

UT-ONE L01A

Rugged Thermometer Readout



User manual

Version 2.07.xx

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1 Introductions

UT-ONE L01A is a rugged thermometer readout for accurate and versatile temperature measurements in harsh environments. UT-ONE L01A features one main channel, which can measure either a Pt100 or thermistor probe (this option is configured during manufacturing and can't be changed by the user).

UT-ONE L01A features the RS232 communication interface for a connection to a computer or control system. An external USB to RS232 converter is provided with the device and enables quick connection to any computer with USB ports. Alternatively, UT-ONE L01A can be configured in standalone configuration, which stores acquired readings in the internal memory. Acquisition software on a computer is used to control the measurements, display the results and perform advanced data analysis.

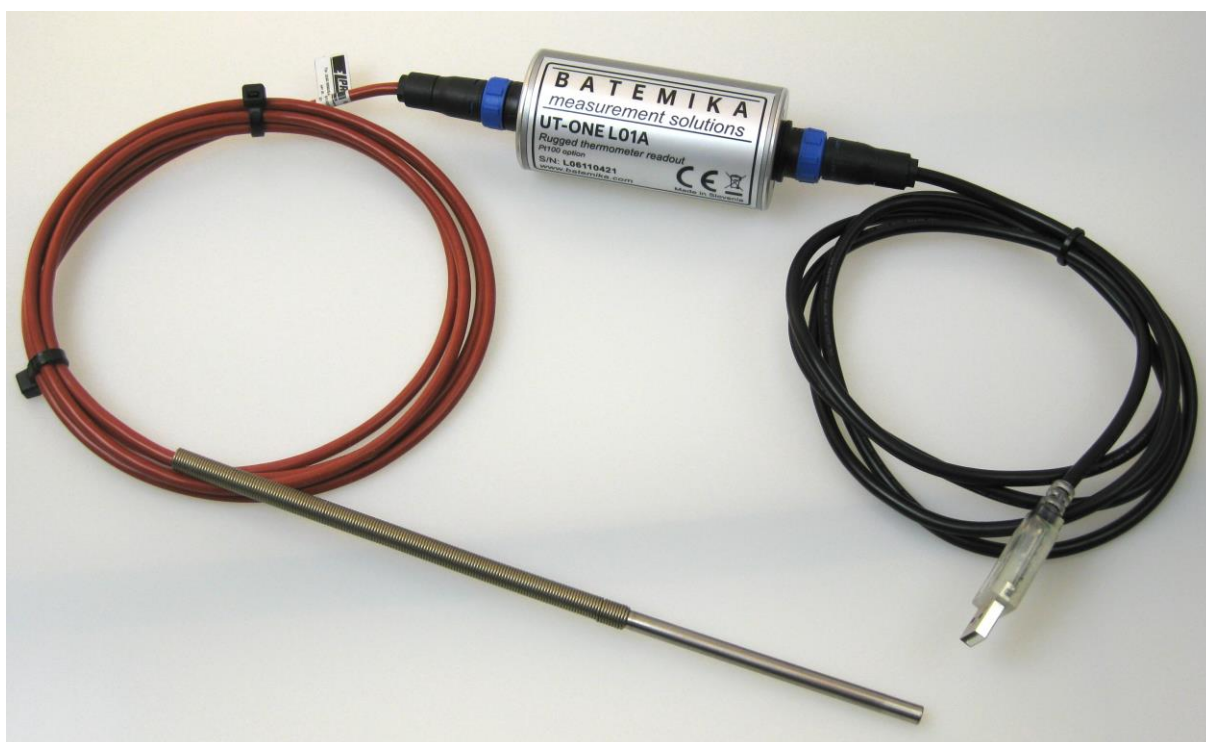


Figure 1: UT-ONE L01A with a Pt100 probe the provided USB to RS232 converter

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 L01A is a rugged device, which is resistant to water and mechanical shock, but as with any instrument, care should be taken to ensure a long instrument lifetime and good measurement performance.
- Use and store UT-ONE according to environmental conditions as listed in Specifications.
- Do not try to open the UT-ONE L01A housing. There are no serviceable parts inside. The interior is potted with encapsulating resin and force-opening will permanently destroy the device.
- UT-ONE L01A is waterproof and protected from ingress of dirt and particles only when the connectors are connected and firmly tightened to the device. When the connectors are not connected, use the provided connector covers to protect both the communication and probe circular connectors.
- Do not connect any of the probe connectors to electric potential, which is lower than -0.3 V or higher than 3 V referred to system ground. Higher voltages may damage the instrument or cause personal injury.
- Avoid using the instrument in environments prone to electrostatic discharges (ESD). ESD may disturb the normal operation of the instrument, and may cause permanent damage to electronic components, which may in long term cause instrument failure.
- Prevent electric contact between probes, cable leads and cable shields and the conductors which are electrically energized. This may result in severe shock, personal injury or death, fire hazard and damage to instruments.
- Connect probe only in floating configuration (not electrically referenced to ground).
- The instrument may be used to measure extremely high or low temperatures. Extreme care must be taken when handling thermometer probes, otherwise personal injury, and damage to equipment or fire may occur. Always allow the thermometer probe to reach ambient temperature in a controlled and supervised manner.
- If instrument or circular connector is damaged, do not use it. Secure the instrument and contact support for further instructions.
- Clean only with a damp cloth. Do not use chemical solvents to clean the instrument or connectors.

2.2 Power supply

UT-ONE L01A is powered from an external DC power supply with nominal voltage of 5 V (voltages from 4.5 V to 12 V are acceptable). When using the provided USB to RS232 converter, power is provided from USB port within the converter and no additional connections are required.

UT-ONE L01A will typically consume 20 mA of DC current at 5 V supply voltage. Peak value of current is 100 mA.

2.3 Starting and stopping the UT-ONE L01A

UT-ONE L01A is started by connecting the power supply or external USB to RS232 converter. There are no additional switches or remote-interface commands for starting and stopping UT-ONE L01A.

UT-ONE L01A can be stopped by disconnecting the power supply or external USB to RS232 converter. There is no need to stop the acquisition in software or perform any other software or hardware procedure before the disconnection of USB cable. UT-ONE L01A 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 L01A, otherwise communication errors may cause the software to become irresponsive and corrupted results may be recorded.

2.4 Communication Drivers

UT-ONE L01A primary communication interface is RS232. There are no particular drivers to be installed for the use of UT-ONE L01A with RS232 interface, as long as the RS232 communication port is properly configured on your computer or control system

External USB to RS232 converter that is provided with the UT-ONE L01A device is based on the FTDI chipset and drivers for this device are included in Windows or in Windows Update website. After you connect the converter to a USB port, Windows will detect it and automatically install the correct drivers.

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 Connections

UT-ONE L01A features two circular connectors for the connection of communication/power and thermometer probe.

2.5.1 Communication/power circular connector

UT-ONE L01A has a six-pin circular connector for RS232 communication interface and power supply. Always use a compatible circular connector to connect the communication/power supply cable to UT-ONE L01A.



Circular connector for communication interface and power supply

Pin configuration for six-pin connector:

- 1 – RXD line of the RS232 communication. Connect to TXD pin on the computer side.
- 2 – TXD line of the RS232 communication. Connect to RXD pin on the computer side.
- 3 – +5 V power line.
- 4 – GND power line.
- 5 – DIG line. This line is reserved for future upgrades. Do not connect unless specifically instructed.
- 6 – SHIELD line is internally connected to the aluminum housing of the device. Connect to the cable shield and system ground on the computer/controller. If you use unshielded cable, connect to GND line.



Communication/Power connector assembly

Communication/Power connector is usually assembled by the end user, so it can fit to the specific user requirements. Connectors is an off-the-shelf part, which is readily available at major electronics webstores. Manufacturer and model of the connector:

- Bulgin 400 Series Buccaneer PX0410/06S (connector housing) and SA3347/1 (pins)

Note that connector housing and pins are sold as separate items. Note also that the connector housing is available in several variants which allows a tight fit to various cable diameters, so make sure you order the variant that is applicable to your selected cable.

Follow the connector manufacturer instructions for the assembly procedure.

2.5.2 Thermometer probe circular connector

UT-ONE L01A has a four-pin circular connector for thermometer probe connection. Always use a compatible circular connector to connect the probe to UT-ONE L01A. Note that UT-ONE L01A supports only resistance measurement using the 4-wire connection. RTD lead wires must be connected in floating configuration, with no electrical connection to system ground or any other electrical potential.



Circular connector for thermometer probe

Pin configuration for four-pin connector:

- 1 – I+ is the positive current lead.
- 2 – I- is the negative current lead.
- 3 – V+ is the positive voltage lead.
- 4 – V- is the negative voltage lead.



4-wire connection of a RTD probe to a circular connector



Thermometer probe connector assembly

Thermometer probe connector is usually assembled by the end user or probe manufacturer, so it can fit to the specific user requirements. Connectors is an off-the-shelf part, which is readily available at major electronics webstores. Manufacturer and model of the connector:

- Bulgin 400 Series Buccanner PX0410/04S (connector housing) and SA3347/1 (pins)

Note that connector housing and pins are sold as separate items. Note also that the connector housing is available in several variants which allows a tight fit to various cable diameters, so make sure you order the variant that is applicable to your selected cable.

Follow the connector manufacturer instructions for the assembly procedure.

2.5.3 USB to RS232 converter

Each UT-ONE L01A device is provided with an external USB to RS232 converter, which allows a quick and simple connection of the device to any Windows computer with a USB port. USB to RS232 converter is a complete solution that includes both the RS232 communication lines and 5 V DC power supply for the UT-ONE L01A device (power is taken from the USB port).

After you connect the device to a computer, the operating system will automatically detect it and it will show up as another system COM port, which can be used for communication just like any other serial port.

Use of RS232 converter is primarily intended for testing, configuration and downloading of measurement results. It can also be used as a permanent solution if the UT-ONE L01A is used in benchtop/laboratory environment. For use in harsh environments we recommend the assembly of a dedicated cable for a connection to a computer or control system.



UT-ONE L01A with the provided USB to RS232 converter

2.5.4 Sealing caps

UT-ONE L01A is provided with a pair of sealing caps, which are used to maintain the IP68 rating of unmated connectors. Note that unmated connector is not protected from water, dirt or chemical contamination, so you should always cover the circular connectors with the sealing caps when not connected.

After the UT-ONE L01A is deployed in the harsh environment, consider removing and storing the sealing caps, so that the interior of the sealing cap does not become dirty or contaminated. Reattach the sealing caps after the device is disconnected.



UT-ONE L01A with sealing caps mounted

2.6 Standalone/logging operation

UT-ONE L01A features an internal flash memory for storing measurement data. This feature allows the device to operate as a temperature logger. In this mode of operation, the device requires only the external power supply and no computer, control system or communication lines.

To configure the UT-ONE L01A for standalone/logging operation, you must first configure it. This is preferably done with a computer, provided USB to RS232 converter and UT-ONE Applications software, but other custom options are also possible. Follow these steps to properly configure the device:

1. Connect the device to a computer with the provided USB to RS232 converter
2. Start the UT-ONE Applications software, UT-ONE Interface application.
3. Configure the device for continuous measurement mode with selected probe, range, measurement current and acquisition rate.
4. Make sure that the "Acq. at Startup" option is set to "Started".
5. Start the measurement to check that the temperature is correctly acquired.
6. Synchronize the real-time clock.
7. Start the UT-ONE Log Viewer application.
8. Make sure that data logging is enabled.
9. Check that the last few measurements were correctly logged.
10. Optionally, you may choose to erase flash memory, so you can start your logging operation with empty memory. Note that this operation takes approximately one minute.
11. Disconnect the device from the USB to RS232 converter and connect it to external power supply.

UT-ONE L01A features no internal batteries, so internal real-time clock will stop if there is no power supply. However, UT-ONE L01A features an internal short-term power backup for the real-time clock. Real-time clock will be running for at least one minute after it is disconnected from the power supply. This allows the user to synchronize the clock with a computer, disconnect the USB to RS232 converter and connect the external power supply without the loss of real-time clock accuracy. This is important, because each logged measurement is equipped with a timestamp from the internal real-time clock.

2.7 Channels

UT-ONE L01A measurement system consists of several measurement channels. There is one main channel C1 for the connection of thermometer probes. TI is the temperature of the internal thermometer, which is used for the internal compensation of the temperature coefficients.

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
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
BI (BTI)	Uncorrected temperature of A/D converter

2.8 Measurement ranges

UT-ONE L01A is available in two variants, which are designated as "Pt100 option" and "Thermistor option". These variants are configured during manufacturing and can't be changed by the end user. Each of the variants has a measurement subsystem that consists of 16 physical measurement ranges, which allow the user to perform the measurements with best accuracy and efficiency. Additionally, range h7 is an auxiliary range, which allows the extension of measurement range up to 200 kΩ 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, Pt100 option

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

Table 3: List of physical measurement ranges for main channels, Thermistor option

Name	Nominal range	Over range	Measurement current	Range group
H1	2500 Ω	3125 Ω	10 μA	Thermistor ranges
H2	5000 Ω	6250 Ω	10 μA	Thermistor ranges
H3	10000 Ω	12500 Ω	10 μA	Thermistor ranges
H4	20000 Ω	25000 Ω	10 μA	Thermistor ranges
H5	40000 Ω	50000 Ω	10 μA	Thermistor ranges
H6	80000 Ω	100000 Ω	10 μA	Thermistor ranges
h1	2500 Ω	3125 Ω	7.07 μA	Thermistor ranges
h2	5000 Ω	6250 Ω	7.07 μA	Thermistor ranges
h3	10000 Ω	12500 Ω	7.07 μA	Thermistor ranges
h4	20000 Ω	25000 Ω	7.07 μA	Thermistor ranges
h5	40000 Ω	50000 Ω	7.07 μA	Thermistor ranges
h6	80000 Ω	100000 Ω	7.07 μA	Thermistor ranges
h7	160000 Ω	200000 Ω	7.07 μA	Auxiliary range

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 25% higher than nominal range limit. Measurements can be normally performed in the over range, but higher linearity error should be expected and taken into account in the uncertainty budget.

Apart from the physical ranges, UT-ONE measurement subsystem implements also 2 virtual autoranges for each variant. Autoranges are implemented to simplify configuration of acquisition channels, so the user doesn't need to know the expected resistance of the thermometer probe. When using autoranging, UT-ONE first samples the approximate value of probe resistance 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 4: List of virtual autoranges for main channels, Pt100 option

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

Table 5: List of virtual autoranges for main channels, Thermistor option

Name	Nominal range	Over range	Measurement current	Range group
HA	0 to 80000 Ω	100000 Ω	10 μA	Thermistor ranges
hA	0 to 80000 Ω	100000 Ω	7.07 μA	Thermistor ranges

3 User Interface

UT-ONE L01A has no built-in user interface for direct reading of measurement results and controlling the acquisition.

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 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:

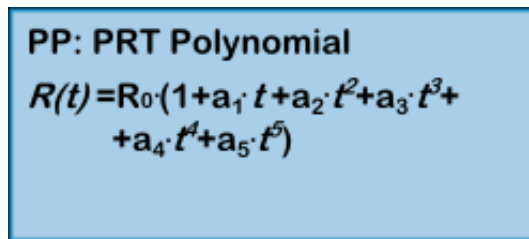
- *Probe name* (20 bytes)
Probe name describes the probe in unique and user-friendly manner. Probe name may consist of probe model, manufacturer, serial number, certificate number, or it can be a functional description of the probe. If probe name is less than 20 characters long, append space characters 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.



