

UT-ONE S04A

4-Channel Thermometer Readout



User manual

Version 2.07.xx

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1 Introductions

UT-ONE S04A is an accurate and versatile system-style thermometer readout. UT-ONE S04A is capable of measuring platinum resistance thermometers, thermistors and thermocouples. UT-ONE S04A is a very compact and efficient solution for multi-channel high-accuracy temperature measurements, as it combines a high accuracy thermometer readout and a 4 channel scanner in a single housing. The user interface is realized using the acquisition software on a personal computer. LabVIEW drivers and sample applications are provided free of charge and enable fast and efficient implementation of any measurement procedure according to end-user requirements.

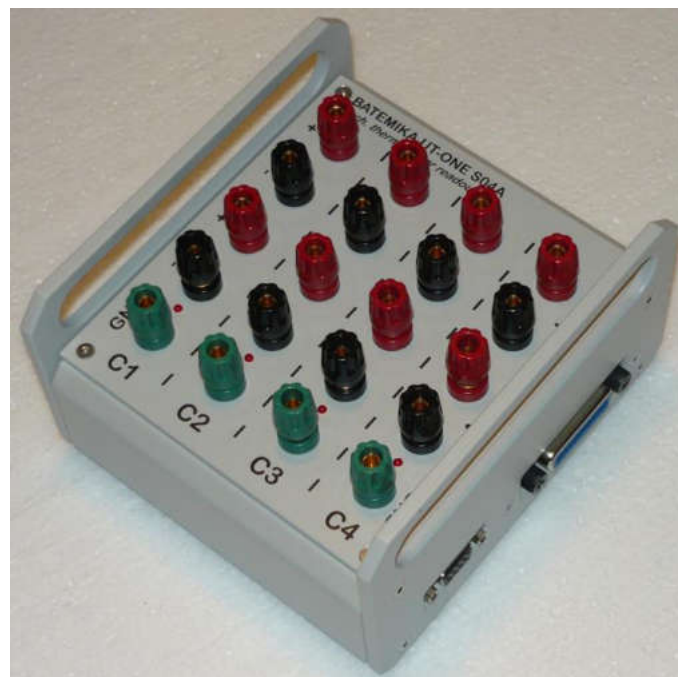


Figure 1: UT-ONE S04A with GPIB+RS232 option

2 Getting Started

2.1 Warnings 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 user manual 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.
- If UT-ONE is powered from an AC USB adapter, use only the adapter originally provided with UT-ONE.
- 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.
- 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 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.
- Do not place objects, liquid containers or other instrumentation on top of the UT-ONE. Handle the instrument carefully to prevent mechanical damage.

2.2 Power supply

UT-ONE S04A can be powered from the USB cable, connected to the computer, USB hub or AC USB adapter. Note that UT-ONE S04A may draw up to 80 mA DC (150 mA with GPIB/RS232 option). 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 S04A.

2.3 Starting and stopping the UT-ONE S04A

UT-ONE S04A is started by connection to the active USB interface. There are no additional switches or remote-interface commands for starting and stopping UT-ONE S04A. As an indication of successful initialization, UT-ONE S04A will sequentially enable each of the active-channel indicators, first in ascending order and then in descending order. This procedure takes approximately one second. After it is completed, channel C1 will remain active.

UT-ONE S04A can be stopped by disconnecting the USB interface cable. There is no need to stop the acquisition in software or perform any other software procedure before the disconnection of USB cable. You also don't need to use "Safely remove hardware" feature in Windows before disconnecting the device. UT-ONE S04A will internally detect the disconnection and automatically perform the internal shut-down procedures. However, it is recommended that the acquisition software is stopped before the UT-ONE S04A, otherwise communication errors may cause the software to become unresponsive and corrupted results may be recorded.

2.4 USB device drivers

UT-ONE thermometer readouts are shipped with a set of USB device drivers, which support Windows XP and later. USB device drivers are located on the installation CD and are also available for download in the Downloads section on www.batemika.com.

After you connect your UT-ONE thermometer readout using the USB interface to a computer for the first time, Windows will automatically try to search for the appropriate drivers. After the automatic search fails, the Windows will prompt you to locate the drivers. Manually select the location of the USB drivers on the installation CD or local directory. Please note that the driver for Windows XP is different from the drivers for higher versions of Windows, so choose the driver according to your operating system.

After the USB device drivers are successfully installed, the UT-ONE device becomes visible in the Windows Device Manager. You may now start using the UT-ONE with USB communication interface.

After the UT-ONE USB interface is reconnected after successful first installation, Windows will automatically detect and recognize your UT-ONE device and load appropriate drivers, without the need for user intervention.

UT-ONE LabVIEW drivers require NI VISA runtime engine to be installed on target computer. NI VISA runtime engine is part of the UT-ONE Applications installer, but a newer version can be manually downloaded from www.ni.com and installed on your computer.

2.5 Connection of thermometer probes

UT-ONE S04A has 4 independent channels for the connection of thermometer probes. 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.

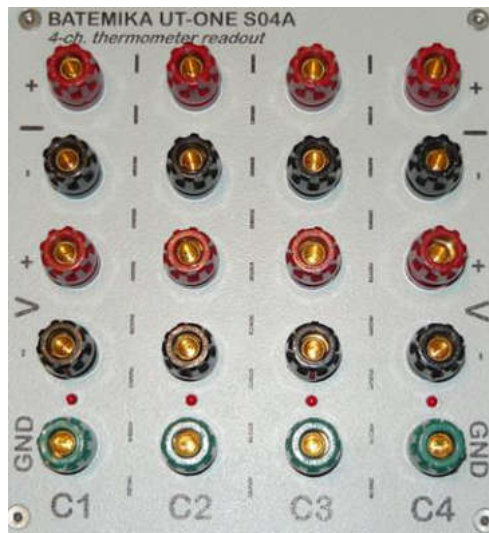


Figure 2: Connectors for the connection of thermometer probes on main channels

Connectors for one channel (Cx) consist of five banana-style connectors (two for current leads, two for voltage leads and one for optional ground/shield connection). Banana-style connectors accept bare wires, spade lugs and banana connectors.

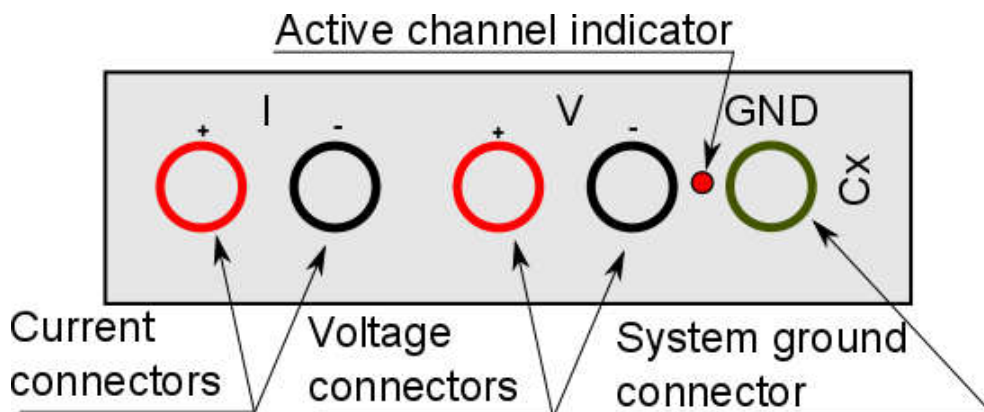


Figure 3: Connectors for one channel

System ground connector (GND) may be used to connect the shield of the probe connection cable with the aim of reducing the noise and interference. Please note that there is no general rule regarding the shielding and grounding connections, so this should be evaluated for each particular case. Note that in some cases ground connection of the cable shield may actually deteriorate measurement performance and cause measurement errors, so it should be used with caution.

2.5.1 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. RTD lead wires must be connected in floating configuration, with no electrical connection to system ground or any other electrical potential.

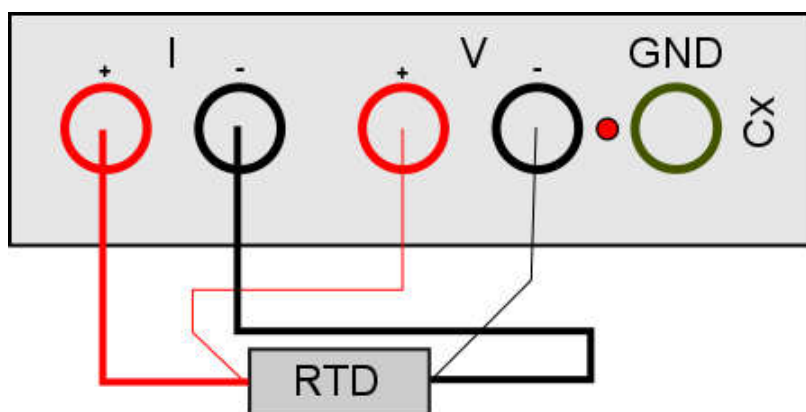


Figure 4: Four-wire connection of a RTD

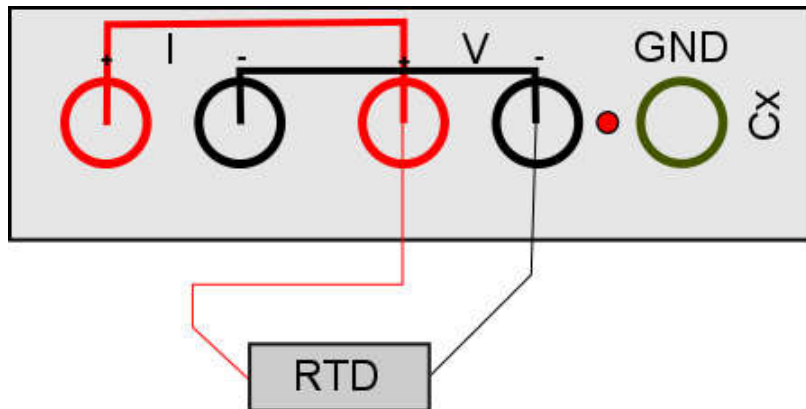


Figure 5: Two-wire connection of a RTD

2.5.2 Connection of thermocouples

Thermocouples are connected directly to the voltage connectors. 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.

Best measurement results are achieved using the external cold-junctions compensation in the ice-point bath. If internal cold-junction compensation is used, it is recommended to connect thermocouple wire directly to the connectors, without spade lugs or banana plugs. Use of spade lugs and especially banana plugs will introduce another source of errors due to parasitic emf.

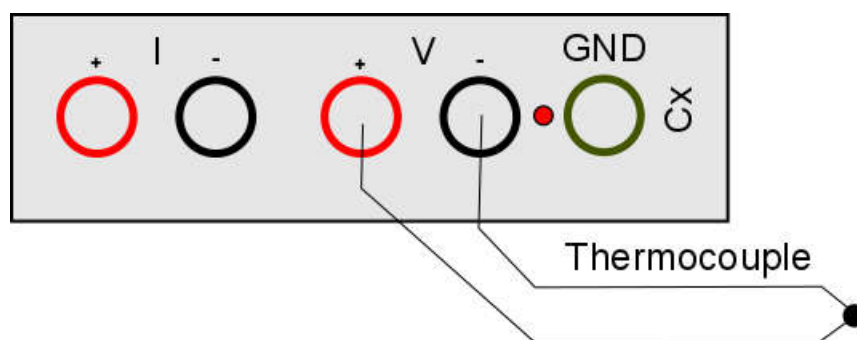


Figure 6: Thermocouple connection using the voltage connectors

2.5.3 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.

2.6 Channels

UT-ONE S04A measurement system consists of several measurement channels. The main channels are C1, C2, C3 and C4, which correspond to 4 main channels for the connection of thermometer probes. TJ is the temperature of the internal thermometer, which is used for the internal compensation of the cold junction of thermocouples.

UT-ONE supports two formats for channel names. Short format consists of two characters and a space, for example "C1 ", while long format consists of three characters, for example "C01". Note that in the remote-interface commands, channel name always consist of three characters, but both short and long format may be used.

Table 1: List of channel names (channel names in long format are given in parenthesis)

Channel	Description
RT (RT)	Real time clock
C1 (C01)	Corrected temperature reading from temperature probe on main channel 1
C2 (C02)	Corrected temperature reading from temperature probe on main channel 2
C3 (C03)	Corrected temperature reading from temperature probe on main channel 3
C4 (C04)	Corrected temperature reading from temperature probe on main channel 4
TJ (CTJ)	Corrected temperature reading of internal thermometer for cold-junction compensation
TI (CTI)	Corrected temperature of the A/D converter. Used for internal correction of temperature coefficients
B1 (B01)	Raw reading (resistance or emf) of the temperature probe on main channel 1
B2 (B02)	Raw reading (resistance or emf) of the temperature probe on main channel 2
B3 (B03)	Raw reading (resistance or emf) of the temperature probe on main channel 3
B4 (B04)	Raw reading (resistance or emf) of the temperature probe on main channel 4
BJ (BTJ)	Uncorrected temperature reading of internal thermometer for cold-junction compensation
BI (BTI)	Uncorrected temperature of A/D converter

2.7 Measurement ranges

UT-ONE measurement subsystem consists of 31 physical measurement ranges, which allow the user to perform the measurements with best accuracy and efficiency. Measurement ranges are divided in three range groups, namely the PRT, thermistor and thermocouple ranges. Range h7 is an auxiliary range, which allows the extension of measurement range up to 100 k Ω at reduced measurement current, but this range is not part of the UT-ONE specifications and should be used with caution.

Table 2: List of physical measurement ranges for main channels

Name	Nominal range	Over range	Measurement current	Range group
R1	25 Ω	31.25 Ω	1 mA	PRT ranges
R2	50 Ω	62.5 Ω	1 mA	PRT ranges
R3	100 Ω	125 Ω	1 mA	PRT ranges
R4	200 Ω	250 Ω	1 mA	PRT ranges
R5	400 Ω	500 Ω	1 mA	PRT ranges
R6	800 Ω	1000 Ω	1 mA	PRT ranges
r1	25 Ω	31.25 Ω	0.707 mA	PRT ranges
r2	50 Ω	62.5 Ω	0.707 mA	PRT ranges
r3	100 Ω	125 Ω	0.707 mA	PRT ranges
r4	200 Ω	250 Ω	0.707 mA	PRT ranges
r5	400 Ω	500 Ω	0.707 mA	PRT ranges
r6	800 Ω	1000 Ω	0.707 mA	PRT ranges
H1	1250 Ω	1562.5 Ω	20 μ A	Thermistor ranges
H2	2500 Ω	3125 Ω	20 μ A	Thermistor ranges
H3	5000 Ω	6250 Ω	20 μ A	Thermistor ranges
H4	10000 Ω	12500 Ω	20 μ A	Thermistor ranges
H5	20000 Ω	25000 Ω	20 μ A	Thermistor ranges
H6	40000 Ω	50000 Ω	20 μ A	Thermistor ranges
h1	1250 Ω	1562.5 Ω	14.1 μ A	Thermistor ranges
h2	2500 Ω	3125 Ω	14.1 μ A	Thermistor ranges
h3	5000 Ω	6250 Ω	14.1 μ A	Thermistor ranges
h4	10000 Ω	12500 Ω	14.1 μ A	Thermistor ranges
h5	20000 Ω	25000 Ω	14.1 μ A	Thermistor ranges
h6	40000 Ω	50000 Ω	14.1 μ A	Thermistor ranges
h7	80000 Ω	100000 Ω	14.1 μ A	Auxiliary range
E1	15 mV	18.28125 mV	Not applicable	Thermocouple ranges
E2	30 mV	36.5625 mV	Not applicable	Thermocouple ranges
E3	60 mV	73.125 mV	Not applicable	Thermocouple ranges
E4	125 mV	146.25 mV	Not applicable	Thermocouple ranges
E5	250 mV	292.5 mV	Not applicable	Thermocouple ranges
E6	500 mV	585 mV	Not applicable	Thermocouple ranges

Each physical range has nominal range limit. Specifications are applicable only to measurements up to nominal range limit. Each physical range features also some over range, which is approximately 20%

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higher than nominal range limit. Measurements can be normally performed in the over range, but significantly higher linearity error should be expected and taken into account in the uncertainty budget.

Apart from the 31 physical ranges, UT-ONE measurement subsystem implements also 5 virtual autoranges. Autoranges are implemented to simplify configuration of acquisition channels, so the user doesn't need to know the expected resistance or emf of the thermometer probe. When using autoranging, UT-ONE first samples the approximate value of prober resistance or emf and then selects the optimal physical measurement range accordingly. Note that there is no difference in accuracy or measurement speed between autorange and equivalent manually-selected physical range.

Table 3: List of virtual autoranges for main channels

Name	Nominal range	Over range	Measurement current	Range group
RA	0 to 800 Ω	1000 Ω	1 mA	PRT ranges
rA	0 to 800 Ω	1000 Ω	0.707 mA	PRT ranges
HA	0 to 40000 Ω	50000 Ω	20 μ A	Thermistor ranges
hA	0 to 40000 Ω	50000 Ω	14.1 μ A	Thermistor ranges
EA	0 to 500 mV	585 mV	Not applicable	Thermocouple ranges

3 User Interface

UT-ONE S04A has no built-in user interface for direct reading of measurement results and controlling the acquisition. The only element of the user interface are the active channel indicators, which are illuminated when the channel becomes active. Note that after a single measurement on the selected channel is completed, the channel remains active until the next measurement is started.

Control of acquisition and displaying of results is displayed exclusively in the acquisition software on a personal computer, which is connected to UT-ONE using the USB communication interface.

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.

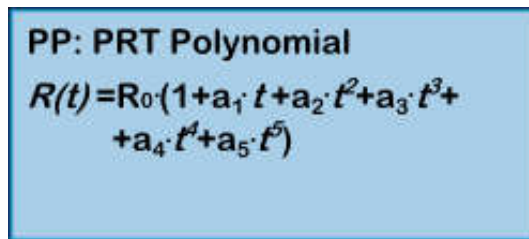

$$\text{PP: PRT Polynomial}$$
$$R(t) = R_0 \cdot (1 + a_1 \cdot t + a_2 \cdot t^2 + a_3 \cdot t^3 + a_4 \cdot t^4 + a_5 \cdot t^5)$$

Figure 7: 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.

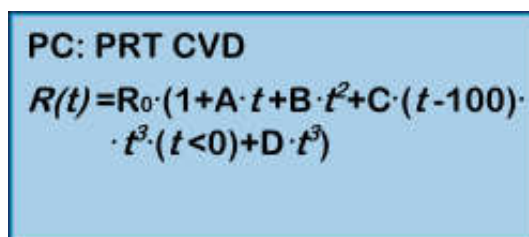

$$\text{PC: PRT CVD}$$
$$R(t) = R_0 \cdot (1 + A \cdot t + B \cdot t^2 + C \cdot (t - 100) \cdot t^3 \cdot (t < 0) + D \cdot t^3)$$

Figure 8: 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 aluminium (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 9: 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 10: 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 11: 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.

$$\begin{aligned} \text{TK: TC Type K} \\ E(t) + E_n(t_0) - E_n(t) = \\ = a_0 + a_1 \cdot t + a_2 \cdot t^2 + a_3 \cdot t^3 \end{aligned}$$

Figure 12: 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.

$$\begin{aligned} \text{TJ: TC Type J} \\ E(t) + E_n(t_0) - E_n(t) = \\ = a_0 + a_1 \cdot t + a_2 \cdot t^2 + a_3 \cdot t^3 \end{aligned}$$

Figure 13: 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.

$$\begin{aligned} \text{TT: TC Type T} \\ E(t) + E_n(t_0) - E_n(t) = \\ = a_0 + a_1 \cdot t + a_2 \cdot t^2 + a_3 \cdot t^3 \end{aligned}$$

Figure 14: 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.

$$\begin{aligned} \text{TE: TC Type E} \\ E(t) + E_n(t_0) - E_n(t) = \\ = a_0 + a_1 \cdot t + a_2 \cdot t^2 + a_3 \cdot t^3 \end{aligned}$$

Figure 15: 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.

$$\begin{aligned} \text{TN: TC Type N} \\ E(t) + E_n(t_0) - E_n(t) = \\ = a_0 + a_1 \cdot t + a_2 \cdot t^2 + a_3 \cdot t^3 \end{aligned}$$

Figure 16: 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.

$$\begin{aligned} \text{TS: TC Type S} \\ E(t) + E_n(t_0) - E_n(t) = \\ = a_0 + a_1 \cdot t + a_2 \cdot t^2 + a_3 \cdot t^3 \end{aligned}$$

Figure 17: 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.

$$\begin{aligned} \text{TR: TC Type R} \\ E(t) + E_n(t_0) - E_n(t) = \\ = a_0 + a_1 \cdot t + a_2 \cdot t^2 + a_3 \cdot t^3 \end{aligned}$$

Figure 18: Conversion equation for TR 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.

$$\begin{aligned} \text{TB: TC Type B} \\ E(t) + E_n(t_0) - E_n(t) = \\ = a_0 + a_1 \cdot t + a_2 \cdot t^2 + a_3 \cdot t^3 \end{aligned}$$

Figure 19: Conversion equation for TB probe type

4.3 Ambient probes

UT-ONE S04A features two 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. 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 Temperature deviation function

Temperature deviation function is applicable to channels 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 USB interface and optional RS232 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 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.



