life depend heavily on conditions of use, especially temperature conditions and discharge profiles. UT-ONE has a built-in cycle counter, which measures the number of performed charging/discharging cycles.

Typical operational time without any power-saving options is 8 hours for standard battery and 24 hours for extended battery. Typical charging time is 6 hours for standard battery and 18 hours for extended battery. The precise operational and charging times depend on temperature, battery operational life and UT-ONE status. Typical charging and discharging curves are presented below.

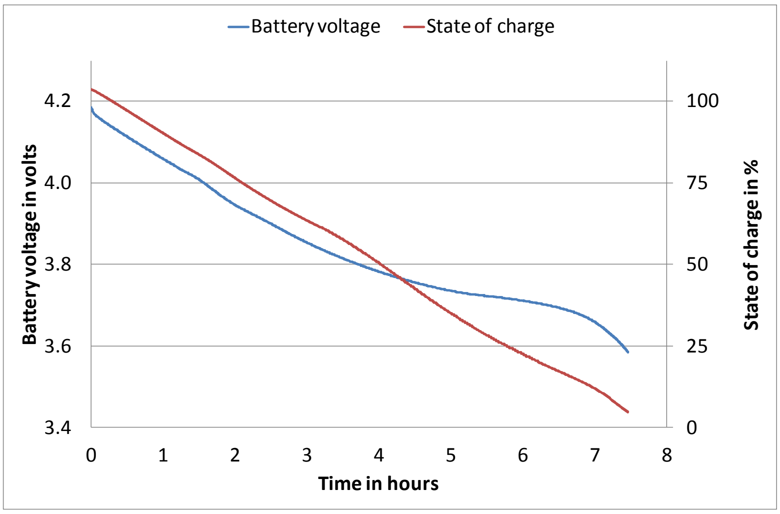

Figure 54: Typical discharging characteristics of standard LiPo battery

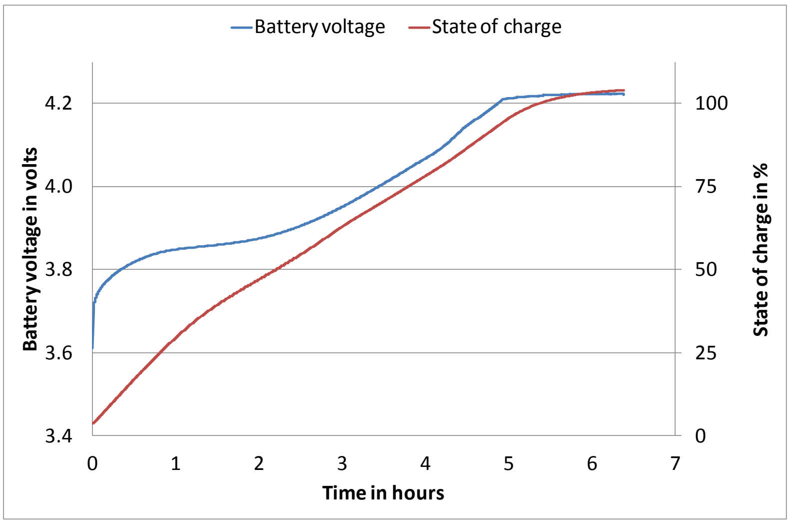

Figure 55: Typical charging characteristics of standard LiPo battery

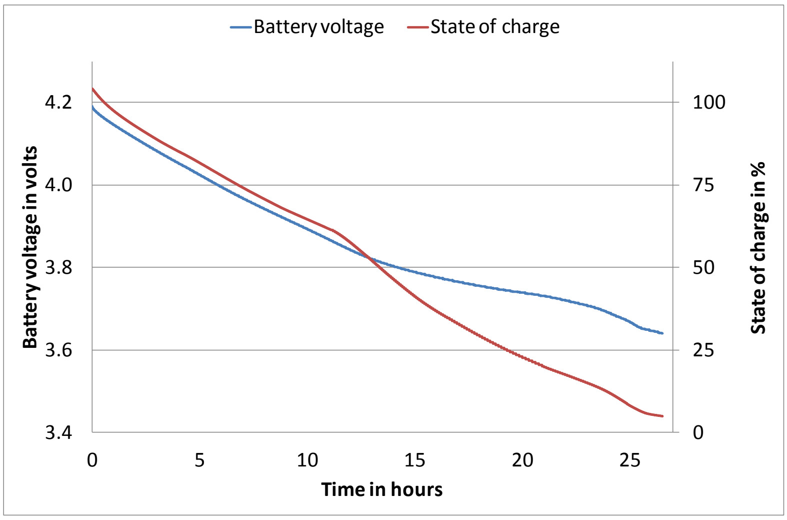

Figure 56: Typical discharging characteristics of extended LiPo battery

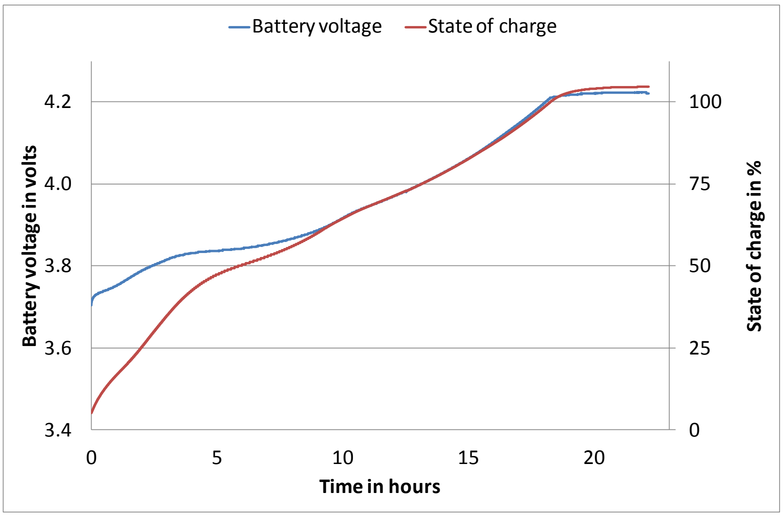

Figure 57: Typical charging characteristics of extended LiPo battery

7.2 Li-ion button battery

UT-ONE has a small Li-ion button battery (CR2032), which is used exclusively as a power backup for the real time clock. All other functions, including storage of calibration and configuration data are independent of the state of this battery.

This battery is not rechargeable. Normal operational life is 5 years, but this depends a lot on the conditions of use, ambient conditions and battery characteristics.

If your real time clock is continuously being reset at startup of UT-ONE, the battery is exhausted and needs to be replaced.

8 UT-ONE Applications Software

UT-ONE Applications is a software package for control and configuration of the UT-ONE thermometer readout via the remote communication interface. The aim of the UT-ONE Applications software is to provide a convenient general-purpose interface to the UT-ONE functionality from computer screen. UT-ONE Applications also demonstrate the capabilities of the UT-ONE thermometer readout and may be used as the starting point for developing user applications, covering a specific measurement solution.

UT-ONE Applications is based on LabVIEW platform and is distributed as executable installer, so LabVIEW development environment or any other additional licenses are not required.

UT-ONE Applications software package is available for free-of-charge download at www.batemika.com. UT-ONE Applications is licensed for use only with the UT-ONE thermometer readout. LabVIEW source code for selected applications and drivers is available on request for qualified customers. Development of derivative applications by the end-user is allowed only for use with UT-ONE thermometer readout. Commercial distribution of derivative applications to third parties is not allowed.

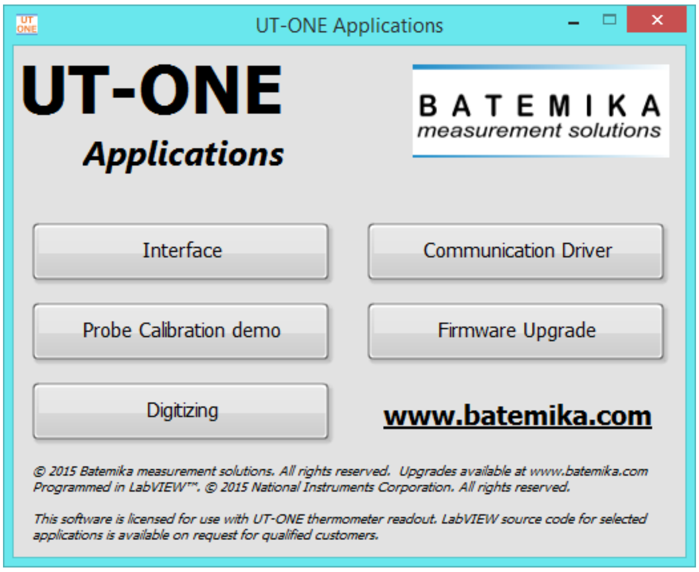

Figure 58: UT-ONE Applications launch panel

UT-ONE Applications starts with the launch panel, which enables the launching of individual applications. Applications may safely run in parallel, however some of the UT-ONE operations may interfere with each other, so some caution is required. After you launch the applications, you may safely close the launch panel and continue to use the launched applications. Launch panel can be reopened from the applications using the *UT-ONE Applications* button.

8.1 UT-ONE Interface

UT-ONE Interface is the application that implements the UT-ONE user interface on computer screen. The pages and views are organized in the same way as in the UT-ONE so the use is intuitive. You can choose between the Measurement and Configuration page using the tab selectors on the right-hand side of the window. You can choose between different views using the tab selectors on the top of the window. Measurements in continuous mode can be started and stopped using the green/red button in the bottom of the window. Clearing the readings will clear the readings from the graph, but not from the UT-ONE display. You can download the readings that are currently displayed on the UT-ONE graph using the *Download Measurements* button. Note that downloading is enabled only when acquisition is stopped and it can take several minutes for very large graphs. Measurements in the graph can be exported to the text file, which is formatted for direct import in MS Excel.

Measurement can be controlled from the UT-ONE user interface and from the UT-ONE Interface application at the same time, and both will adapt to the changes in the other interface.