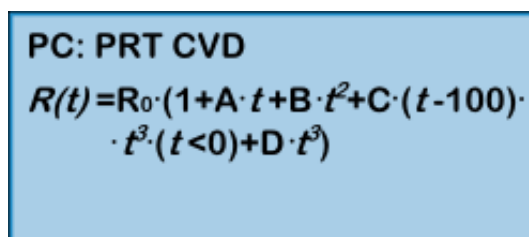
PP: PRT Polynomial

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

Figure 2: Conversion equation for PP probe type

4.2.2 PC: PRT CVD

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



PC: PRT CVD

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

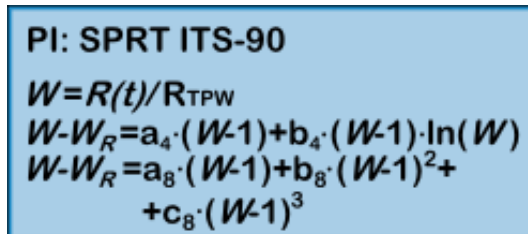
Figure 3: Conversion equation for PC probe type

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.



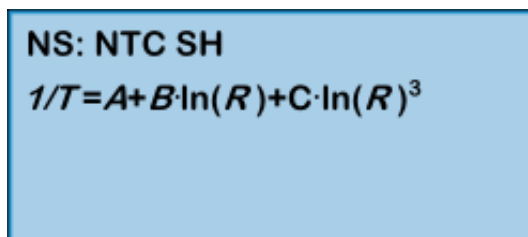
PI: SPRT ITS-90

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

Figure 4: 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.



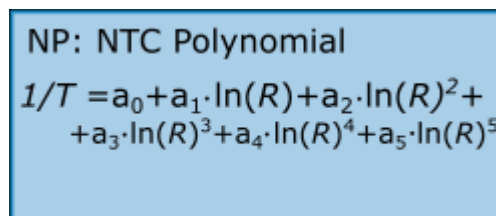
NS: NTC SH

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

Figure 5: Conversion equation for NS probe type

4.2.5 NP: NTC Polynomial

NTC polynomial is a generalized form of the Steinhart-Hart equation. It features polynomial of up to fifth order which permits better fitting accuracy than Steinhart-Hart equation. Note that temperature T in the equation has the unit kelvin.



NP: NTC Polynomial

$$1/T = a_0 + a_1 \cdot \ln(R) + a_2 \cdot \ln(R)^2 + a_3 \cdot \ln(R)^3 + a_4 \cdot \ln(R)^4 + a_5 \cdot \ln(R)^5$$

Figure 6: Conversion equation for NP probe type

4.3 Ambient probes

UT-ONE L01A features one additional ambient probe. The internal thermometer on channel TI is used for the temperature compensation of resistance and emf readings. Ambient probe has a direct indication in temperature, 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 channel 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 GPIB/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 RS232 interface

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

RS232 interface settings:

- Odd parity (configurable to none or even parity)
- 8 data bits
- 1 or 2 stop bit
- Baud rate is software selectable (300, 600, 1200, 4800, 9600, 19200, 38400, 56000, 57600, 115200, 128000, 230400 and 25000 baud)

5.2 HyperTerminal

HyperTerminal is an industry-standard tool for testing the communication via serial interface. UT-ONE supports HyperTerminal operation using a modified communication protocol. UT-ONE can automatically detect the use of HyperTerminal and change the termination character from LF to CR+LF. It also removes the timeout between the individual received characters, so user can type commands at any pace. Note that the first command over HyperTerminal is ignored, so that UT-ONE can internally switch to modified communication protocol.

HyperTerminal must be configured using the following settings:

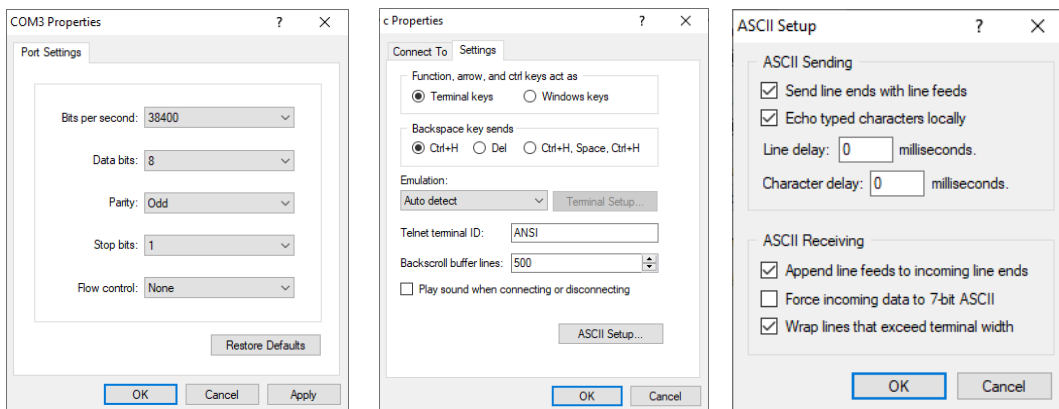


Figure 7: HyperTerminal settings for communication with UT-ONE

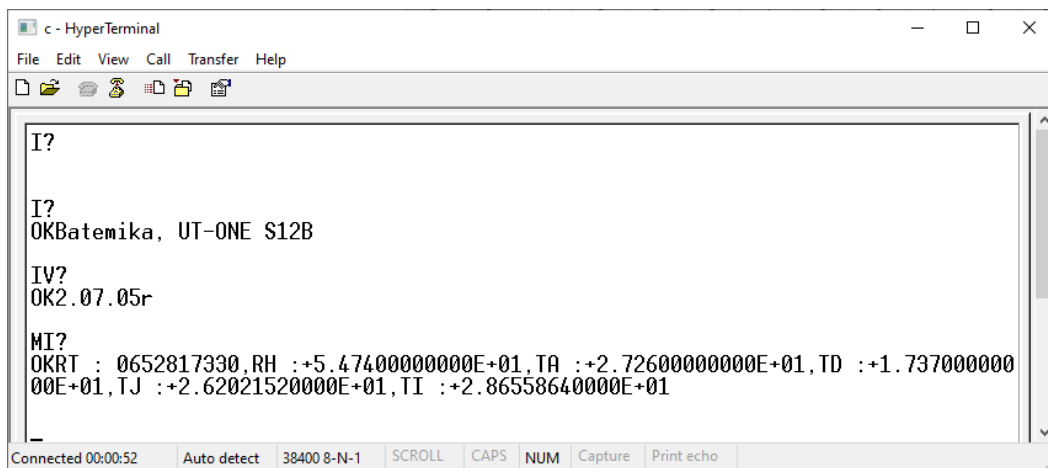


Figure 8: HyperTerminal example

5.3 MODBUS Protocol Support

UT-ONE thermometer readout provides a limited support for communication using the MODBUS protocol via serial interface. This feature is primarily intended for connecting UT-ONE to PLC industrial controllers. MODBUS support is limited to basic configuration of communication parameters and reading of acquired measurements in continuous measurement mode. Use *UT-ONE Command Set* or *UT-ONE Applications* software to access full configuration and acquisition capabilities of the UT-ONE device.

This user manual provides only a basic description of the MODBUS protocol. For detailed description refer to "MODBUS Application Protocol Specification" available for free download at www.modbus.org.

5.3.1 MODBUS message structure

MODBUS defines a digital communication network to have one MASTER device (PLC or computer) and one or more SLAVE devices (UT-ONE). Note that when using RS232 communication interface, only one SLAVE device can be connected. Communication is always initiated by the MASTER device and only the addressed SLAVE device will reply.

UT-ONE only supports RTU mode of transmission.

Message frame format is presented in the following table:

Frame start	Device address	Function code	Data	CRC	End of transmission
----	1 byte	1 byte	n bytes	2 bytes	----

- *Frame Start* is a period of inactivity at least 3.5 times the single character transmission time
- *Device address* is a single-byte (8 bits) identifier unique to each slave device. Default UT-ONE device address is 1, but it can be changed to any value between 1 and 247. Device address 0 is a special case that will broadcast a message to all slave device and slave device will not respond.
- *Function code* is a single-byte (8 bits) instruction to the slave describing the action to perform. UT-ONE supports function codes 3, 4, 6 and 16.
- *Data* segment if the message depends on the function code. Typically it will contain a parameter address, number of parameters and parameter data.
- *CRC* (Cyclic Redundancy Check) is an error-check code and is two bytes (16 bits) long. CRC polynomial is 0xA001 and initial value is 0xFFFF.
- *End of transmission* is a period of inactivity 3.5 times the single-character transmission time. The EOT segment at the end of a message indicates to the listening device that the next transmission will be a new message.

5.3.2 Function codes

UT-ONE supports a minimal set of MODBUS function codes which enable writing and reading parameter values in the UT-ONE parameter table. Parameter values are 16-bit integer words, however more than one consecutive 16-bit parameter value can be combined to represent one data value.

- **READ N WORDS (3 or 4)**

Reads specified number of parameter values starting at specified parameter address. Maximum of 32 16-bit parameter values can be read in a single message.

Command:

Device address	Function code 3 or 4	Starting address		Number of words to read		CRC	
1 byte	1 byte	MSB	LSB	MSB	LSB	MSB	LSB

Response:

Device address	Function code 3 or 4	Number of bytes read	Value of first word	...	Value of last word	CRC			
1 byte	1 byte	1 byte	MSB	LSB	...	MSB	LSB	MSB	LSB

- **WRITE A WORD (6)**

Writes a single parameter value to the specified parameter address. Using a device address 0 will broadcast parameter value to all devices regardless of their device address.

Command:

Device address	Function code 6	Parameter address		Parameter value		CRC	
1 byte	1 byte	MSB	LSB	MSB	LSB	MSB	LSB

Response:

Device address	Function code 6	Parameter address		Parameter value		CRC	
1 byte	1 byte	MSB	LSB	MSB	LSB	MSB	LSB

- **WRITE N WORDS (16)**

Writes N parameter values starting at the specified parameter address. Using a device address 0 will broadcast parameter values to all devices regardless of their device address.

Maximum of 32 16-bit parameter values can be written in a single message.

Command:

Device address	Function code 10	Starting address		Number of words		Number of bytes (N)		Data	CRC	
1 byte	1 byte	MSB	LSB	MSB	LSB	1 byte		N bytes	MSB	LSB

Response:

Device address	Function code 10	Starting address		Number of words written		CRC	
1 byte	1 byte	MSB	LSB	MSB	LSB	MSB	LSB

5.3.3 MODBUS Parameter Table

MODBUS protocol is based on reading and writing parameter values in an addressable parameter table. Each parameter is a 16-bit integer word (signed or unsigned). Several consecutive parameter words can be combined in a larger data type.

The following table lists all addressable parameters supported by UT-ONE. Parameters with R/W access can be read and written while parameters with R access can only be read (writing to the parameter will result in an error).

Address DEC	Address HEX	Description	Size	Access
1	0x0001	Continuous acquisition status (0=Idle, 1=Acquiring)	1 word	R/W
16	0x0010	Device address	1 word	R/W
17	0x0011	Baud rate (0=300, 1=600, 2=1200, 3=2400, 4=4800, 5=9600, 6=19200, 7=38400, 8=56000, 9=57600, 10=115200, 11=128000, 12=23400, 13=250000)	1 word	R/W
18	0x0012	Parity (0=No parity, 1=Odd parity, 2=Even parity)	1 word	R/W
256	0x0100	C1 temperature value in 16-bit integer format	1 word	R
257	0x0101	C2 temperature value in 16-bit integer format	1 word	R
258	0x0102	C3 temperature value in 16-bit integer format	1 word	R
259	0x0103	C4 temperature value in 16-bit integer format	1 word	R
260	0x0104	C5 temperature value in 16-bit integer format	1 word	R
261	0x0105	C6 temperature value in 16-bit integer format	1 word	R
262	0x0106	C7 temperature value in 16-bit integer format	1 word	R
263	0x0107	C8 temperature value in 16-bit integer format	1 word	R
264	0x0108	C9 temperature value in 16-bit integer format	1 word	R
265	0x0109	C10 temperature value in 16-bit integer format	1 word	R
266	0x010A	C11 temperature value in 16-bit integer format	1 word	R
267	0x010B	C12 temperature value in 16-bit integer format	1 word	R
320	0x0140	B1 raw value in 16-bit integer format	1 word	R
321	0x0141	B2 raw value in 16-bit integer format	1 word	R
322	0x0142	B3 raw value in 16-bit integer format	1 word	R
323	0x0143	B4 raw value in 16-bit integer format	1 word	R
324	0x0144	B5 raw value in 16-bit integer format	1 word	R
325	0x0145	B6 raw value in 16-bit integer format	1 word	R
326	0x0146	B7 raw value in 16-bit integer format	1 word	R
327	0x0147	B8 raw value in 16-bit integer format	1 word	R
328	0x0148	B9 raw value in 16-bit integer format	1 word	R
329	0x0149	B10 raw value in 16-bit integer format	1 word	R
330	0x014A	B11 raw value in 16-bit integer format	1 word	R
331	0x014B	B12 raw value in 16-bit integer format	1 word	R
384	0x0180	RH relative humidity value in 16-bit integer format	1 word	R
385	0x0181	TA temperature value in 16-bit integer format	1 word	R
386	0x0182	TD temperature value in 16-bit integer format	1 word	R
387	0x0183	TJ temperature value in 16-bit integer format	1 word	R
388	0x0184	TI temperature value in 16-bit integer format	1 word	R
448	0x01C0	BH relative humidity raw value in 16-bit integer format	1 word	R
449	0x01C1	BA temperature raw value in 16-bit integer format	1 word	R
450	0x01C2	BD temperature raw value in 16-bit integer format	1 word	R
451	0x01C3	BJ temperature raw value in 16-bit integer format	1 word	R
452	0x01C4	BI temperature raw value in 16-bit integer format	1 word	R
512	0x0200	C1 temperature value in 32-bit integer format	2 words	R

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514	0x0202	C2 temperature value in 32-bit integer format	2 words	R
516	0x0204	C3 temperature value in 32-bit integer format	2 words	R
518	0x0206	C4 temperature value in 32-bit integer format	2 words	R
520	0x0208	C5 temperature value in 32-bit integer format	2 words	R
522	0x020A	C6 temperature value in 32-bit integer format	2 words	R
524	0x020C	C7 temperature value in 32-bit integer format	2 words	R
526	0x020E	C8 temperature value in 32-bit integer format	2 words	R
528	0x0210	C9 temperature value in 32-bit integer format	2 words	R
530	0x0212	C10 temperature value in 32-bit integer format	2 words	R
532	0x0214	C11 temperature value in 32-bit integer format	2 words	R
534	0x0216	C12 temperature value in 32-bit integer format	2 words	R
640	0x0280	B1 raw value in 32-bit integer format	2 words	R
642	0x0282	B2 raw value in 32-bit integer format	2 words	R
644	0x0284	B3 raw value in 32-bit integer format	2 words	R
646	0x0286	B4 raw value in 32-bit integer format	2 words	R
648	0x0288	B5 raw value in 32-bit integer format	2 words	R
650	0x028A	B6 raw value in 32-bit integer format	2 words	R
652	0x028C	B7 raw value in 32-bit integer format	2 words	R
654	0x028E	B8 raw value in 32-bit integer format	2 words	R
656	0x0230	B9 raw value in 32-bit integer format	2 words	R
658	0x0232	B10 raw value in 32-bit integer format	2 words	R
660	0x0234	B11 raw value in 32-bit integer format	2 words	R
662	0x0236	B12 raw value in 32-bit integer format	2 words	R
768	0x0300	RH relative humidity value in 32-bit integer format	2 words	R
770	0x0302	TA temperature value in 32-bit integer format	2 words	R
772	0x0304	TD temperature value in 32-bit integer format	2 words	R
774	0x0306	TJ temperature value in 32-bit integer format	2 words	R
776	0x0308	TI temperature value in 32-bit integer format	2 words	R
896	0x0380	BH relative humidity raw value in 32-bit integer format	2 words	R
898	0x0382	BA temperature raw value in 32-bit integer format	2 words	R
900	0x0384	BD temperature raw value in 32-bit integer format	2 words	R
902	0x0386	BJ temperature raw value in 32-bit integer format	2 words	R
904	0x0388	BI temperature raw value in 32-bit integer format	2 words	R
512	0x0400	C1 temperature value in Float32 format	2 words	R
514	0x0402	C2 temperature value in Float32 format	2 words	R
516	0x0404	C3 temperature value in Float32 format	2 words	R
518	0x0406	C4 temperature value in Float32 format	2 words	R
520	0x0408	C5 temperature value in Float32 format	2 words	R
522	0x040A	C6 temperature value in Float32 format	2 words	R
524	0x040C	C7 temperature value in Float32 format	2 words	R
526	0x040E	C8 temperature value in Float32 format	2 words	R
528	0x0410	C9 temperature value in Float32 format	2 words	R
530	0x0412	C10 temperature value in Float32 format	2 words	R
532	0x0414	C11 temperature value in Float32 format	2 words	R
534	0x0416	C12 temperature value in Float32 format	2 words	R
640	0x0480	B1 raw value in Float32 format	2 words	R
642	0x0482	B2 raw value in Float32 format	2 words	R
644	0x0484	B3 raw value in Float32 format	2 words	R
646	0x0486	B4 raw value in Float32 format	2 words	R
648	0x0488	B5 raw value in Float32 format	2 words	R
650	0x048A	B6 raw value in Float32 format	2 words	R

652	0x048C	B7 raw value in Float32 format	2 words	R
654	0x048E	B8 raw value in Float32 format	2 words	R
656	0x0430	B9 raw value in Float32 format	2 words	R
658	0x0432	B10 raw value in Float32 format	2 words	R
660	0x0434	B11 raw value in Float32 format	2 words	R
662	0x0436	B12 raw value in Float32 format	2 words	R
768	0x0500	RH relative humidity value in Float32 format	2 words	R
770	0x0502	TA temperature value in Float32 format	2 words	R
772	0x0504	TD temperature value in Float32 format	2 words	R
774	0x0506	TJ temperature value in Float32 format	2 words	R
776	0x0508	TI temperature value in 32 Float32 format	2 words	R
896	0x0580	BH relative humidity raw value in Float32 format	2 words	R
898	0x0582	BA temperature raw value in Float32 format	2 words	R
900	0x0584	BD temperature raw value in Float32 format	2 words	R
902	0x0586	BJ temperature raw value in Float32 format	2 words	R
904	0x0588	BI temperature raw value in Float32 format	2 words	R

5.3.4 Data formats

UT-ONE supports reading of temperature and raw-data values in three different numeric formats.