Figure 20: USB connector on the side panel of UT-ONE



Figure 21: USB cable with ferrite cores

5.2 GPIB Interface

GPIB interface is an optional accessory for UT-ONE S04A. Note that even if you are using GPIB interface for communication, you still have to power the UT-ONE S04A using the USB interface.

GPIB interface (also known as HP-IB and IEEE488) is an industry-standard communication interface for the connection of measurement instruments with a personal computer. GPIB interface is fast and reliable with transfer rates of up to 1 Mbyte per second. GPIB allows the connection of up to 15 instruments in a single measurement system. Each instrument must have a unique GPIB address in range from 1 to 30.

UT-ONE GPIB interface is fully compatible with IEEE 488.1 standard. The interface supports the following interface functions according to IEEE 488.1: SH1, AH1, T6, L4, SR1, RL0, DC1, DT0, C0 and E2. The interface supports serial polling, but it will never generate a serial poll request and will always return a constant status byte. Recommended settling time for multiline messages (T1) is 1100 ns.

GPIB address can be set only via the remote communication interface using the GA command or the UT-ONE Interface application. Optionally, if GPIB interface is not used, you may disable it and consequentially reduce the power consumption.

Changes to GPIB address and enable status will become valid only after you restart the UT-ONE by cycling the power supply.

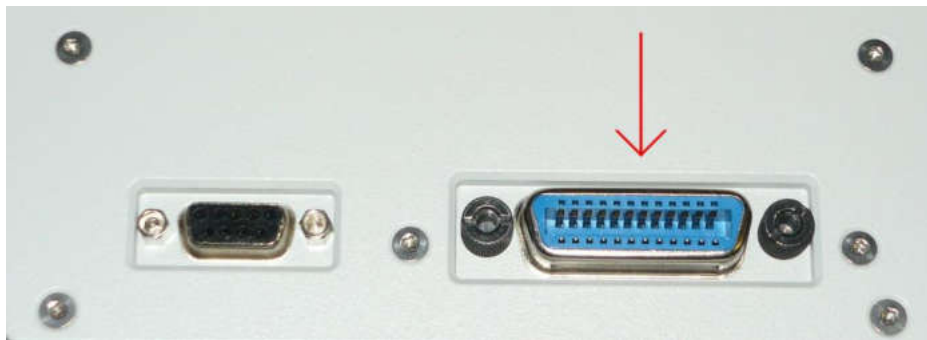


Figure 22: GPIB connector on the side panel of UT-ONE

5.3 RS232 interface

RS232 is optional accessory on UT-ONE S04A. Note that even if you are using RS232 interface for communication, you still have to power the UT-ONE S04A using the USB 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 interface 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.

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RS232 connector is located on the side panel of UT-ONE. 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.

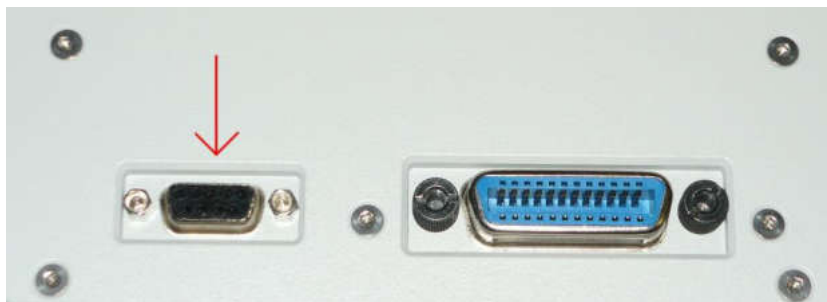


Figure 23: RS232 connector on the side panel of UT-ONE



Figure 24: RS232 connection cable



Figure 25: USB-RS232 adapter

5.4 Command syntax

Command set is identical for both the GPIB, RS232 and USB communication interfaces. However, RS232 and GPIB interfaces are 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 exceeding 255 characters will result in a communication error.

USB interface can be used independently at the same time as the GPIB or RS232 interface. GPIB and RS232 share the same resources, so you can only use one of them at the same time. If you perform communication over one of them, make a communication pause of at least 200 ms before resuming communication with the other interface. UT-ONE will automatically start the communication on the activated communication interface.

Commands can be sent at any rate without affecting the device operation or accuracy of measurements. Always read the response message before starting the next command. Sending several concatenated command messages together is not allowed. When using USB or GPIB 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 below 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* signals that command is valid, but it is not supported by the particular device configuration
- *E8* 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.ddddddddddE±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

5.5 Command set

UT-ONE command set is the same for all thermometer readouts from the UT-ONE family, but note that some commands are applicable only to particular UT-ONE models. For example, commands for streaming readings from the SD card are applicable only to models with a display, commands for setting GPIB parameters are applicable only to devices with GPIB option installed, etc.

5.5.1 B?

Return the binary block with binary values directly from analog to digital converter (ADC). Each block contains up to 40 ADC readings. This command is useful only for troubleshooting and advanced applications, as well as for reading the data in digitizing acquisition mode.

Command message: B?

Response message: #<binary block size>{<binary block data>}OK<Measurement range label>

Binary block data consists of:

- ADC buffer index (0x00 or 0x80) (1 byte)
- Channel index (0x00 = C1, 0x01 = C2 and 0x02 = C3, etc) (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)
- N uncorrected ADC readings in displaced binary format (N * 3 bytes)

Example:

Command message: B?

Response message: #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 }OKR4

LabVIEW driver: *UT-ONE Digitizing Driver.vi*

5.5.2 CPccc?

Return the currently selected probe index for main channel *ccc*. *ccc* is the channel name in short or long format (for example 'C1 ', 'B3 ', 'C01', 'C02' or 'B01'). Refer to table 1 for full list of applicable channel names. Probe index can be any probe index according to probe list from 0 to 48.

Command message: CPccc?

Response message: OK<Probe index>

Example:

Command message: CPC1 ?

Response message: OK21

LabVIEW driver: *UT-ONE Channel Driver.vi*

5.5.3 CPccc <Probe index>

Set the new probe index for main channel ccc. ccc is the channel name in short or long format (for example 'C1 ', 'B3 ', 'C01', 'C02' or 'B01'). Refer to table 1 for full list of applicable channel names. Probe index can be any probe index according to probe list from 0 to 48.

Command message: CPccc <Probe index>
Response message: OK

Example:

Command message: CPB1 23
Response message: OK
LabVIEW driver: *UT-ONE Channel Driver.vi*

5.5.4 CRccc?

Return the currently selected measurement range label for main channel ccc. ccc is the channel name in short or long format (for example 'C1 ', 'B3 ', 'C01', 'C02' or 'B01'). Refer to table 1 for full list of applicable channel names. 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: CRccc?
Response message: OK<Measurement range label>

Example:

Command message: CRC1 ?
Response message: OKR3
LabVIEW driver: *UT-ONE Channel Driver.vi*

5.5.5 CRccc <Measurement range label>

Set the new measurement range label for main channel ccc. ccc is the channel name in short or long format (for example 'C1 ', 'B3 ', 'C01', 'C02' or 'B01'). Refer to table 1 for full list of applicable channel names. 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: CRccc <Measurement range label>
Response message: OK

Example:

Command message: CRC2 E1
Response message: OK
LabVIEW driver: *UT-ONE Channel Driver.vi*

5.5.6 CEccc?

Return the channel status for main channel ccc. ccc is the channel name in short or long format (for example 'C1 ', 'B3 ', 'C01', 'C02' or 'B01'). Refer to table 1 for full list of applicable channel names. 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: CEccc?
Response message: OK<Channel status>

Example:

Command message: CEC1 ?
Response message: OKON
LabVIEW driver: UT-ONE Channel Driver.vi

5.5.7 CEccc <Channel Status>

Set the new channel status for main channel ccc. ccc is the channel name in short or long format (for example 'C1 ', 'B3 ', 'C01', 'C02' or 'B01'). Refer to table 1 for full list of applicable channel names. 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: CSccc <Channel status>
Response message: OK

Example:

Command message: CSC01 OF
Response message: OK
LabVIEW driver: UT-ONE Channel Driver.vi

5.5.8 CAccc?

Return the averaging time in seconds for main channel ccc. ccc is the channel name in short or long format (for example 'C1 ', 'B3 ', 'C01', 'C02' or 'B01'). Refer to table 1 for full list of applicable channel names. 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: CAccc?
Response message: OK<Averaging time>

Example:

Command message: CAC01?
Response message: OK010
LabVIEW driver: UT-ONE Channel Driver.vi

5.5.9 CAccc <Averaging time>

Set the averaging time for main channel ccc. ccc is the channel name in short or long format (for example 'C1 ', 'B3 ', 'C01', 'C02' or 'B01'). Refer to table 1 for full list of applicable channel names. 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: CAccc <Averaging time>
Response message: OK

Example:

Command message: CAC1 012
Response message: OK
LabVIEW driver: UT-ONE Channel Driver.vi

5.5.10 CCccc?

Return the measurement current setting for main channel ccc. ccc is the channel name in short or long format (for example 'C1 ', 'B3 ', 'C01', 'C02' or 'B01'). Refer to table 1 for full list of applicable channel names. 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 $\sqrt{2}$. Use this feature to estimate the self-heating error.

Command message: CCccc?
Response message: OK<Measurement current setting>

Example:

Command message: CCC1 ?
Response message: OKNR
LabVIEW driver: UT-ONE Channel Driver.vi

5.5.11 CCccc <Measurement current setting>

Set the measurement current for main channel ccc. ccc is the channel name in short or long format (for example 'C1 ', 'B3 ', 'C01', 'C02' or 'B01'). Refer to table 1 for full list of applicable channel names. 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 $\sqrt{2}$. Use this feature to estimate the self-heating error.

Command message: CCccc <Measurement current setting>
Response message: OK

Example:

Command message: CCC2 RD
Response message: OK
LabVIEW driver: UT-ONE Channel Driver.vi

5.5.12 DA?

Return current setting for auto-start continuous measurement. This setting allows you to control if the UT-ONE will immediately start with acquisition in continuous measurement mode after UT-ONE is started. Available settings are:

- OF = UT-ONE will start without starting continuous measurement
- ON = UT-ONE will start with started continuous measurement
- AU = UT-ONE will start with started continuous measurement if it was shutdown with started continuous measurement

Command message: DA?

Response message: OK<Auto-start setting>

Example:

Command message: DA?

Response message: OKON

LabVIEW driver: *UT-ONE Acquisition Status Driver.vi*

5.5.13 DA <Auto-start setting>

Set new setting for auto-start continuous measurement.

Command message: DA <Auto-start setting>

Response message: OK

Example:

Command message: DA AU

Response message: OK

LabVIEW driver: *UT-ONE Acquisition Status Driver.vi*

5.5.14 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

LabVIEW driver: Not available

5.5.15 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
LabVIEW driver: Not available

5.5.16 DS?

Return current acquisition status. UT-ONE supports four different acquisition statuses:

- OF = UT-ONE is currently not acquiring and is in idle state
- ON = UT-ONE is currently acquiring in continuous measurement mode
- SR = UT-ONE is currently acquiring in single-reading mode
- DG = UT-ONE is currently acquiring in digitizing mode

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

Example:

Command message: DS?
Response message: OKON
LabVIEW driver: *UT-ONE Acquisition Status Driver.vi*

5.5.17 DS <Acquisition status>

Set new acquisition status. You can only change acquisition status for the continuous measurement mode: Available options are:

- OF = stop acquiring in continuous measurement mode and enter idle state
- ON = start acquiring in continuous measurement mode

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

Example:

Command message: DS OF
Response message: OK
LabVIEW driver: *UT-ONE Acquisition Status Driver.vi*

5.5.18 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

LabVIEW driver: *UT-ONE Acquisition Status Driver.vi*

5.5.19 DDccc< Measurement range label >< Frequency index >

Start acquisition on main channel ccc in fast digitizing mode with specified measurement range and using specified sampling frequency. ccc is the channel name in short or long format (for example 'c1', 'B3', 'C01', 'C02' or 'B01'). Refer to table 1 for full list of applicable channel names. Fast digitizing mode will stop normal acquisition sequence. Valid measurement range labels are R1, R2, R3, R4, R5, R6, H1, H2, H3, H4, H5, H6, E1, E2, E3, E4, E5, E6, r1, r2, r3, r4, r5, r6, h1, h2, h3, h4, h5, h6 and h7. Note that auto ranging is not supported. 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)
- D8.33 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: DDccc< Measurement range label >< Frequency index >

Response message: OK

Example:

Command message: DDC1 R3A

Response message: OK

LabVIEW driver: *UT-ONE Digitizing Driver.vi*

Acquisition of samples is continuous and there is no current reversal. Note that absolute accuracy is significantly worse in fast digitizing mode and readings may be subject to interference and drift.

After the command is successfully processed, UT-ONE enters in fast digitizing mode and starts automatic acquisition of ADC reading at specified sampling frequency. Note that the data throughput at high sampling frequencies is considerable, so the use of USB interface is recommended in order to avoid missing samples. ADC readings can be read using the B? command. Refer to the sample application UT-ONE Digitizing for more information.

5.5.20 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: #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}OK
LabVIEW driver: UT-ONE Probe Driver.vi

5.5.21 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
LabVIEW driver: UT-ONE Probe Driver.vi

5.5.22 EPN<Probe index>?

Returns probe name for given probe index, as defined in probe data structure. Probe data is stored in a binary structure specified in the *Probe coefficients* chapter. Probe name is 20 characters long (shorter probe names are filled with trailing spaces).

Command message: EPN<Probe index>?
Response message: OK

Example:

Command message: EPN21?
Response message: OKPt-100 ISO/IEC751
LabVIEW driver: UT-ONE Probe Driver.vi

5.5.23 GA?

Return current GPIB address. This command is applicable only for UT-ONE devices with optional GPIB+RS232 interface. If optional interface is not present, UT-ONE will reply with E7 response message.

Command message: GA?
Response message: OK< GPIB Address>

Example:
Command message: GA?
Response message: OK07
LabVIEW driver: *UT-ONE GPIB Configuration Driver.vi*

5.5.24 GA <GPIB Address>

Set new GPIB address. This command is applicable only for UT-ONE devices with optional GPIB+RS232 interface, otherwise UT-ONE will reply with E7 error. Valid GPIB addresses are in range from 1 to 30.

Command message: GA < GPIB Address>
Response message: OK

Example:
Command message: GA 05
Response message: OK
LabVIEW driver: *UT-ONE GPIB Configuration Driver.vi*

5.5.25 GE?

Return the enable status of the GPIB and RS232 interface. This command is applicable only for UT-ONE devices with optional GPIB+RS232 interface, otherwise UT-ONE will reply with E7 error.

Command message: GE?
Response message: OK< Enable status>

Example:
Command message: GE?
Response message: OKON, OF
LabVIEW driver: *UT-ONE GPIB Configuration Driver.vi*

5.5.26 GE <Enable status>

Set new enable status for the GPIB and RS232 interface. This command is applicable only for UT-ONE devices with optional GPIB+RS232 interface. If optional interface is not present, UT-ONE will reply with E7 response message. Valid status is ON (interface enabled), OF (interface disabled) and OK (no changes to current setting).

Command message: GE < GPIB enable status>, <RS232 enable status>
Response message: OK

Example:
Command message: GE ON, OK
Response message: OK
LabVIEW driver: *UT-ONE GPIB Configuration Driver.vi*

5.5.27 I?

Return identification string from UT-ONE.

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

Example:
Command message: I?
Response message: OKBatemika, UT-ONE
LabVIEW driver: *UT-ONE ID Strings Driver.vi*

5.5.28 IS?

Return serial number from UT-ONE.

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

Example:
Command message: IS?
Response message: OKB01010915
LabVIEW driver: *UT-ONE ID Strings Driver.vi*

5.5.29 IP?

Return production number from UT-ONE.

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

Example:
Command message: IP?
Response message: OKUTONE 0201250813-04020402
LabVIEW driver: *UT-ONE ID Strings Driver.vi*

5.5.30 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
LabVIEW driver: *UT-ONE ID Strings Driver.vi*

5.5.31 IV?

Return firmware version from UT-ONE.

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

Example:
Command message: IV?
Response message: OK2.07.00r
LabVIEW driver: *UT-ONE ID Strings Driver.vi*

5.5.32 IC?

Return firmware CRC (cyclic redundancy code) from UT-ONE.

Command message: IC?
Response message: OK< application firmware CRC > < bootloader firmware CRC >

Example:
Command message: IC?
Response message: OK532EA4 D20BF4
LabVIEW driver: *UT-ONE ID Strings Driver.vi*

5.5.33 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: #040{ 0001 0000 0001 0C00 0000 0000 0000 0C00 0000 0000
0000 0C00 0000 0000 0000 0C00 0000 0000 0000 0C00 }OK
LabVIEW driver: *UT-ONE SD Streaming Driver.vi*

5.5.34 LW

Send data 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
LabVIEW driver: *UT-ONE SD Streaming Driver.vi*

5.5.35 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 name can be in either short or long format. 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

LabVIEW driver: UT-ONE Continuous Measurement Driver.vi

5.5.36 MA< Channel name >?

Return the current measurement for the given channel including real time value, channel value, raw channel value, measurement range, unit and probe index. Channel name can be any channel name except real time value RT, which is returned by default. Channel name can be in either short or long format. Channel values are updated after the end of the acquisition sequence.

Command message: MA< Channel name >?

Response message: OKRT :< Real time value >,< Channel name >:< Channel value >,< Raw channel name >:< Raw channel value >,RNG:< Measurement range label >,UNT:< Raw value unit >,< PRB:< Probe index>

Example:

Command message: MAC1 ?

Response message: OKRT : 0578423734,C1 :+2.29986400000E+01,B1
:+1.08958008000E+02,RNG:R4,UNT:ohm,PRB:21

LabVIEW driver: UT-ONE Continuous Measurement Driver.vi

5.5.37 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 :+2.45400060000E+01,TD
:+1.63703740000E+01,TJ :+2.50272300000E+01

LabVIEW driver: UT-ONE Continuous Measurement Driver.vi

5.5.38 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 :+2.43200060000E+01,BD :+1.56051900000E+01,BJ :+2.44171180000E+01

LabVIEW driver: *UT-ONE Continuous Measurement Driver.vi*

5.5.39 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

LabVIEW driver: *UT-ONE Continuous Measurement Driver.vi*

5.5.40 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 :+2.13098540000E+01

LabVIEW driver: *UT-ONE Continuous Measurement Driver.vi*

5.5.41 MI< Channel name >?

Return the immediate measurement for the given channel. Channel name can be in either short or long format. Channel name can be any channel name except real time value RT, which is returned by default. This command returns the immediate value for the channel and is not synchronized with the acquisition sequence. Note that if acquisition status is OF, main channels are not updated, but ambient channels are 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: MI< Channel name >?

Response message: OKRT :< Real time value >,< Channel name >:< Channel value >

Example:

Command message: MITA ?

Response message: OKRT : 0457638877,TA :+2.45400060000E+01

LabVIEW driver: *UT-ONE Continuous Measurement Driver.vi*

5.5.42 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

LabVIEW driver: *UT-ONE Battery Driver.vi*

5.5.43 S<Channel><Reference Channel><Range><Samples>

Starts a single reading with selected settings. Channel name can be in either short or long format. *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 both 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, h6 and h7). *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: SB1 B3 R315?
Response message: OKRT : 0457654321, B1
LabVIEW driver: *UT-ONE Single Reading Driver.vi*

5.5.44 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
LabVIEW driver: *UT-ONE Single Reading Driver.vi*

5.5.45 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 $^{\circ}\text{C}$, 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*

LabVIEW driver: *UT-ONE Single Reading Driver.vi*

5.5.46 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*

LabVIEW driver: *UT-ONE RealTimeClock Driver.vi*

5.5.47 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*

LabVIEW driver: *UT-ONE RealTimeClock Driver.vi*

5.5.48 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*

LabVIEW driver: *Not available*

5.5.49 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 $X3 = \text{Sonntag function}(X1, X2)$
- K square root $X3 = \text{sqrt}(X2)$
- 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-1.000000000000E+00*

LabVIEW driver: *Not available*

5.5.50 XC< 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. Channel names can be in either short or long format.

Command message: XC< Channel name >?

Response message: OK< BCD result >

Example:

Command message: XCC01?

Response message: OK-1.025000000000E+01

LabVIEW driver: *Not available*

5.5.51 XP< 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: XP< Probe index >?

Response message: OK< BCD result >

Example:

Command message: XP21?

Response message: OK+1.145000000000E+02

LabVIEW driver: *Not available*

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.

Auto-start setting can be used to specify the state of the continuous measurement mode at UT-ONE startup. UT-ONE can be configured to start with continuous measurement mode started, stopped or the same as during the last UT-ONE shutdown.