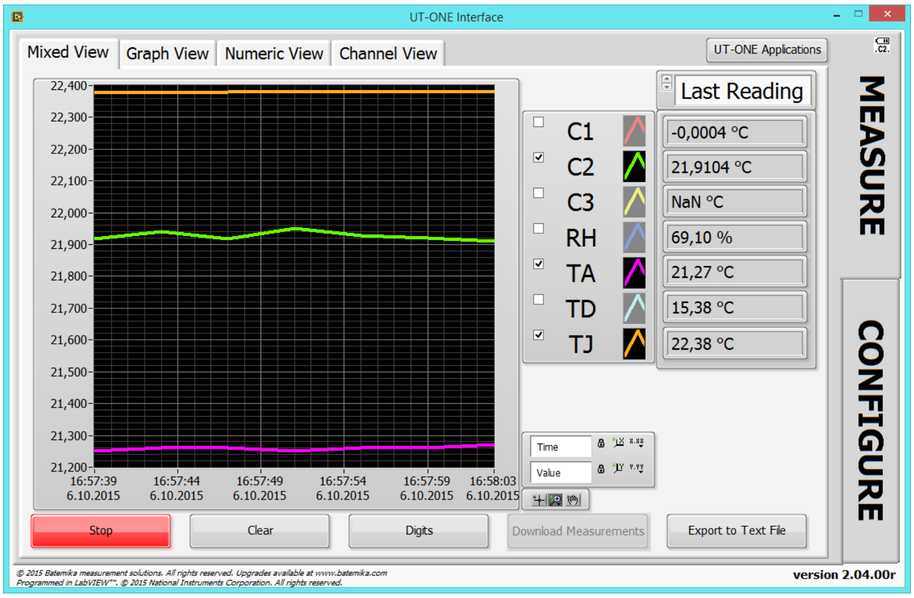

Figure 59: UT-ONE Interface mixed measurement view

Configuration page has similar views as in the UT-ONE user interface. User can change channel configuration, check the battery status and version information, synchronize UT-ONE time with the computer time, manage probe and range data, and take a snapshot of the UT-ONE screen.

When you make the changes to UT-ONE channel configuration, a green *Save* button and a red *Cancel* button are displayed. Note that changes are applied only after you click the Save button. If you change channels or views, changes will be lost without warning.

User probes can be conveniently reviewed, deleted and edited in the *Probes* view. This enables you to use copy/paste operation to enter coefficient, therefore reducing the possibility of typing errors. You can also save the probe data in a file, so it can be used as a backup or to be distributed to another UT-ONE unit.

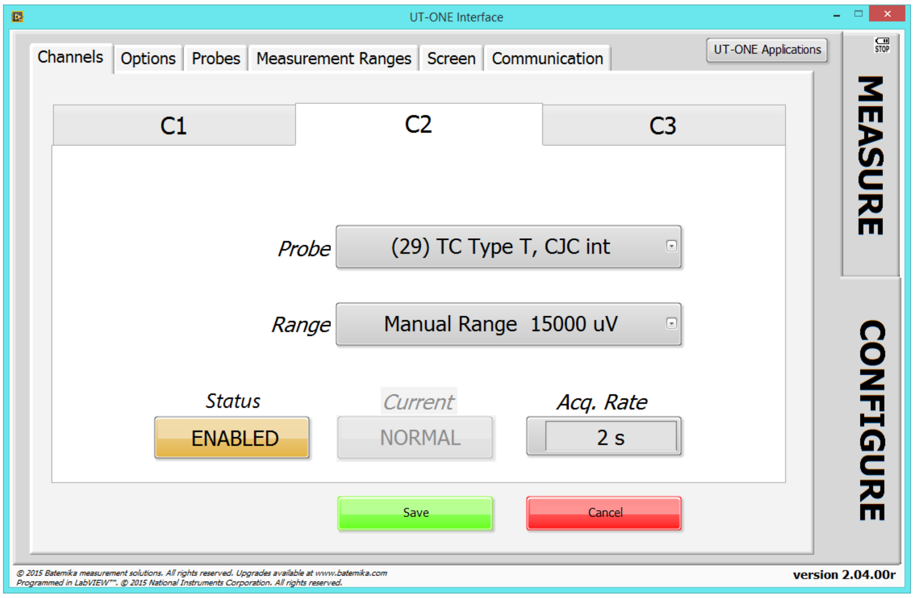

Figure 60: UT-ONE Interface channel configuration view

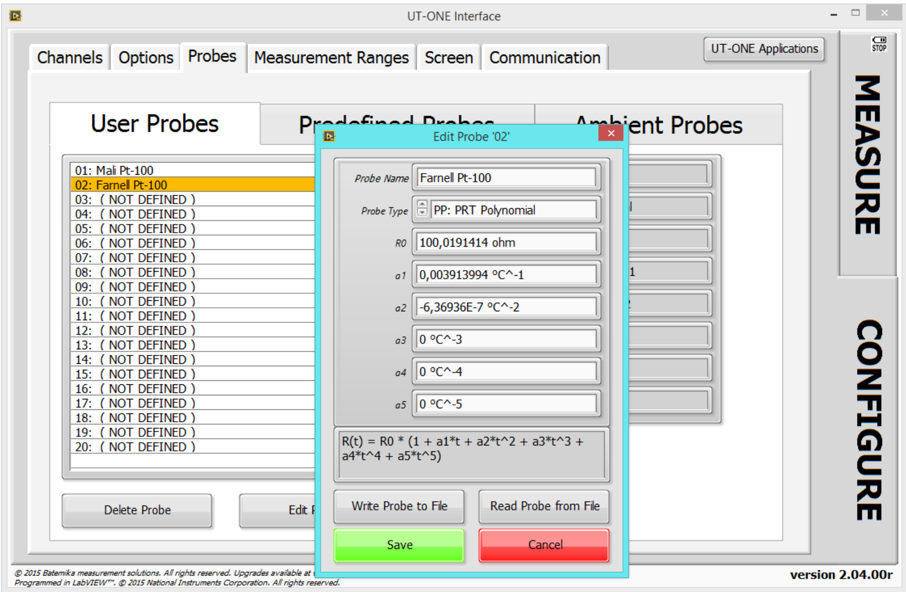

Figure 61: UT-ONE Interface probe editing

8.2 UT-ONE Probe Calibration Demo

UT-ONE Probe Calibration Demo application is a simple and convenient tool for calibration by comparison of platinum resistance, thermistor and thermocouple probes. This application performs the acquisition, data analysis and optionally stores the results to UT-ONE non-volatile memory.

Calibration by comparison of a temperature probe is performed by placing a reference thermometer and a unit under test in stable and homogeneous calibration medium, typically a calibration bath, furnace or climatic chamber. The reading of the unit under test is then associated with the temperature measured with the reference thermometer. This is repeated at several calibration points within the required temperature range. Calibration points are then used to calculate calibration coefficients for the particular probe characterization.

The reference thermometer must be connected to one of the UT-ONE main channels and must be properly configured to measure true temperature. Make sure that probe data for the reference thermometer is valid.

Unit under test must be connected to one of the remaining UT-ONE main channels and must be configured to measure the resistance or emf. In most cases, it is most convenient to use the auto range for the Pt-100, thermistor or thermocouple. Selecting the UUT probe is recommended, as it will be used to indicate approximate UUT temperature and it is used in the visualization of results in data analysis. Note that UUT probe selection has no direct effect on final calibration results. If you are recalibrating the UUT, and the results of the previous calibration are stored in UT-ONE probe list, you can select the existing probe characterization, otherwise select one of the predefined probe characterizations that best fits your probe.

Calibration uncertainty can be improved by using the external standard, which must be connected to the remaining UT-ONE main channel.

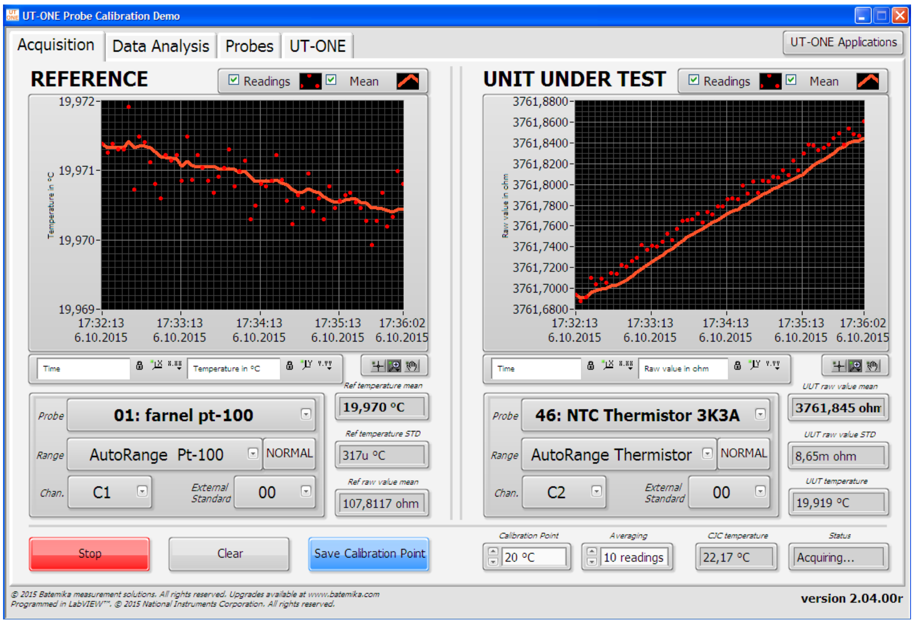

Figure 62: Acquisition window

Acquisition can be started using the *Start/Stop* button in the bottom of the window. Measurements are acquired in single reading mode. If there is a problem with the acquisition, the *Status* box will display the error message. Readings can be cleared from the graph using the *Clear* button. Application uses the specified number of readings to calculate the mean value and standard deviations. Specify the calibration point (nominal temperature) in the *Calibration Point* input box for each calibration medium setting. After the application acquires the specified number of readings, *Save Calibration Point* button becomes active and you can manually save the current measurement to the calibration point list.

After you save the calibration point, the application automatically displays it in the *Calibration Points* list, so you can review it. Note that you can make several calibration points at on temperature. You can later select/deselect each calibration point or even delete it from the list. Note that only selected calibration points (with the checkmark in the calibration point list) are used in the data analysis.

Calibration points can be selected/deselected and deleted using the popup menu on the calibration points list.

After you acquire all calibration points, you can start with the data analysis. First select one of the available probe types for your probe characterization. If applicable, select the function order for the fitting procedure. Application will automatically calculate the probe coefficients and display them in the *New Probe Data* box.

If you would like to save the probe data to UT-ONE non-volatile memory, enter the *Probe Name* and select an empty user-defined probe location. Note that any previous probe data at selected location will be overwritten. Click the *Save to UT-ONE* button to save the results to UT-ONE non-volatile memory.