- 16-bit integer format is the simplest data format that stores the value in a single 16-bit word with reduced accuracy and range. Numeric resolution is 0.01 and range is -327.67 to +327.67. Values out of ranges are truncated to range limits. Readings are converted directly to numeric values regardless of unit.

Examples:

12412 (0x307C) = +124.12
 -2334 (0xF6E2) = -23.34
 0 (0x0000) = 0.00
 32767 (0x7FFF) = +327.67
 -32767 (0x8001) = -327.67
 -32768 (0x8000) = ERROR or EMPTY

- 32-bit integer format is the data format that UT-ONE uses to store readings to internal flash memory. The value in the 3 least significant bits determines the unit and resolution:

0 = temperature in kelvin with resolution 0.000001 K
 1 = ERROR or EMPTY
 2 = relative humidity in %rh with resolution 0.000001 %rh
 3 = emf in μV with resolution 0.001 μV
 4 = resistance in ohm with resolution 0.0001 ohm
 5 = resistance in ohm with resolution 0.00001 ohm
 6 = resistance in ohm with resolution 0.000001 ohm
 7 = resistance in ohm with resolution 0.0000001 ohm

Examples:

(0) 0728273456 (0x2B689230) = 728.273456 K = 455.123456 °C
 (0) 0268026544 (0xFF9C2B0) = 268.026544 K = -5.123456 °C
 (2) 0055120002 (0x03491082) = 55.120000 %rh
 (3) 0032566123 (0x01F0EB6B) = 32566.120 μV
 (3) 4294151811 (0xFFF38E83) = -815.488 μV
 (4) 1554441244 (0x5CA6E41C) = 155444.1240 ohm
 (7) 1011234575 (0x3C46370F) = 101.1234568 ohm
 (1) 0016843009 (0x01010101) = EMPTY
 (1) 0033686017 (0x02020201) = ERROR

- Float32 is a single-precision floating-point format as defined in IEEE 754 standard. Float32 represents all UT-ONE temperature and raw-data readings with full precision and entire range. Float32 is most commonly used for advanced floating-point calculations in industrial controllers. Float32 is stored in 32 bits:

Sign	Exponent		Fraction	
31	30	23	22	0

The Float32 is stored in two consecutive words (example value 20.91):

Lower MODBUS address		Higher MODBUS address	
MSB	LSB	MSB	LSB
0x41	0xA7	0x47	0xAE

Examples:

0x41A747AE = 20.91

0xC2FAE969 = -125.45588

0x4879AF8E = 255678.22

0x42C83F35 = 100.12345

0xFFFFFFFF = NaN (EMPTY or ERROR)

5.3.5 MODBUS Examples

Start acquisition by writing 1 to parameter at address 0x0001, device address 1:

Command: 01 06 00 01 **00 01** 19 CA

Response: 01 06 00 01 00 01 19 CA

Stop acquisition by writing 0 to parameter at address 0x0001, device address 1:

Command: 01 06 00 01 **00 00** D8 0A

Response: 01 06 00 01 00 00 D8 0A

Set communication parameters (device address = 22, baud rate = 9600, parity=odd) by writing to three consecutive parameters starting at address 0x0001, device address 0 (broadcast to all connected devices regardless of device address):

Command: 00 10 00 10 00 03 06 **00 16 00 05 00 01** 7D 96

Response:

Read temperature value of channels C1 and C2 in 16-bit integer format. Device address is 1. Acquired temperature values are 22.23 °C and 21.95 °C.

Command: 01 03 01 00 00 02 C5 F7

Response: 01 03 04 **08 AF 08 93** 8F DF

Read temperature value of channels C1 and C2 in 32-bit integer format. Device address is 1. Acquired temperature values are 22.237344 °C and 21.951616 °C.

Command: 01 03 02 00 00 04 45 B1

Response: 01 03 08 **11 9B 40 D0 11 96 E4 B0** 1F 68

Read temperature value of channels C1 and C2 in Float32 format. Device address is 1. Acquired temperature values are 22.237345 °C and 21.951616 °C.

Command: 01 03 04 00 00 04 45 39

Response: 01 03 08 **41 B1 E6 15 41 AF 9C E9** 66 76

5.3.6 QModMaster Test Software

QModMaster is an industry-standard free-of-charge software for communication between a computer and a MODBUS serial device such as UT-ONE. QModMaster can be used for testing MODBUS communications and is a good starting point for troubleshooting or developing your own applications.

QModMaster is available for download at <https://sourceforge.net/projects/qmodmaster/>.

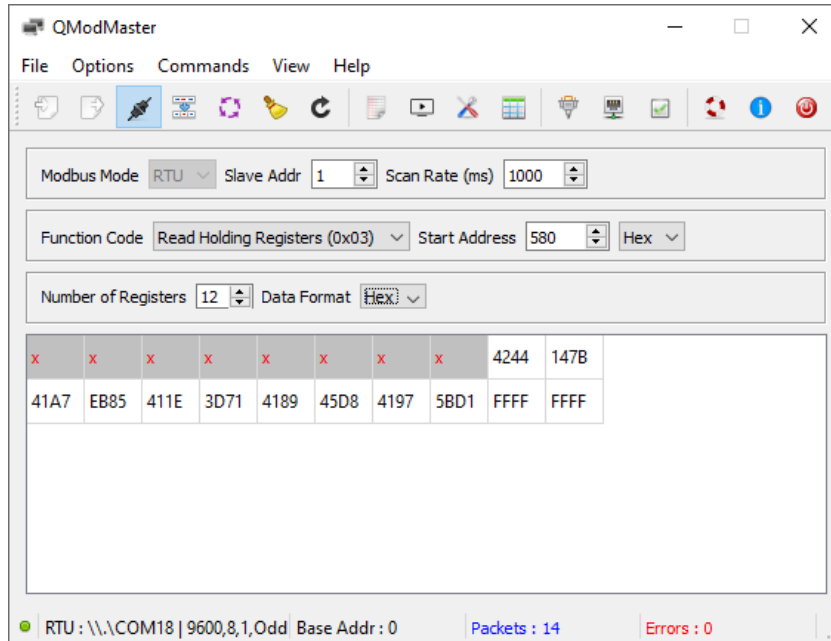


Figure 9: QModMaster software

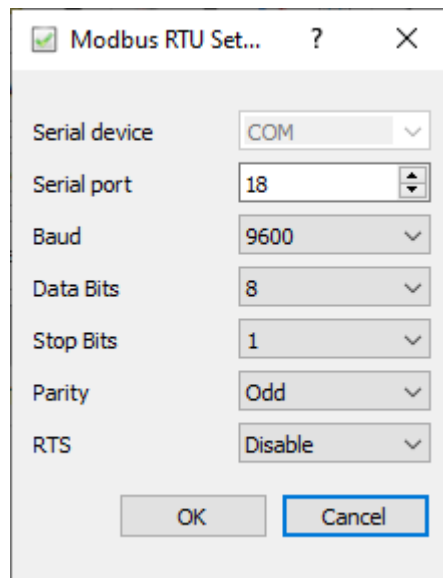


Figure 10: QModMaster communication configuration (UT-ONE set to 9600 baud)

5.4 Command set

UT-ONE command set is the default command set used for communication with UT-ONE devices over communication interfaces. This command set is recommended for developing user applications and provides a complete interface to UT-ONE functionality.

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.

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

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.

Messages 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 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 command processing time is typically a few ms and always less than 100 ms. Note that this does not include the data transfer time, which may be considerable for long messages and low baud rates with RS232 interface.

5.4.1 Command syntax

Command and response messages are constructed exclusively of printable ASCII characters. Messages are case sensitive, so use only capital letters.

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).

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

5.4.1.1 Binary blocks

Binary data of any value can be sent using a binary block structure. This allows you to send non-printable characters without interfering with the communication protocol. 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 characters #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.

Example:

Binary block: `#010{ 33 66 AF 30 20 20 49 53 }`

5.4.1.2 BCD numeric format

UT-ONE stores floating-point numbers using a signed BCD (Binary Coded Decimal) numeric format with 12 digits and exponent in range from -99 to +99:

`±d.dddddddddE±ee`

BCD numbers are often used in command and response messages in ASCII format, which must follow exact syntax defined above. 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.

Examples:

Valid ASCII BCD numbers: `-1.23456789012E-34`
`+3.14159265359E+00`
`+1.00185000000E+02`
`+0.00000000000E+00`
`+9.99999999999E+99`

Invalid ASCII BCD numbers: `-1.23452E-34`
`+3.14159265359`
`100.00185`
`0`
`0.000123`

BCD numbers can also be stored in packed BCD format, which 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`

Packed BCD numbers are often used in commands that store data directly to UT-ONE non-volatile memory. Packed BCD number format includes non-printable characters, so they can only be used in a message inside a binary block.

Examples:

Packed BCD numbers: `12 34 56 78 90 12 0D DE`
`31 41 59 26 53 59 0C 00`
`10 01 85 00 00 00 0C 02`
`00 00 00 00 00 00 00 00`
`99 99 99 99 99 99 0C 63`

5.4.1.3 Time format

UT-ONE stores time information in 32-bit integer format, which represents the number of seconds elapsed since 2000-01-01 00:00:00. Resolution of time values is 1 second.

UT-ONE does not support automatic time-zone and daylight-saving-time correction. If required, correct this by manually setting the correct time.

Time values are normally used in messages in ASCII text format. It is a fixed length string consisting of a positive sign and 10 decimal digits:

`+ddddddddd`

Alternatively, when transferring readings in binary format using binary blocks, time values can be stored in as unsigned 32-bit integer. Least significant byte is stored first.

Examples:

Date and time	ASCII time format	Binary time format
2000-01-01 00:00:00	+0000000000	00 00 00 00
2021-08-23 12:34:56	+0683037296	70 52 B6 28
2021-09-16 17:39:52	+0685129192	E8 3D D6 28
2035-12-20 22:08:51	+1135116531	F3 80 A8 43

5.4.1.4 Readings binary format

Temperature, relative humidity, emf and resistance readings are stored in UT-ONE internal memory in readings binary format. Readings binary format is a 32-bit integer with flexible resolution. Least significant byte is stored first.

Readings binary format represent readings in full accuracy in least number of characters, so it is very useful for quickly transferring large blocks of readings from UT-ONE internal memory to a computer.

The value in the 3 least significant bits determines the unit and resolution:

- 0 = temperature in kelvin with resolution 0.000001 K
- 1 = ERROR or EMPTY
- 2 = relative humidity in %rh with resolution 0.000001 %rh
- 3 = emf in μV with resolution 0.001 μV
- 4 = resistance in ohm with resolution 0.0001 ohm
- 5 = resistance in ohm with resolution 0.00001 ohm
- 6 = resistance in ohm with resolution 0.000001 ohm
- 7 = resistance in ohm with resolution 0.0000001 ohm

Examples:

Unit	Value	ASCII number format	Binary number format
0	728.273456 K	+0728273456	30 92 68 2B
0	268.026544 K	+0268026544	B0 C2 F9 0F
2	55.120000 %rh	+0055120002	82 10 49 03
3	32566.120 μV	+0032566123	6B EB F0 01
3	-815.488 μV	-0000815485	83 8E F3 FF
4	155444.1240 ohm	+1554441244	1C E4 A6 5C
7	101.1234568 ohm	+1011234575	0F 37 46 3C
1	EMPTY	+0016843009	01 01 01 01
1	ERROR	+0033686017	01 02 02 02

5.4.2 Channel configuration commands

This group of commands enables you to configure acquisition settings for each of the main channels. This configuration is applicable only to acquisition in continuous measurement mode, acquisition in other measurement mode is configured for each individual reading. Channel configuration includes probe index, measurement range, averaging time, status, measurement current and connection.

5.4.2.1 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

5.4.2.2 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

5.4.2.3 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

5.4.2.4 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

5.4.2.5 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

5.4.2.6 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

5.4.2.7 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

5.4.2.8 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

5.4.2.9 CWccc <Connection>

Set the new connection type 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 connection types for PRTs and thermistors are DF (default 4-wire connection), 3W (3-wire connection) and 2W (2-wire connection).

Valid connection types for thermocouples are DF (default thermocouple connection to thermocouple connector or voltage connectors) and AX (thermocouple auxiliary connection on current connectors).

If you set an invalid connection type for a particular probe type, acquisition will be performed using the default connection type.

Command message: CWccc <Connection type>

Response message: OK

Example:

Command message: CWC03 3W

Response message: OK

LabVIEW driver: UT-ONE Channel Driver.vi

5.4.2.10 CWccc?

Returns the connection type 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 connection types for PRTs and thermistors are DF (default 4-wire connection), 3W (3-wire connection) and 2W (2-wire connection).

Valid connection types for thermocouples are DF (default thermocouple connection to thermocouple connector or voltage connectors) and AX (thermocouple auxiliary connection on current connectors).

Command message: CWccc?

Response message: OK<Connection type>

Example:

Command message: CWC03?

Response message: OKAX

LabVIEW driver: UT-ONE Channel Driver.vi

5.4.2.11 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

5.4.2.12 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

5.4.3 Parameter configuration commands

This group of commands enables you to read or write various parameters related to UT-ONE operation.

5.4.3.1 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

5.4.3.2 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*

5.4.3.3 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)
- B8 = 56000 baud
- B9 = 57600 baud
- BA = 115200 baud
- BB = 128000 baud
- BC = 230400 baud
- BD = 250000 baud
- BE = reserved
- BF = reserved

Command message: DB?

Response message: OK<*Baud rate setting*>

Example:

Command message: DB?

Response message: OKB7

LabVIEW driver: Not available

5.4.3.4 DB <Baud rate setting>

Set new baud rate setting for RS232 communication interface. New setting will become active after you restart UT-ONE. This command will also set parity setting to default odd parity.

Command message: DB <*Baud rate setting*>

Response message: OK

Example:

Command message: DB B5

Response message: OK

LabVIEW driver: Not available

5.4.3.5 DP?

Return current parity setting for RS232 communication interface. Parity settings are:

- N = none
- E = even parity
- O = odd parity (default)

Command message: DP?