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.

Alternatively, you can use the "S<Probe index>?" command, which will also convert the acquired raw reading using the specified probe.

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 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 $^{\circ}\text{C}$, 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 per second 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 behaviour 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 S04A has no internal batteries.

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 software is applicable to all models of the UT-ONE family of thermometer readouts, so certain features may not be available for your particular UT-ONE model.

UT-ONE Applications is based on LabVIEW platform and is distributed as an 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 readouts. 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 without a written permission from the Batemika.

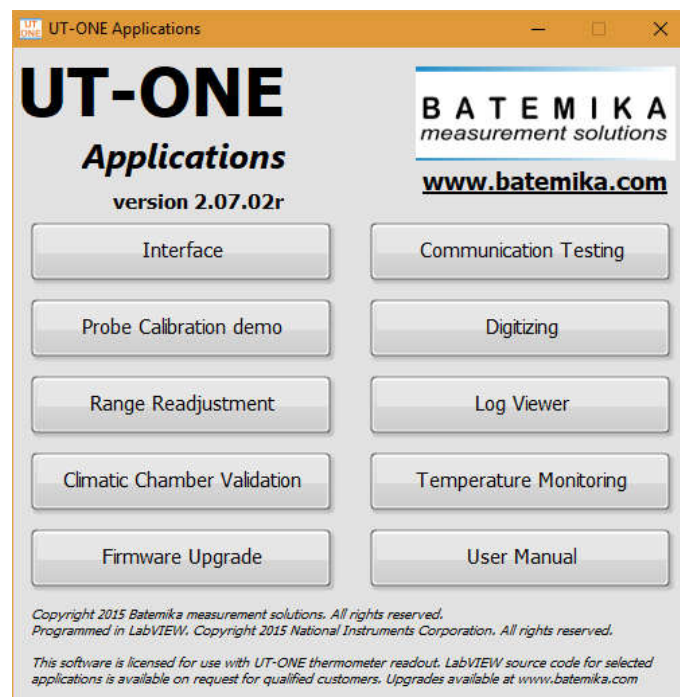


Figure 26: UT-ONE Applications launch panel

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.

Probe Calibration Demo, *Climatic Chamber Validation* and *Temperature Monitoring* applications allow you to start and execute more than one instance of the application at the same time. To start another instance of the application, use the associated button in the UT-ONE Applications launch panel.

This user manual can be accessed in pdf format by clicking the *User Manual* button.

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4-Channel Thermometer Readout

After you launch one of the UT-ONE applications using the launch panel, the application will first try to automatically establish the communication with UT-ONE using the last successfully used communication interface. If communication interface has not been selected before, or the communication with UT-ONE can't be established, the application will automatically switch to *UT-ONE* page and paint the *UT-ONE Communication interface* control to red. Use the right-click button to activate the popup menu with the list of available communication interfaces, which include USB interfaces, serial interfaces and GPIB interfaces.

After you select a communication interface from the list, the application will attempt to establish communication with UT-ONE over the selected interface. If communication is successfully established, the *UT-ONE Communication interface* control is painted grey and UT-ONE information is retrieved and displayed.

If communication is not established over the selected interface, *UT-ONE Communication interface* control will remain red and UT-ONE information will not be displayed. Check that communication cables are properly attached and that UT-ONE is switched. Also, check if any other application (outside *UT-ONE Applications*) is currently communicating with UT-ONE and has consequently locked the communication interface.

To change the interface or UT-ONE device after the communication was already established using the default interface, click the *Change Interface* button. The application will restart with blank *Communication Interface* box and you will be able to reselect it. Note that any data acquired so far using this application will be lost.

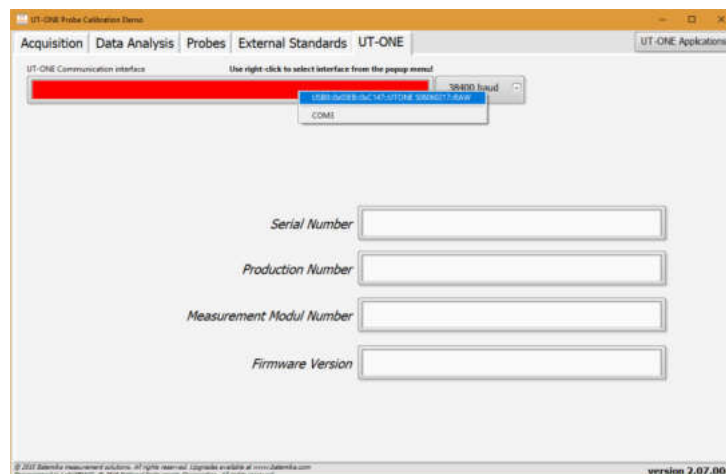


Figure 27: UT-ONE page before communication with UT-ONE is established

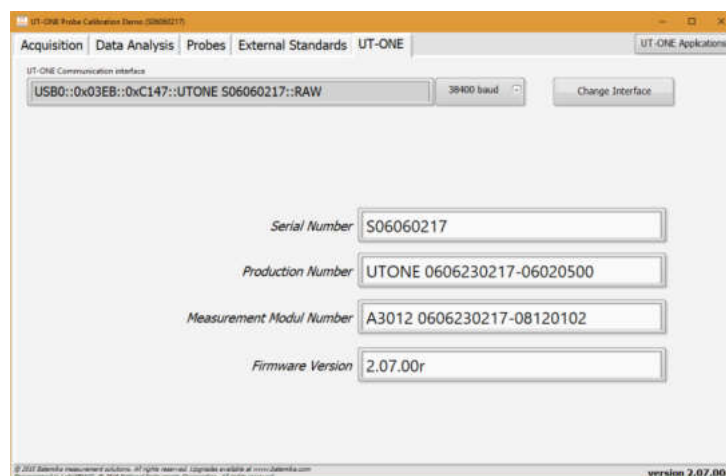


Figure 28: UT-ONE page after communication with UT-ONE is established

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 a similar way as in the UT-ONE B03A display, so the use is intuitive. UT-ONE Interface application is also applicable to UT-ONE SxxA models, but in this case functions that are related to UT-ONE display, internal logging and battery are not applicable.

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 B03A display. You can download the readings that were logged in the UT-ONE B03A display memory using the *Download Measurements* button. 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 B03A 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 29: UT-ONE Interface mixed measurement view

Configuration page has similar views as in the UT-ONE B03A 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.

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4-Channel Thermometer Readout

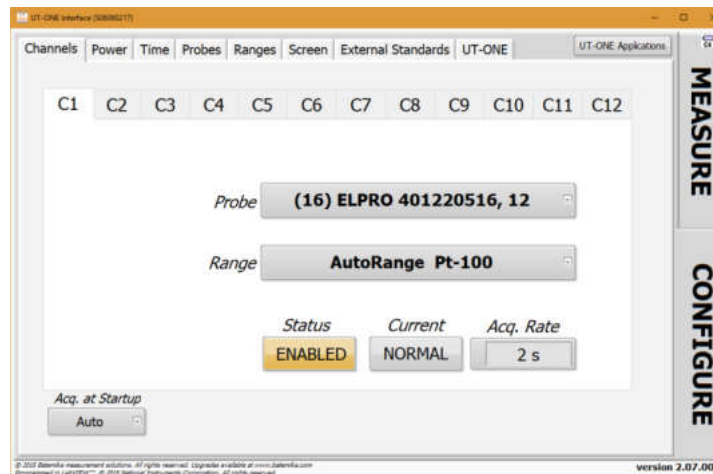


Figure 30: UT-ONE Interface channel configuration view

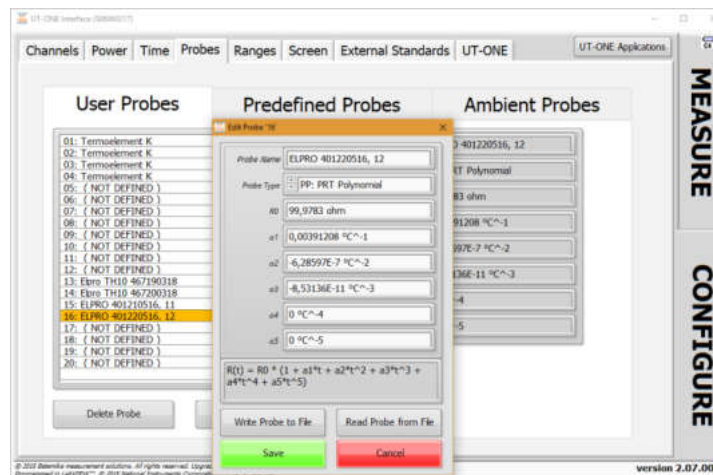


Figure 31: UT-ONE Interface probe editing

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.

This application is a limited demo version of the Batemika calibration software, as it enables the calibration of only one probe at the same time, it has no uncertainty calculation and no printing of calibration certificates. Contact Batemika to get more information about the full version of our custom-made calibration software.

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.

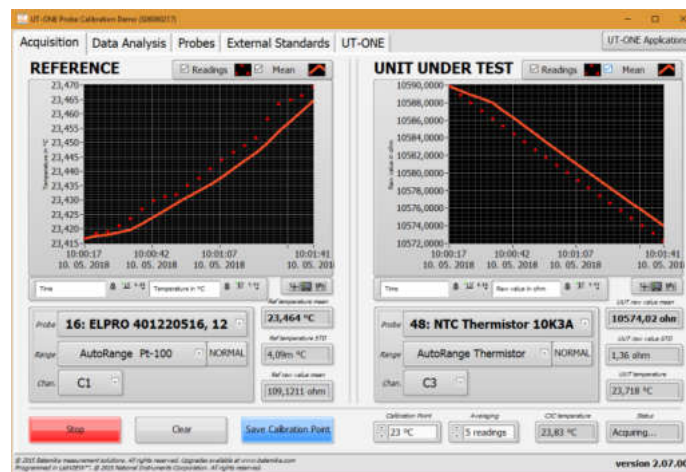


Figure 32: Acquisition window

Calibration uncertainty can be improved by using the external standard, which must be connected to the remaining UT-ONE main channel. To enable the use of external standards, go to the *External Standards* page and check the *Enable External Standards* checkbox. Verify that the correct external standards are set up and saved to the UT-ONE internal memory. You can now select the external standards in the channel configuration for the reference and UUT probe. Note that external standards must be enabled and set up before you make the first measurement.

Acquisition can be started using the *Start/Stop* button in the bottom of the window. Measurements are acquired in the 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

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4-Channel Thermometer Readout

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 one 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.

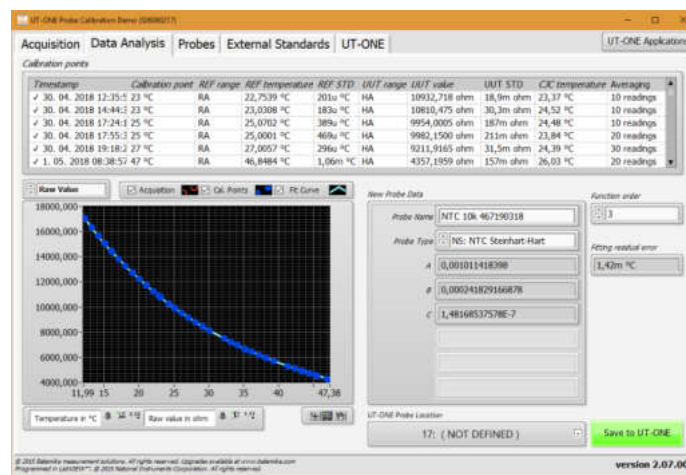


Figure 33: Data Analysis window with results of NTC 10k calibration

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.

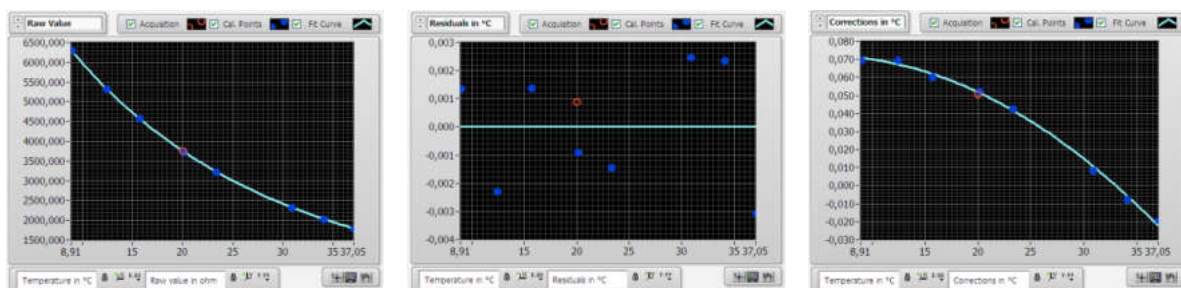


Figure 34: Visualization of data analysis results for NTC 3k calibration

8.3 UT-ONE Range Readjustment

UT-ONE Range Readjustment application is a tool for checking the internal drift of the UT-ONE measurement circuits and optional adjustment of the reference value for each measurement range. Note that adjustment removes the drift error, but it may also invalidate the traceability obtained from a UT-ONE calibration certificate, so depending on your requirements, a recalibration may also be required after readjustment procedure. If measured drift errors are within specified accuracy, it may therefore not be optimal to store them to UT-ONE non-volatile memory.

UT-ONE Range Readjustment application also feature a manual mode, which just measures and averages the raw value (resistance or DC voltage) on selected channel. The results are just recorded and there is no adjustment performed. This is a useful tool for the calibration of UT-ONE in an external calibration laboratory, especially for UT-ONE units with no display.

Range readjustment requires the connection of external standards, typically reference resistors or DC voltage sources. External standards must be connected to main channels and configured in the *External Standards* page before adjustment can start.

Range adjustment is always performed in three distinct levels:

- In the first level the value of configured external standards is measured and displayed in the list, together with the drift error in ppm. At this point there are no changes to UT-ONE and procedure may be stopped at any time. If you want just to check the drift of the UT-ONE, you should stop at this point
- In the second level, all or selected ranges with the READY TO SAVE status are stored to UT-ONE volatile memory. Changes take effect immediately, so the results of the adjustment can be observed. Note that at this point, if the UT-ONE is shut down, all changes will be lost and UT-ONE will return to original state
- In the third level, you may choose to save changes to non-volatile EEPROM memory in UT-ONE. Note that at this point changes are permanently stored and previous values may not be recovered.

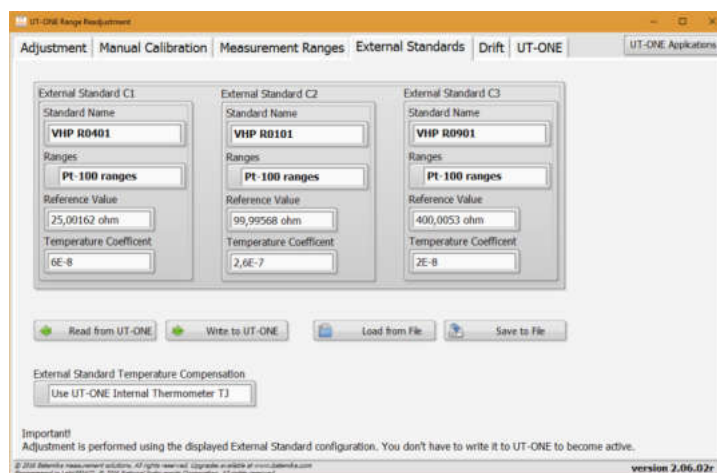


Figure 35: External Standards page

The first step is the configuration of the external standards. For each external standard, you must specify the name, range set, reference value and temperature coefficient. *Standard name* is used just for the user convenience and has no effect on adjustment. *Ranges* selects the set of ranges for which the external standard is applicable. If external standard is not connected, you should select the *Not used* option. *Reference Value* specifies the true value of the external standard at 23 °C. *Temperature coefficient* specifies the temperature coefficient of the external standard, which allows the automatic temperature compensation of the external standard. If temperature compensation is not applicable, use 0. The source of temperature for automatic compensation can be selected in *External Standard*

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4-Channel Thermometer Readout

Temperature Compensation. You may choose between no compensation, internal TJ thermometer or optional ambient conditions probe TA.

External standards configuration has the same format as the external standards configuration used in UT-ONE to improve measurement accuracy, but it can be used independently, so you don't have to write to UT-ONE memory to become active for the scope of adjustment. Nevertheless, you may read or write external configuration to UT-ONE memory, as well as to *.esc files on your local computer.

After the external standards are configured, you may proceed to *Adjustment* page to start the adjustment. First select the set of ranges (Pt-100 ranges, thermistor ranges or thermocouple ranges) that you wish to adjust. The range list will be automatically populated with applicable measurement ranges. Note that range set must match the range set selected in the external standard configuration, otherwise external standard won't be used.

Next select the number of readings that are acquired and averaged for each range adjustment. The default value is 40, which gives good results, but you may wish to choose higher or lower value according to your time and accuracy constraints.

Next select how the external standards are selected for each measurement range. You have three options:

- *Auto-select external standards* will select all external standards that are between 15% and 90% of the range reference value
- *Use all applicable external standards* will select all select all standards that are less than 100% of the range reference value
- *Use highest applicable external standard* will select only the largest external standard, which is less than 90% of the range reference value

Adjustment for a particular range will make measurements on one or more applicable external standards and use the weighted mean of all results, where external standards with higher value have a higher weight. If there is no applicable external standard for the particular range, an error will be reported and adjustment for the particular range will be stopped.

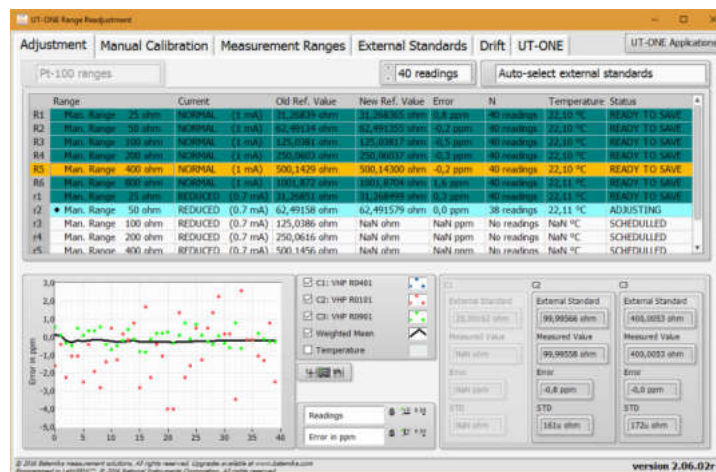


Figure 36: Adjustment page

Adjustment can be controlled using the popup menu on the range list. Popup menu consists of nine commands:

- *Monitor Selected Range* starts the acquisition for the selected range using the applicable external standards. Acquisition must be stopped manually using the popup menu command.
- *Adjust Selected Range* clears any existing data for the selected range, starts the acquisition using the applicable external standards and acquires specified number of readings. After the acquisition is completed, adjusted range is ready to be saved to UT-ONE memory.
- *Adjust ALL Ranges* schedules all ranges for adjustment procedure.
- *Stop Acquisition* stops the acquisition and clears and scheduled ranges
- *Clear Selected Range* clears the readings and status for the selected range

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- *Clear ALL Ranges* clears the readings and status for all ranges
- *Save Selected Range* sends the adjusted reference value for the selected range to UT-ONE volatile memory
- *Save ALL Ranges* sends the adjusted reference value for all applicable ranges to UT-ONE volatile memory
- *Export Data to Clipboard* copies data presented in the range list to clipboard. Data is available for pasting to applications such as Notepad, MS Excel or MS word.

Measurements for the selected range are presented in graph and in numeric indicator.

Measurement Ranges page displays the information about calibration coefficients for all available ranges that are stored in the UT-ONE volatile memory. You can manually change the reference value for the selected range by double-clicking it or by using the popup menu command.

Measurement ranges can be written or read from a *.rng file on your local computer using the popup menu commands. It is recommended that you make a backup copy of the coefficients before you make the adjustment, so you can restore the previous state in case of a failed adjustment. Range coefficients in the *.rng file can also be used to evaluate the drift between consecutive adjustments.

Use the *Export Data to Clipboard* command in the popup menu to copy the data in the list to clipboard.

After you make any changes to range coefficients in the UT-ONE volatile memory (either manually or using the adjustment procedure), the green *Save to EEPROM* button and red *Discard Changes* button will appear. Use the *Save to EEPROM* button to permanently save the changes to UT-ONE non-volatile EEPROM memory. Use the *Discard Changes* button to restore the range coefficients from the non-volatile memory and therefore discard any changes in the volatile memory.