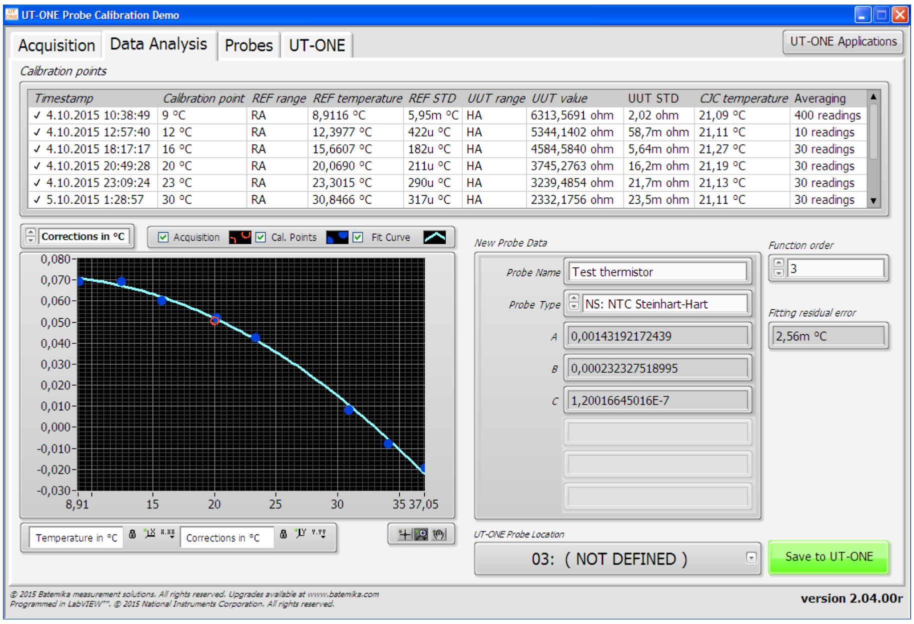

Figure 63: Data Analysis window

Calibration results can be conveniently visualized on a data analysis graph. The graph displays the currently acquired point as an orange ring, the selected calibration points as blue circles and the resulting probe characteristic as the light blue curve. You can view the data as the raw value (resistance or emf) against temperature, as fitting residuals or as a correction. Correction is calculated as the difference between actual values and nominal values according to selected UUT probe. Data visualization allows better evaluation of calibration results and detection of any faulty measurements.

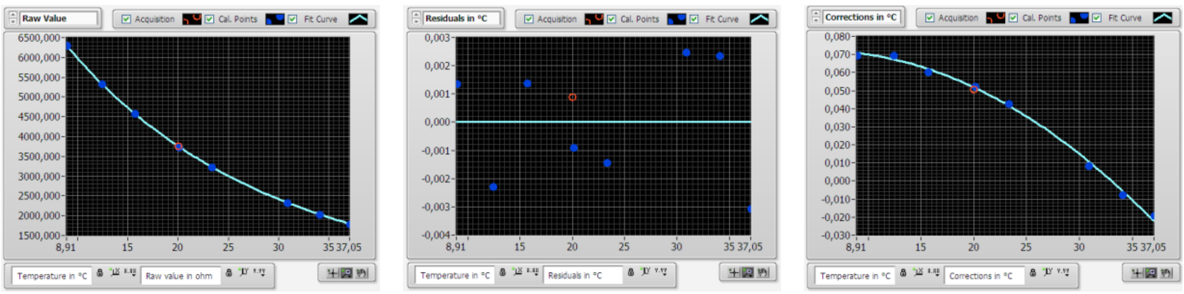

Figure 64: Visualization of data analysis results

8.3 UT-ONE Digitizing

UT-ONE Digitizing is the application for fast acquisition of raw data on temperature probes, connected to UT-ONE main channels. This application takes advantage of the special UT-UNE feature, which enables direct transfer of raw samples from the ADC to the USB interface. This feature enables fast sampling (digitizing) with up to 470 samples per second. Note that measurements in this mode have reduced accuracy and resolution, and there is no temperature coefficient correction, linearity correction, EMI rejection and parasitic emf compensation.

UT-ONE Digitizing application is primarily used to capture fast temperature transients in various temperature-related tests and experiments. Also, if you suspect your measurement configuration is prone to electromagnetic interference, you can analyses the raw samples before they are digitally filtered, so you can observe any traces of mains frequency interference.

This application is applicable only with communication via USB interface. When performing digitizing, stop all other applications, as any command received via USB interface will terminate digitizing.

After launching the UT-ONE Digitizing application, select the USB interface, channel and sampling frequency. Note that the probe and measurement range must be selected in UT-ONE channel configuration. Also note that auto ranging is not supported in digitizing mode, so select an appropriate manual range.

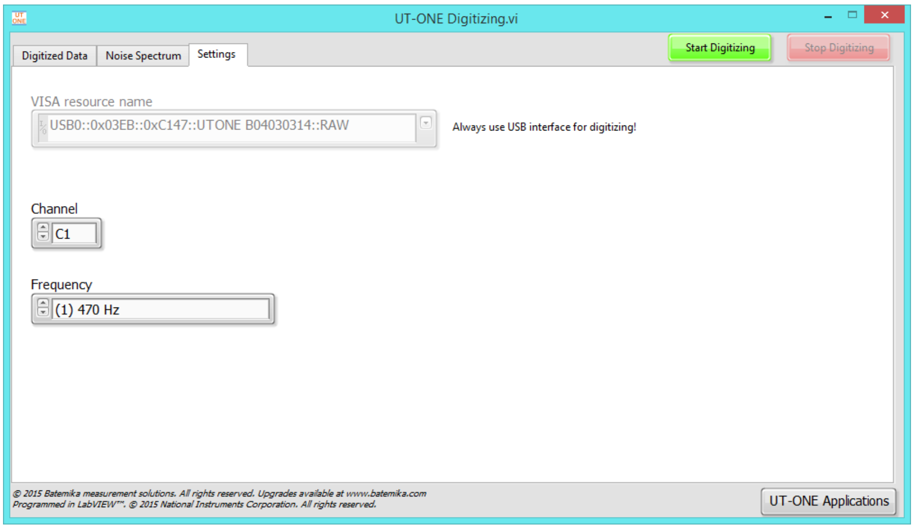

Figure 65: Settings for UT-ONE Digitizing application

Digitizing can be started using the green *Start Digitizing* button. Application will automatically switch to *Digitized Data* page and display acquired samples on graph. Note that samples are transferred in groups of 80 samples, so if low sampling frequency is selected, it may take up to 19 seconds to refresh the graph.

UT-ONE Digitizing application can display up to 65536 samples, which is approximately 140 seconds at the highest sampling frequency. After reaching this limit, older samples are discarded.

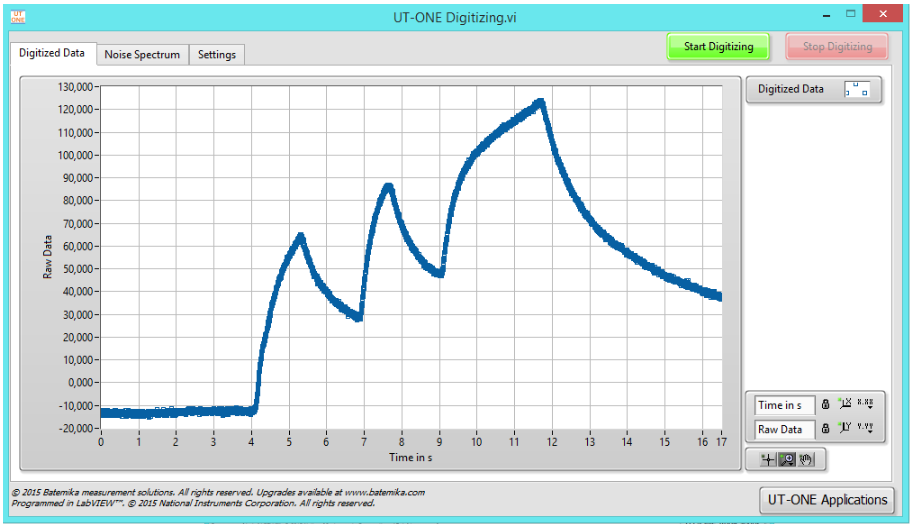

Figure 66: Observing of fast transients in digitizing mode

Noise Spectrum page presents the frequency spectrum of the acquired samples. This feature is especially useful for detecting any interference signals that are being acquired on the thermometer input. Most commonly, this effect is detected with unshielded thermocouple wires located near high-power electrical machines.

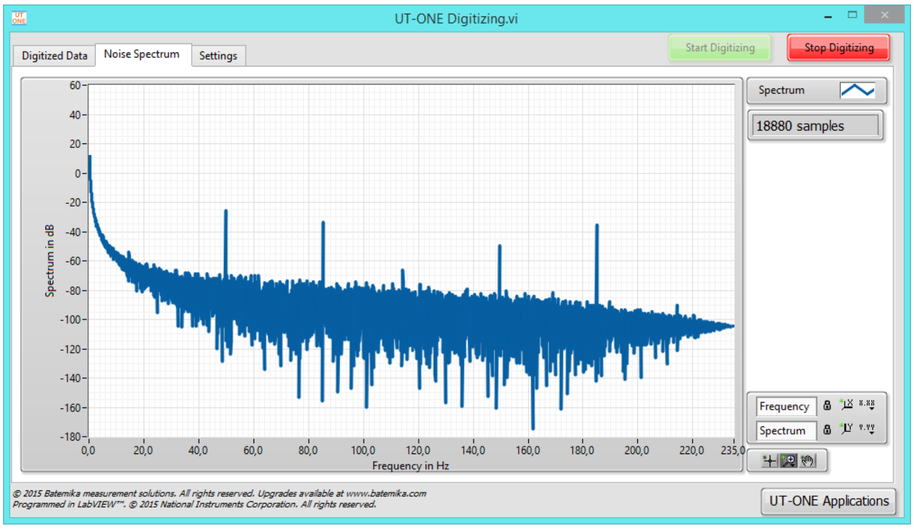

Figure 67: Noise spectrum with considerable 50 Hz interference

8.4 UT-ONE Communication Driver

UT-ONE Communication Driver is a simple application, which is used to directly establish the communication with the UT-ONE and to test the syntax of the commands and responses in the UT-ONE remote command set.

Enter the UT-ONE command in the *Command in* input box in ASCII text format. Optional binary data can be entered in the *Binary Block in* array for some commands. Note that the terminating line feed character is appended automatically. Send the command to UT-ONE using the *Execute Command* button. The application will generate the command, display it in the *Actual Data sent* box and send it to UT-ONE. After UT-ONE sends the command response, the application will display it in the *Actual Data received* box and extract the command status, ASCII text response and binary block. Application will also measure the time required to send, process and receive the command and display it in the *Execution time* box.