Response message: OK<*Parity setting*>

Example:

Command message: DP?
Response message: OKO
LabVIEW driver: Not available

5.4.3.6 DP <Parity setting>

Set new parity setting for RS232 communication interface. New setting will become active after you restart UT-ONE. Note that default parity setting is odd parity. UT-ONE LabVIEW drivers and UT-ONE Applications software always use odd parity. Use different parity setting only for other external applications. Note that setting baud rate will also reset parity to default odd parity.

Command message: DP <Parity setting>
Response message: OK

Example:

Command message: DP E
Response message: OK
LabVIEW driver: Not available

5.4.4 Device control commands

This group of commands enables you to set the UT-ONE device in a particular operating mode. This includes starting various acquisition modes and switching the UT-ONE device off.

5.4.4.1 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*

5.4.4.2 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*

5.4.4.3 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*

5.4.4.4 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)
- D 8.33 Hz (50 Hz and 60 Hz line rejection)
- E 6.25 Hz (50 Hz and 60 Hz line rejection)
- F 4.17 Hz (50 Hz and 60 Hz line rejection)

Command message: 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.

5.4.5 Probe management commands

This group of commands is used to read, write and list probe data, which can be used to convert acquired raw readings to temperature.

5.4.5.1 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: #128{ Probe data } OK

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

5.4.5.2 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

5.4.5.3 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

5.4.6 Internal flash memory commands

This group of commands is used to manage the readings stored in the internal flash memory. Internal flash memory is an optional feature and is not available on all UT-ONE devices. The size of the internal flash memory is 32 MB and can store up to 2 million readings. When the flash memory is full, new readings will automatically overwrite the oldest readings.

If optional internal flash memory is not available, UT-ONE will reply with E7 response message.

5.4.6.1 FB?

Get a block of binary data from the internal flash memory at specified memory address and with specified size. This command is applicable only for UT-ONE devices with optional internal flash memory.

Memory address is given as first four byte address in the binary block (least significant byte first). Block size is given as fifth byte. Block size is limited to 240 bytes.

Command message: *<Binary block with memory address and block size>*FB?

Response message: *< Binary block with flash memory data }OK*

Example:

Read 32 bytes (2 readings) from memory address 784.

Command message: #005{10 03 00 00 20}FB?

Response message: #032{A3 47 E9 26 20 44 E9 11 20 44 E9 11 81 00 81 DE A3 47 E9 26 60 D5 59 11 60 D5 59 11 82 00 00 2D}OK

LabVIEW driver: *UT-ONE Flash Memory Driver.vi*

5.4.6.2 FR <Reading Index>?

Get reading data at given reading index in text format. This command is applicable only for UT-ONE devices with optional internal flash memory.

Command message: FR <Reading Index>?

Response message: OKRT :< Real time value >,< Raw channel name >:< Raw channel value >,< UNB:<Raw channel unit>,< Channel name >:< Channel value >,< UNC:<Channel unit>,< RNG:< Measurement range label >,< CON:< Connection Configuration>,< PRB:< Probe index>

Example:

Command message: FR 0000000008?

Response message: OKRT : 0652822763, B3 :+2.50017968000E+01, UNB:OHM, C3 :+2.80160000000E-02, UNC:DEG, RNG:R1, CON:DF, PRB:22

LabVIEW driver: *UT-ONE Flash Memory Driver.vi*

5.4.6.3 FA?

Get memory address of first reading, last reading and total memory size. This command is applicable only for UT-ONE devices with optional internal flash memory.

Memory address is returned in a binary block as 32-bit integer (least significant byte first).

Command message: FA?

Response message: *< Binary block with memory address data }OK*

Example:

Command message: FA?

Response message: #012{00 00 00 00 50 F1 00 00 00 00 00 02 }OK

LabVIEW driver: *UT-ONE Flash Memory Driver.vi*

5.4.6.4 FI?

Get reading index of first reading, last reading and total number of reading locations. This command is applicable only for UT-ONE devices with optional internal flash memory.

Memory address is returned in a binary block as 32-bit integer (least significant byte first).

Command message: FI?

Response message: OKSTA:<Reading index of first reading>,END:<Reading index of last reading>,SIZ:<Number of reading locations>

Example:

Command message: FA?

Response message: OKSTA: 0000000000,END: 0000003944,SIZ: 0002097152

LabVIEW driver: *UT-ONE Flash Memory Driver.vi*

5.4.6.5 FW?

Get status of write to flash memory flag. This command is applicable only for UT-ONE devices with optional internal flash memory.

Command message: FW?

Response message: OK<Write to memory flag>

Example:

Command message: FW?

Response message: OKON

LabVIEW driver: *UT-ONE Flash Memory Driver.vi*

5.4.6.6 FW <Write to Memory flag>

Set status of write to flash memory flag. This command is applicable only for UT-ONE devices with optional internal flash memory.

Command message: FW <Write to memory flag>

Response message: OK

Example:

Command message: FW OF

Response message: OK

LabVIEW driver: *UT-ONE Flash Memory Driver.vi*

5.4.6.7 FS?

Get startup status of write to flash memory flag. This command is applicable only for UT-ONE devices with optional internal flash memory.

Command message: FS?

Response message: OK<Startup Write to Memory flag>

Example:

Command message: FS?

Response message: OKOF

LabVIEW driver: *UT-ONE Flash Memory Driver.vi*

5.4.6.8 FS <Startup Write to Memory flag>

Set status of startup write to flash memory flag. This command is applicable only for UT-ONE devices with optional internal flash memory.

Command message: FS <Startup Write to memory flag>
Response message: OK

Example:

Command message: FS OF
Response message: OK
LabVIEW driver: UT-ONE Flash Memory Driver.vi

5.4.6.9 FE <Erase Password>

Erase entire flash memory. This operation can't be undone. Erasing takes approximately 100 seconds. Make sure that UT-ONE remains powered during erasing. This command is applicable only for UT-ONE devices with optional internal flash memory.

Erasing is protected with erase memory password: **R0q11maH**

Command message: FE <Erase Password>
Response message: OK

Example:

Command message: FE R0q11maH
Response message: OK
LabVIEW driver: UT-ONE Flash Memory Driver.vi

5.4.6.10 FE?

Get erase memory status. This command is applicable only for UT-ONE devices with optional internal flash memory.

This command is used in software to check when the erase command is completed.

Command message: FE?
Response message: OK <Erase status>

Example:

Command message: FE?
Response message: OKBUSY
LabVIEW driver: UT-ONE Flash Memory Driver.vi

5.4.7 GPIB interface configuration commands

This group of commands enables you to set the parameters of the GPIB communication interface, including setting the GPIB address and enabling the GPIB interface. GPIB is an optional communication interface and is not available on all UT-ONE devices. Communication via GPIB interface uses the same command set as communication via the default USB interface.

If optional GPIB interface is not present, UT-ONE will reply with E7 response message to all commands in this group.

5.4.7.1 GA?

Return current GPIB address.

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

Example:

Command message: GA?

Response message: OK07
LabVIEW driver: *UT-ONE GPIB Configuration Driver.vi*

5.4.7.2 GA <GPIB Address>

Set new GPIB address. 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*

5.4.7.3 GE?

Return the enable status of the GPIB and RS232 interface.

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

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

5.4.7.4 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. Valid status is ON (interface enabled), OF (interface disabled) and OK (no changes to current setting).

If GPIB interface is installed, but it is not used, it is recommended to set the GPIB enabled status to OF. This will reduce device power consumption.

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*

5.4.8 Identification string commands

5.4.8.1 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*

5.4.8.2 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*

5.4.8.3 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*

5.4.8.4 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*

5.4.8.5 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*

5.4.8.6 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*

5.4.9 Display data streaming commands

5.4.9.1 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*

5.4.9.2 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*

5.4.10 Continuous measurement commands

5.4.10.1M< 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*

5.4.10.2 MA< Channel name >?

Return the current measurement for the given channel including real time value, raw channel value, channel value, measurement range, connection configuration 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 >,< Raw channel name >:< Raw channel value >,< UNB:<Raw channel unit>,< Channel name >:< Channel value >,< UNC:<Channel unit>,< RNG:< Measurement range label >,< CON:< Connection Configuration>,< PRB:< Probe index>

Example:

Command message: MAC01?

Response message: OKRT : 0659553013,B01:+9.99537256000E+01,UNB:OHM,C01:-1.18400000000E-01,UNC:DEG,RNG:R3,CON:DF,PRB:21

LabVIEW driver: UT-ONE Continuous Measurement Driver.vi

5.4.10.3 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

5.4.10.4 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*

5.4.10.5 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*

5.4.10.6 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*

5.4.10.7 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*

5.4.10.8 MB?

Returns the current values of LiPo battery monitoring channels (VB, SC and ES). VB monitors battery voltage, SC monitors state of charge in %, ES gives extended battery/charger status and BC in count

of battery charge cycles. 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 values are 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 : 0659553560,VB :+4.17360000000E+00,SC :+9.59120000000E+01,ES :+5.20000000000E+01,BC :+3.00000000000E+00

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

5.4.11 Single measurement commands

5.4.11.1 S<Channel> <Reference Channel> <Range> <Samples> <Connection> <Probeindex>

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. *Connection* is the connection configuration, valid values are DF (default 4 wire connection for resistance measurement and voltage connectors for emf measurement), 3W (3-wire connection for resistance measurement), 2W (2-wire connection for resistance measurement) and AX (auxiliary connection on current connectors for emf measurement). Note that some UT-ONE models support only default connection. *Probe index* specifies the probe that is used to convert raw value to corrected value. Valid values are 0 to 48.

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 R315DF21

Response message: OKRT : 0457654321, B1

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

5.4.11.2 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: RT : 0652829943, B1 :+1.99996088000E+04

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

5.4.11.3 SV?

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. Temperature value is converted using the probe index specified in the command used to initiate single reading.

Command message: SV?

Response message: OKRT :< Real time value >,Bx:< Channel Bx raw value > Cx:< Channel Cx temperature value >

Example:

Command message: SV?

Response message: RT : 0652829943, B1 :+1.99996088000E+04, C1
: +9.89901600000E+00

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

5.4.11.4 SA?

Return all data for the last completed single reading including real time value, raw channel value, channel value, measurement range, connection configuration and probe index. 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.

Command message: SA?

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

Example:

Command message: SA?

Response message: OKRT : 0659554014, B1 :+9.99537104000E+01, , UNB:OHM, C1 :-
1.18440000000E-01, UNC:DEG, RNG:R3, CON:DF, PRB:21

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

5.4.11.5 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*

5.4.12 Real time clock commands

5.4.12.1 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*

5.4.12.2 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*

5.4.13 Raw ADC commands

This group of commands provides direct access to the acquired raw ADC binary values prior to any linearization or characterization procedures. It is primarily used for fast digitizing procedure and for advanced validation purposes.

5.4.13.1B?

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*

5.4.14 Validation commands

5.4.14.1 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*

5.4.14.2 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-1.00000000000E+00*
LabVIEW driver: *Not available*

5.4.14.3 *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-1.02500000000E+01*
LabVIEW driver: *Not available*

5.4.14.4 *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+1.14500000000E+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 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?", "SV?" or "SA?" 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

7 Batteries

UT-ONE L01A has no internal lithium ion 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.

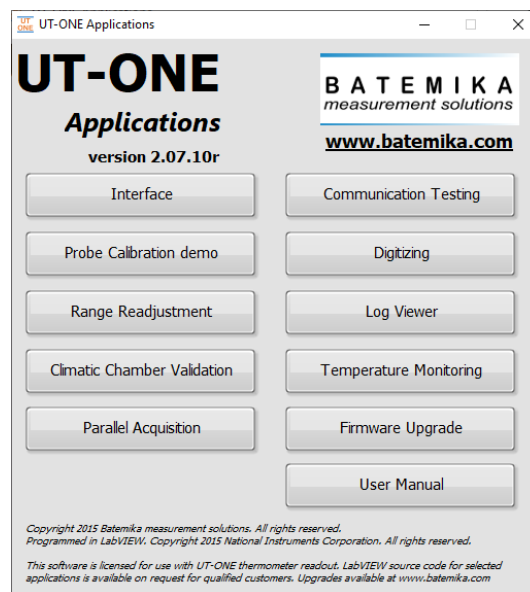


Figure 11: UT-ONE Applications launch panel

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.

Interface, *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.

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.

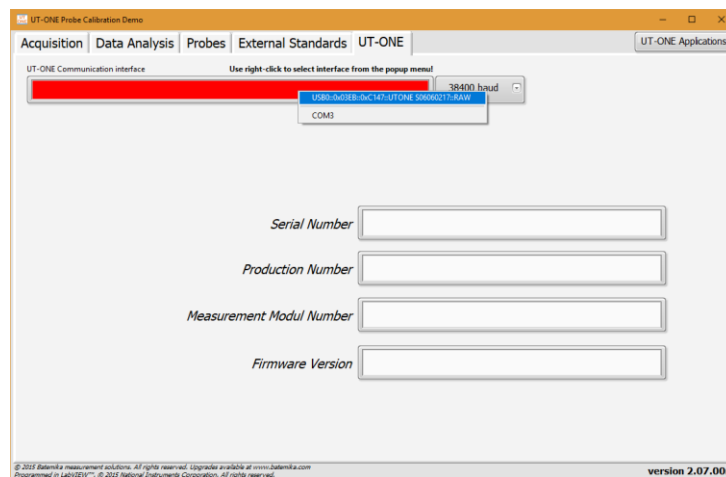


Figure 12: UT-ONE page before communication with UT-ONE is established

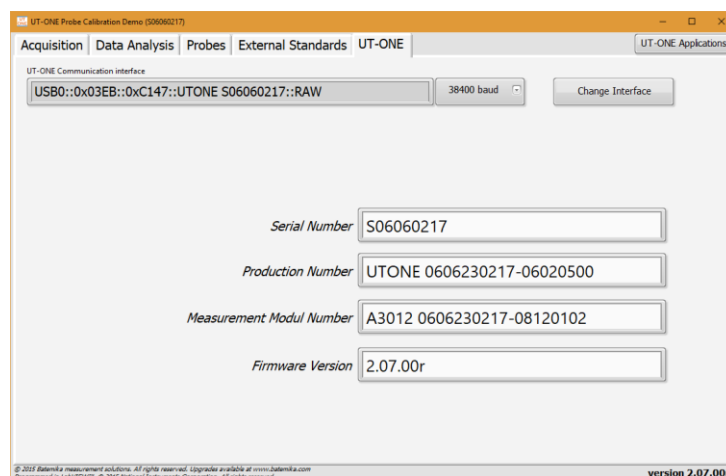


Figure 13: UT-ONE page after communication with UT-ONE is established

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 B03x display, so the use is intuitive. UT-ONE Interface application is also applicable to models without display, but in this case functions that are related to UT-ONE display, internal logging and battery are not applicable.

Measurement can be controlled from the UT-ONE B03x display and from the UT-ONE Interface application at the same time, and both will adapt to the changes in the other interface.

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 B03x display. You can download the readings that were logged in the UT-ONE B03x 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.