Range	Current	Reference Value	Linearity Correction	Temperature coefficient
R1 Man. Range 25 ohm	NORMAL (1 mA)	31,28929 ohm	1,25E-14	5,23E-7
R2 Man. Range 50 ohm	NORMAL (1 mA)	62,53468 ohm	7,3E-15	-4,32E-7
R3 Man. Range 100 ohm	NORMAL (1 mA)	125,0563 ohm	1,06E-14	-9,87E-7
R4 Man. Range 200 ohm	NORMAL (1 mA)	250,1745 ohm	6,4E-15	-5,17E-7
R5 Man. Range 400 ohm	NORMAL (1 mA)	500,2739 ohm	4,8E-15	-7,2E-7
R6 Man. Range 800 ohm	NORMAL (1 mA)	1001,933 ohm	-1E-15	-3,2E-7
r1 Man. Range 25 ohm	REDUCED (0,7 mA)	31,28929 ohm	7,5E-15	5,28E-7
r2 Man. Range 50 ohm	REDUCED (0,7 mA)	62,53468 ohm	4,6E-15	-1,98E-7
r3 Man. Range 100 ohm	REDUCED (0,7 mA)	125,0566 ohm	6,9E-15	-9,74E-7
r4 Man. Range 200 ohm	REDUCED (0,7 mA)	250,1756 ohm	4,3E-15	-4,85E-7
r5 Man. Range 400 ohm	REDUCED (0,7 mA)	500,2766 ohm	3,8E-15	-7,1E-7
r6 Man. Range 800 ohm	REDUCED (0,7 mA)	1001,942 ohm	-2E-16	-2,83E-7
H1 Man. Range 1250 ohm	NORMAL (20 uA)	3126,781 ohm	1,2E-14	1,09E-6
H2 Man. Range 2500 ohm	NORMAL (20 uA)	6253,1822 ohm	7E-15	2,1E-7
H3 Man. Range 5000 ohm	NORMAL (20 uA)	12505,07 ohm	1,1E-14	-3E-7
H4 Man. Range 10000 ohm	NORMAL (20 uA)	25010,347 ohm	7E-15	8E-8
H5 Man. Range 20000 ohm	NORMAL (20 uA)	50020,67 ohm	5E-15	-2,1E-7
H6 Man. Range 40000 ohm	NORMAL (20 uA)	100189,17 ohm	-1E-15	2E-8
h1 Man. Range 1250 ohm	REDUCED (14 uA)	3126,8057 ohm	7E-15	9,7E-7
h2 Man. Range 2500 ohm	REDUCED (14 uA)	6253,2416 ohm	4E-15	9E-8
h3 Man. Range 5000 ohm	REDUCED (14 uA)	12506,194 ohm	7E-15	-4E-7
h4 Man. Range 10000 ohm	REDUCED (14 uA)	25016,595 ohm	4E-15	-3E-8
h5 Man. Range 20000 ohm	REDUCED (14 uA)	50025,77 ohm	4E-15	-3,1E-7

Figure 37: Measurement Ranges page

Drift page allows you to review the drift between the adjustments for the selected ranges. Use the popup menu to load range coefficients from the older *.rng files.

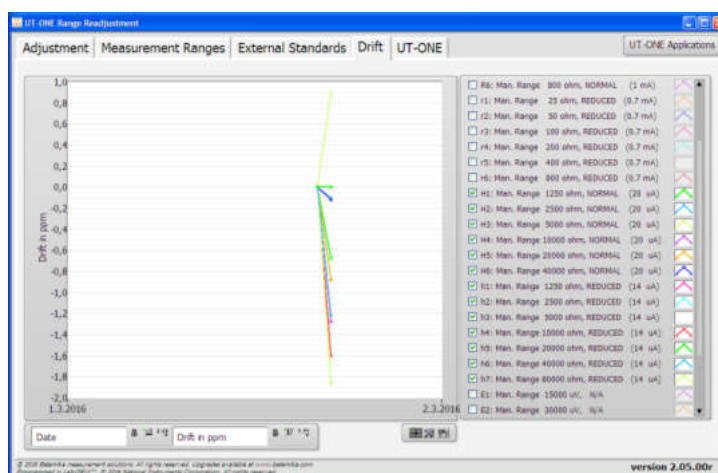


Figure 38: Drift page

The *Adjustment* page provides a fully automated procedure for routine readjustments and calibration checks for the UT-ONE thermometer readout. However, in many practical situations, especially when UT-ONE is sent to calibration in an accredited calibration laboratory, the setup of external standards and the complete adjustment procedure may be too complex, so a simpler alternative is provided in the *Manual Calibration* page.

To perform manual calibration, connect the reference resistance or DC voltage to one of the main channels and select that channel in the *Channel* dropdown list. Next select the manual range from the *Range* dropdown list. For resistance ranges you may also choose between the normal and reduced current. Click the green *Start* button to start the acquisition with given settings. The green *Start* button will change to red *Stop* button, which can be used to stop acquisition.

The acquired readings are displayed on the graph and in the numeric indicator. Average and standard deviation of the last N readings are calculated and displayed. N is specified in the *Averaging* input box.

Use the *Clear Graph* button to clear readings from graph and averaging memory.

You may change the channel and range during the acquisition. If you change the range between resistance and voltage ranges, readings are automatically cleared.

You can perform acquisition on either *Adjustment* or *Manual Calibration* page, but not on both at the same time. When you start acquisition, acquisition on the other page will be automatically stopped.

The displayed average reading for the selected range can be compared to the reference value of resistance or DC voltage standard and reported on the calibration certificate.

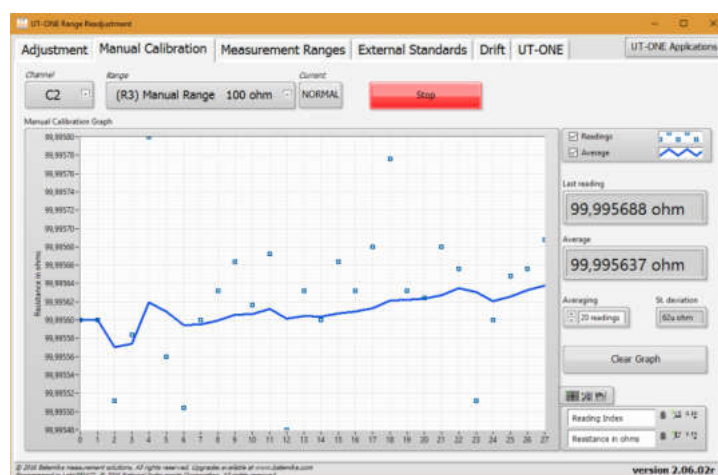


Figure 39: Manual Calibration page

8.4 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-ONE 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 analyse 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.

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

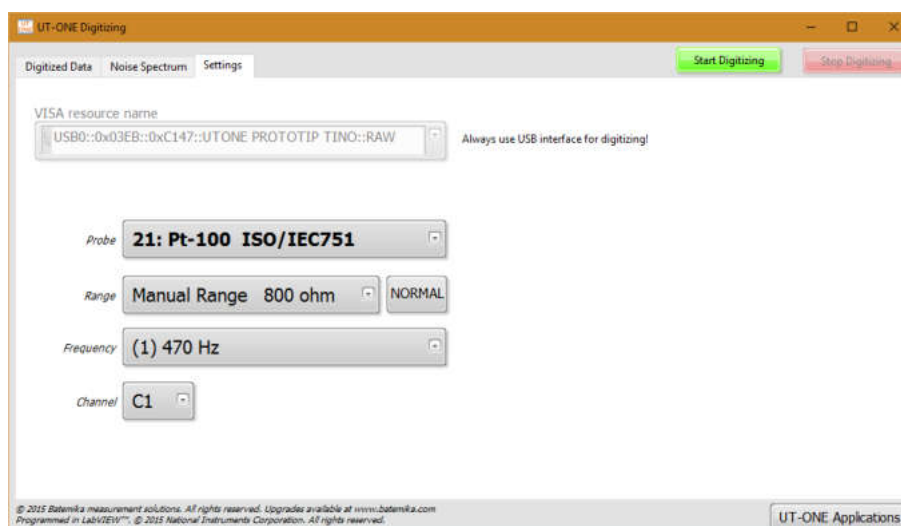


Figure 40: Settings for UT-ONE Digitizing application

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 40 samples, so if low sampling frequency is selected, it may take up to 10 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.

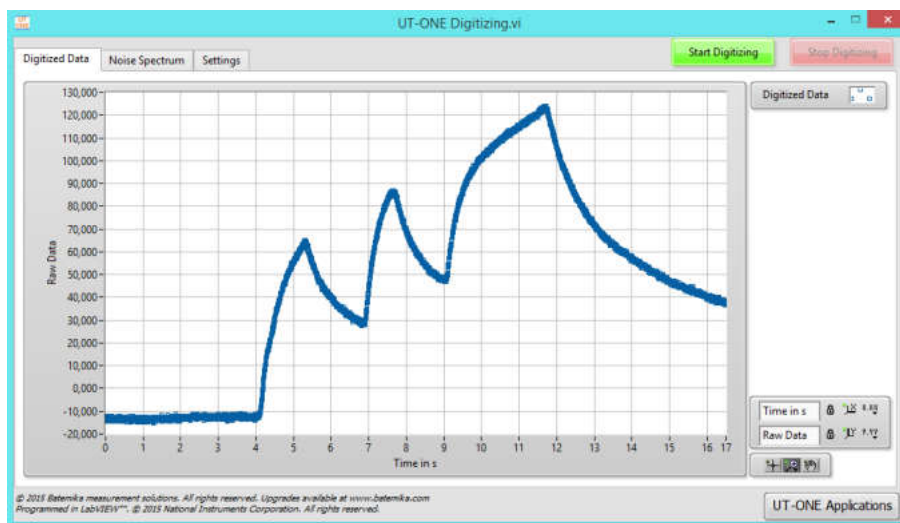


Figure 41: Observing of fast transients in digitizing mode

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.

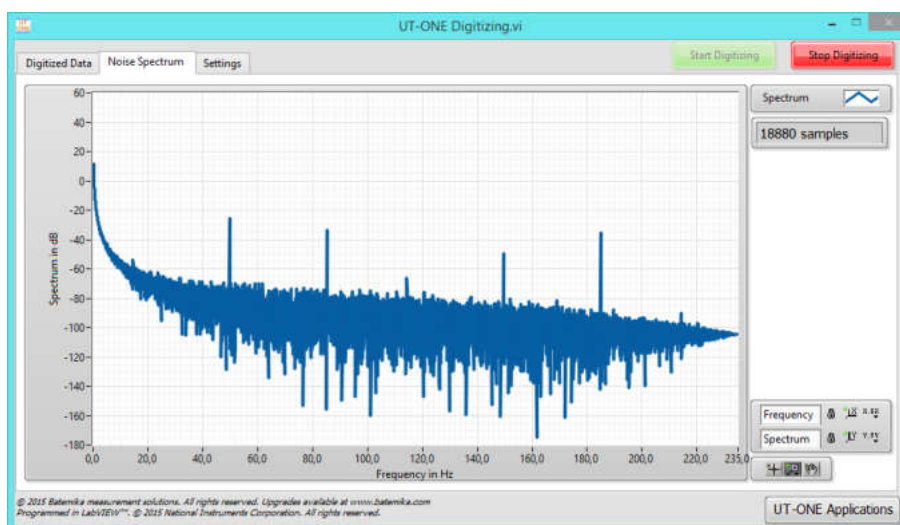


Figure 42: Noise spectrum with considerable 50 Hz interference

8.5 UT-ONE Communication Testing

UT-ONE Communication Testing 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.

To check the precise timing and the performance of UT-ONE interface, you may click the *Execute Command 1000 times* button, which will execute the specified command 1000 times and display the average execution time. If an error is reported or a timeout of 20 seconds is reached, the execution is stopped before 1000 transactions are completed.

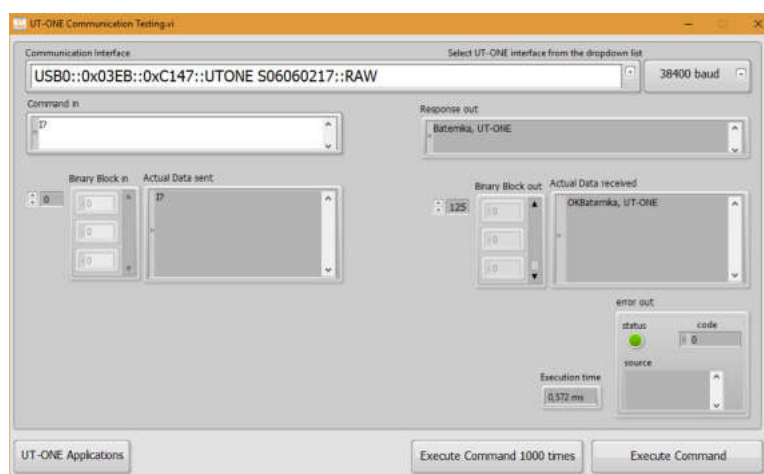


Figure 43: UT-ONE Communication Testing

8.6 UT-ONE Log Viewer

UT-ONE Log Viewer is a support application, which allows the user to browse the contents of the UT-ONE internal logging memory. Note that logging function is supported only on benchtop model with the integrated display, such as the UT-ONE B03A. System-style models without the integrated display, such as UT-ONE S12A have no internal logging memory, so this application is not applicable to them.

You may use the Log Viewer application during measurements, but this will result in slower data-transfer rates and newly acquired data will not be automatically refreshed.

Internal logging memory consists of 67108864 memory locations, which is equivalent to more than four years of logging at 2 seconds sampling rate. Each memory location can store the reading timestamp and temperatures/relative humidity for 7 channels. For UT-ONE B03A this corresponds to temperatures for three main channels, relative humidity, air temperature and dew-point temperature for the optional ambient probe and temperature of the internal CJC thermometer. Besides this main data log, UT-ONE logs also the raw data for each channel and statistics for blocks of 16 and 256 readings, which include average value, minimum value, maximum value and a time index. This auxiliary data is also accessible.

After you launch the application, you must first specify the VISA resource name for the communication interface to your UT-ONE device. If the application successfully detects a UT-ONE on the last used interface, this interface is automatically selected and no user interaction is required.

Log Viewer application first loads a preview of logged readings and displays it on the Preview graph. Preview load starts with the most recent readings and proceeds to older readings. If there is an overwhelming quantity of logged readings, you may click the *Stop Streaming* button to stop preview loading as soon as the date of interest is loaded.

Use the graph cursors to select the data of interest. Note that each data point on the preview graph corresponds to 16 readings. Each reading is identified by its memory location (unique ascending index within the logging memory). The *Memory Location* slider is a graphic representation of selected readings within the logging memory. You may use the *Min* and *Max* controls to select data by memory location or make a finer selection than with graph cursors.

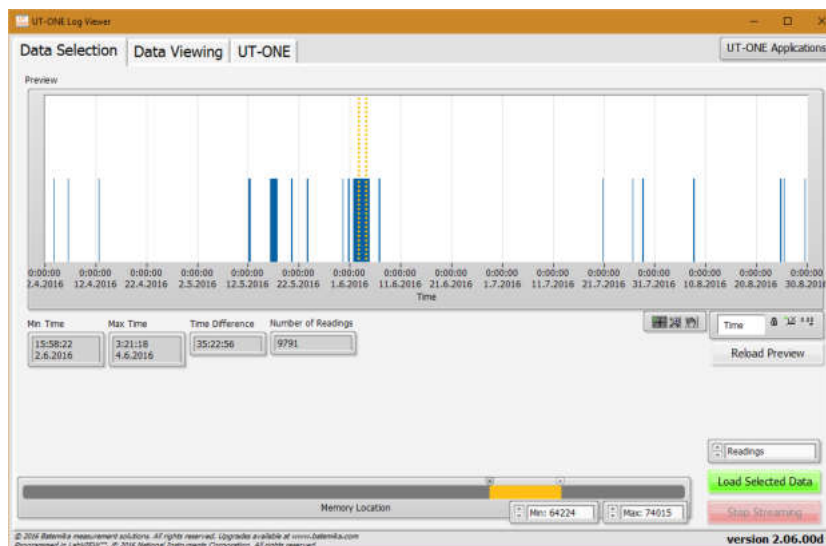


Figure 44: UT-ONE Log Viewer data selection page

After you select the data of interest, choose the data to be viewed. The default setting is *Readings*, which loads all temperature readings from selected memory locations. Other options include average of 16 or 256 readings, minimum and maximum of 16 or 256 readings and raw data. Averaged and minmax data is especially useful if there are too many readings, as this option significantly reduces the data to be downloaded from the UT-ONE.

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Click the *Load Selected Data* button to start loading data. The tab control will automatically switch to *Data Viewing* page. The *Memory Location* slider will change to progress indicator, so you can observe the download progress. Use the *Stop Streaming* button to stop download before it is completed.

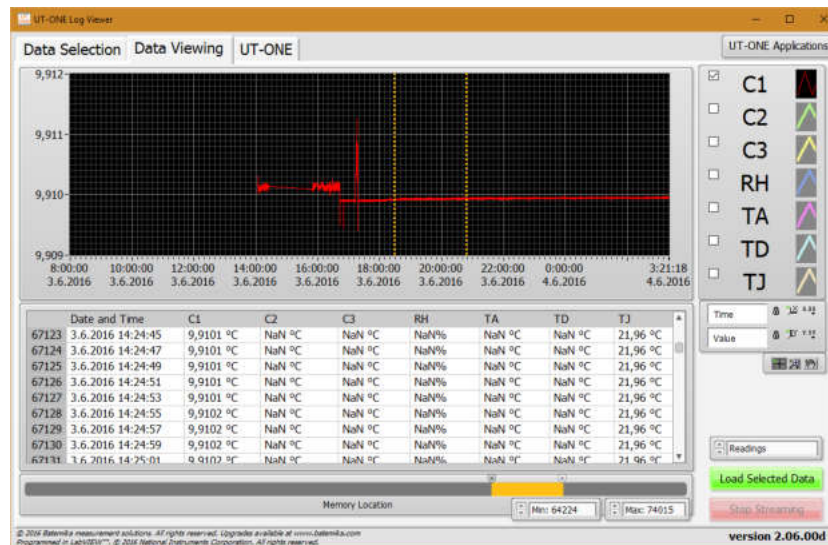


Figure 45: UT-ONE Log Viewer data viewing page

Loaded data is presented in the graph and in the list. You may use the graph cursors to select data on graph. Alternatively, you may use the shift and control keys to click and select ranges or individual readings in the list. Both modes of selection are related and result in a common block of readings.

UT-ONE supports the deletion of individual readings, which is especially useful for removal of readings that were erroneous or out of range. Note that the deleted reading is actually not deleted and memory location is not freed, it is just marked as deleted and therefore ignored by software. Also, deleted readings can still be reviewed and even restored, so data integrity is not jeopardized.

You may right-click on the readings graph or list to display the popup menu with the following menu items:

- *Copy Selected Data to Clipboard* copies the readings, selected with graph cursors, to the Windows clipboard using a tab-separated ASCII format, which can be pasted in a text editor or MS Excel.
- *Copy All Data to Clipboard* copies all readings to the Windows clipboard using a tab-separated ASCII format, which can be pasted in a text editor or MS Excel.
- *Export Selected Data to File* writes the readings, selected with graph cursors, to a specified file using a tab-separated ASCII format.
- *Export All Data to File* writes the all readings to a specified file using a tab-separated ASCII format.
- *Delete Selected Readings* marks selected readings as deleted and removes them from graph and list. This command is available only by selection in list control.
- *Undelete Selected Readings* restores the selected readings that were previously marked as deleted. This command is available only by selection in list control. To be able to view and select deleted readings, you must first choose to enable the display of deleted readings.
- *Display Deleted Readings* enables the option to display the readings that were previously marked as deleted. This option is useful if you would like to undelete some readings or check if the deletion was valid.
- *Show Selection* moves the current position in the list control to first selected readings. This command is useful if you select the readings using the graph cursors and you would like to review the selection in the list control.
- *Bring Cursor to Center* moves the graph cursor in to graph area that is currently displayed. This command is useful if you zoom-in to particular data and graph cursors are no longer visible.
- *Zoom Graph to Cursors* changes the graph scale settings so that the graph cursors are positions at 10% and 90% of the scale. Note that this operation does not change the selection of readings.

8.7 UT-ONE Temperature Monitoring

UT-ONE Temperature Validation is a simple application that is capable of acquiring temperature from up to 12 probes connected to UT-ONE main channels. This application has a very straightforward configuration, so if you need an application with more complex configuration ability, you may consider also the *UT-ONE Climatic Chamber Validation* application.