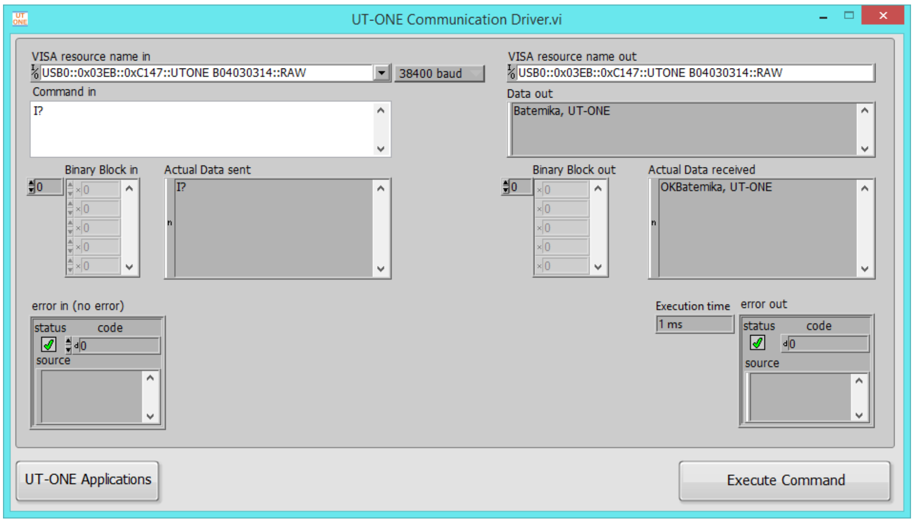

Figure 68: UT-ONE Communication Driver

8.5 UT-ONE Firmware Upgrade

UT-ONE Firmware Upgrade is a support application used to upgrade the UT-ONE firmware. At Batemika we are constantly improving our products and this application allows you to update your existing unit with new features.

Firmware upgrade can only be performed using the RS232 serial interface. Always use the communication cable supplied with the UT-ONE unit. Use the 38400 baud rate setting, lower settings are useful only if communication errors are detected. Note that full upgrade takes about two hours at maximum baud rate.

After you select the COM port and baud rate for the serial interface, click the *Connect* button to enter either Normal or Upgrade mode.

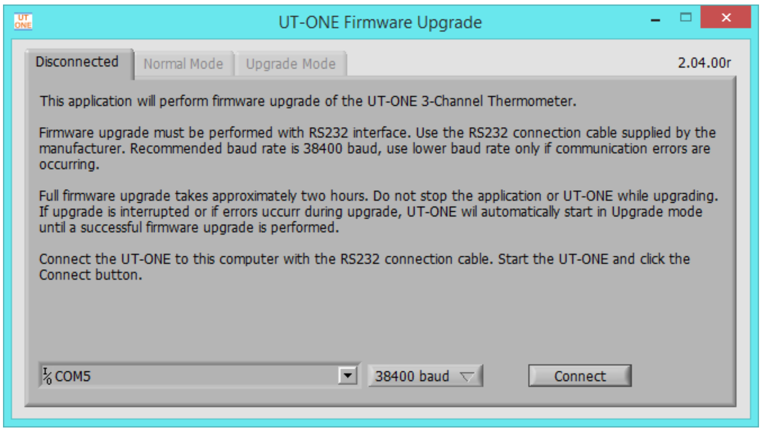

Figure 69: UT-ONE Firmware Upgrade

If UT-ONE is running normally, application will connect to *Normal Mode* and display the UT-ONE information. Application also checks the firmware version in the device and compares it the version in the upgrade. If versions are identical, the box is coloured in green, otherwise in red. If you decide to proceed with the upgrade, click the *Enter Upgrade Mode* button. The application will set the upgrade flag in the UT-ONE and shut it down. You have to manually switch it back on. UT-ONE starts in the upgrade mode, displaying the message "Firmware is ready for update!". Click the *Connect* button to enter the *Upgrade mode*.

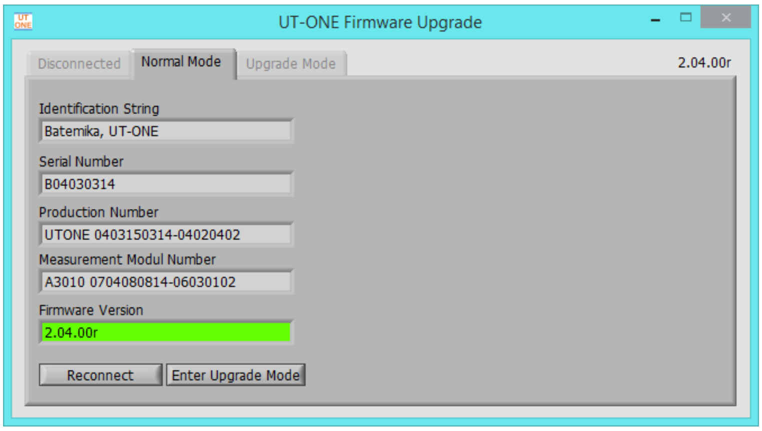

Figure 70: UT-ONE Firmware Upgrade in normal mode

After the applications connects to upgrade mode, it checks the cyclic redundancy check (CRC) of the firmware in the device and in the upgrade and displays it in the table. Note that firmware consists of the boot section and application section, each having a separate CRC. Firmware upgrade will only update the application section. If there is a mismatch in the boot section CRC, upgrade may not be possible.

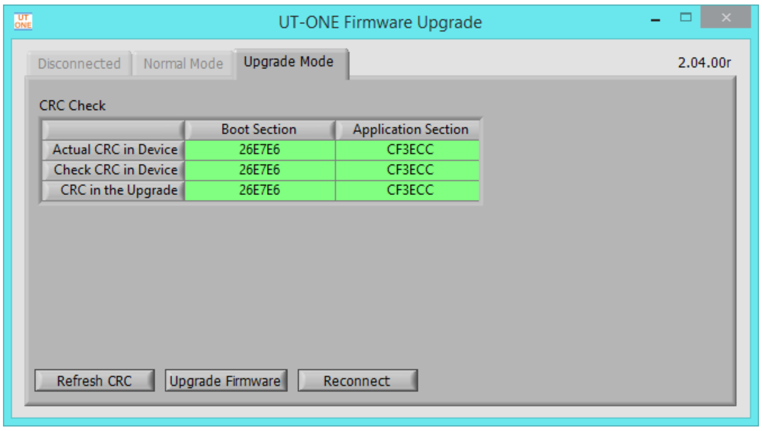

Figure 71: UT-ONE Firmware Upgrade in normal mode

To start the upgrade, click the *Upgrade Firmware* button. Upgrade procedure consist of three steps. Do not interrupt the upgrade during the first and second step. In the first step main processor firmware is upgraded. This takes approximately 2 minutes. In the second step, display firmware is upgraded, taking about 7 minutes. In the third step, display data is upgraded, taking approximately 2 hours. This step can be safely aborted by clicking the *Abort Upgrade* button. This is particularly useful in case of minor upgrades or bug fixes, as display data consists mainly of images, which are rarely changed.

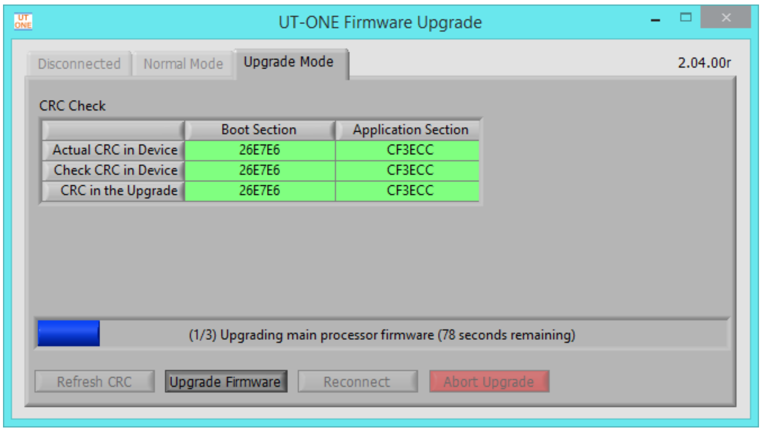

Figure 72: UT-ONE Firmware Upgrade during upgrade

After the upgraded is completed, click the *Reconnect* button to shut down the UT-ONE unit. After you manually restart the device, it will launch with the upgraded firmware.

Important!
Always connect the UT-ONE to external power supply during the update. Power consumption during update is considerably higher than normal, so battery may drain out faster than expected, resulting in data corruption!

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9 Specifications

This chapter provides detailed specifications for UT-ONE thermometer readout accuracy, operating conditions and other parameters.

Batemika is dedicated to constant improvement of our products and associated measurement procedures. We reserve the right to changes without prior notice.

9.1 General specifications

Specification	Value
Number of main channels	3
Thermometer probes	platinum resistance thermometers, thermistors, thermocouples
Temperature range	-200 °C to 1800 °C max, limited by the probe range
Type of sampling	consecutive
Sampling period	2 to 240 seconds per enabled channel
Fast digitizing mode	up to 470 samples per second with reduced accuracy
Measurement current	1 mA / 0.707 mA for PRTs, 20 µA / 14.1 µA for thermistors
Keep-warm current	automatically adjusted for all PRT and thermistor channels
Measurement current accuracy	0.5%
Parasitic emf suppression	full current reversal (PRT and thermistor channels only)
Logging	67108864 readings (over 4 years at 2 s sampling period)
Communication interfaces	RS232 and USB
Display	3.2” color LCD (320x240 pixels) with touch screen
Power supply	USB bus or external power supply
External power supply	6 V DC ± 0.5 V, 0.5 A to 1 A
Battery capacity	2000 mAh / 6000 mAh (8 hours / 24 hours of operation)
Battery lifetime	500 cycles typical, battery capacity degrades with use
Power consumption	1 W typical, 2.5 W maximum (when recharging battery)
Weight	1.5 kg
External dimensions (WxHxD)	160 x 100 x 290 mm
Warm up time	no warm up time required to achieve specified accuracy

9.2 Main channels

Accuracy specification is applicable to readout unit only and does not include the thermometer probe accuracy. Note that thermometer probe will practically determine the temperature range and in may be the dominant contributor in the complete measurement uncertainty.

Specifications for PRT and thermistor ranges are specified for normal measurement current setting (1 mA and 20 µA). Using the reduced measurement current setting will result in deterioration of effective resolution for approximately 40%.

Effective resolution is given as the standard deviation of 1000 readings of stable input resistance or emf under optimal conditions. Effective resolution is specified for the 2 second acquisition rate. Increasing the acquisition rate will improve the effective resolution according to the square root rule (for example increasing the acquisition rate to 18 seconds will improve the effective resolution by a factor of 3). Effective resolution (expressed in µΩ or µV) is constant over particular measurement range.

Specifications for thermocouple ranges do not include cold junction compensation error. If internal temperature probe is used for cold junction compensation, refer to its specification and add "CJC accuracy" value to the thermocouple measurement uncertainty. CJC accuracy includes both probe accuracy and error due to temperature gradients.

Short-term drift is defined as the maximum drift of the measured value within the 48 hours from last recalibration. Ambient temperature during this period must be within ±3 °C from the calibration ambient temperature.

Long-term drift is defined as the maximum drift of the measured value within 12 months from last recalibration. UT-ONE must be used during this period within specified operational environmental specifications.