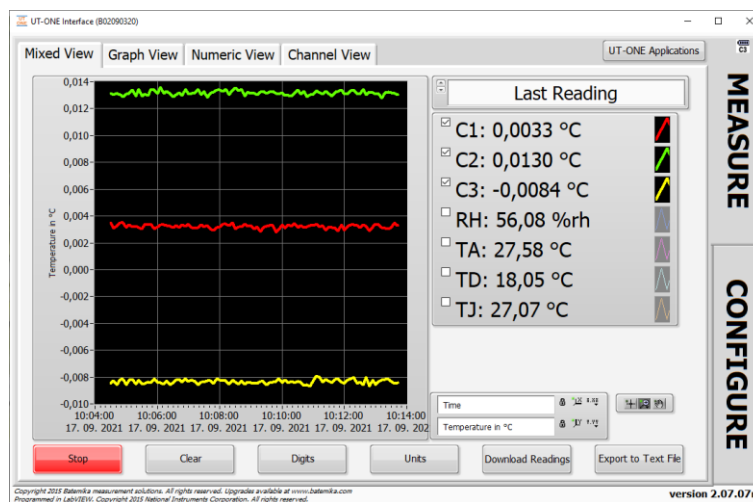


Figure 14: UT-ONE Interface mixed measurement view

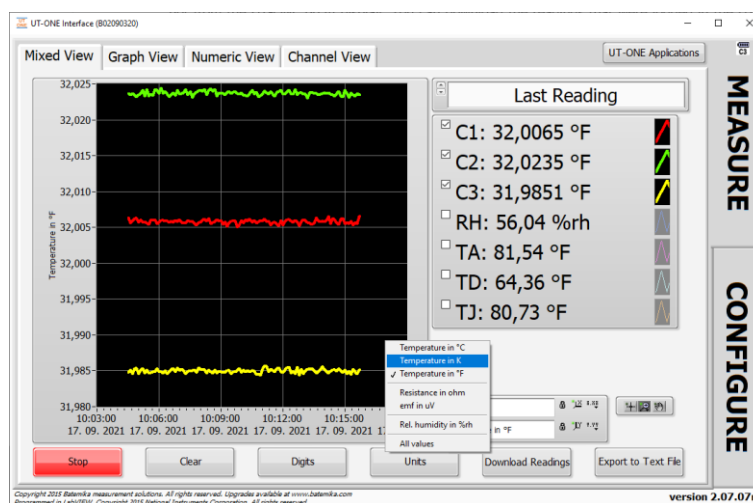


Figure 15: UT-ONE Interface selection of temperature unit

UT-ONE L01A

Rugged Thermometer Readout

Temperature values on the graph can be displayed in °C, K or °F. Use the right-click to display the popup-menu and select the menu command for required unit. You can also choose to display raw values of main channels (resistance or emf) in units of Ω or μV , or the relative humidity. You can also display *All values* on the graph, regardless of the unit (for example you can display temperature, relative humidity, resistance and emf values). In this case, the scale is just a numeric value without a particular unit designation.

Temperature units on the numeric indicators can also be changed between °C, K and °F using the *Units* button.

UT-ONE Interface application by default displays the last measured values. Note that values are updated only if the continuous measurement is started. You can also choose to display the measurement statistics, which include minimum measured value, maximum measured value and the difference between the maximum and minimum measured value. Statistics is calculated from all values displayed on the graph. Statistics can be reinitialized by clicking the *Clear* button, which will also clear all data on the graph.

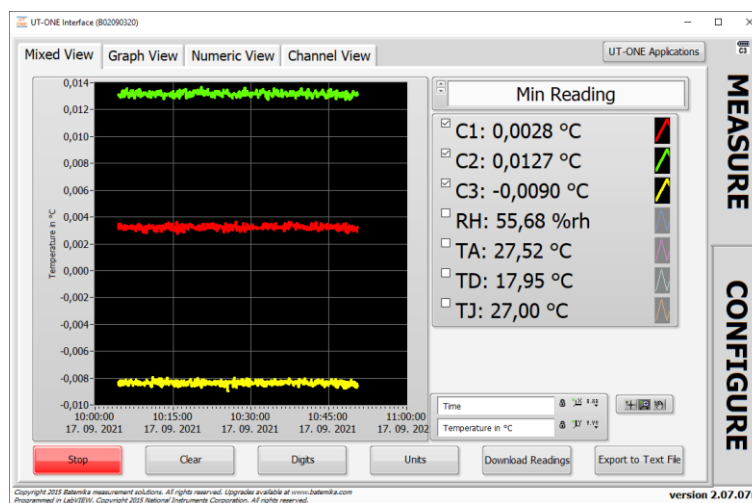


Figure 16: UT-ONE Interface statistics display

Measurement values from the main channels can be presented as the temperature difference between the channel value and the reference channel value. Reference channel can be selected using the command in the popup menu. Reference channel is marked with label Cxx and displays actual temperature value, difference channels are marked with label Dxx and display temperature difference in selected temperature unit. This is not applicable to ambient probe and TJ channels.

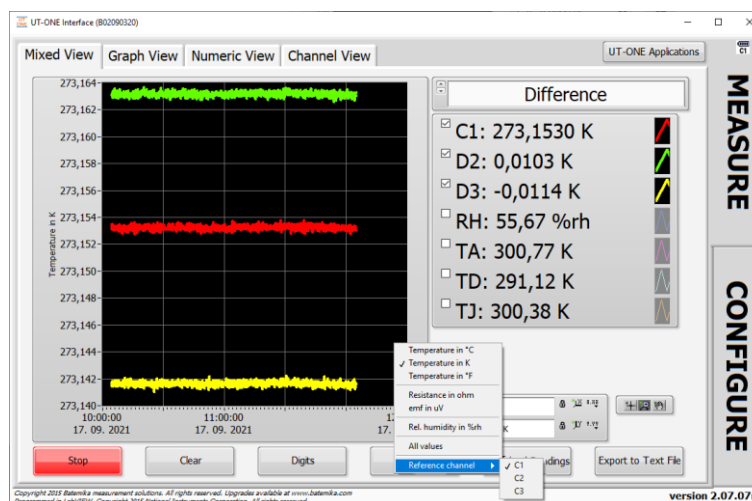


Figure 17: UT-ONE Interface channel difference display

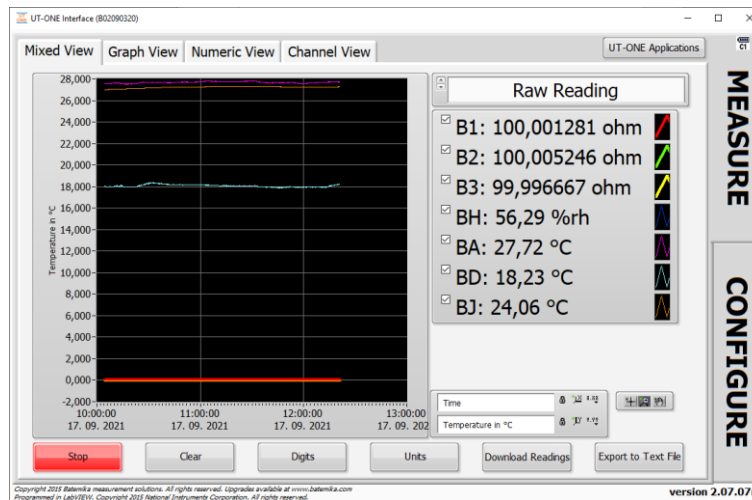


Figure 18: UT-ONE Interface Raw Reading display

UT-ONE Interface can display raw readings for the last acquired measurement. Note that this does not apply to readings on the graph, just to the displayed numeric values in *Mixed View*. For main channels the raw reading is the acquired probe resistance or emf in ohm or μV . For ambient probe, raw reading is displayed in %rh or $^{\circ}\text{C}$, but before the probe corrections are applied. Raw readings can be used for diagnostics and validation, and also during the probe recalibration procedure.

UT-ONE Interface application can display readings on a large graph in the *Graph View* display. All graph settings can be configured in the *Mixed View* display and are automatically applied after you change the view.

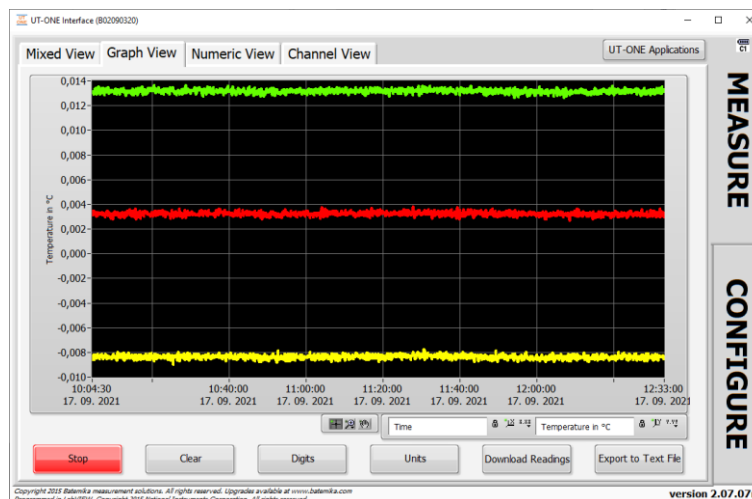


Figure 19: UT-ONE Interface Graph View

UT-ONE Interface application can display readings just as numeric values with a large font for easy reading. Values of up to four channels can be observed at the same time and you can use the vertical slider to view more channels if available. You can choose between observing the values of main channels and ambient probe readings using the page selector.

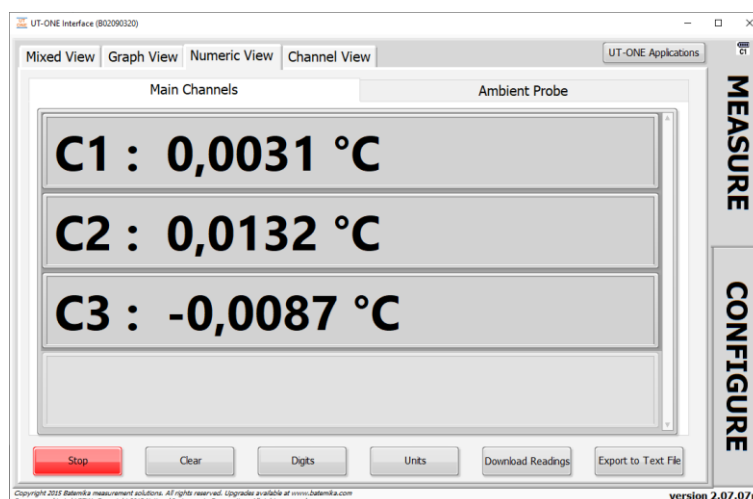


Figure 20: UT-ONE Interface Numeric View

UT-ONE Interface application can also display measurement results for each channel separately and with all associated information, including the last measured value, raw value, statistics, probe information and measurement range. You can use page selectors to choose between available channels.

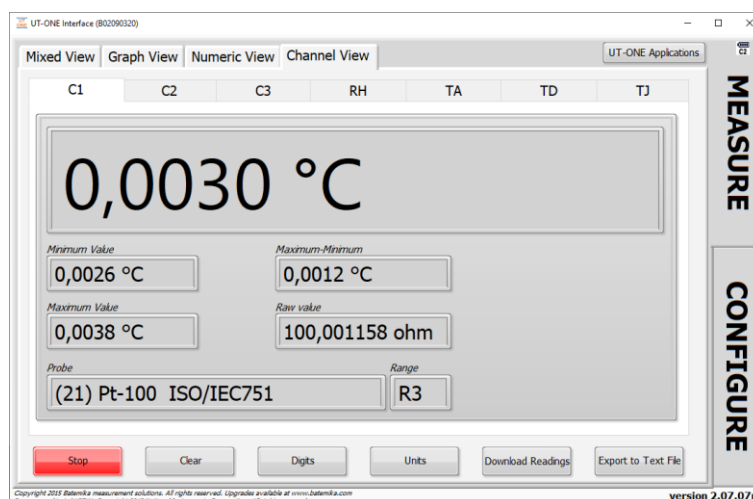


Figure 21: UT-ONE Interface Channel View

Configuration page has similar views as in the UT-ONE B03x 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 display.

Channels view allows you to configure main channels in the continuous-measurement mode. It is recommended to select the probe first and the application will automatically select the default measurement range. Alternatively, you may also select a *Not Defined* empty probe and in this case you can select any measurement range with results presented without conversion to temperature. 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.

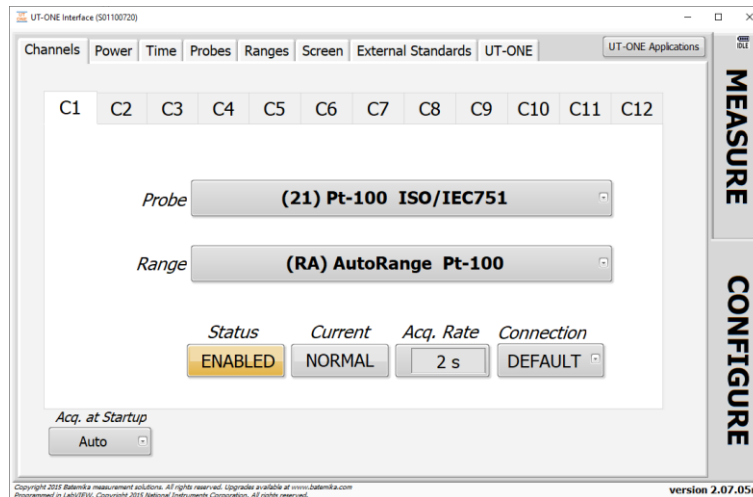


Figure 22: UT-ONE Interface Channels view

Power view present the information about the battery status (if available) and the power source. There are no configurable options available in this view.

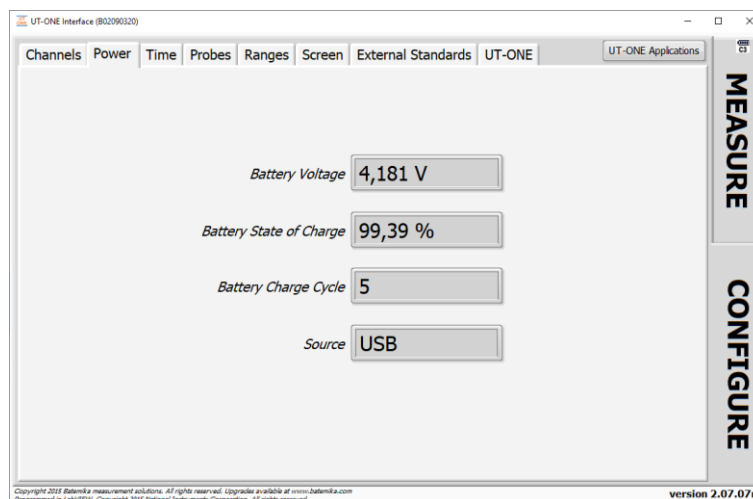


Figure 23: UT-ONE Interface Power view

Time view allows you to compare internal UT-ONE real-time clock with the computer clock. Internal clock may drift for a few seconds per day, so by clicking the *Synchronize Time* button you can set the device time to the computer time. The time and date format is determined by your computer Regional Settings, so the application window may look slightly different than the figure below.

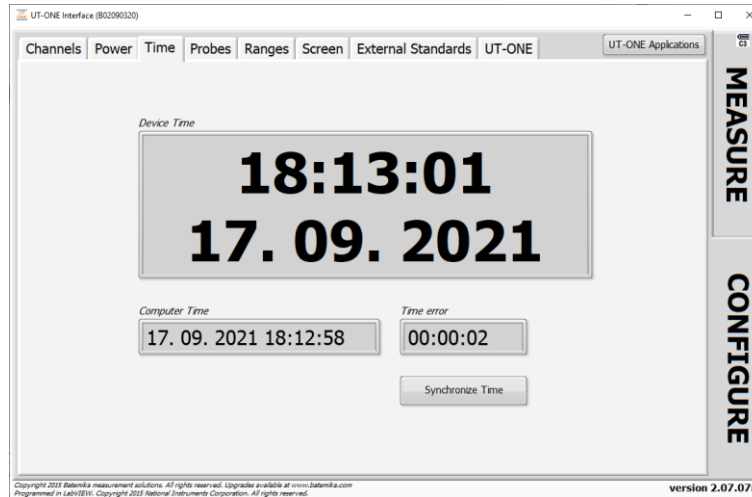


Figure 24: UT-ONE Interface Times view

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. Commands for probe manipulation are available in the popup menu. 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 device. Probe data can be saved as individual probes or as a group of all probes. Saving all probes in as single file provides a convenient way to use the same UT-ONE device with different probe sets.