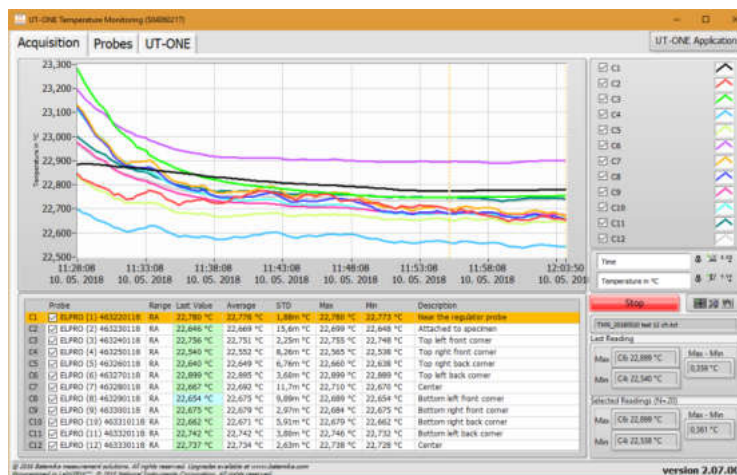


Figure 46: UT-ONE temperature monitoring

This application acquires temperature on UT-ONE main channels. Probes are automatically assigned to channels in ascending order from 1 to the number of available main channels (for example probe 01 is used for channel C1, probe 02 for channel C2, etc). Application will use probe data stored in internal UT-ONE memory to calculate the temperature from acquired raw data, so make sure that connected thermometer probes match the probe data in the *Probes* list and make sure that probe data is valid.

The application will perform acquisition in single-reading mode. Measurement range will be set automatically to autorange, which is default for the selected probe (for example range RA for Pt-100 probes, range EA for thermocouple and range HA for thermistors). Acquisition rate will be set to affixed value of 2 seconds.

Note that you don't have to provide probe data or connect actual probes for all available main channels. Unused channels can be removed from the acquisition sequence by double-clicking the checkbox in the channel list. If the checkbox is unchecked, the channel will be skipped in the acquisition sequence.

To add or change a description of the particular channel, double-click the channel *Description* column in the channel list. This will open a dialog box, which allows you to edit the channel description. It is recommended that you set all descriptions before you start the measurement, otherwise the descriptions stored in the measurement file may not be correct.

This application can store acquired temperatures in the measurement file. Data is stored in the tab-separated text format, which allows you to review data in a text editor such as Notepad or directly import it in the MS Excel. When you start the application you are immediately prompted to provide the path and name for the measurement file. By default, the application will use the UT-ONE root path for the current year and a default name, but you can manually change it. If you cancel the measurement file selection, data will not be saved to file and *Measurement File path* indicator will be painted in red. You can select the file path later using the command in the popup menu. Commands in the popup menu also allow you to open the file in the default text editor and to explore the file location. Note that after you start the acquisition and the measurement file is generated, you are no longer able to change its name or location.

If you select the existing measurement file, you can choose to load the data that was previously stored in the measurement file and review it on the graph. You may also choose to continue with the acquisition

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and the data will be stored in the same file. In this case, you must assure that the current probe configuration is the same as used during the acquisition of the original measurements, otherwise a data inconsistency will occur.

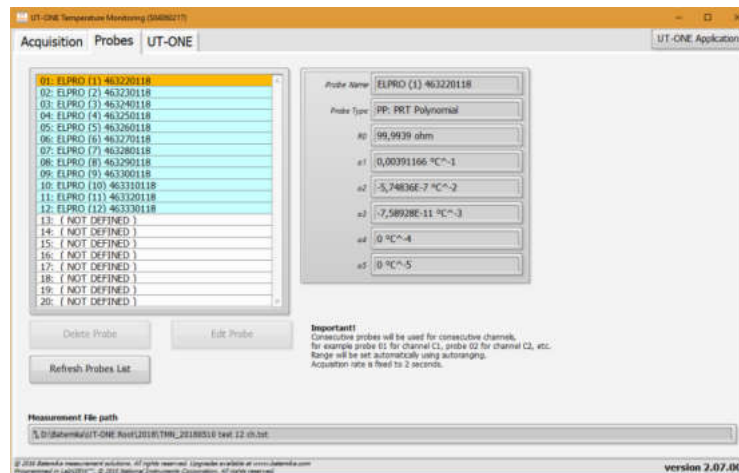


Figure 47: UT-ONE probe and measurement file configuration

You may use the *Probes* page to review the probe data. Use the *Edit Probe* button to open the *Edit Probe* dialog box to change the probe data or manage the backup copy of the probe data in a *.prb file. Note that changes that you make to probe data are permanently stored in the non-volatile memory of the UT-ONE device.

The acquisition is started by clicking the green *Start* button. After the acquisition is started, the green *Start* button changes to red *Stop* button. Acquisition can be stopped by clicking the red *Stop* button or by closing the application.

Measurement results can be observed on the graph, in the channel list and in two statistics indicators. Graph features two cursors, which can be used to select a portion of the measured data.

Right click on the graph area to display the popup menu with the following menu items:

- *Clear Selected Readings* removes the readings, selected with graph cursor, from the graph. Note that this operation can't be undone, but a copy of acquired data is saved in the autosaved file.
- *Clear All Readings* removes all readings from the graph
- *Copy Selected Readings to Clipboard* copies the readings, selected with graph cursors, to the Windows clipboard using a tab-separated ASCII format, which can be pasted in a text editor or MS Excel. The exported data includes also probe captions and channel descriptions.
- *Copy Statistics to Clipboard* copies the statistic information about selected readings to the Windows clipboard using a tab-separated ASCII format, which can be pasted in a text editor or MS Excel. The exported data includes also probe captions and channel descriptions. Statistics include average value, standard deviation, minimum value and maximum value.
- *Zoom Graph to Cursors* will change the graph X scale, so that graph cursors and selected data are visible in the graph. Note that the location of cursors and consequently selected data are not changed by this operation.
- *Move Cursors to Graph Center* will move the graph cursors and consequently the selected data to the middle of the currently visible portion of the X scale. Graph scaling is not changed by this operation.

8.8 UT-ONE Climatic Chamber Validation

UT-ONE Climatic Chamber Validation is a specialised application, which is used for the measurement of relative humidity and temperature distributions in a climatic chamber. This application is highly configurable and allows you to perform the validation in a wide variety of different ways.

8.8.1 Theoretical background

The operating principle of this application is based on the generally-accepted fact that although the temperature and relative humidity inside a climatic chamber may vary, the water vapour pressure (and also dew point) can be assumed to be constant over the entire volume of the climatic chamber. This assumption is valid if the following conditions are fulfilled:

- useful volume of the climatic chamber is not too large. For volumes larger than approximately 2 m³, you should consider measuring water vapour pressure in more than one point
- there is sufficient mixing of air in the useful volume of the climatic chamber
- there are no sources or sinks of water vapour in the useful volume of the climatic chamber
- there are no leaks that would lead to air being exchanged with the environment

As the vapour pressure is assumed to be constant over the entire useful volume of the climatic chamber, it is sufficient to measure it in a single location and just copy the measured value to all other measurement points. Note that dew-point temperature is directly related to vapour pressure and can be calculated using the Sonntag equation.

Temperature, relative humidity and vapour pressure at a given measurement point are also related with each other and if two of them are known, the third one can be calculated. For example, if relative humidity and temperature are known, vapour pressure (and dew point) can be calculated. Also, if vapour pressure and temperature are known, relative humidity can be calculated. Also, if you measure dew point using a mirror hygrometer, vapour pressure can be directly calculated.

Some of the calculations depend also on the air barometric pressure, most notably if psychrometers are used to measure relative humidity. The software allows you to enter the barometric pressure measured by the external barometer, however if the relative humidity is measured with a capacitive sensor or a mirror hygrometer, using normal barometric pressure will typically introduce a negligible error.

Note that all water vapour pressure values includes enhancement factor for air at specified barometric pressure.

8.8.2 Measurement procedure

In accordance with the presented theoretical background, the following measurement procedure can be outlined. Please note that this procedure is automatically executed by software and is completely transparent to the user.

1. Temperature is acquired sequentially in all measurement points. This is applicable also to relative humidity probes, mirror hygrometers and psychrometers, which all feature also an associated temperature probe.
2. Relative humidity is acquired from the relative humidity probes and optionally from the mirror hygrometers.
3. Vapour pressure is acquired or calculated from the mirror hygrometers, relative humidity probes and psychrometers.
 - For the mirror hygrometers, vapour pressure is normally calculated from the directly measured dew-point temperature, but it can be also acquired directly from the mirror hygrometer or calculated from the acquired temperature and relative humidity.
 - For the relative humidity probes, vapour pressure is calculated from the acquired temperature and relative humidity

- For the psychrometers, vapour pressure is calculated using the psychrometric equation from the acquire temperature of the wet and dry thermometer and specified barometric pressure.
4. Vapour pressure is copied from the reference measurement point for all remaining measurement points. The value of vapour pressure at the reference measurement point was determined in step 3.
 5. Dew point is calculated directly from the vapour pressure using the Sonntag equation. For temperatures below 0 °C, saturation over ice and not over super-cooled water is assumed in the calculation.
 6. Relative humidity is calculated in the measurement points that were not processed in step 2. Relative humidity is calculated from the acquired temperature and acquired or copied vapour pressure.

This measurement procedure allows you to determine temperature, relative humidity, vapour pressure and dew point in all measurement points.

8.8.3 Configuration

UT-ONE Climatic Chamber Validation application was designed with the goal of being extremely flexible and configurable and it allows many different combinations of hygrometers and thermometers. Temperature can be acquired from one or more UT-ONE units, as well as an external mirror hygrometer. Relative humidity and related vapour pressure can be determined from the external mirror hygrometer, UT-ONE ambient probe (a capacitive relative humidity probe) or from psychrometer (wet and dry probe temperature is acquired by UT-ONE).

The configuration can be reviewed and changed on the *Configuration* page. Setting up the configuration for your particular measurement system takes some time and effort, so the most common configurations are usually configured only once and then stored in the configuration file, where they can be later retrieved. For your convenience, the application also automatically stores the last used configuration, which is automatically loaded at application startup.

Note that once you start the measurement, configuration is locked and can't be changed any more, except for the Description, which can be changed if the measurement is stopped.

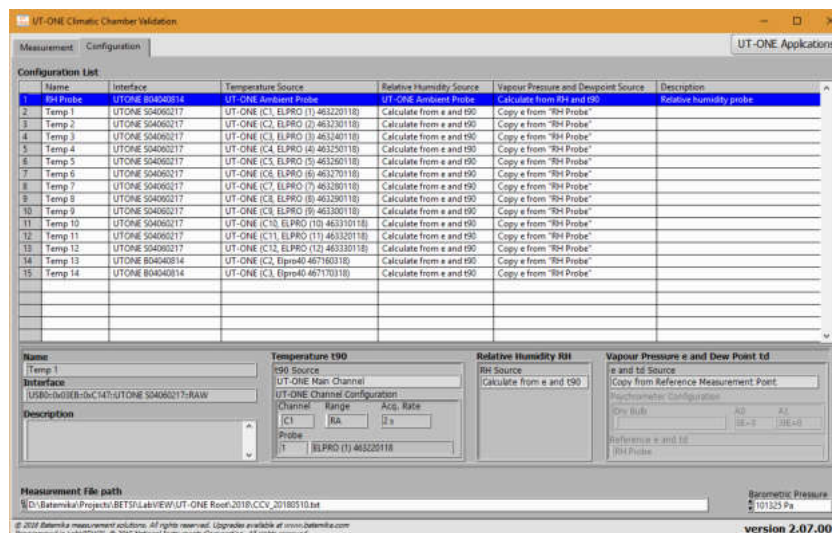


Figure 48: Configuration page

Setting up the configuration normally starts from an empty configuration list. If there are some entries in the configuration list, you can clear them using the *Clear Configuration* command from the popup menu.

New measurement point can be added by double-clicking an empty row in the configuration list or by selecting the *Add Measurement Point* command from the popup menu. The new measurement point is always added at the end of the list and its position can't be changed later. New measurement point is added in the *Add New Measurement Point* dialog. Entries that are either missing or conflicting are painted in red. If you try to add a measurement point with some red entries, you will be warned before proceeding, but you can add the point anyway and correct it later before you start the measurement.

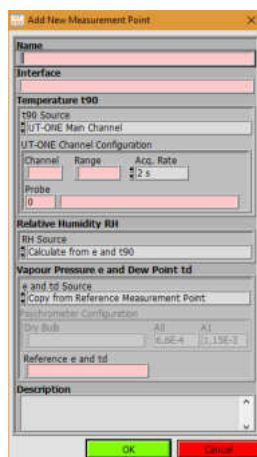


Figure 49: Dialog for adding a new measurement point

The dialog for the configuration of a measurement point has the following entries:

- *Name* is the unique label that is used to identify the measurement point. Name is used to identify the measurement point in graphs and lists and to reference the measurement point from other measurement points.
- *Interface* is the communication interface that used to communicate with the measurement instrument. Use the right-click to display a popup menu with a list of detected interface and select the correct entry. Note that some of the options for configuring the UT-ONE will only be available if UT-ONE is connected, switched on and the interface is not locked by another software package.
- *t90 Source* determines how the temperature is acquired for this measurement point using the specified communication interface. There are three options available:
 - *UT-ONE Main Channel* will acquire the temperature from the UT-ONE over specified communication interface and with given channel configuration. Use right-click to select one of the available channels and probes from the popup menu. Range is selected automatically after you select the probe, but you can change it manually later. Acquisition rate is 2 seconds by default, but you can change from 1 to 5 seconds.
 - *UT-ONE Ambient Probe* will acquire temperature from the ambient probe connected to UT-ONE with specified interface. No further configuration is required.
 - *External Hygrometer* will acquire temperature from the temperature probe of the MBW 473 mirror hygrometer connected to specified interface. No further configuration is required.
- *RH Source* determines how the relative humidity is acquired or calculated. There are five options available:
 - *Not Used* will not acquire or calculate relative humidity. Use this option if you would like to acquire only temperature.
 - *Calculate from e and t90* will calculate the relative humidity from acquired temperature and acquired or copied vapour pressure at this measurement point.

- *UT-ONE Ambient Probe* will acquire relative humidity from the ambient probe connected to UT-ONE with specified interface.
- *External Hygrometer* will acquire relative humidity from the MBW 473 mirror hygrometer connected to specified interface. Use this option if mirror hygrometer was calibrated to relative humidity and not to dew point. Using this option should give the same result as using *Calculate from e and t90*, if vapour pressure was acquired from hygrometer.
- *Psychrometer* will calculate relative humidity from the temperatures of wet and dry thermometer using the psychrometric equation. If you select this option, make sure you also select *Psychrometer* option for the vapour pressure source.
- *e and td source* determines how water vapour pressure and associated dew-point temperature are acquired or calculated. There are five options available:
 - *Not Used* will not acquire or calculate vapour pressure and dew-point temperature. Use this option if you would like to acquire only temperature.
 - *Calculate from RH and t90* will calculate the water vapour pressure and dew-point temperature from acquired temperature and acquired relative humidity at this measurement point. Use this option if relative humidity was acquired using the UT-ONE ambient probe.
 - *Copy from Reference Measurement Point* will copy the vapour pressure and dew-point temperature from the measurement point that you specify in the *Reference e and td* box. You can select the name of the reference measurement point from the popup menu.
 - *External Hygrometer* will acquire dew-point temperature from the MBW 473 mirror hygrometer connected to specified interface. Vapour pressure will be calculated from the acquired dew point temperature using the Sonntag equation.
 - *Psychrometer* will calculate water vapour from the temperatures of wet and dry thermometer using the psychrometric equation. If you select this option, make sure you also select *Psychrometer* option for the relative humidity source. Temperature measured at this measurement point will be used for wet-bulb temperature. You must specify the measurement point where dry-bulb temperature was measured in the *Dry Bulb* control (you may use the popup menu to display a list of available names). Specify the value of the psychrometric constant ($A = A0 + A1 \cdot t_w$) or use the popup menu to select one of the commonly used values.
- *Description* is a longer text that usually describes the position or function of the measurement point. Description is often changed after the configuration is loaded from the configuration file to describe the particular measurement case. Description has no effect on measurement procedure, but it is stored in the measurement header in the measurement file and can be used to identify measurements.

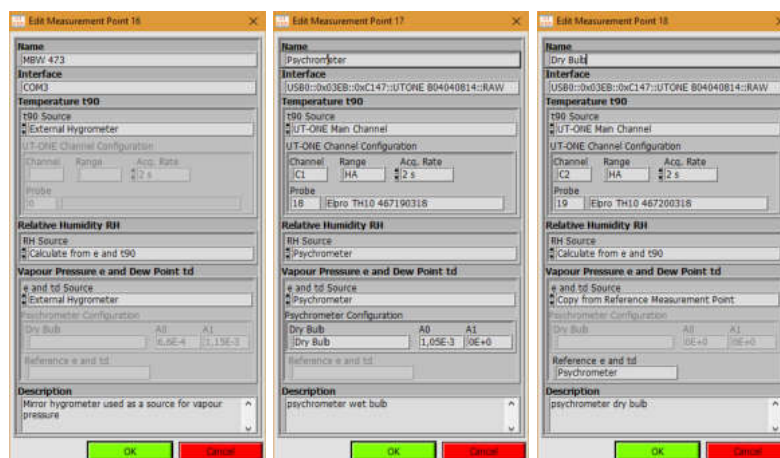


Figure 50: Examples of measurement point configuration

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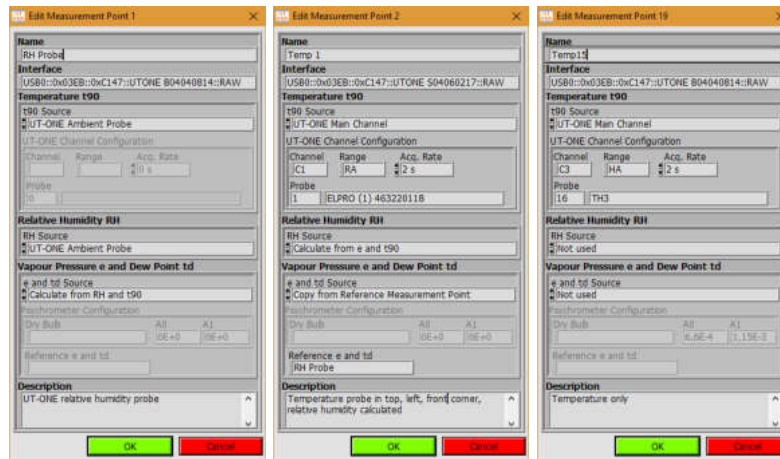


Figure 51: More examples of measurement point configuration

Most commonly, the first measurement point is the source of the vapour pressure value and is used as reference measurement point in the following measurement points. If you enter a temperature-only measurement point before the source of vapour pressure, you will not be able to choose the reference measurement point for vapour pressure, so you will have to readjust it after you finally enter the reference measurement point. Note that the measurement procedure will be able to perform measurements regardless of the order of the measurement points.

The source of vapour pressure can be a relative humidity probe, mirror hygrometer or a psychrometer, as presented in the examples above. Note that you can measure vapour pressure at more than one point and that you can use any of them as a reference measurement point.

The rest of the measurement points acquire only temperature, while the relative humidity is calculated from the copied vapour pressure. Alternatively, you may also choose to ignore relative humidity, so only temperature is acquired and recorded.

Some of the most common configurations are presented in figures below. Note that there are many more valid configurations with different combinations of sensors and acquisition parameters.