Temperature coefficient is factory-adjusted for each measurement range. Accuracy specification provides residual temperature coefficient after the correction is applied internally by UT-ONE algorithms. Accuracy specification is valid after the instrument has reached stable temperature, as indicated by internal thermometers TJ and TI.

Parasitic emf is a small voltage caused by thermal gradients on input connections. In resistance measurement, parasitic emf is eliminated by reversing the polarity of measurement current, but for thermocouple measurements, thermal emf cannot be distinguished from thermocouple emf. Parasitic emf is independent of measurement range and measured value. Parasitic emf can be minimized by placing UT-ONE in thermally stable environment and by thermally shielding input connectors.

9.2.1 Specifications for PRT subranges

Range name	Range limit	Effective resolution	Nonlinearity	Short-term drift	Long-term drift	Temperature coefficient
R1	25 Ω	27 µΩ	1 ppm of range	6 ppm of value	15 ppm of value	0.25 ppm/°C
R2	50 Ω	35 µΩ	1 ppm of range	6 ppm of value	15 ppm of value	0.25 ppm/°C
R3	100 Ω	70 µΩ	1 ppm of range	6 ppm of value	15 ppm of value	0.25 ppm/°C
R4	200 Ω	120 µΩ	1 ppm of range	6 ppm of value	15 ppm of value	0.25 ppm/°C
R5	400 Ω	200 µΩ	1 ppm of range	6 ppm of value	15 ppm of value	0.25 ppm/°C
R6	800 Ω	500 µΩ	1 ppm of range	6 ppm of value	15 ppm of value	0.25 ppm/°C

9.2.2 Specifications for thermistor subranges

Range name	Range limit	Effective resolution	Nonlinearity	Short-term drift	Long-term drift	Temperature coefficient
H1	1.25 kΩ	1.5 mΩ	5 ppm of range	8 ppm of value	20 ppm of value	0.5 ppm/°C
H2	2.5 kΩ	2 mΩ	5 ppm of range	8 ppm of value	20 ppm of value	0.5 ppm/°C
H3	5 kΩ	3.5 mΩ	5 ppm of range	8 ppm of value	20 ppm of value	0.5 ppm/°C
H4	10 kΩ	5 mΩ	5 ppm of range	8 ppm of value	20 ppm of value	0.5 ppm/°C
H5	20 kΩ	10 mΩ	5 ppm of range	8 ppm of value	20 ppm of value	0.5 ppm/°C
H6	40 kΩ	25 mΩ	5 ppm of range	8 ppm of value	20 ppm of value	0.5 ppm/°C

9.2.3 Specifications for thermocouple subranges

Range name	Range limit	Effective resolution	Nonlinearity	Short-term drift	Long-term drift	Temperature coefficient	Parasitic emf
E1	15 mV	0.03 µV	10 ppm of range	30 ppm of value	60 ppm of value	2 ppm/°C	0.5 µV
E2	30 mV	0.04 µV	10 ppm of range	30 ppm of value	60 ppm of value	2 ppm/°C	0.5 µV
E3	60 mV	0.07 µV	10 ppm of range	30 ppm of value	60 ppm of value	2 ppm/°C	0.5 µV
E4	125 mV	0.11 µV	10 ppm of range	30 ppm of value	60 ppm of value	2 ppm/°C	0.5 µV
E5	250 mV	0.2 µV	10 ppm of range	30 ppm of value	60 ppm of value	2 ppm/°C	0.5 µV
E6	500 mV	0.5 µV	10 ppm of range	30 ppm of value	60 ppm of value	2 ppm/°C	0.5 µV

9.2.4 Pt-100 specifications

This chapter presents UT-ONE accuracy specification applied to the industrial-grade platinum resistance thermometer with nominal resistance of 100 ohms. Presented accuracy specification is applicable to measurements with normal measurement current (1 mA) and with auto ranging feature enabled. Accuracy for measurements with external resistor depends on accuracy of external resistor, 3 ppm accuracy is used in this example.

Note that presented accuracy is the accuracy of measurement instrument only and does not include probe drift and accuracy!

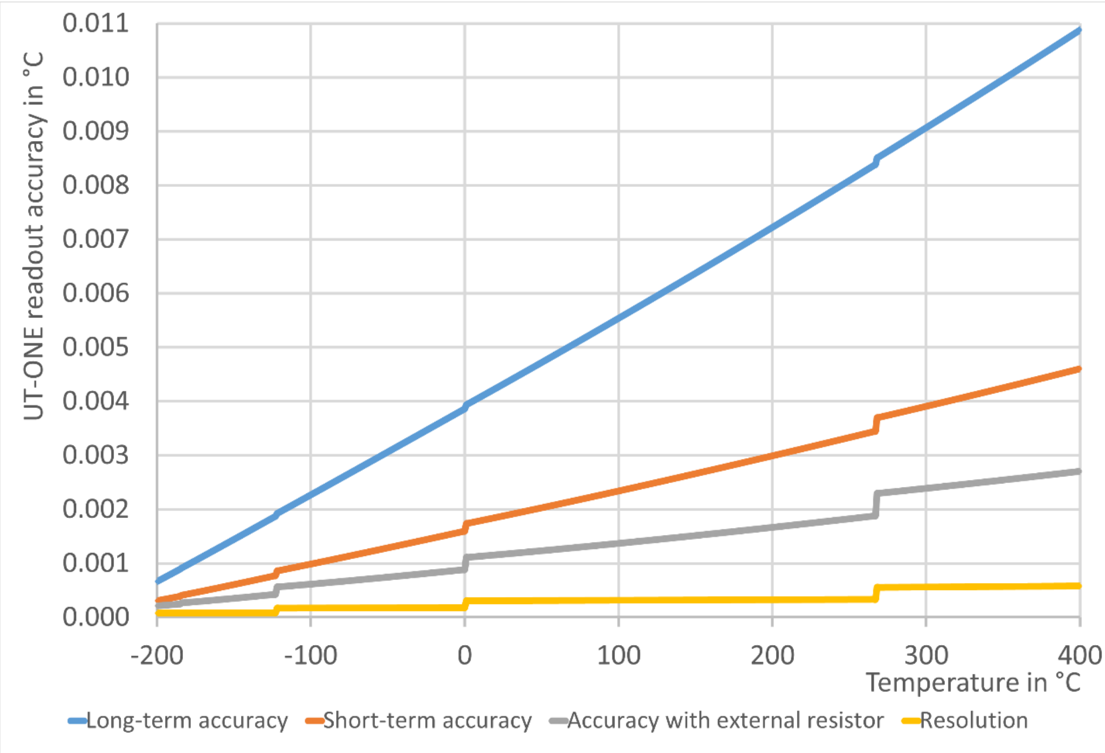


Figure 73: UT-ONE accuracy specification for Pt-100 probe

As a convenience to the user, graphs of Pt-100 probe resistance and sensitivity are presented. Note that this is a general property of this particular type of probes and is not originating from UT-ONE characteristics.

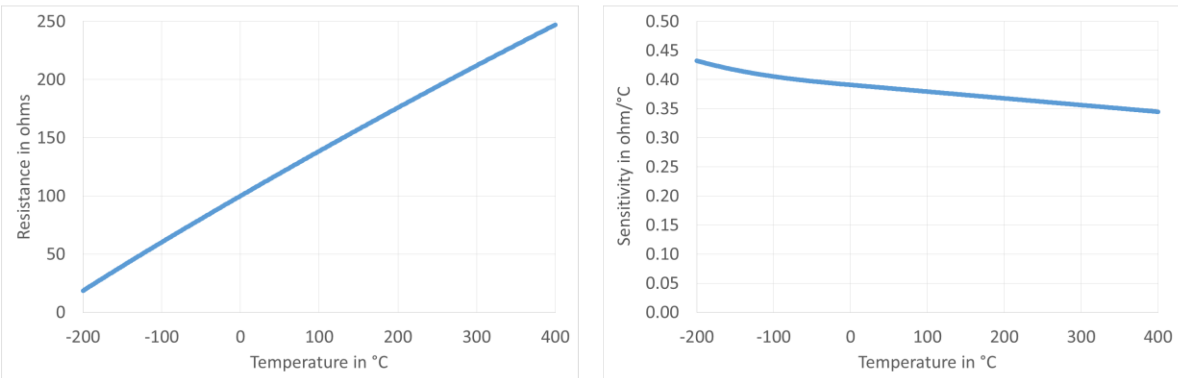


Figure 74: Resistance and sensitivity characteristic for Pt-100 probe

9.2.5 Pt-25 specifications

This chapter presents UT-ONE accuracy specification applied to the standard platinum resistance thermometer with nominal resistance of 25 ohms. Presented accuracy specification is applicable to measurements with normal measurement current (1 mA) and with auto ranging feature enabled. Accuracy for measurements with external resistor depends on accuracy of external resistor, 3 ppm accuracy is used in this example.

Note that presented accuracy is the accuracy of measurement instrument only and does not include probe drift and accuracy!

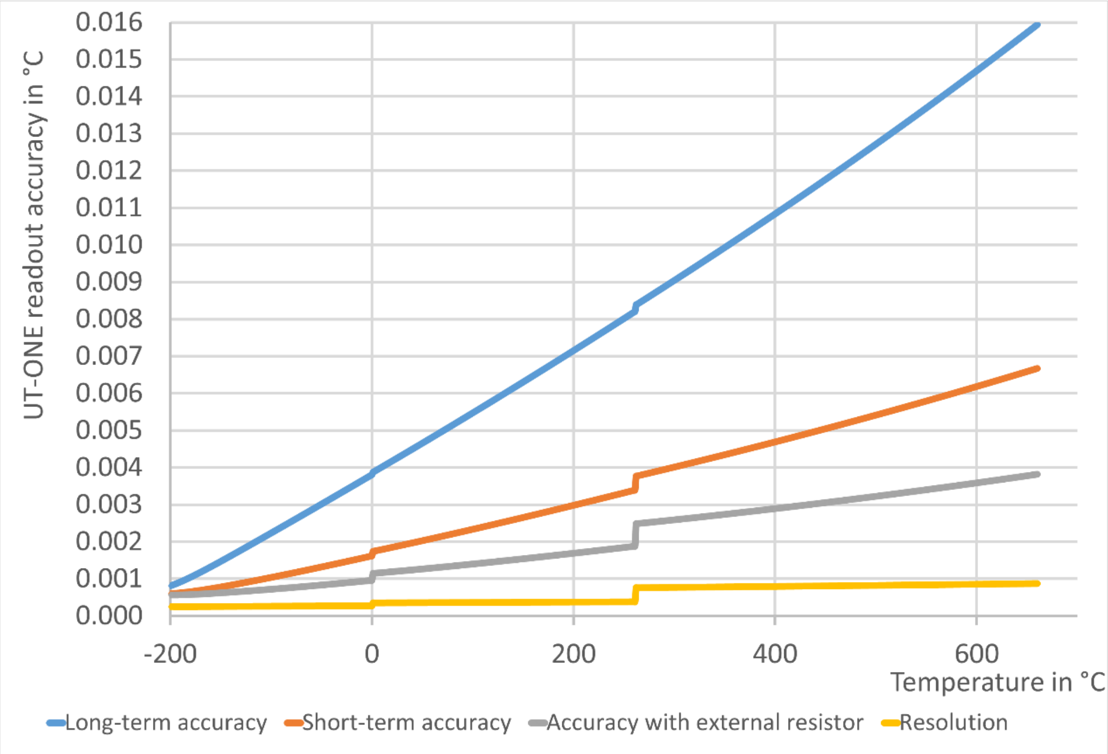


Figure 75: UT-ONE accuracy specification for Pt-25 probe

As a convenience to the user, graphs of Pt-25 probe resistance and sensitivity are presented. Note that this is a general property of this particular type of probes and is not originating from UT-ONE characteristics.