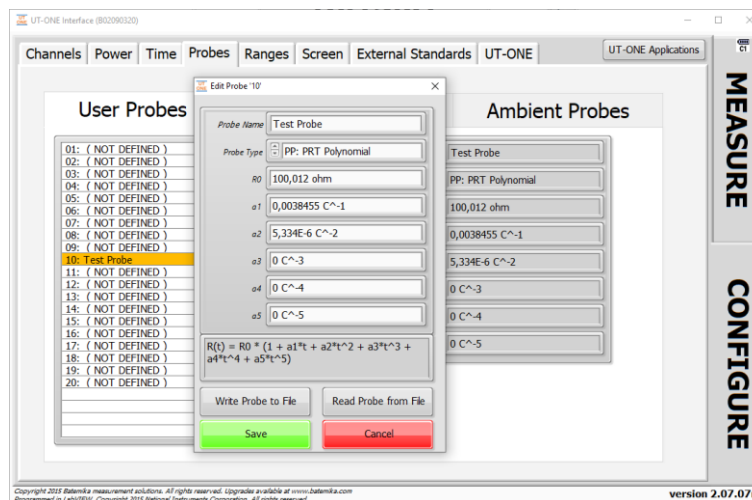


Figure 25: UT-ONE Interface Probes view with probe editing dialog

UT-ONE L01A

Rugged Thermometer Readout

Ranges view can be used for reviewing UT-ONE internal calibration constants.

Range	Current	Reference Value	Linearity Correction	Temperature coefficient
R1	Man. Range 25 ohm NORMAL (1 mA)	31,260775 ohm	1,21E-14	9,4E-7
R2	Man. Range 50 ohm NORMAL (1 mA)	62,487558 ohm	7,9E-15	2,7E-7
R3	Man. Range 100 ohm NORMAL (1 mA)	125,03137 ohm	1,14E-14	3,9E-7
R4	Man. Range 200 ohm NORMAL (1 mA)	249,99717 ohm	6,8E-15	1,8E-7
R5	Man. Range 400 ohm NORMAL (1 mA)	499,96436 ohm	4,8E-15	8E-8
R6	Man. Range 800 ohm NORMAL (1 mA)	1002,2383 ohm	-1E-16	4,8E-7
r1	Man. Range 25 ohm REDUCED (0.7 mA)	31,260823 ohm	7E-15	9,5E-7
r2	Man. Range 50 ohm REDUCED (0.7 mA)	62,487773 ohm	4,4E-15	3,1E-7
r3	Man. Range 100 ohm REDUCED (0.7 mA)	125,03167 ohm	6,7E-15	4,1E-7
r4	Man. Range 200 ohm REDUCED (0.7 mA)	249,99833 ohm	3,9E-15	2,1E-7
r5	Man. Range 400 ohm REDUCED (0.7 mA)	499,96708 ohm	2,9E-15	9E-8
r6	Man. Range 800 ohm REDUCED (0.7 mA)	1002,245 ohm	-1,1E-15	5,2E-7
H1	Man. Range 2500 ohm NORMAL (10 uA)	3125,9293 ohm	1,2E-14	2,53E-6
H2	Man. Range 5000 ohm NORMAL (10 uA)	6248,4522 ohm	8E-15	1,84E-6
H3	Man. Range 10000 ohm NORMAL (10 uA)	12502,566 ohm	1,1E-14	1,94E-6
H4	Man. Range 20000 ohm NORMAL (10 uA)	24998,99 ohm	7E-15	1,64E-6
H5	Man. Range 40000 ohm NORMAL (10 uA)	49994,202 ohm	5E-15	1,53E-6
H6	Man. Range 80000 ohm NORMAL (10 uA)	100218,93 ohm	0E+0	2,01E-6
h1	Man. Range 2500 ohm REDUCED (7 uA)	3125,9505 ohm	7E-15	2,6E-6
h2	Man. Range 5000 ohm REDUCED (7 uA)	6248,5078 ohm	4E-15	1,87E-6
h3	Man. Range 10000 ohm REDUCED (7 uA)	12502,63 ohm	7E-15	2E-6
h4	Man. Range 20000 ohm REDUCED (7 uA)	24998,792 ohm	4E-15	1,68E-6

Figure 26: UT-ONE Interface Ranges view

Screen view can be used to acquire a screenshot of the image currently displayed on the UT-ONE built-in display. This feature is only applicable for UT-ONE models with screen. Acquired image can be saved in an image file and can be used for diagnostics or achieving purposes.

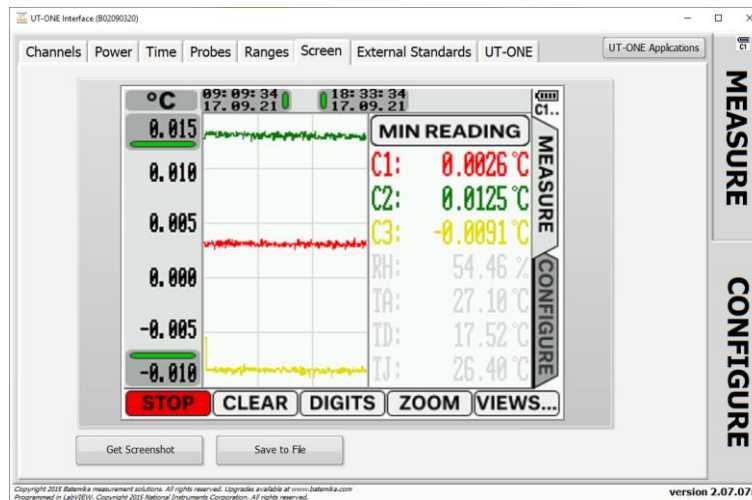


Figure 27: UT-ONE Interface Screen view

External Standards view is used to manage the properties of external standards that can be used to improve the accuracy of measurements in single-reading measurement mode. Use buttons in this view to store that to and from internal UT-ONE non-volatile memory and to store them in files on a computer.

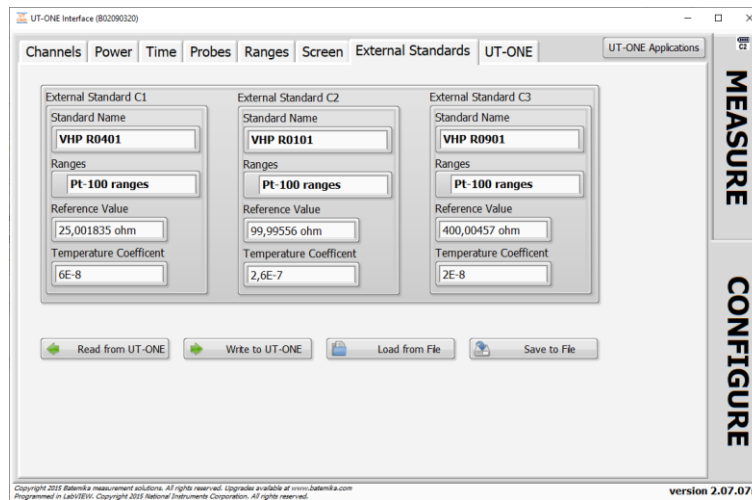


Figure 28: UT-ONE Interface External Standards view

UT-ONE view is used to select the UT-ONE communication interface and consequentially the particular UT-ONE device, if more UT-ONE devices are connected to a computer. After the communication is established, the application retrieves serial number and other device information from the device.

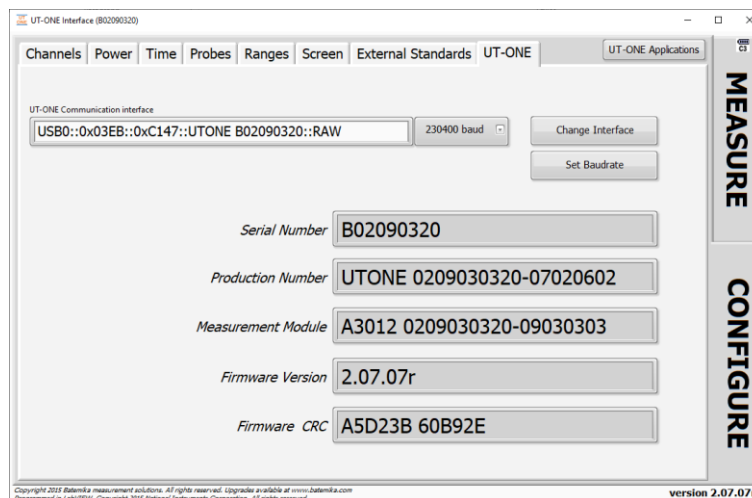


Figure 29: UT-ONE Interface UT-ONE view

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 the 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.

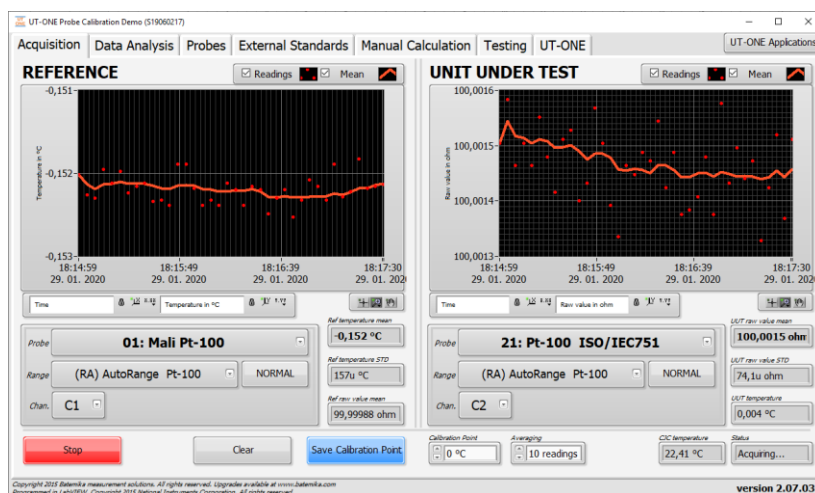


Figure 30: Acquisition window

Calibration uncertainty can be improved by using the external standard, which must be connected to one of the remaining UT-ONE main channels (C1, C2 or C3). 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 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.

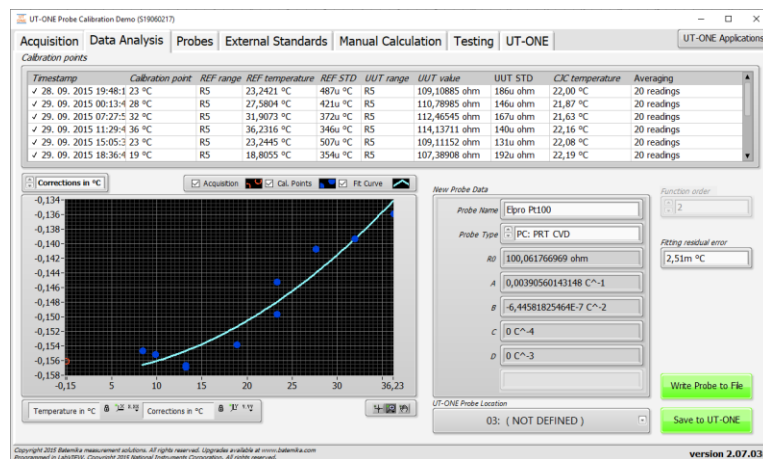


Figure 31: Data Analysis window with results of Pt-100 calibration

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.

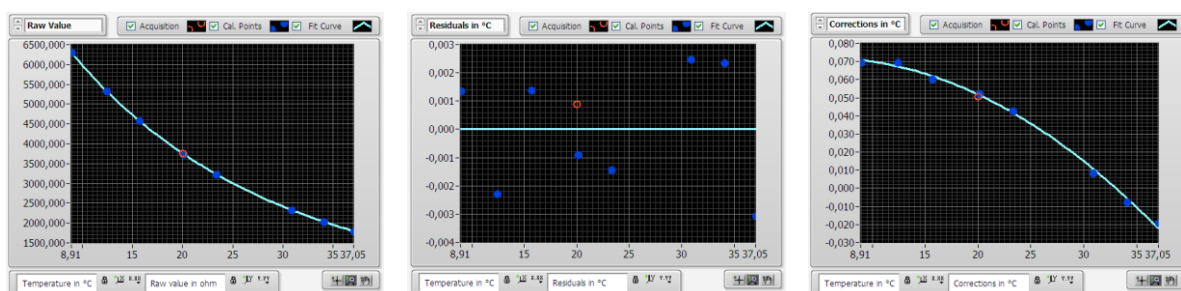


Figure 32: Visualization of data analysis results for NTC 3k calibration

If calibration results are obtained externally and are presented as a set of temperature and resistance/emf pairs, you can use the *Manual Calculation* tab to calculate the calibration coefficients and store them directly to the UT-ONE non-volatile memory.

Calibration data can be entered by typing in the values for reference temperature and UUT resistance/emf directly to the *Input Data*. Alternatively, you can copy and paste data directly from Excel (one column of data for reference temperature and one column of data for UUT resistance/emf). After you entered the data, check the values in the *Imported input data* indicator to verify that data was entered and imported correctly.

Note that this feature can be used even without the UT-ONE unit connected to the computer. To start calculation without UT-ONE unit, select OFFLINE option in the *Interface* selection.

To start with data analysis, first select the *Probe Template*. This will enable more convenient data presentation in the graph and will limit the available probe types to applicable values only. Alternatively, you can also select *No probe template* option, which will allow you to select any probe type for data analysis.

Next, select one of the available probe types for the selected probe template. If applicable, set the function order of the equation used in the fitting procedure. Check calculated fitting residual error and verify on the graph that the fit curve traces the calibration points. If some of the points significantly deviate from the fit curve, check for typing errors and verify your calibration procedure.

If you would like to store the calculated probe data to UT-ONE non-volatile memory, you will have to enter the *Probe Name* and click the *Write Probe to File* button. This will store the probe data in a *.prb file. If UT-ONE unit is connected to the computer, you can now select the *Probes* tab and read probe data from file and save it to the selected location in the UT-ONE non-volatile memory.

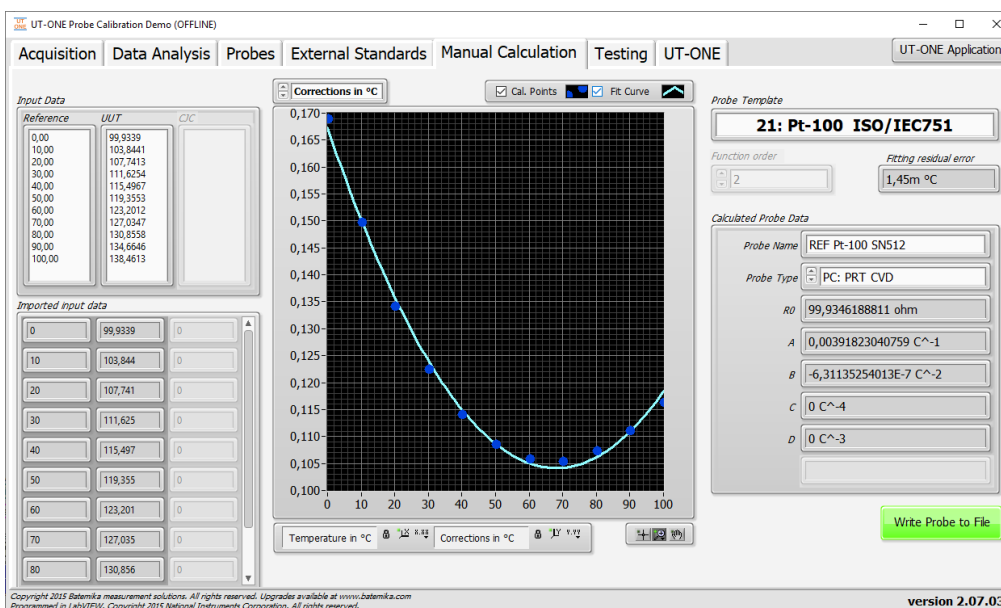


Figure 33: Manual Calculation window with results of Pt-100 calibration

UT-ONE L01A

Rugged Thermometer Readout

UT-ONE internal calculation of temperature from probe resistance or emf can be verified in the *Testing* tab. This allows the user to check the accuracy of the calibration coefficients and to validate the internal conversions.