Configuration List					
Name	Interface	Temperature Source	Relative Humidity Source	Vapour Pressure and Dewpoint Source	Description
1	Mirror Hygromer COM3	External Hygrometer	Calculate from e and t90	External Hygrometer	Source of vapour pressure and dew point
2	Point 1	UT-ONE (C1, ELPRO (1) 4632011B)	Calculate from e and t90	Copy e from "Mirror Hygrometer"	TRF
3	Point 2	UT-ONE (C2, ELPRO (2) 4632011B)	Calculate from e and t90	Copy e from "Mirror Hygrometer"	TRB
4	Point 3	UT-ONE (C3, ELPRO (3) 4632011B)	Calculate from e and t90	Copy e from "Mirror Hygrometer"	TLB
5	Point 4	UT-ONE (C4, ELPRO (4) 4632011B)	Calculate from e and t90	Copy e from "Mirror Hygrometer"	TLF
6	Point 5	UT-ONE (C5, ELPRO (5) 4632011B)	Calculate from e and t90	Copy e from "Mirror Hygrometer"	Center right
7	Point 6	UT-ONE (C6, ELPRO (6) 4632011B)	Calculate from e and t90	Copy e from "Mirror Hygrometer"	Center left
8	Point 7	UT-ONE (C7, ELPRO (7) 4632011B)	Calculate from e and t90	Copy e from "Mirror Hygrometer"	BRF
9	Point 8	UT-ONE (C8, ELPRO (8) 4632011B)	Calculate from e and t90	Copy e from "Mirror Hygrometer"	BRB
10	Point 9	UT-ONE (C9, ELPRO (9) 4632011B)	Calculate from e and t90	Copy e from "Mirror Hygrometer"	BLB
11	Point 10	UT-ONE (C10, ELPRO (10) 46331011B)	Calculate from e and t90	Copy e from "Mirror Hygrometer"	BLF
12	Point 11	UT-ONE (C11, ELPRO (11) 46332011B)	Calculate from e and t90	Copy e from "Mirror Hygrometer"	Specimen
13	Point 12	UT-ONE (C12, ELPRO (12) 46333011B)	Calculate from e and t90	Copy e from "Mirror Hygrometer"	Fan inlet

Figure 52: Configuration with external hygrometer and 12 thermometers

Configuration List					
Name	Interface	Temperature Source	Relative Humidity Source	Vapour Pressure and Dewpoint Source	Description
1	RH Probe	UT-ONE Ambient Probe	UT-ONE Ambient Probe	Calculate from RH and t90	UT-ONE Relative humidity probe
2	Point 1	UT-ONE (C7, ELPRO (1) 4632011B)	Calculate from e and t90	Copy e from "RH Probe"	Ceiling
3	Point 2	UT-ONE (C8, ELPRO (9) 46330011B)	Calculate from e and t90	Copy e from "RH Probe"	Left wall
4	Point 3	UT-ONE (C9, ELPRO (9) 46330011B)	Calculate from e and t90	Copy e from "RH Probe"	Right wall
5	Point 4	UT-ONE (C10, ELPRO (10) 46331011B)	Calculate from e and t90	Copy e from "RH Probe"	Back wall
6	Point 5	UT-ONE (C11, ELPRO (11) 46332011B)	Calculate from e and t90	Copy e from "RH Probe"	Front wall
7	Point 6	UT-ONE (C12, ELPRO (12) 46333011B)	Calculate from e and t90	Copy e from "RH Probe"	Bottom

Figure 53: Configuration with UT-ONE Ambient Probe and 6 thermometers

Configuration List					
Name	Interface	Temperature Source	Relative Humidity Source	Vapour Pressure and Dewpoint Source	Description
1	Wet Bulb	UT-ONE (C1, Elpro TH10 46719031B)	Psychrometer	Psychrometer (Dry Bulb: "Dry Bulb")	Psychrometer (Wet bulb)
2	Dry Bulb	UT-ONE (C2, Elpro TH10 46720031B)	Calculate from e and t90	Copy e from "Wet Bulb"	Psychrometer (Dry Bulb)
3	Corner 1	UT-ONE (C4, ELPRO (4) 46325011B)	Calculate from e and t90	Copy e from "Wet Bulb"	TRF
4	Corner 2	UT-ONE (C5, ELPRO (5) 46326011B)	Calculate from e and t90	Copy e from "Wet Bulb"	TRB
5	Corner 3	UT-ONE (C6, ELPRO (6) 46327011B)	Calculate from e and t90	Copy e from "Wet Bulb"	TLB
6	Corner 4	UT-ONE (C7, ELPRO (7) 46328011B)	Calculate from e and t90	Copy e from "Wet Bulb"	TLF
7	Corner 5	UT-ONE (C8, ELPRO (8) 46329011B)	Calculate from e and t90	Copy e from "Wet Bulb"	BRF
8	Corner 6	UT-ONE (C9, ELPRO (9) 46330011B)	Calculate from e and t90	Copy e from "Wet Bulb"	BRB
9	Corner 7	UT-ONE (C10, ELPRO (10) 46331011B)	Calculate from e and t90	Copy e from "Wet Bulb"	BLB
10	Corner 8	UT-ONE (C11, ELPRO (11) 46332011B)	Calculate from e and t90	Copy e from "Wet Bulb"	BLF
11	Center	UT-ONE (C3, ELPRO (3) 46324011B)	Calculate from e and t90	Copy e from "Wet Bulb"	Center

Figure 54: Configuration with psychrometer and 9 thermometers

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Configuration List					
Name	Interface	Temperature Source	Relative Humidity Source	Vapour Pressure and Dewpoint Source	Description
1 Temp 1	UTONE S04060217	UT-ONE (C1, ELPRO (1) 46322011B)	NOT USED	NOT USED	Temperature in top left front corner
2 Temp 2	UTONE S04060217	UT-ONE (C2, ELPRO (2) 46323011B)	NOT USED	NOT USED	Temperature in top left back corner
3 Temp 3	UTONE S04060217	UT-ONE (C3, ELPRO (3) 46324011B)	NOT USED	NOT USED	Temperature in top right front corner
4 Temp 4	UTONE S04060217	UT-ONE (C4, ELPRO (4) 46325011B)	NOT USED	NOT USED	Temperature in top right back corner
5 Temp 5	UTONE S04060217	UT-ONE (C5, ELPRO (5) 46326011B)	NOT USED	NOT USED	Temperature in center
6 Temp 6	UTONE S04060217	UT-ONE (C6, ELPRO (6) 46327011B)	NOT USED	NOT USED	Temperature in bottom left front corner
7 Temp 7	UTONE S04060217	UT-ONE (C7, ELPRO (7) 46328011B)	NOT USED	NOT USED	Temperature in bottom left back corner
8 Temp 8	UTONE S04060217	UT-ONE (C8, ELPRO (8) 46329011B)	NOT USED	NOT USED	Temperature in bottom right front corner
9 Temp 9	UTONE S04060217	UT-ONE (C9, ELPRO (9) 46330011B)	NOT USED	NOT USED	Temperature in bottom right back corner

Figure 55: Configuration with 9 thermometers and no relative humidity

Configuration List					
Name	Interface	Temperature Source	Relative Humidity Source	Vapour Pressure and Dewpoint Source	Description
1 MBW 473	COM3	External Hygrometer	Calculate from e and t90	External Hygrometer	Mirror hygrometer
2 Ambient Probe	UTONE B04040814	UT-ONE Ambient Probe	UT-ONE Ambient Probe	Calculate from RH and t90	UT-ONE Ambient probe on 3-ch UT-ONE
3 Wet Bulb	UTONE B04040814	UT-ONE (C2, Elpro TH10 46719031B)	Psychrometer	Psychrometer (Dry Bulb= "Dry Bulb")	Psychrometer wet bulb
4 Dry Bulb	UTONE B04040814	UT-ONE (C3, Elpro TH10 46720031B)	Calculate from e and t90	Copy e from "Wet Bulb"	Psychrometer dry bulb
5 Corner 1	UTONE S04060217	UT-ONE (C1, ELPRO (1) 46322011B)	Calculate from e and t90	Copy e from "MBW 473"	Top left back corner
6 Corner 2	UTONE S04060217	UT-ONE (C2, ELPRO (2) 46323011B)	Calculate from e and t90	Copy e from "MBW 473"	Top left front corner
7 Corner 3	UTONE S04060217	UT-ONE (C3, ELPRO (3) 46324011B)	Calculate from e and t90	Copy e from "MBW 473"	Top right front corner
8 Corner 4	UTONE S04060217	UT-ONE (C4, ELPRO (4) 46325011B)	Calculate from e and t90	Copy e from "MBW 473"	Top right back corner
9 Center	UTONE S04060217	UT-ONE (C5, ELPRO (5) 46326011B)	Calculate from e and t90	Copy e from "Ambient Probe"	Center
10 Corner 5	UTONE S04060217	UT-ONE (C6, ELPRO (6) 46327011B)	Calculate from e and t90	Copy e from "Wet Bulb"	Bottom left back corner
11 Corner 6	UTONE S04060217	UT-ONE (C7, ELPRO (7) 46328011B)	Calculate from e and t90	Copy e from "Wet Bulb"	Bottom left front corner
12 Corner 7	UTONE S04060217	UT-ONE (C8, ELPRO (8) 46329011B)	Calculate from e and t90	Copy e from "Wet Bulb"	Bottom right front corner
13 Corner 8	UTONE S04060217	UT-ONE (C9, ELPRO (9) 46330011B)	Calculate from e and t90	Copy e from "Wet Bulb"	Bottom right back corner
14 Aux 1	UTONE S04060217	UT-ONE (C10, ELPRO (10) 46331011B)	NOT USED	NOT USED	Outside temperature

Figure 56: Configuration with three different vapour-pressure sources, two UT-ONE units and 10 thermometers

8.8.4 Measurement file

This application can store the results of measurements in a tab-separated text file, which can be opened in a text editor (such as Notepad) or imported to MS Excel or similar software package for further analysis and report generation.

When you start the application, you are immediately prompted to enter the measurement file path and name. You can change the default path and location. By default, measurement files are stored in a specified root path in a current year directory. Default file name consist of CCV prefix and date stamp. The first time you start this application you will be prompted to select the root path where measurement files will be stored by default. You can change the root path later by editing the "UT-ONE Settings.ini" file in the application directory.

If you select an existing file, you will be prompted to load the existing measurements and configuration from the file. New measurements will be appended to this file.

If you cancel the measurement file selection, the measurements will not be saved to the measurement file and the *Measurement File* control will be painted in red. You can use the popup menu to select the file later, but any previously made measurements will be lost.

Measurement file stores both the configuration and measurement data. Note that configuration files are basically measurement files with no measurement data. It is therefore possible to load the configuration in the configuration list from an existing measurement file.

Measurement file is created when you start the measurement for the first time. After the file is created, you can't change its name or path any more.

Use the popup menu on the *Measurement File* control to open the measurement file in the default text editor or explore its location in Windows Explorer.

Measurements can be reload from existing measurement files by selecting the file during the application startup. This allows you to perform data analysis, calculate statistics and export readings after you completed the measurements.

8.8.5 Measurement

After you load or configure measurement configuration and optionally select the measurement file, you can proceed with measurements. Note that measurements are performed automatically and the measurement procedure is completely transparent to the user.

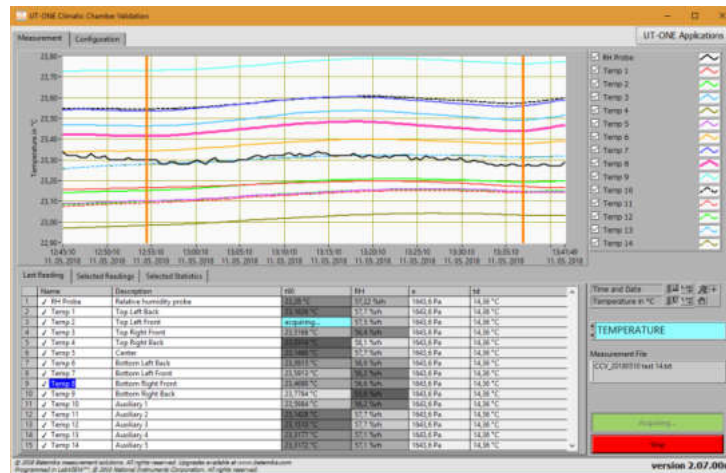


Figure 57: Measurement page with temperature display selected

To start the measurement, select the *Measurement* page and click the green *Start* button. The application will immediately start the acquisition and display the results in the measurement list. After all measurement points are acquired, the measurement is appended to the graph and optionally saved to the measurement file.

If you can't start the measurement because the green *Start* button is disabled, check that the configuration list was configured and all entries are valid. Invalid entries will be painted in red.

To stop the measurement, click the red *Stop* button. The acquisition will stop immediately and the last acquired readings will be discarded.



Figure 58: Measurement page with relative humidity display selected and auxiliary points excluded

8.8.6 Data analysis

Analysis of the measurement data can be performed during the acquisition or after the acquisition is completed, possibly even by reloading the measurement data from the measurement file.

The results for the current reading are displayed in the measurement list on the *Last Reading* page. Measurement list includes readings for all four acquired quantities. The readings are painted in grey scale according to their value. Some measurement points can be excluded from the graph and statistical analysis by unchecking the graph in the graph legend or by double clicking the measurement point in the measurement list. Note that the excluded measurement point will be normally acquired and stored, it will just not be displayed on graph and included in statistics.

Name	Description	150 °C	RH	Pa	td
17	RH Probe	21.40 °C	57.55 %rh	1063.1 Pa	14.55 °C
1	Temp 1	23.000 °C	58.3 %rh	1063.1 Pa	14.55 °C
2	Temp 2	23.000 °C	58.3 %rh	1063.1 Pa	14.55 °C
3	Temp 3	23.004 °C	58.3 %rh	1063.1 Pa	14.55 °C
4	Temp 4	23.000 °C	58.3 %rh	1063.1 Pa	14.55 °C
5	Temp 5	23.000 °C	58.3 %rh	1063.1 Pa	14.55 °C
6	Center	22.4067 °C	57.4 %rh	1063.1 Pa	14.55 °C
7	Temp 6	23.011 °C	58.3 %rh	1063.1 Pa	14.55 °C
8	Temp 7	23.000 °C	58.3 %rh	1063.1 Pa	14.55 °C
9	Temp 8	23.000 °C	58.3 %rh	1063.1 Pa	14.55 °C
10	Temp 9	23.018 °C	58.3 %rh	1063.1 Pa	14.55 °C
11	Temp 10	23.0490 °C	58.3 %rh	1063.1 Pa	14.55 °C
12	Temp 11	23.0490 °C	58.3 %rh	1063.1 Pa	14.55 °C
13	Temp 12	23.000 °C	58.3 %rh	1063.1 Pa	14.55 °C
14	Temp 13	23.000 °C	57.8 %rh	1063.1 Pa	14.55 °C
15	Temp 14	23.012 °C	57.7 %rh	1063.1 Pa	14.55 °C

Figure 59: Last Reading page with "RH probe" excluded

The graph and statistics can display values only for one quantity, so use the blue display selector to select between temperature, relative humidity, vapour pressure and dew point. Note that although only one quantity is displayed, all quantities are acquired and stored according to the selected configuration.

The graph has two cursors, which allow you to select a range of measurements that are used in the analysis and for exporting the data. You can review selected readings in the *Selected Readings* page. Use the popup menu on the readings list to copy the readings to clipboard. This allows you to paste the readings directly to MS Excel and simply create graphs and reports.

Date and Time	150 1	150 2	150 3	150 4	150 5	150 6	150 7	150 8	150 9	150 10
11. 05. 2018 12:54:42	23.0000 °C	23.1468 °C	23.1508 °C	23.4429 °C	23.9829 °C	23.1027 °C	23.3437 °C	23.5252 °C	23.4143 °C	23.7205 °C
11. 05. 2018 12:55:14	23.3000 °C	23.1651 °C	23.1520 °C	23.4638 °C	22.9638 °C	23.1014 °C	23.3437 °C	23.5350 °C	23.4142 °C	23.7300 °C
11. 05. 2018 12:55:46	23.3005 °C	23.1656 °C	23.1526 °C	23.4636 °C	22.9643 °C	23.1021 °C	23.3439 °C	23.5356 °C	23.4150 °C	23.7311 °C
11. 05. 2018 12:56:18	23.3060 °C	23.1661 °C	23.1531 °C	23.4639 °C	22.9649 °C	23.1028 °C	23.3442 °C	23.5360 °C	23.4163 °C	23.7317 °C
11. 05. 2018 12:56:47	23.3060 °C	23.1670 °C	23.1544 °C	23.4644 °C	22.9658 °C	23.1038 °C	23.3448 °C	23.5372 °C	23.4165 °C	23.7319 °C
11. 05. 2018 12:57:17	23.2960 °C	23.1672 °C	23.1549 °C	23.4653 °C	22.9666 °C	23.1038 °C	23.3457 °C	23.5386 °C	23.4175 °C	23.7327 °C
11. 05. 2018 12:57:47	23.2960 °C	23.1679 °C	23.1562 °C	23.4658 °C	22.9677 °C	23.1054 °C	23.3470 °C	23.5400 °C	23.4192 °C	23.7327 °C
11. 05. 2018 12:58:17	23.2860 °C	23.1679 °C	23.1574 °C	23.4676 °C	22.9682 °C	23.1058 °C	23.3483 °C	23.5418 °C	23.4207 °C	23.7337 °C
11. 05. 2018 12:58:48	23.2800 °C	23.1685 °C	23.1585 °C	23.4682 °C	22.9691 °C	23.1060 °C	23.3500 °C	23.5437 °C	23.4224 °C	23.7344 °C
11. 05. 2018 12:59:18	23.2800 °C	23.1694 °C	23.1598 °C	23.4707 °C	22.9700 °C	23.1073 °C	23.3509 °C	23.5456 °C	23.4240 °C	23.7351 °C
11. 05. 2018 12:59:48	23.2900 °C	23.1701 °C	23.1614 °C	23.4730 °C	22.9694 °C	23.1079 °C	23.3508 °C	23.5473 °C	23.4260 °C	23.7367 °C

Figure 60: Selected Readings page

The statistics for the selected readings, selected measurement points and selected display quantity is displayed in the *Selected Statistics* page. Note that excluded measurement points are not displayed in the statistics list at all. This allows you to eliminate some additional measurements points that are not supposed to be part of the climatic chamber validation (for example measurement at the fan inlet) or some auxiliary measurements, such as the temperature of the psychrometer wet bulb, which is not a temperature related to the performance of the climatic chamber. Use the popup menu to copy the selected statistics to the clipboard.

Channel Statistics	Global Statistics																																																																																																																																							
<table border="1"> <thead> <tr> <th>Name</th> <th>Description</th> <th>Avg</th> <th>STD</th> <th>Min</th> <th>Max</th> <th>Max-Min</th> </tr> </thead> <tbody> <tr> <td>Temp 1</td> <td>Top Left Back</td> <td>57.26 %rh</td> <td>0.0840 %rh</td> <td>57.40 %rh</td> <td>57.10 %rh</td> <td>0.300 %rh</td> </tr> <tr> <td>Temp 2</td> <td>Top Left Front</td> <td>57.34 %rh</td> <td>0.0690 %rh</td> <td>57.40 %rh</td> <td>57.10 %rh</td> <td>0.300 %rh</td> </tr> <tr> <td>Temp 3</td> <td>Top Right Front</td> <td>56.15 %rh</td> <td>0.0628 %rh</td> <td>56.30 %rh</td> <td>56.00 %rh</td> <td>0.300 %rh</td> </tr> <tr> <td>Temp 4</td> <td>Top Right Back</td> <td>57.63 %rh</td> <td>0.0622 %rh</td> <td>58.00 %rh</td> <td>57.00 %rh</td> <td>0.400 %rh</td> </tr> <tr> <td>Temp 5</td> <td>Center</td> <td>57.42 %rh</td> <td>0.0629 %rh</td> <td>57.60 %rh</td> <td>57.20 %rh</td> <td>0.400 %rh</td> </tr> <tr> <td>Temp 6</td> <td>Bottom Left Back</td> <td>56.59 %rh</td> <td>0.0602 %rh</td> <td>56.70 %rh</td> <td>56.40 %rh</td> <td>0.300 %rh</td> </tr> <tr> <td>Temp 7</td> <td>Bottom Left Front</td> <td>55.92 %rh</td> <td>0.0549 %rh</td> <td>56.00 %rh</td> <td>55.80 %rh</td> <td>0.200 %rh</td> </tr> <tr> <td>Temp 8</td> <td>Bottom Right Front</td> <td>56.33 %rh</td> <td>0.0569 %rh</td> <td>56.40 %rh</td> <td>56.20 %rh</td> <td>0.200 %rh</td> </tr> <tr> <td>Temp 9</td> <td>Bottom Right Back</td> <td>55.28 %rh</td> <td>0.0687 %rh</td> <td>55.40 %rh</td> <td>55.10 %rh</td> <td>0.300 %rh</td> </tr> <tr> <td>Temp 10</td> <td>Auxiliary 1</td> <td>59.90 %rh</td> <td>0.0608 %rh</td> <td>56.00 %rh</td> <td>55.80 %rh</td> <td>0.200 %rh</td> </tr> <tr> <td>Temp 11</td> <td>Auxiliary 2</td> <td>57.44 %rh</td> <td>0.0763 %rh</td> <td>57.60 %rh</td> <td>57.30 %rh</td> <td>0.300 %rh</td> </tr> <tr> <td>Temp 12</td> <td>Auxiliary 3</td> <td>57.42 %rh</td> <td>0.0797 %rh</td> <td>57.60 %rh</td> <td>57.20 %rh</td> <td>0.400 %rh</td> </tr> <tr> <td>Temp 13</td> <td>Auxiliary 4</td> <td>56.83 %rh</td> <td>0.0701 %rh</td> <td>57.00 %rh</td> <td>56.70 %rh</td> <td>0.300 %rh</td> </tr> <tr> <td>Temp 14</td> <td>Auxiliary 5</td> <td>56.83 %rh</td> <td>0.0687 %rh</td> <td>57.00 %rh</td> <td>56.70 %rh</td> <td>0.300 %rh</td> </tr> </tbody> </table>	Name	Description	Avg	STD	Min	Max	Max-Min	Temp 1	Top Left Back	57.26 %rh	0.0840 %rh	57.40 %rh	57.10 %rh	0.300 %rh	Temp 2	Top Left Front	57.34 %rh	0.0690 %rh	57.40 %rh	57.10 %rh	0.300 %rh	Temp 3	Top Right Front	56.15 %rh	0.0628 %rh	56.30 %rh	56.00 %rh	0.300 %rh	Temp 4	Top Right Back	57.63 %rh	0.0622 %rh	58.00 %rh	57.00 %rh	0.400 %rh	Temp 5	Center	57.42 %rh	0.0629 %rh	57.60 %rh	57.20 %rh	0.400 %rh	Temp 6	Bottom Left Back	56.59 %rh	0.0602 %rh	56.70 %rh	56.40 %rh	0.300 %rh	Temp 7	Bottom Left Front	55.92 %rh	0.0549 %rh	56.00 %rh	55.80 %rh	0.200 %rh	Temp 8	Bottom Right Front	56.33 %rh	0.0569 %rh	56.40 %rh	56.20 %rh	0.200 %rh	Temp 9	Bottom Right Back	55.28 %rh	0.0687 %rh	55.40 %rh	55.10 %rh	0.300 %rh	Temp 10	Auxiliary 1	59.90 %rh	0.0608 %rh	56.00 %rh	55.80 %rh	0.200 %rh	Temp 11	Auxiliary 2	57.44 %rh	0.0763 %rh	57.60 %rh	57.30 %rh	0.300 %rh	Temp 12	Auxiliary 3	57.42 %rh	0.0797 %rh	57.60 %rh	57.20 %rh	0.400 %rh	Temp 13	Auxiliary 4	56.83 %rh	0.0701 %rh	57.00 %rh	56.70 %rh	0.300 %rh	Temp 14	Auxiliary 5	56.83 %rh	0.0687 %rh	57.00 %rh	56.70 %rh	0.300 %rh	<table border="1"> <thead> <tr> <th>Max</th> <th>Min</th> </tr> </thead> <tbody> <tr> <td>57.43 %rh</td> <td>55.28 %rh</td> </tr> <tr> <td>Name</td> <td></td> </tr> <tr> <td>Temp 4</td> <td>Temp 9</td> </tr> <tr> <td>Description</td> <td>Description</td> </tr> <tr> <td>Top Right Back</td> <td>Bottom Right Back</td> </tr> <tr> <td>Max-Min</td> <td>max STD</td> <td>0</td> </tr> <tr> <td>0.50 %rh</td> <td>0.0629 %rh</td> <td>05 readings</td> </tr> <tr> <td>Start Time</td> <td>Time Interval</td> <td></td> </tr> <tr> <td>11. 05. 2018 12:54:42</td> <td>00:42:26</td> <td></td> </tr> <tr> <td>End Time</td> <td></td> <td></td> </tr> <tr> <td>11. 05. 2018 13:37:08</td> <td></td> <td></td> </tr> </tbody> </table>	Max	Min	57.43 %rh	55.28 %rh	Name		Temp 4	Temp 9	Description	Description	Top Right Back	Bottom Right Back	Max-Min	max STD	0	0.50 %rh	0.0629 %rh	05 readings	Start Time	Time Interval		11. 05. 2018 12:54:42	00:42:26		End Time			11. 05. 2018 13:37:08		
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Figure 61: Selected Statistics page