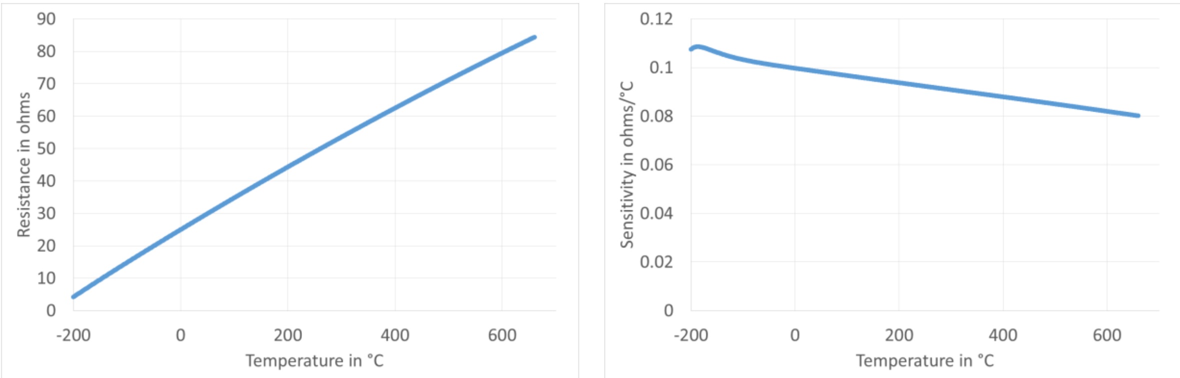


Figure 76: Resistance and sensitivity characteristic for Pt-25 probe

9.2.6 Thermistor 3K3A specifications

This chapter presents UT-ONE accuracy specification applied to the thermistor probe with nominal resistance of 3000 ohms. Presented accuracy specification is applicable to measurements with normal measurement current (20 µA) and with auto ranging feature enabled. Accuracy for measurements with external resistor depends on accuracy of external resistor, 3 ppm accuracy is used in this example.

Note that presented accuracy is the accuracy of measurement instrument only and does not include probe drift and accuracy!

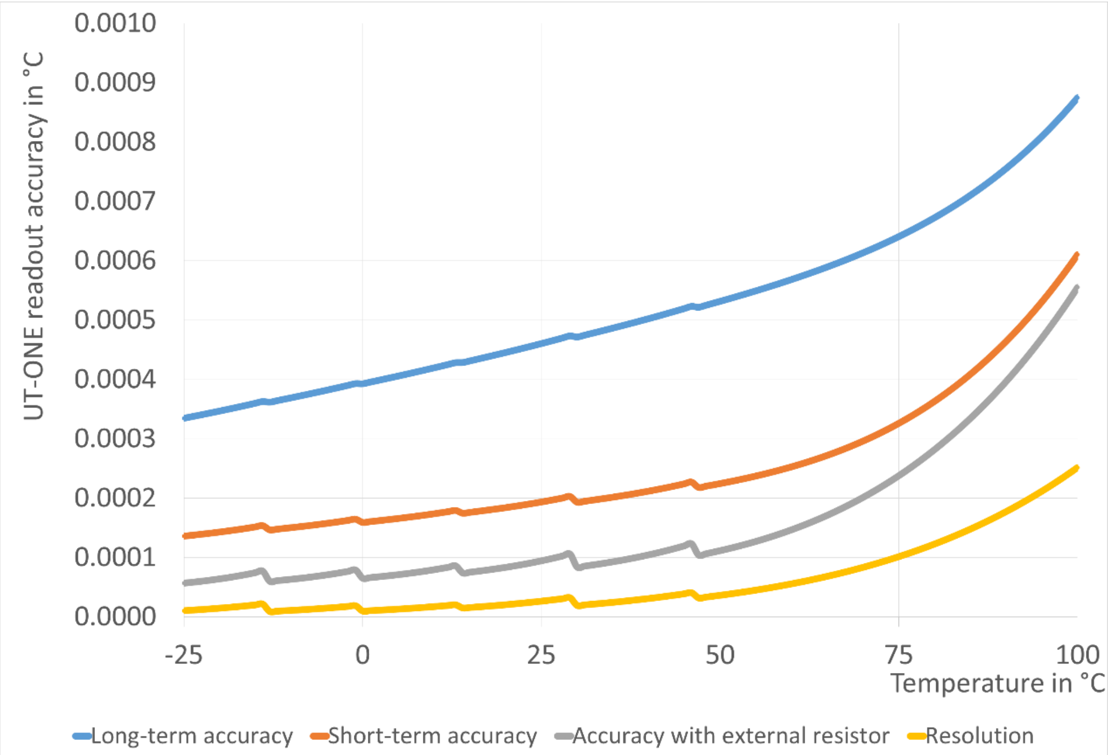


Figure 77: UT-ONE accuracy specification for 3K3A thermistor probe

As a convenience to the user, graphs of 3K3A thermistor probe resistance and sensitivity are presented. Note that this is a general property of this particular type of probes and is not originating from UT-ONE characteristics.

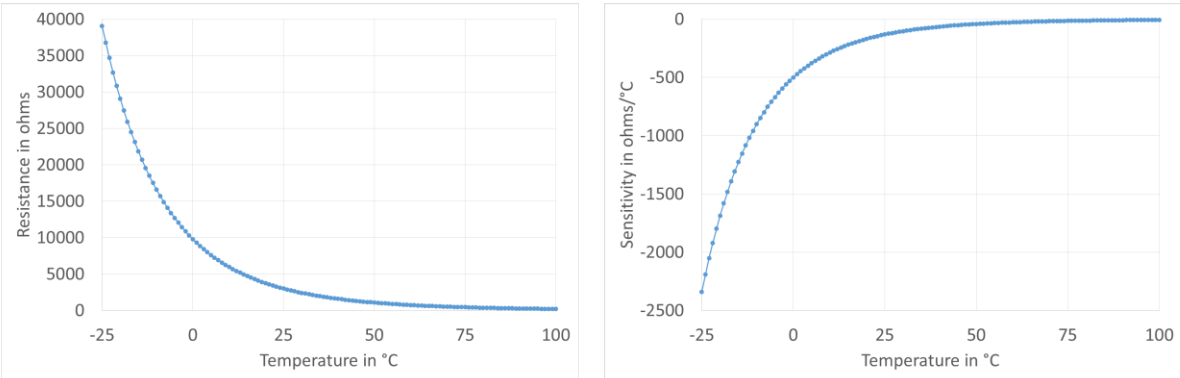


Figure 78: Resistance and sensitivity characteristic for 3K3A thermistor probe

9.2.7 Thermistor 10K3A specifications

This chapter presents UT-ONE accuracy specification applied to the thermistor probe with nominal resistance of 10000 ohms. Presented accuracy specification is applicable to measurements with normal measurement current (20 µA) and with auto ranging feature enabled. Accuracy for measurements with external resistor depends on accuracy of external resistor, 3 ppm accuracy is used in this example.

Note that presented accuracy is the accuracy of measurement instrument only and does not include probe drift and accuracy!

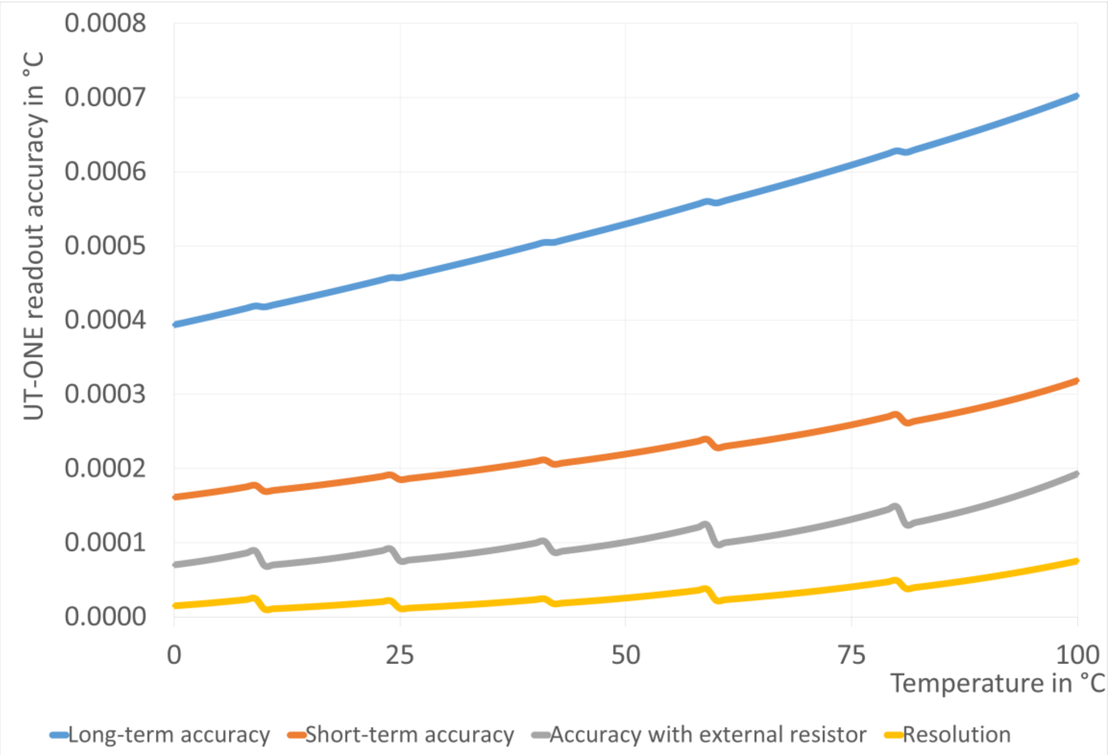
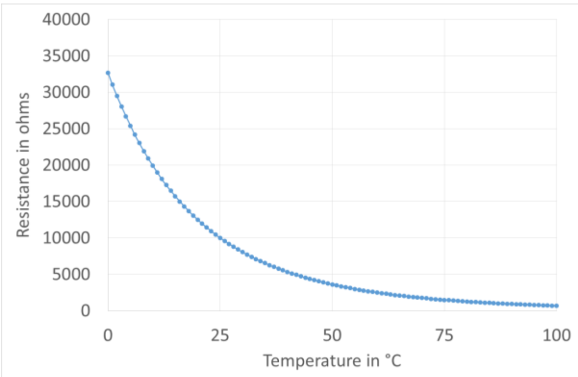


Figure 79: UT-ONE accuracy specification for 10K3A thermistor probe

As a convenience to the user, graphs of 10K3A thermistor probe resistance and sensitivity are presented. Note that this is a general property of this particular type of probes and is not originating from UT-ONE characteristics.