Probe coefficients must be first stored in one of the probe locations in the UT-ONE non-volatile memory. Select the probe in the *Probe testing* dropdown list and review its data.

You can now enter raw value (resistance or emf) in the *Raw Value in* and the application will send it to the UT-ONE unit and return the converted temperature value. The application will also calculate the temperature in the application software (computer), so you can check if there are any differences.

The calculation in the UT-ONE unit is possible only from raw value to temperature. The inverse calculation from temperature to raw value is possible only in application software.

Additional check can be performed by generating 1000 random measurement points in the specified calibration range and observing the difference between the UT-ONE and application calculations for the selected probe. This will give you a good indication of the numeric error that can be expected from calculations in the UT-ONE firmware.

Equations for conversion of temperature probes tend to be simple in one direction and more complicated in the inverse direction. For example, CVD equation is very simple for calculation of resistance from temperature, but is complicated for calculation of temperature from resistance. The validity of conversion in both directions can be checked by selecting *Difference between Forward and Backward Calculation*. This is applicable only to conversions in the application software.

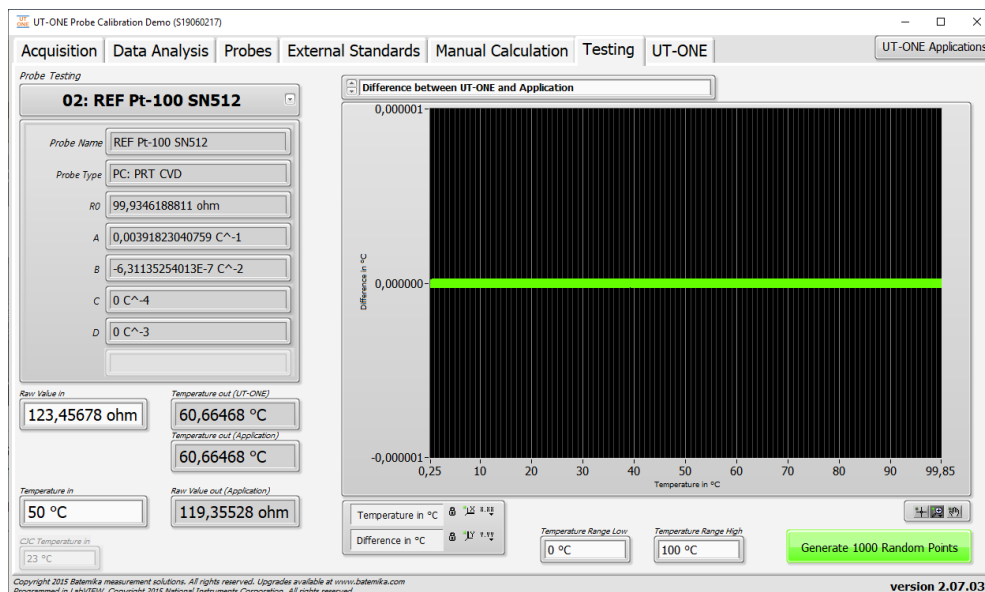


Figure 34: Testing window with results of Pt-100 calculation

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 calibration standards, typically reference resistors or DC voltage sources. Calibration standards must be connected to lowest-four main channels and configured in the *Calibration Standards* page before adjustment can start.

Range adjustment is always performed in three distinct levels:

- In the first level the value of configured calibration 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.

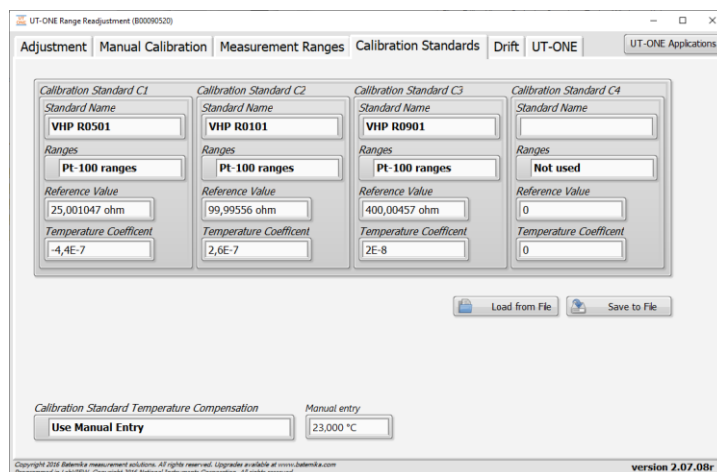


Figure 35: Calibration Standards page

The first step is the configuration of the calibration standards. For each calibration 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 calibration standard is applicable. If calibration standard is not connected, you should select the *Not used* option. *Reference Value* specifies the true value of the calibration standard at 23 °C. *Temperature coefficient* specifies the temperature coefficient of the calibration standard, which allows the automatic temperature compensation of the calibration standard. If temperature compensation is not applicable,

use 0. The source of temperature for automatic compensation can be selected in *Calibration Standard Temperature Compensation*. You may choose between no compensation, internal TJ thermometer, optional ambient conditions probe TA and manual entry.

Calibration standards configuration has the same file format as the external standards configuration used in UT-ONE to improve measurement accuracy, but it is used independently, so you don't have to write external standards to UT-ONE memory to become active for the scope of adjustment.

After the calibration 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 calibration standard configuration, otherwise calibration 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 calibration standards are selected for each measurement range. You have three options:

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

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

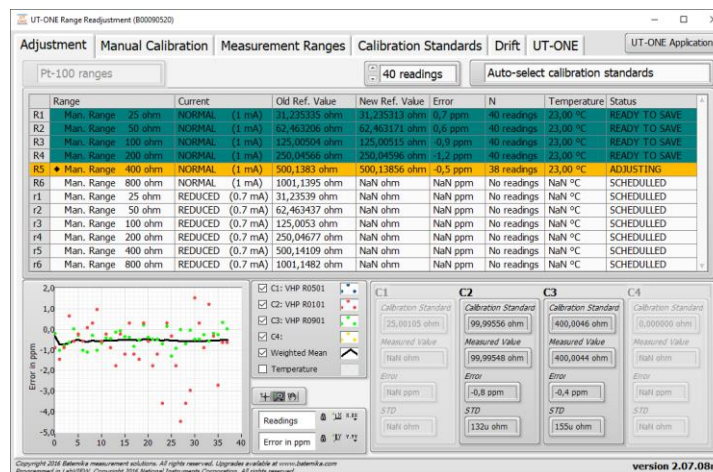


Figure 36: Adjustment page

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 calibration 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 calibration 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

- *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)	31,23325 ohm	1,2E-14	6,6E-7
R2 Man. Range 50 ohm	NORMAL (1 mA)	62,463206 ohm	7,4E-15	3E-7
R3 Man. Range 100 ohm	NORMAL (1 mA)	125,00504 ohm	1,08E-14	3,4E-7
R4 Man. Range 200 ohm	NORMAL (1 mA)	250,04566 ohm	7E-15	6E-7
R5 Man. Range 400 ohm	NORMAL (1 mA)	500,1383 ohm	5,7E-15	7,3E-7
R6 Man. Range 800 ohm	NORMAL (1 mA)	1001,1395 ohm	-7E-16	-4,8E-7
r1 Man. Range 25 ohm	REDUCED (0,7 mA)	31,23339 ohm	7,8E-15	6,7E-7
r2 Man. Range 50 ohm	REDUCED (0,7 mA)	62,463437 ohm	4,2E-15	3,7E-7
r3 Man. Range 100 ohm	REDUCED (0,7 mA)	125,0053 ohm	6,3E-15	3,6E-7
r4 Man. Range 200 ohm	REDUCED (0,7 mA)	250,04677 ohm	4,3E-15	6,8E-7
r5 Man. Range 400 ohm	REDUCED (0,7 mA)	500,14109 ohm	4E-15	7,5E-7
r6 Man. Range 800 ohm	REDUCED (0,7 mA)	1001,1482 ohm	-1E-15	-4,4E-7
H1 Man. Range 2500 ohm	NORMAL (10 uA)	3123,3409 ohm	1,3E-14	2,22E-6
H2 Man. Range 5000 ohm	NORMAL (10 uA)	6245,9292 ohm	7E-15	1,88E-6
H3 Man. Range 10000 ohm	NORMAL (10 uA)	12499,719 ohm	1,1E-14	1,87E-6
H4 Man. Range 20000 ohm	NORMAL (10 uA)	25003 ohm	7E-15	2,13E-6
H5 Man. Range 40000 ohm	NORMAL (10 uA)	50010,753 ohm	6E-15	2,25E-6
H6 Man. Range 80000 ohm	NORMAL (10 uA)	100107,92 ohm	-1E-15	1,08E-6
h1 Man. Range 2500 ohm	REDUCED (7 uA)	3123,3628 ohm	8E-15	2,26E-6
h2 Man. Range 5000 ohm	REDUCED (7 uA)	6245,9857 ohm	4E-15	1,87E-6
h3 Man. Range 10000 ohm	REDUCED (7 uA)	12499,811 ohm	6E-15	1,91E-6
h4 Man. Range 20000 ohm	REDUCED (7 uA)	25003,246 ohm	4E-15	2,15E-6
h5 Man. Range 40000 ohm	REDUCED (7 uA)	50011,31 ohm	4E-15	2,3E-6

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.

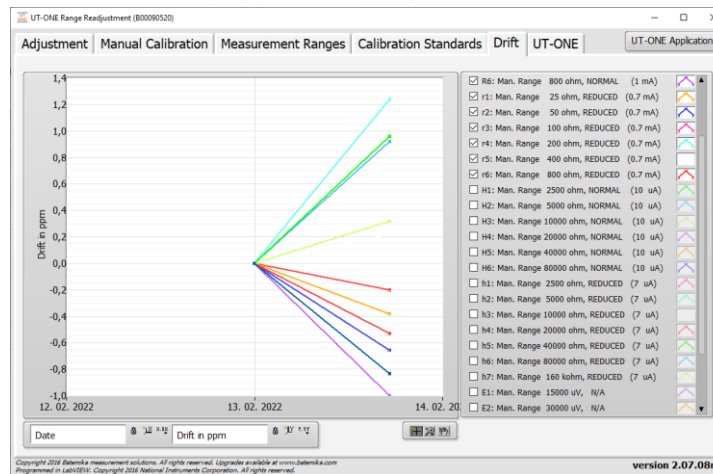


Figure 38: Drift page

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 calibration 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.

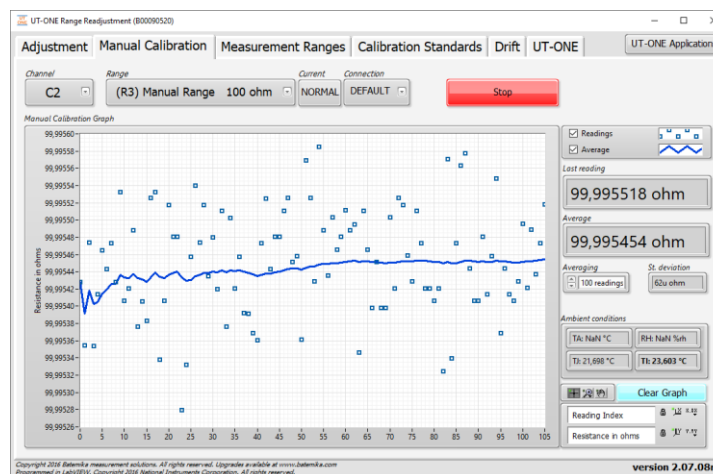


Figure 39: Manual Calibration page

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.

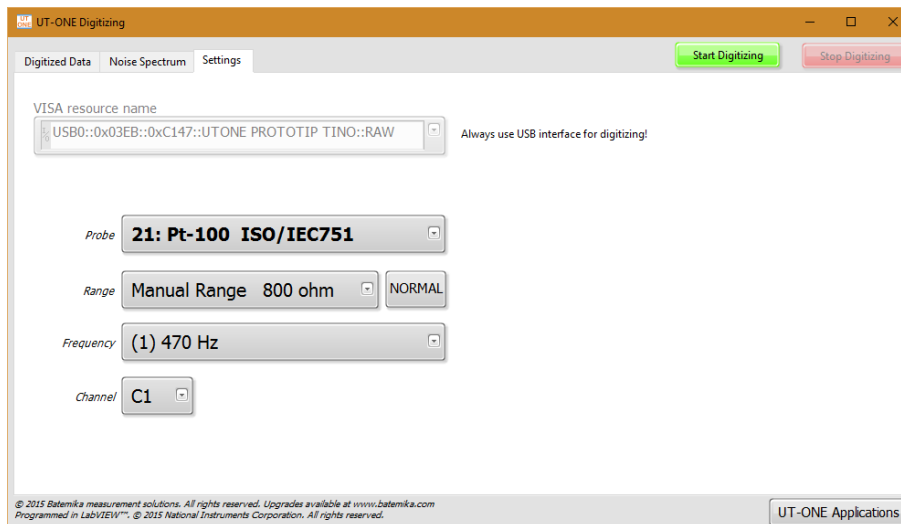


Figure 40: Settings for UT-ONE Digitizing application

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.

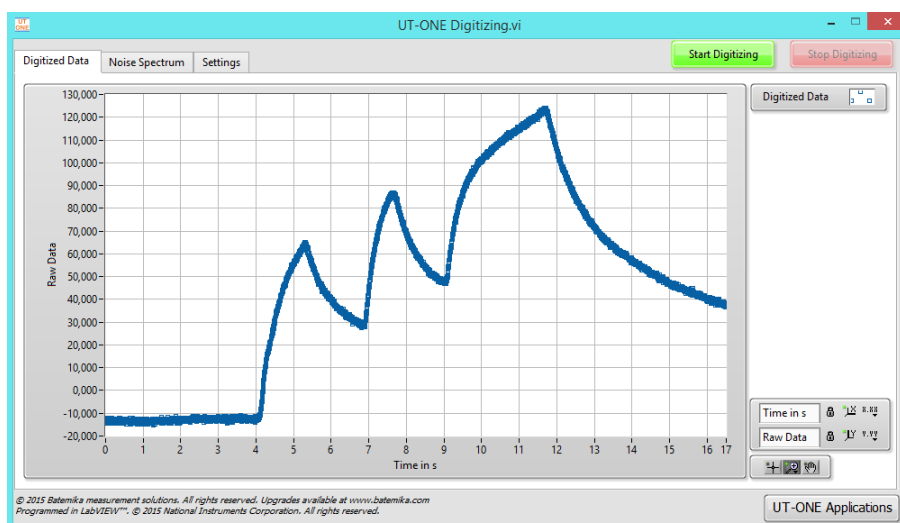


Figure 41: Observing of fast transients in digitizing mode

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.