Use the popup menu on the graph to execute these menu commands:

- *Clear All Readings* will clear all acquired readings from graph and memory, but they will remain stored in the measurement file (if measurement file was selected). Use this command before you start a new set of measurements and the existing readings would interfere with graph autoscaling.
- *Clear Selected Readings* will clear readings that are selected between graph cursors. Readings will be removed from graph and memory, but they will remain stored in the measurement file (if measurement file was selected). Use this commands if there are just a few readings that are either erroneous or out of scale.
- *Zoom Graph to Cursors* will change graph X scale so that the graph cursors are clearly visible in the middle of the graph area. Cursor position and consequently selected data will not be changed. Use this command if you would like to review the selected readings or if you would like to make a fine adjustment of the selected readings range.
- *Move Cursors to Graph Center* will move the cursors and consequently the selected data to the center of the graph area. Graph scaling is not changed by this operation. Use this command if you have zoomed in the graph and cursors are no longer visible in the currently visible graph area.
- *Graph Legend* allows you to select the label that is used to identify plots in the graph legend. You can choose between measurement point name, description and index.
- *Export ALL Readings to File* will create a new measurement file with the name and path that you specify and save all available readings to file. If any of the readings were previously cleared, they will not be exported. Note that this file is independent of the measurement file, which is used to save readings during measurement. This operation can take several minutes if there are a lot of readings. Graph cursors are used to indicate export progress. This command is only available when the measurement is stopped.
- *Export SELECTED Readings to File* is similar to the previous command, but instead of exporting all readings, it exports only readings that were selected with graph cursors.
- *Restore Readings from Current File* will reload all readings that were previously saved in the currently selected measurement file. Note that this command will overwrite any readings that may be currently displayed on the graph, so make sure that all required readings were actually stored in the measurement file. This command is useful if you have (accidentally) cleared some readings and you would like to restore them back. This command is only available when the measurement is stopped.

Readings can be reviewed in graphical format on the main graph. Main graph offers many features that are inherent to LabVIEW graphs, such as zooming, scaling and autoscaling the graph axes, changing graph colours and plot appearance, etc. Most of these features are accessible in the graph legend, axis legend and tools palette on the right-hand side of the main graph. If you are not familiar with LabVIEW and LabVIEW graph features, you may consider learning more about LabVIEW graphs in LabVIEW support at www.ni.com.

8.9 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.

UT-ONE firmware upgrade is applicable to all models of the UT-ONE family of thermometer readouts.

On some models, 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.

On models with no RS232 interface, upgrade must be performed using USB interface. This includes models with GPIB+RS232 interface option.

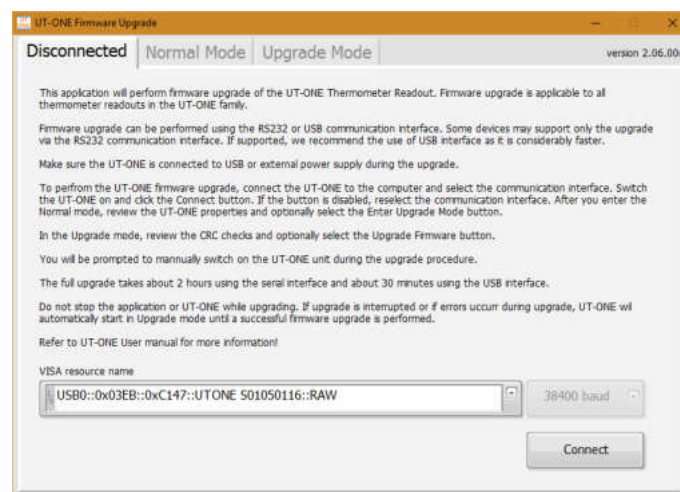


Figure 62: UT-ONE Firmware Upgrade

Start the upgrade procedure by closing all other applications that are communicating with UT-ONE. To avoid confusion, connect only one UT-ONE unit at a time during the upgrade.

Select the *VISA resource name* for your particular UT-ONE and communication interface. If UT-ONE is successfully detected on selected *VISA resource name*, the colour of the input box will change from red to white and the *Connect* button will be enabled.

Click the *Connect* button to proceed to *Normal Mode* or *Upgrade Mode* screen. Note that you can safely connect, the application will ask you later to confirm any changes to UT-ONE firmware.

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*.

If you are using the USB interface, the VISA resource name of your UT-ONE device will change to "USB0::0x03EB::0xC147::BOOT::RAW". Select this entry to proceed with upgrade.

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.

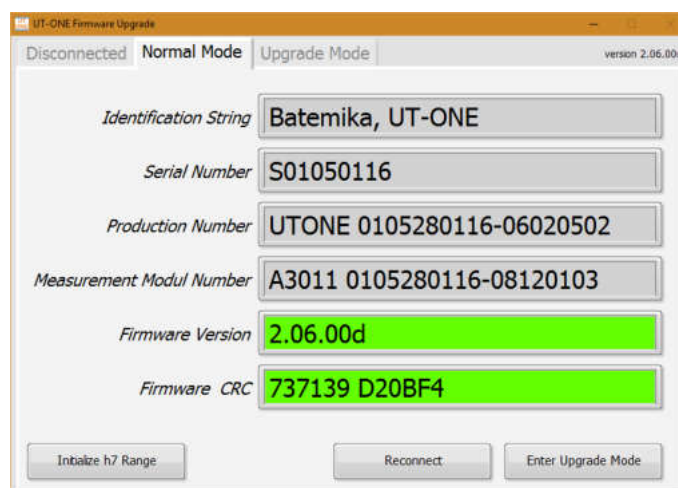


Figure 63: UT-ONE Firmware Upgrade in normal mode

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. In the second step, the display firmware is updated and in the third step display data is updated. 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. UT-ONE models without the display will finalize the upgrade after the first step.

The full upgrade takes about 2 hours using RS232 interface and 30 minutes using the USB interface.

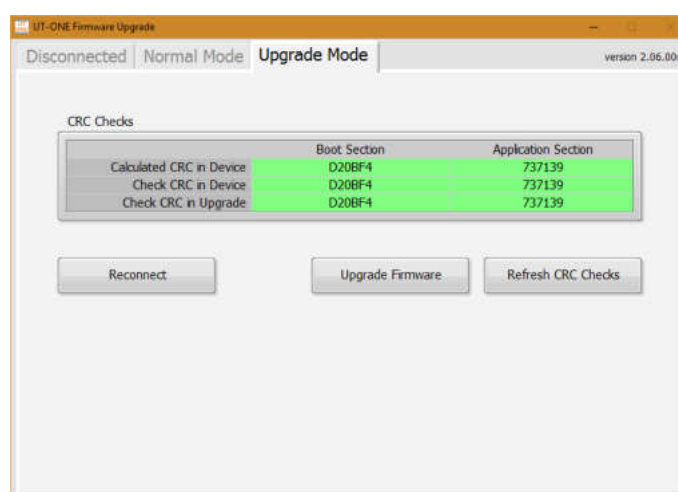


Figure 64: UT-ONE Firmware Upgrade during upgrade

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!

9 Specifications

This chapter provides detailed specifications for UT-ONE S04A 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
<i>Number of main channels</i>	4
<i>Thermometer probes</i>	platinum resistance thermometers, thermistors, thermocouples
<i>Temperature range</i>	-200 °C to 1800 °C max, limited by the probe range
<i>Type of sampling</i>	consecutive
<i>Sampling period</i>	2 to 240 seconds per enabled channel (continuous mode)
	1 to 5 seconds per reading (single-reading mode)
	up to 470 samples/second (digitizing mode)
<i>Measurement current</i>	1 mA / 0.707 mA for PRTs, 20 µA / 14.1 µA for thermistors
<i>Keep-warm current</i>	automatically adjusted for all PRT and thermistor channels
<i>Measurement current accuracy</i>	0.5%
<i>Keep-warm current accuracy</i>	2%
<i>Channel matching</i>	PRTs: <0.5 ppm typical, ±1 ppm maximum
	Thermistors: <1 ppm typical, ±3 ppm maximum
	Thermocouples: <0.2 µV typical, ±0.4 µV maximum
<i>Parasitic emf suppression</i>	full current reversal (PRT and thermistor channels only)
<i>Communication interfaces</i>	USB (GPIB+RS232 optional)
<i>Power supply</i>	USB bus
<i>Power consumption</i>	0.3 W typical, 1 W maximum (with GPIB option)
<i>Weight</i>	1.1 kg
<i>External dimensions (WxHxD)</i>	140 x 90 x 155 mm
<i>Warm up time</i>	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 μ A). Using the reduced measurement current setting will result in deterioration of effective resolution by 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 $\mu\Omega$ or μ V) 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 $\mu\Omega$	1 ppm of range	6 ppm of value	15 ppm of value	0.25 ppm/ $^{\circ}\text{C}$
R2	50 Ω	35 $\mu\Omega$	1 ppm of range	6 ppm of value	15 ppm of value	0.25 ppm/ $^{\circ}\text{C}$
R3	100 Ω	70 $\mu\Omega$	1 ppm of range	6 ppm of value	15 ppm of value	0.25 ppm/ $^{\circ}\text{C}$
R4	200 Ω	120 $\mu\Omega$	1 ppm of range	6 ppm of value	15 ppm of value	0.25 ppm/ $^{\circ}\text{C}$
R5	400 Ω	200 $\mu\Omega$	1 ppm of range	6 ppm of value	15 ppm of value	0.25 ppm/ $^{\circ}\text{C}$
R6	800 Ω	500 $\mu\Omega$	1 ppm of range	6 ppm of value	15 ppm of value	0.25 ppm/ $^{\circ}\text{C}$

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 k Ω	1.5 m Ω	5 ppm of range	8 ppm of value	20 ppm of value	1 ppm/ $^{\circ}\text{C}$
H2	2.5 k Ω	2 m Ω	5 ppm of range	8 ppm of value	20 ppm of value	1 ppm/ $^{\circ}\text{C}$
H3	5 k Ω	3.5 m Ω	5 ppm of range	8 ppm of value	20 ppm of value	1 ppm/ $^{\circ}\text{C}$
H4	10 k Ω	5 m Ω	5 ppm of range	8 ppm of value	20 ppm of value	1 ppm/ $^{\circ}\text{C}$
H5	20 k Ω	10 m Ω	5 ppm of range	8 ppm of value	20 ppm of value	1 ppm/ $^{\circ}\text{C}$
H6	40 k Ω	25 m Ω	5 ppm of range	8 ppm of value	20 ppm of value	1 ppm/ $^{\circ}\text{C}$

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/ $^{\circ}\text{C}$	0.5 μV
E2	30 mV	0.04 μV	10 ppm of range	30 ppm of value	60 ppm of value	2 ppm/ $^{\circ}\text{C}$	0.5 μV
E3	60 mV	0.07 μV	10 ppm of range	30 ppm of value	60 ppm of value	2 ppm/ $^{\circ}\text{C}$	0.5 μV
E4	125 mV	0.11 μV	10 ppm of range	30 ppm of value	60 ppm of value	2 ppm/ $^{\circ}\text{C}$	0.5 μV
E5	250 mV	0.2 μV	10 ppm of range	30 ppm of value	60 ppm of value	2 ppm/ $^{\circ}\text{C}$	0.5 μV
E6	500 mV	0.5 μV	10 ppm of range	30 ppm of value	60 ppm of value	2 ppm/ $^{\circ}\text{C}$	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!

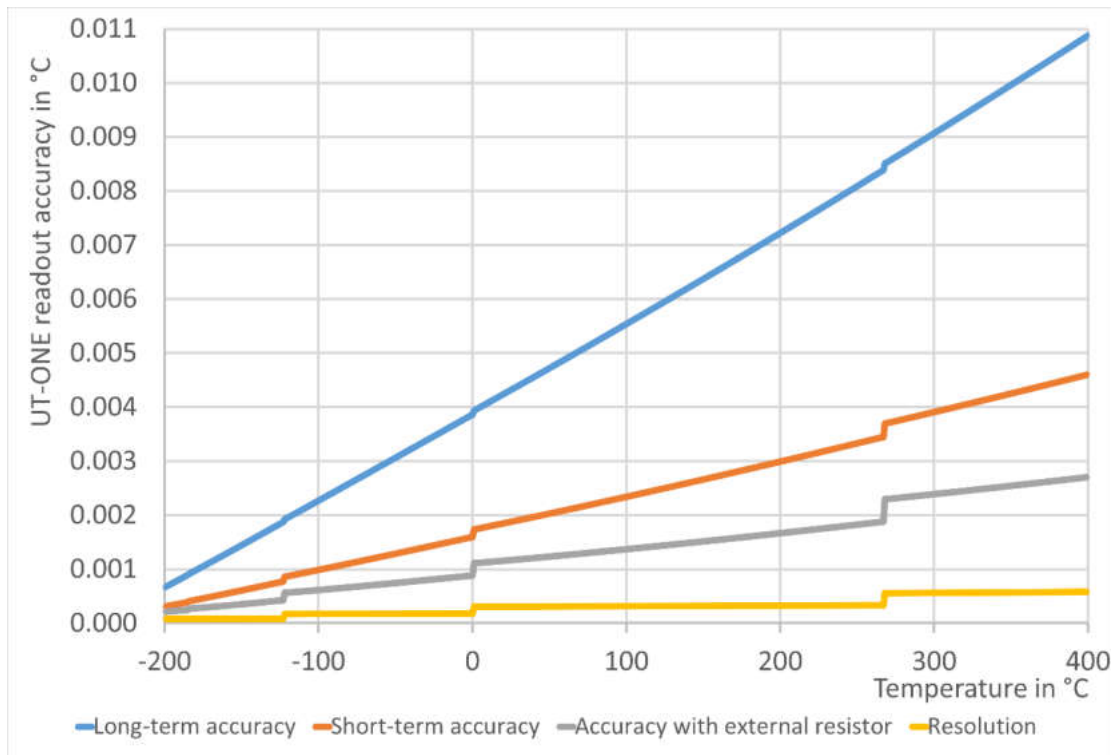


Figure 65: UT-ONE accuracy specification for Pt-100 probe

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.

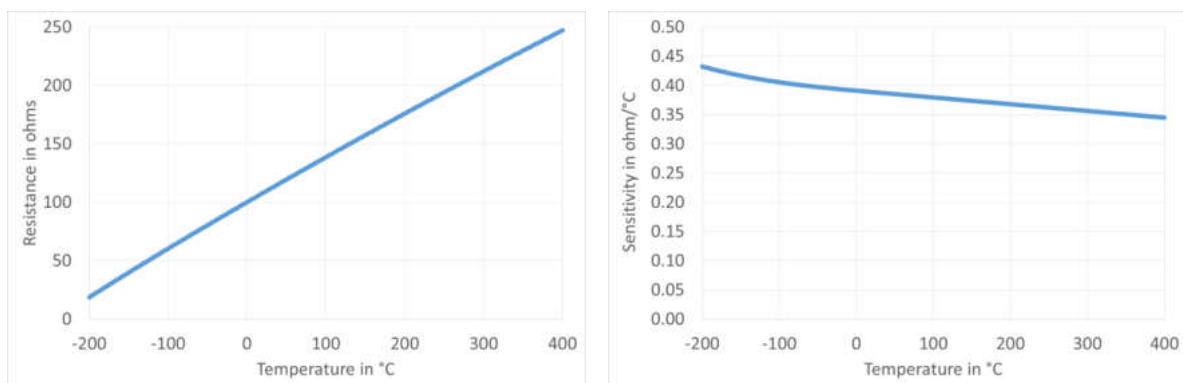


Figure 66: Resistance and sensitivity characteristic for Pt-100 probe

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!

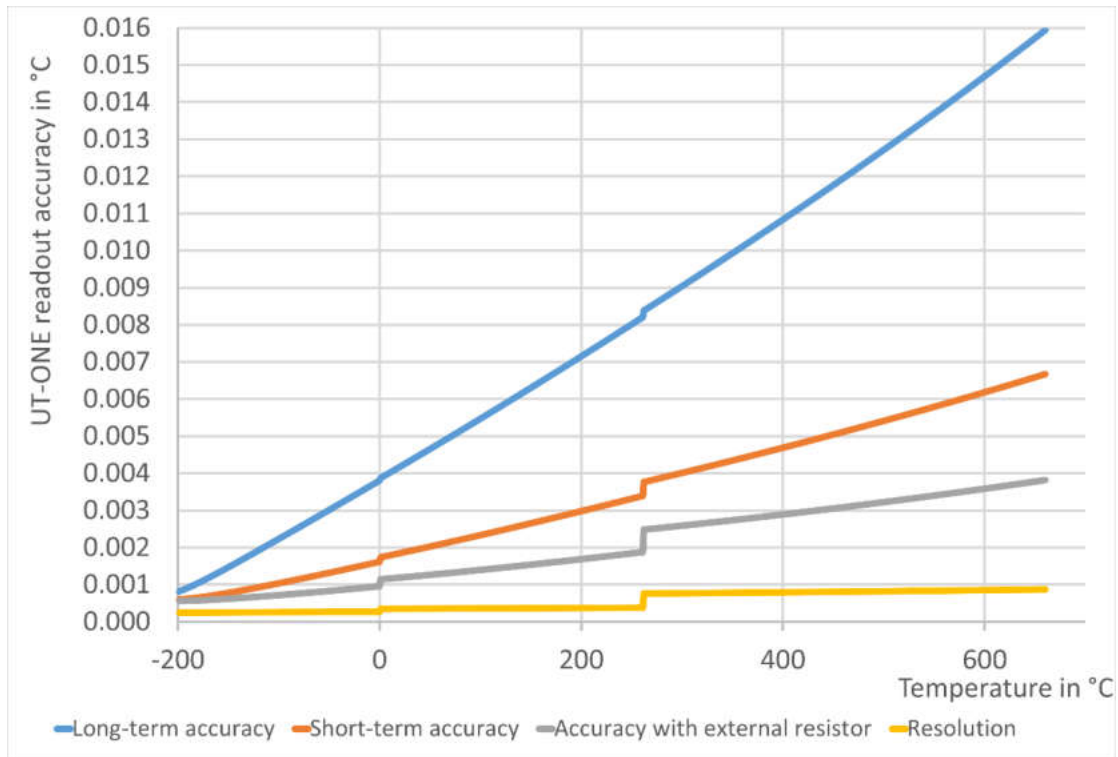


Figure 67: UT-ONE accuracy specification for Pt-25 probe

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.