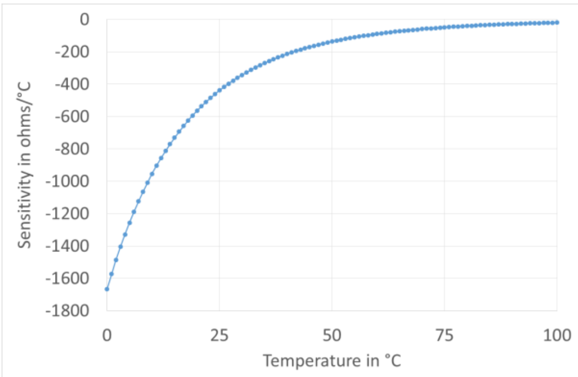


Figure 80: Resistance and sensitivity characteristic for 10K3A thermistor probe

9.2.8 Thermocouple Type K specifications

This chapter presents UT-ONE accuracy specification applied to the thermocouple probe of type K. Presented accuracy specification is applicable to measurements with auto ranging feature enabled and use of external cold-junction compensation. For measurements with internal cold-junction compensation, add the specified cold-junction accuracy.

Note that presented accuracy is the accuracy of measurement instrument only and does not include probe drift and accuracy!

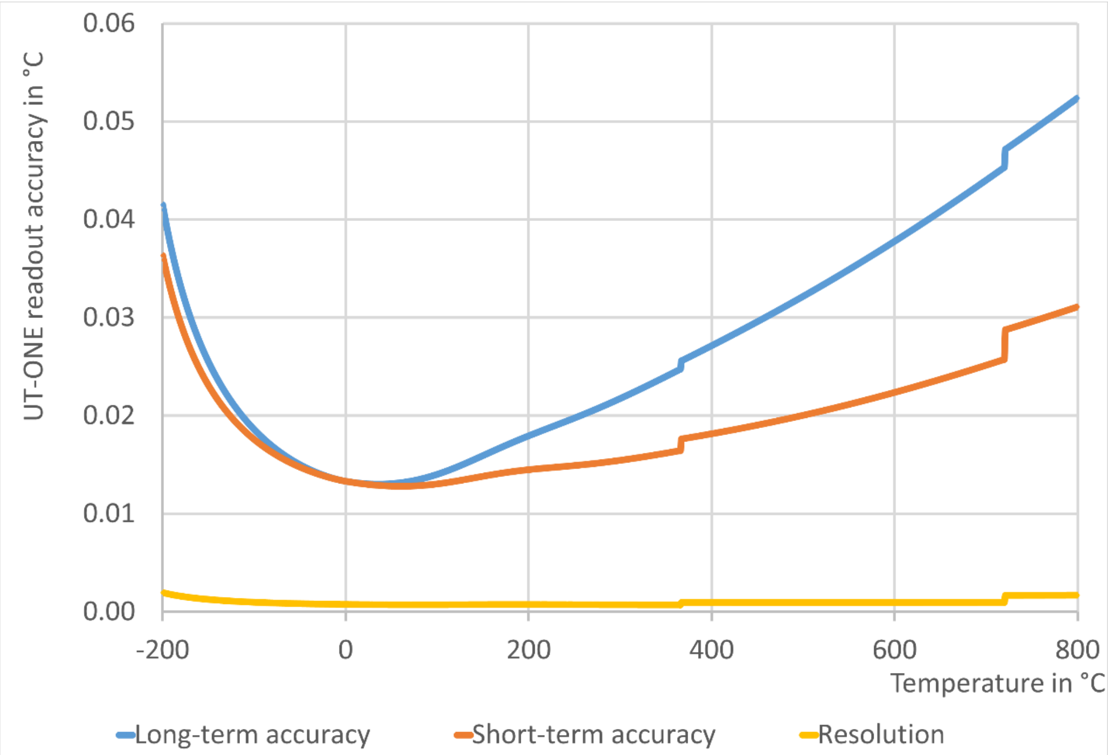


Figure 81: UT-ONE accuracy specification for type K thermocouple probe

As a convenience to the user, graphs of type K thermocouple probe emf and sensitivity are presented. Note that this is a general property of this particular type of probes and is not originating from UT-ONE characteristics.

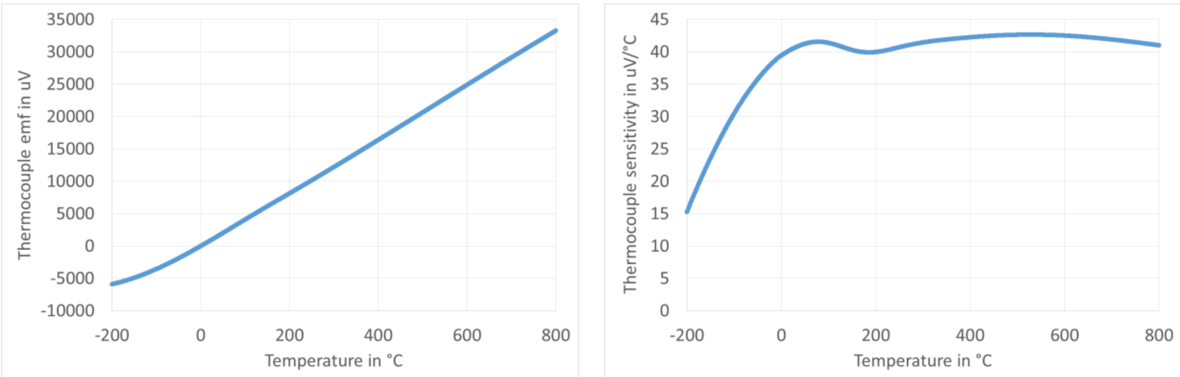


Figure 82: Emf and sensitivity characteristic for type K thermocouple probe

9.2.9 Thermocouple Type S specifications

This chapter presents UT-ONE accuracy specification applied to the thermocouple probe of type S. Presented accuracy specification is applicable to measurements with auto ranging feature enabled and use of external cold-junction compensation. For measurements with internal cold-junction compensation, add the specified cold-junction accuracy.

Note that presented accuracy is the accuracy of measurement instrument only and does not include probe drift and accuracy!

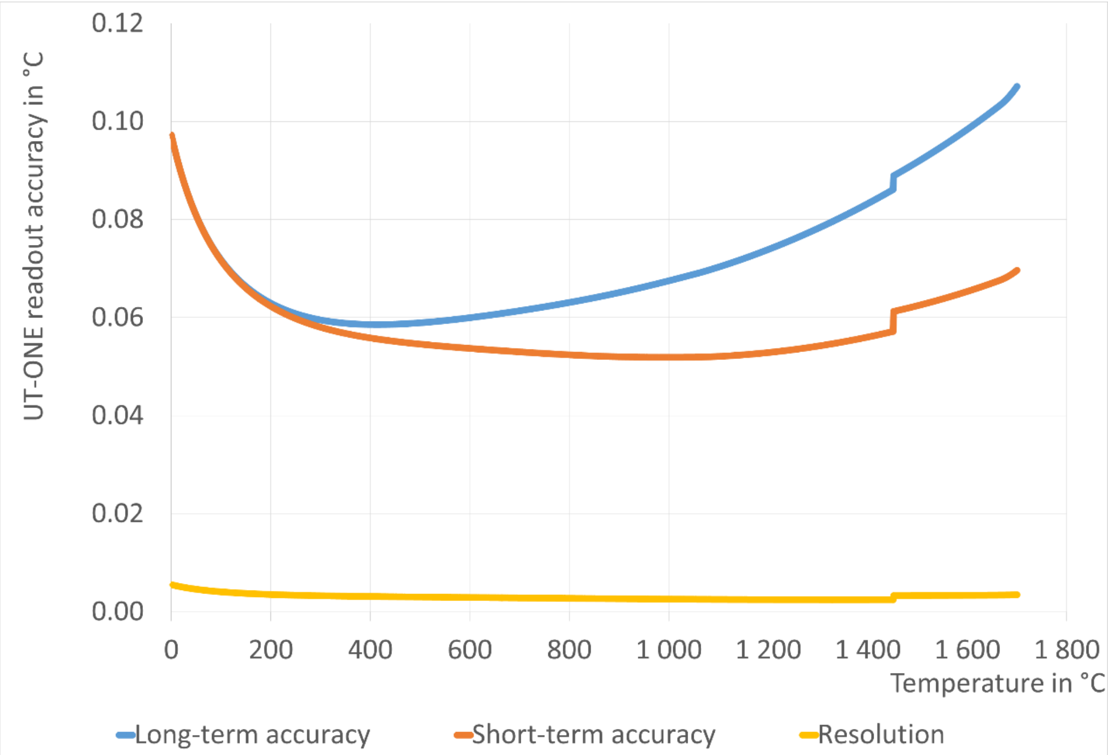


Figure 83: UT-ONE accuracy specification for type S thermocouple probe

As a convenience to the user, graphs of type S thermocouple probe emf and sensitivity are presented. Note that this is a general property of this particular type of probes and is not originating from UT-ONE characteristics.