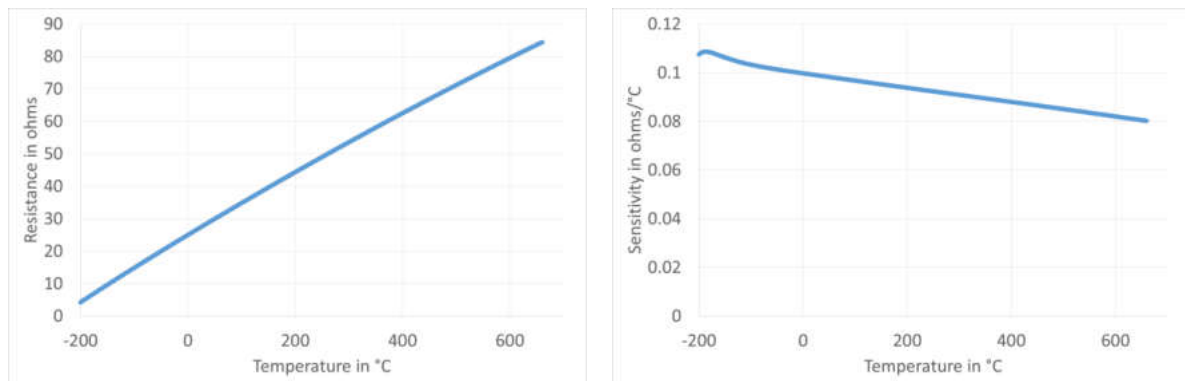


Figure 68: Resistance and sensitivity characteristic for Pt-25 probe

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 μ A) 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!

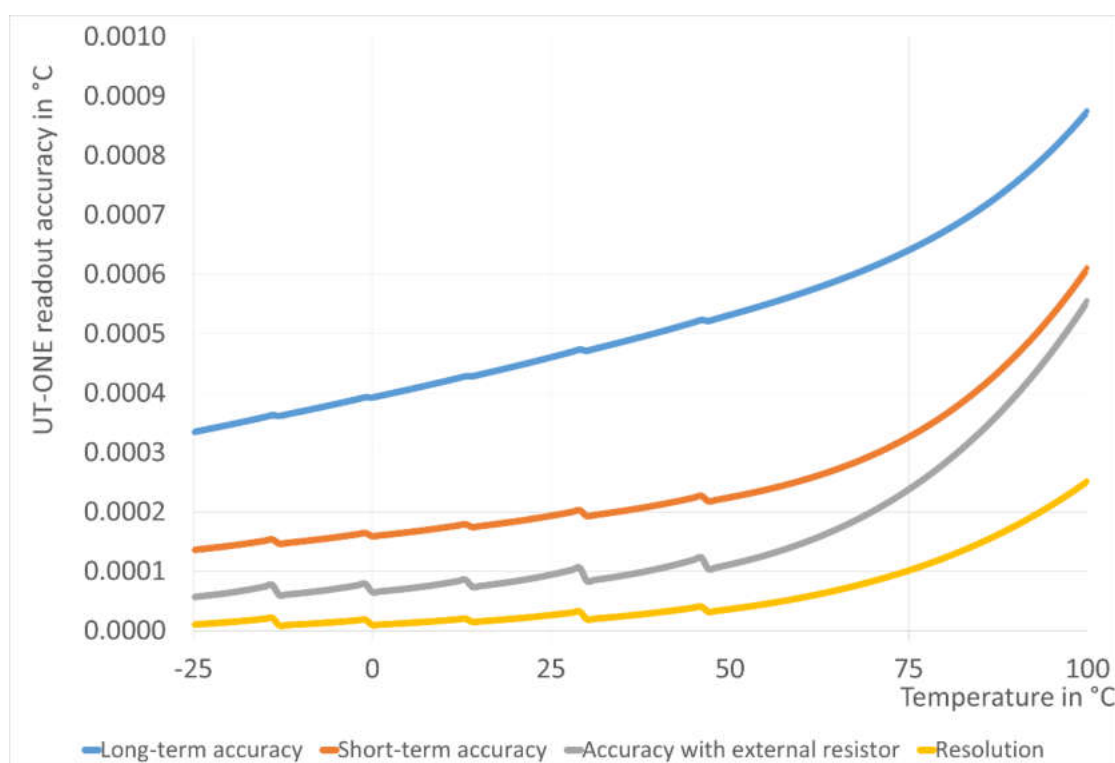


Figure 69: UT-ONE accuracy specification for 3K3A thermistor probe

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.

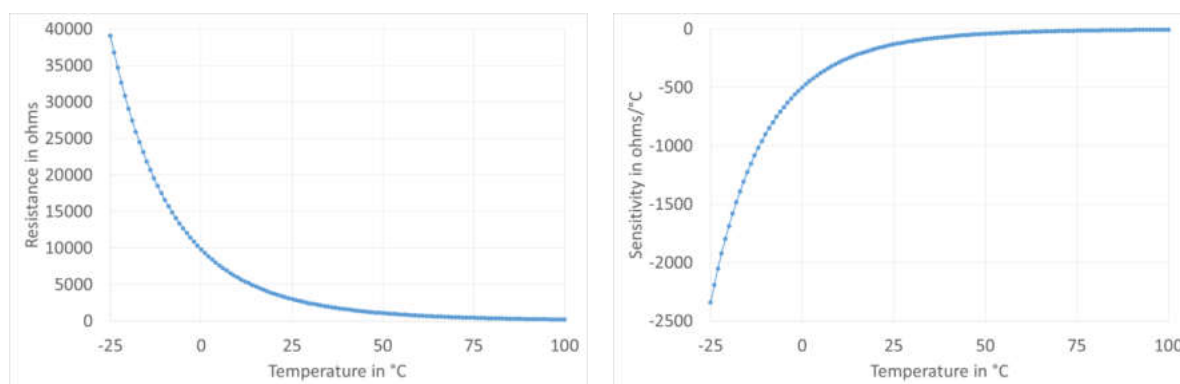


Figure 70: Resistance and sensitivity characteristic for 3K3A thermistor probe

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 μ A) 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!

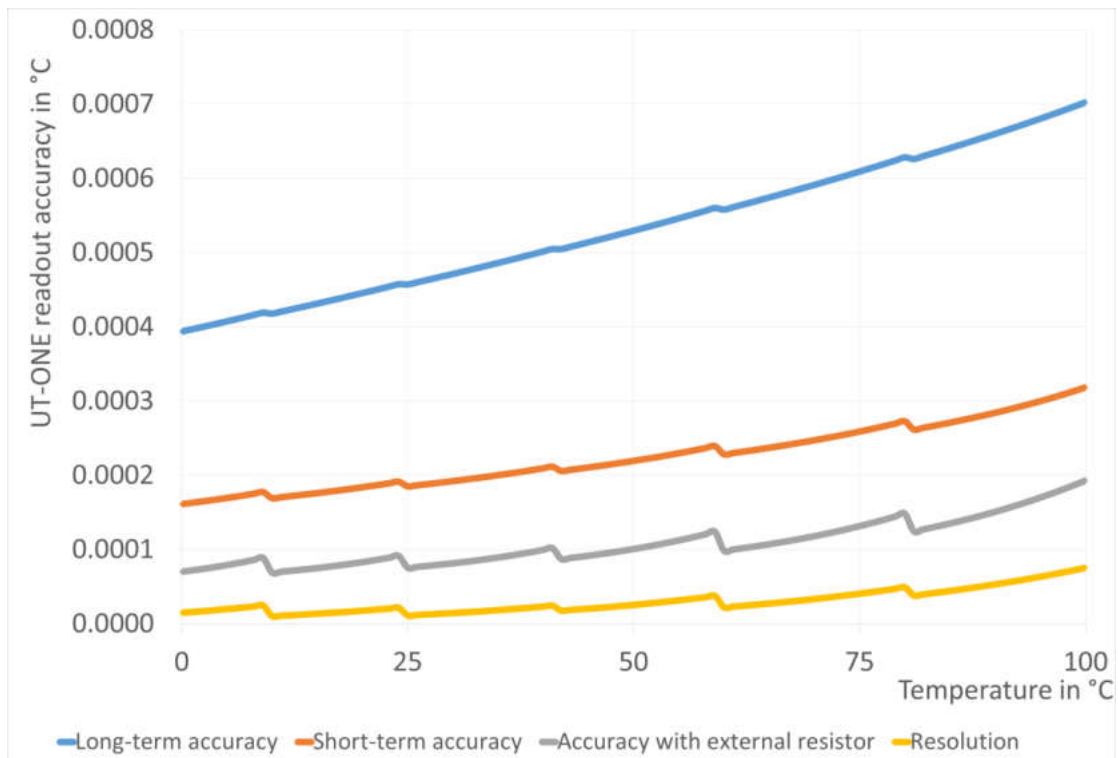


Figure 71: UT-ONE accuracy specification for 10K3A thermistor probe

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.

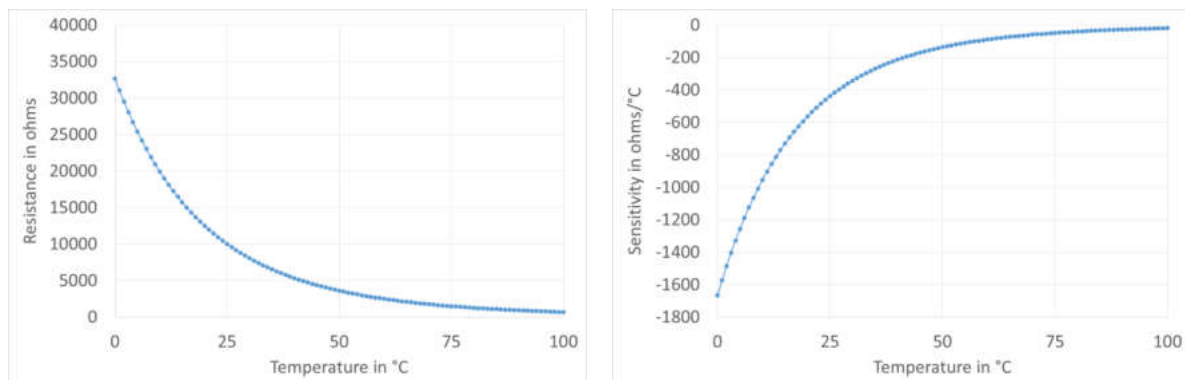


Figure 72: Resistance and sensitivity characteristic for 10K3A thermistor probe

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!

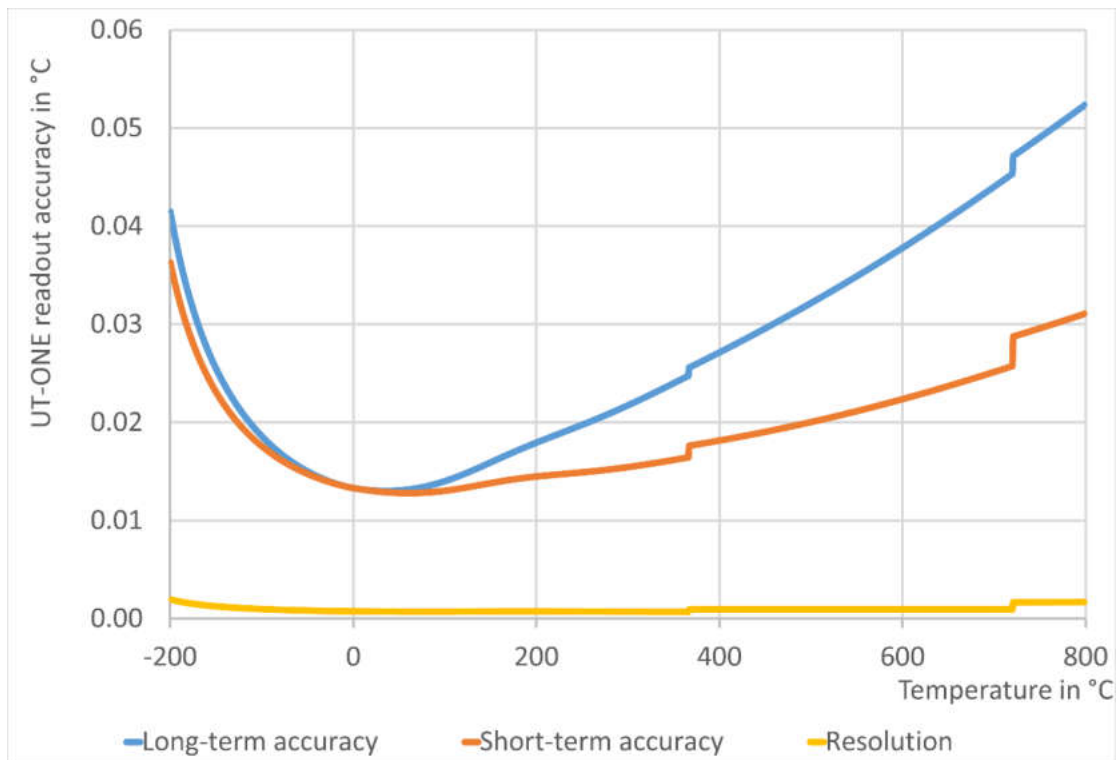


Figure 73: UT-ONE accuracy specification for type K thermocouple probe

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.

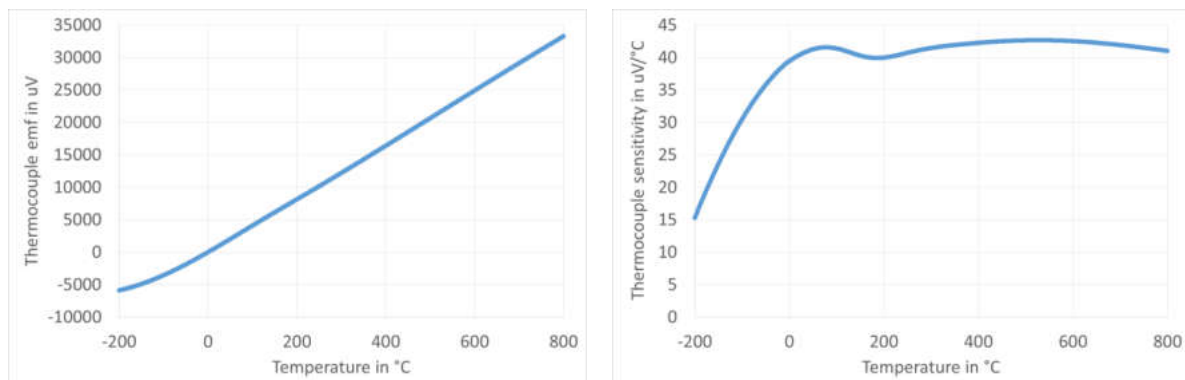


Figure 74: Emf and sensitivity characteristic for type K thermocouple probe

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!

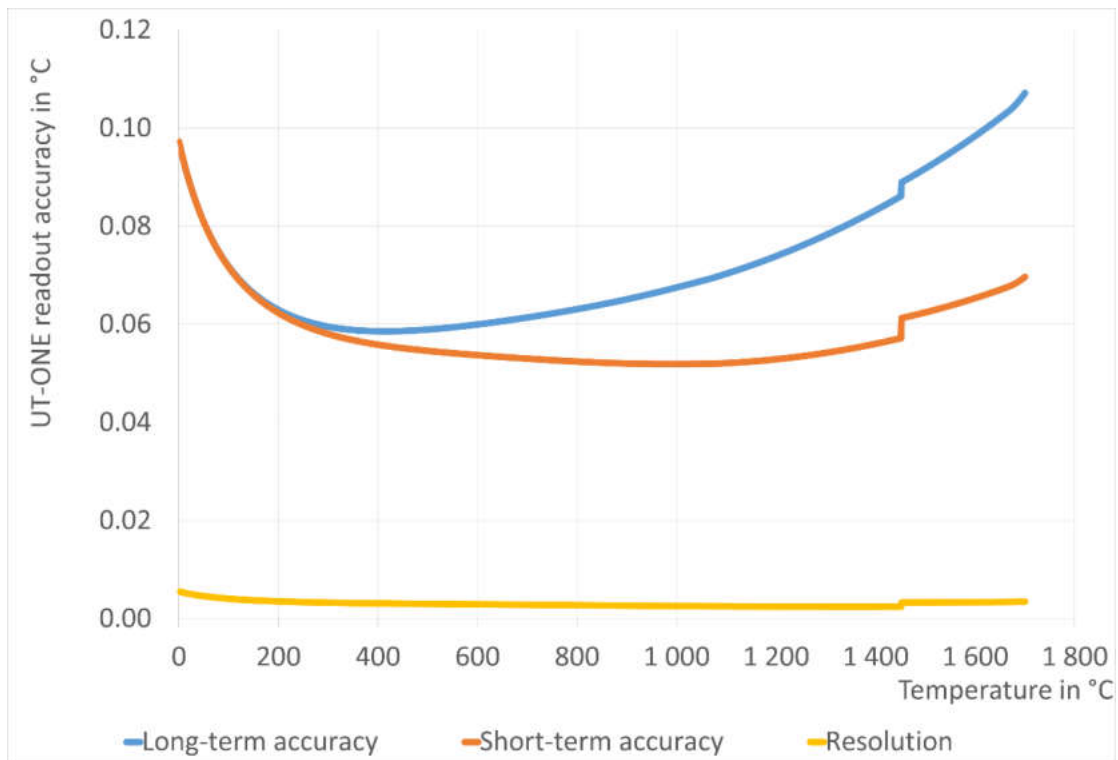


Figure 75: UT-ONE accuracy specification for type S thermocouple probe

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.

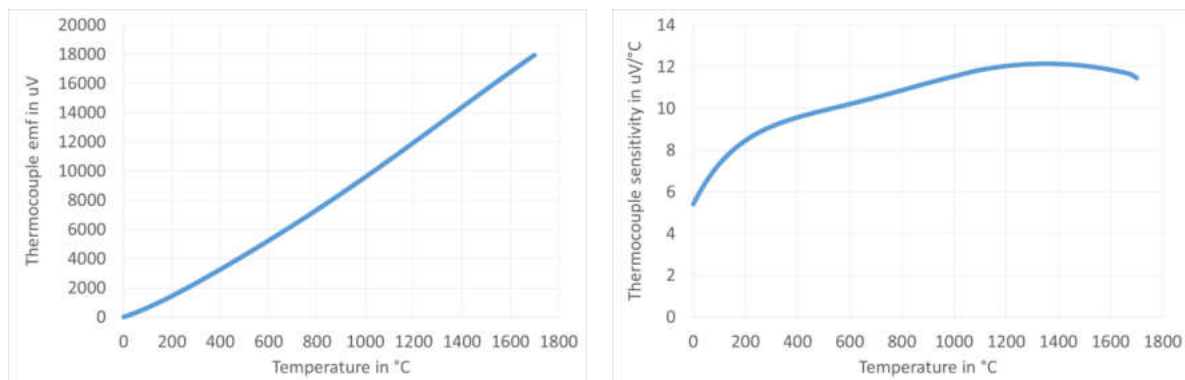


Figure 76: Emf and sensitivity characteristic for type S thermocouple probe

9.3 Auxiliary channels

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

Internal ADC thermometer	
<i>Sensor type</i>	Digital temperature sensor
<i>Sampling period</i>	Synchronized with readings on main channels
<i>Response time</i>	10 minutes (typical)
<i>Probe characterization</i>	Polynomial correction function
<i>Temperature range</i>	5 to 45 °C
<i>Temperature resolution</i>	0.01 °C
<i>Temperature accuracy</i>	±0.5 °C

9.4 Environmental specifications

Operating environment:	laboratory and light industrial environment, indoor use only, avoid dust, water vapour and fumes
Operating temperature:	10 °C to 36 °C
Operating relative humidity:	30% to 70%, non-condensing
Storage temperature:	5 °C to 45 °C
Storage relative humidity:	20% to 80%, 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 display is displaying * instead of the measured temperature.*
Make sure the particular channel is enabled and acquisition is started.
3. *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.
4. *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.
5. *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.
6. *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.
7. *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.
8. *GPIB or RS232 interface is not responding. Communication over USB interface is normal.*
Check the settings of GPIB address and RS232 Baud rate. Make sure the requested communication interface is enabled. You may change these settings using the UT-ONE Applications software or applicable remote commands. Make sure you restart the UT-ONE after you make changes to remote interface settings!
9. *I am trying to readjust the resistance and voltage ranges using the electrical calibrator, but the readings are noisy and have a large drift.*
UT-ONE S12A requires floating inputs (not referenced to ground), because the inputs are internally referenced to ground. If inputs are not floating, a ground loop is created, which tries to equalize the ground potentials. Most electrical calibrators have inputs that are referenced to ground. To solve this issue, connect the UT-ONE S12A to a portable computer and disconnect all other cables, including computer power supply (computer will run from its batteries).

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 multiple main 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 in continuous measurement mode?*
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. Overage is primarily intended for measurements of fault conditions, where measurements are normally 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 mK), 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 readings 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

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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.