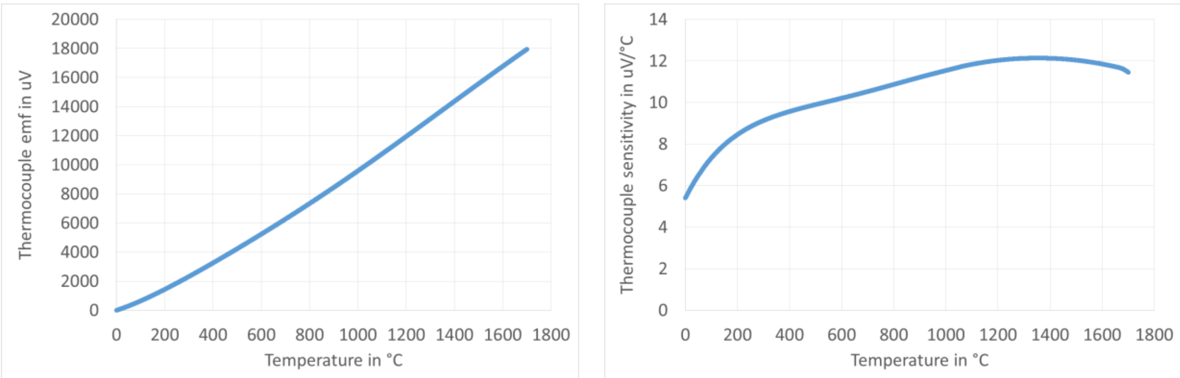


Figure 84: Emf and sensitivity characteristic for type S thermocouple probe

9.3 Auxiliary channels

External ambient conditions probe	
Sensor type	Sensirion SHT75
Extension cable	2 metre
Sampling period	4 seconds
Response time	1 minute (typical)
Probe characterization	Polynomial correction function
Temperature range	-20 to 70 °C
Temperature resolution	0.01 °C
Temperature accuracy	±0.5 °C
Relative humidity range	10% to 90%, non-condensing
Relative humidity resolution	0.01%
Relative humidity accuracy	±2%

Internal CJC thermometer	
Sensor type	Digital temperature sensor
Sampling period	1 second
Response time	10 minutes (typical)
Probe characterization	Polynomial correction function
Temperature range	5 to 45 °C
Temperature resolution	0.01 °C
Temperature accuracy	±0.4 °C
CJC accuracy	±0.5 °C (assuming stable ambient temperature)

9.4 Environmental specifications

Operating environment:	laboratory and light industrial environment, indoor use only, avoid dust, water vapor and fumes
Operating temperature:	10 °C to 36 °C
Operating relative humidity:	30% to 80%, non condensing
Storage temperature:	5 °C to 45 °C
Storage relative humidity:	20% to 90%, non condensing

10 Troubleshooting

1. *Device will not start when I press the ON/OFF button.*
   You are running on battery and your battery is fully discharged. Check if the external power supply or USB cable are attached and powered. If you are running on low battery, you may have to press the ON/OFF button for a few seconds in order to start.
2. *The device stopped responding to touch screen, communication interface and/or ON/OF button.*
   Press and hold the ON/OFF button for more than ten seconds. This will execute a hardware shutdown of the power supplies and reset the device. Wait at least 30 seconds before restarting the device.
3. *The display is displaying * instead of the measured temperature.*
   Make sure the particular channel is enabled and acquisition is started.
4. *The acquisition was started, but there is no response on the screen.*
   Check the averaging time. The maximum average time is 240 seconds per channel, which require up to 12 minutes before the first reading is displayed.
5. *The temperature readings are completely incorrect.*
   Check the raw data value (resistance or emf).
   If the raw data is within expected value, the problem is in probe coefficients. Check if the correct probe is selected. Check probe coefficients for typing and calculation errors.
   If the raw data is invalid, check the measurement range. Check probe connections. Check if a PRT and a thermocouple are simultaneously connected on the same channel. Check probe leads for broken wires and short circuits. Try the probe on a different channel and on a different instrument.
6. *Ambient conditions from the external probe are not refreshed or showing illegal values.*
   Ambient conditions from the external probe are refreshed and logged only when acquisition sequence is started. If you require only the acquisition of ambient conditions, disable channels C1, C2 and C3, and start the acquisition sequence.
   Check if the external probe is properly attached. You may try to attach the external probe directly without the extension cable.
7. *The measurements are noisier than expected according to specifications.*
   Use the device away from sources of electromagnetic interference, such as electric motors, switched-mode power supplies, wireless communication devices, etc.
   Use a shielded and grounded cable for your probes.
   Cover the connectors of thermometer probes. Exposure to severe draft conditions may cause excessive parasitic emf variations, which results in noise increase.
8. *RS232 communication is not working.*
   Check the communication cable. Cable must be straight (extension) cable.
   Check the COMx setting on the computer. Note that some USB-to-serial converters may change the COM address when attached to a different USB port.
   Check the baud rate. Baud rate can be set in the COMM configuration view. Note that the new baud rate setting will be applicable only after the device is restarted.

11 Frequently Asked Questions

1. *What is the temperature range of the UT-ONE?*
   Temperature range is limited by the thermometer probe. Note that exceeding the temperature range limits will permanently damage the thermometer probe. UT-ONE has 18 flexible measurement ranges, which allow the measurement of most commonly used platinum resistance thermometers, thermistors and thermocouples.
2. *Can I measure a PRT, a thermistor and a thermocouple at the same time?*
   UT-ONE has three channels, which can be configured individually for different probe types, measurement ranges, averaging times and measurement currents. Note however that channels are measured consecutively and not simultaneously.
3. *Can I change the order of channels in the acquisition sequence?*
   No, the channels are always acquired in ascending order, but some channels may be excluded from the acquisition sequence by disabling them.
4. *Can I perform the measurements in overrange region?*
   Each measurement range has a safety margin of approximately 25% over its nominal range limit. Exact value of overrange is equal to the calibration coefficient for the particular measurement range. Measurements can be normally performed in the overrange region, but the accuracy, especially linearity, is degraded. Doubling the accuracy specification is usually sufficient to account for this additional error. Overrange is primarily intended for measurements of fault conditions, where measurements are normaly recorded even after the temperature limits of the probe are exceeded.
5. *What is self heating?*
   Self heating is a phenomenon, which occurs in resistance measurement when the measurement current dissipates power in the thermometer sensor. This dissipated power additionally heats up the sensor, resulting in the self-heating error. The self heating error depends on the value of the measurement current, the probe resistance, the probe construction and the medium in which the probe is immersed. Typical values of self heating errors range from less than a mK to several tens of mK. Most thermometer probes are calibrated at specified measurement current (most commonly 1 mA for PRTs), so the self-heating error is largely included in the calibration coefficients.
6. *How do I estimate the self-heating error?*
   Self-heating error can be easily estimated with UT-ONE by changing the value of the measurement current. The currents are selected in such ratio that the dissipated power in NORMAL setting is double compared to REDUCED setting.
   Place the thermometer probe at a stable temperature. Set the measurement current setting from NORMAL to REDUCED. Record the change of temperature. Set the measurement current setting from REDUCED to NORMAL. Record the change of temperature. The sum of the absolute values of both recorded changes is equal to the estimated self-heating error at NORMAL current setting. The average of the absolute values of both recorded changes is equal to the estimated self-heating error at REDUCED current setting.
   Absolute value of both recorded changes should be approximately equal, otherwise the temperature stability is insufficient. You may have to repeat the procedure several times to get a reliable result.
7. *Should I use the REDUCED setting for measurement current to decrease the self-heating error in my measurements?*
   Measurements should be performed at the same measurement current as used in calibration of the probe. Note also that the UT-ONE specifications are applicable to measurements with NORMAL measurement current setting. Measurements with REDUCED measurement current setting will degrade noise performance, so in most cases reduction of measurement current is not recommended.
   In cases where the self-heating error is the dominant source of error (if estimated self-heating

error is several tens of milikelvins), using the REDUCED measurement current setting may be beneficial. In this case, it is recommended that you calibrate the thermometer probe using the UT-ONE with the REDUCED measurement current setting (calibration must be performed using the same conditions as the following measurements).

8. *Why is UT-ONE performing current reversal to suppress parasitic emf?*
   Parasitic emf are small voltages, which are generated when temperature gradients are present on joints of dissimilar metals. This phenomenon is called the Seebeck effect and is the same principle that is used for the operation of thermocouples. Although special care is taken to minimize parasitic emf, it cannot be completely eliminated. However, if the thermometer resistance is measured first with measurement current with one polarity and then with measurement current of opposite polarity, the averaging of the two reading eliminates the parasitic emf from the measurement results.
   UT-ONE measures the resistance by averaging two readings. Each of these reading takes 1 second and uses the reversed current polarity. This eliminates any static parasitic emf, but very fast temperature variations may not be completely eliminated, resulting in a slightly increased measurement noise.
   Thermocouple measurements do not have the possibility to eliminate parasitic emf, so additional effort must be made in probe design to reduce the parasitic emf generation to minimum.
9. *What is cold-junction compensation in thermocouple measurements?*
   Thermocouples are differential thermometers, which measure the temperature difference between the hot (active) junction and the cold (reference) junction. Temperature can be therefore measured only, if the reference temperature of the cold junction is known. The process of merging the measured temperature difference and the cold junction temperature is called cold-junction compensation (CJC). Cold junction compensation can be performed in several ways.
   The most accurate CJC method is to place the cold junction in ice-point bath (mixture of demineralized water and ice) at 0 °C. In this case, the temperature reading is equal to measured temperature difference in °C without any calculations. The disadvantage of this method is the use of ice, which is cumbersome and melts quickly.
   Another CJC method requires the measurement of the CJC temperature with an additional thermometer. As the cold junction can be placed at room temperature, this additional thermometer can be very simple and with a narrow temperature range. The measured CJC temperature can then be used to compensate the cold junction at any temperature and produced the measurement result. This method is very user friendly, but is less accurate.
   UT-ONE supports the use of both described CJC methods. UT-ONE has a built-in internal thermometer, which measures the CJC temperature and automatically performs cold junction compensation.
10. *Can I use UT-ONE for measurements of DC voltage and resistance not related to thermometry?*
    Although UT-ONE is specialized for temperature measurements, it can be readily used for accurate measurements of DC voltage and resistance within the available measurement ranges. However, note that the inputs are internally related to system ground, so the input configuration must have floating electric potential.
11. *I accidentally set the wrong measurement range and the reading was out of range. Will this damage the device?*
    Setting the wrong measurement range will not damage the UT-ONE, as long as the absolute maximum limits are not exceeded. UT-ONE can handle resistance from 0 Ω (short circuit) to infinity (open circuit). Maximum input voltage is limited to ±1 V. At the same time, applied voltage potential to any connector must be within -0.3 V and 3 V relative to system ground.
12. *Do I have to calibrate the UT-ONE resistance and voltage ranges in regular intervals?*
    UT-ONE resistance and voltage ranges are factory adjusted to correct values within specified accuracy. However, as for any instrument, UT-ONE calibration values are subject to drift and regular calibration is recommended.
    However, if UT-ONE is used only with a fixed set of non interchangeable thermometer probes for measurement of temperature, the combination of UT-ONE and thermometer probes can be

calibrated as single measurement instrument. This requires only temperature calibration (no voltage and resistance calibrations) and will generally produce best accuracy. The disadvantage of this approach is that the thermometer probes calibrations are linked to the particular UT-ONE unit and the readings of resistance and emf are irrelevant.