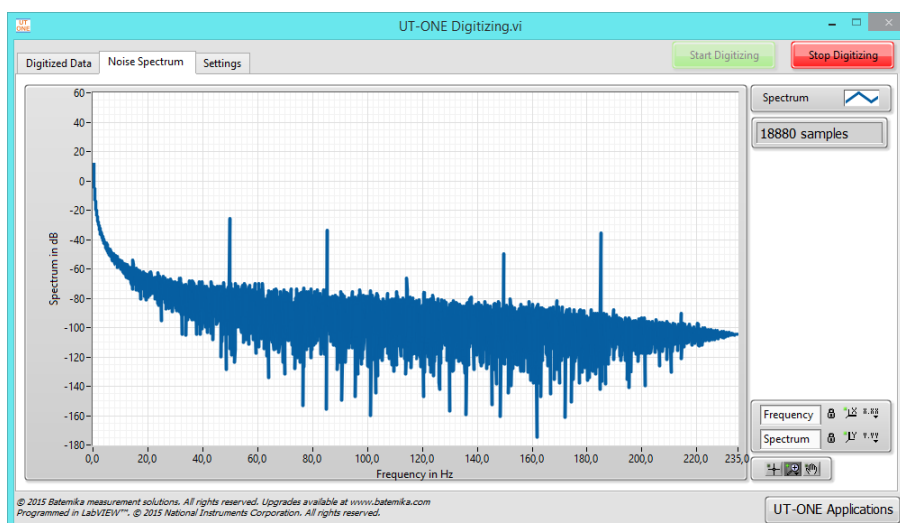


Figure 42: Noise spectrum with considerable 50 Hz interference

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. The application will display a progress bar with the number of errors and total number of messages. If the

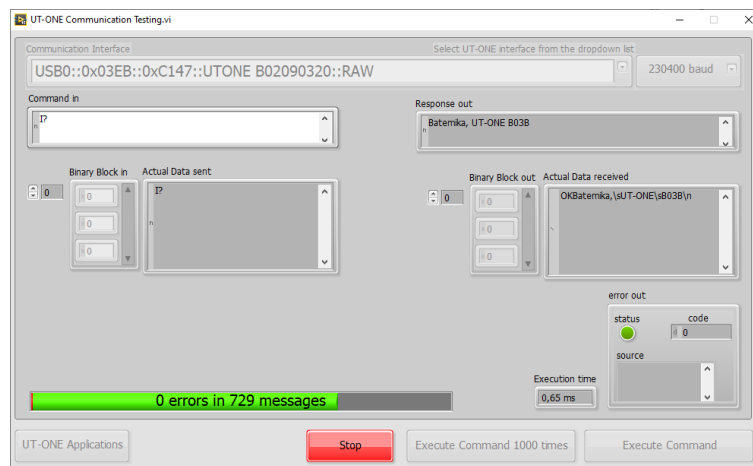


Figure 43: UT-ONE Communication Testing

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.

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.

Depending on your UT-ONE model, the device may support logging to internal SD card, internal flash memory or both. Logging to internal SD card is only supported on device with built-in display (UT-ONE B03A and UT-ONE B03B). Logging to internal flash memory is only supported on UT-ONE SxxB and selected UT-ONE B03B devices.

8.6.1 Logging to internal SD card

Internal SD card logging memory consists of 67 108 864 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/B 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.

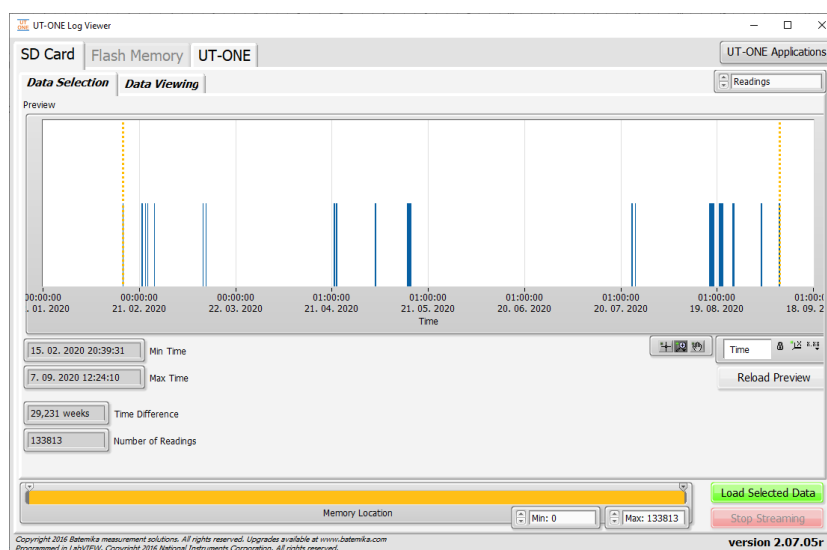


Figure 44: UT-ONE Log Viewer data selection page

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.

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.

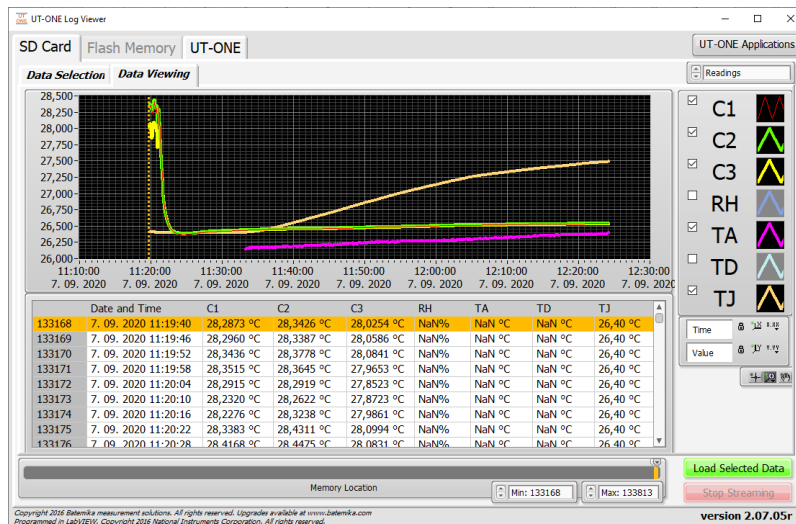


Figure 45: UT-ONE Log Viewer data viewing page

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.

8.6.2 Logging to internal Flash Memory

Internal Flash Memory consists of 2 097 152 memory locations. Each memory location can store one reading. Readings can be acquired from main channels in single-reading or continuous-measurement mode, or from ambient probes (RH, TA, TD and TJ channels). Each stored reading consists of the timestamp, raw value (resistance, emf or uncorrected temperature/relative humidity), corrected value (temperature or relative humidity), channel name, measurement range and connection configuration, and probe index. A CRC8 byte is appended to each reading data to insure data integrity.

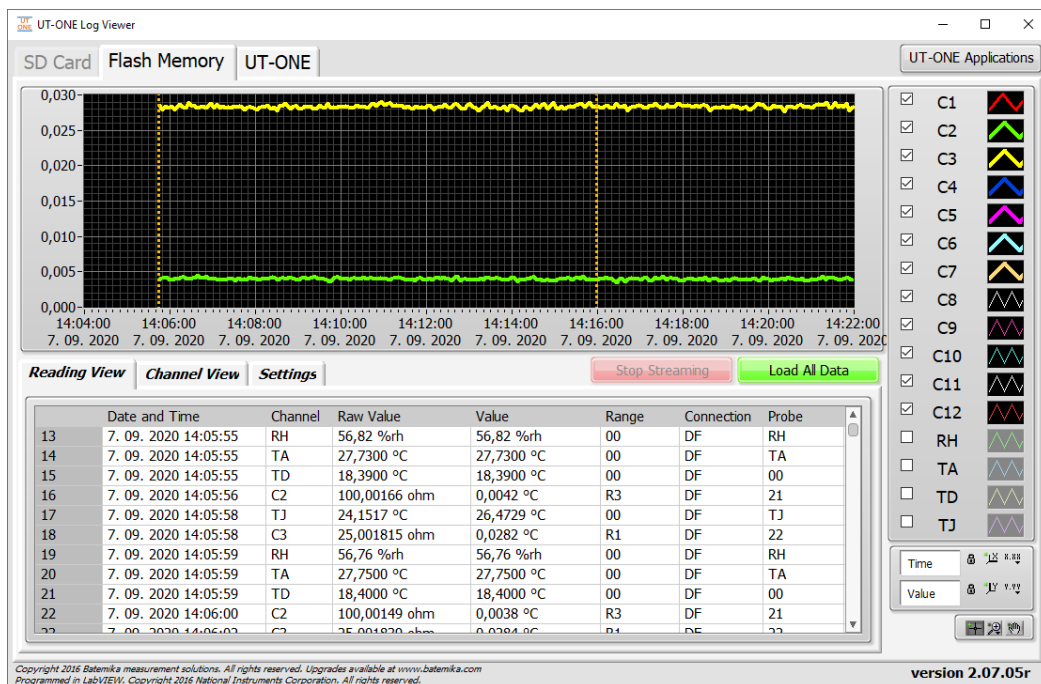


Figure 46: UT-ONE Flash Memory Viewer

Start loading data from the flash memory by clicking the green *Load All Data* button. Application will clear any existing data and start displaying the preview of the TJ channel data on the graph. When required data is loaded, click the red *Stop Streaming* button. Alternatively, you may load the entire content of the flash memory to the application memory. This takes six to seven minutes. After the data is loaded, it is displayed on the graph and in reading/channel view.

Readings can be stored to binary file using the popup menu command. You can later load and review the data from the file. Note that this is full data in the same format as stored in Flash Memory.

Readings can be exported to clipboard in various formats using popup menu commands. You can paste this data into other applications, such as MS Excel. Note that for large number of readings, copying of data can take a lot of time.

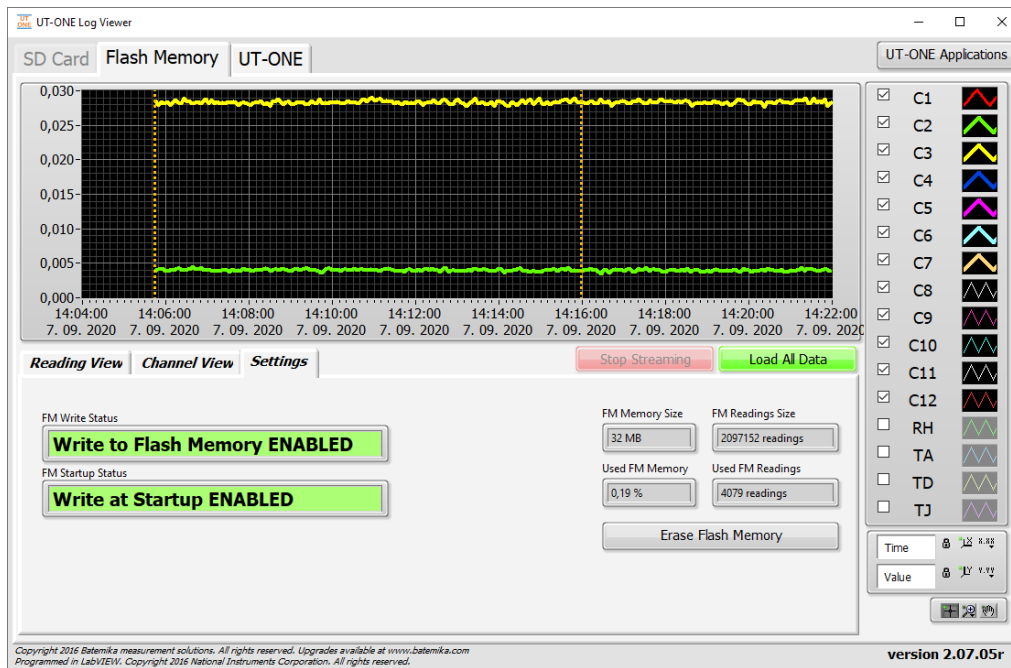


Figure 47: UT-ONE Flash Memory Settings

Write status and settings of the internal flash memory can be configured in the *Settings* tab.

Writing in flash memory can be temporarily enabled or disabled using the popup menu command on the *FM Write Status* indicator. Note that this is a temporary setting and will be lost after the device is switched off.

The setting of writing to flash memory at startup can be enabled or disabled using the popup menu on the *FM Startup Status* indicator. This enables you to configure the device for operation in standalone mode with enabled writing to flash memory at startup.

Total and used flash memory is displayed in four indicators on the right hand side. Note that after memory is full, the device will automatically overwrite the oldest readings.

The content of the flash memory can be erased by clicking the *Erase Flash Memory* button. This will erase all readings and it cannot be undone. To confirm this operation, the application will require you to confirm the operation with a password. Password for erasing entire flash memory is:

R0q11maH

8.7 UT-ONE Temperature Monitoring

UT-ONE Temperature Validation is a simple application that is capable of acquiring temperature from up to 16 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.

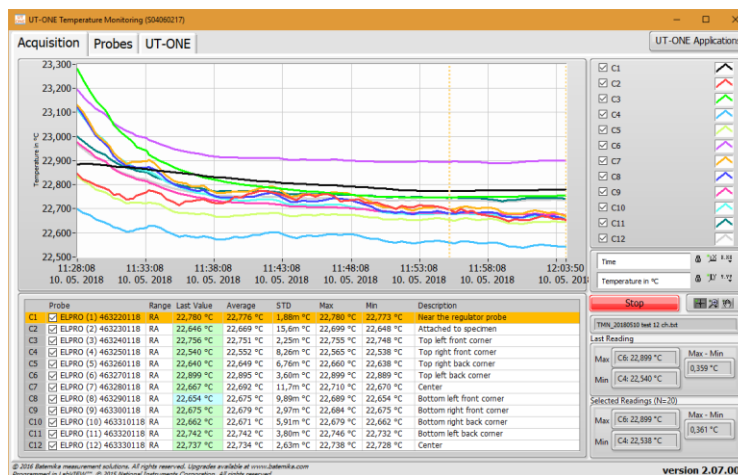


Figure 48: UT-ONE temperature monitoring

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

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.

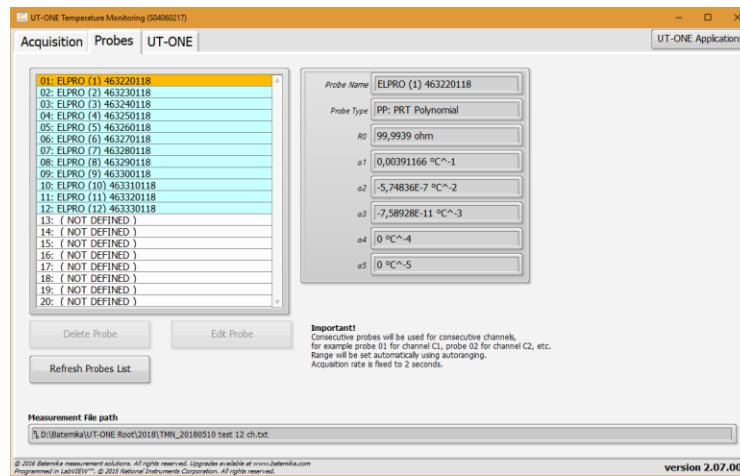


Figure 49: UT-ONE probe and measurement file configuration

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 and combined probes. Relative humidity and related vapour pressure can be determined from the external mirror hygrometer, combined 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.

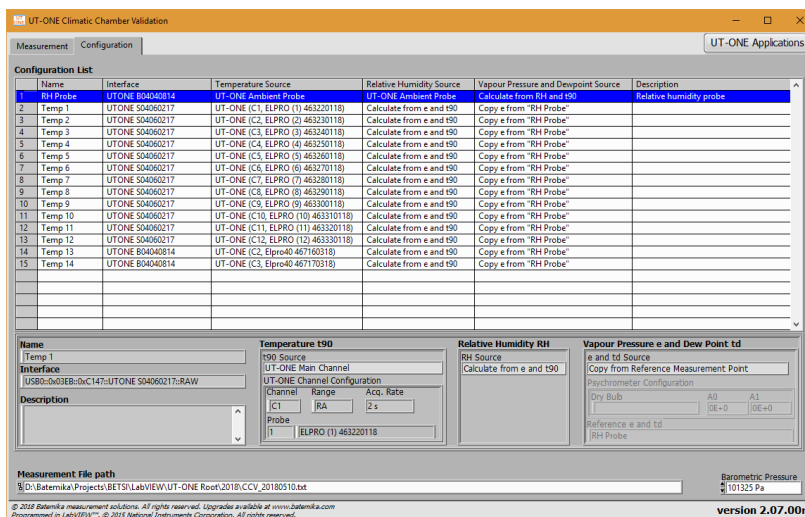


Figure 50: Configuration page

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.

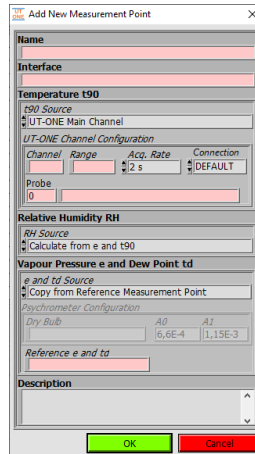


Figure 51: Dialog for adding a new measurement point

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 eight 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. Connection configuration allows you to configure the channel for 3-wire or 2-wire connection or thermocouple acquisition on the auxiliary input. Use Default for 4-wire resistance measurement or thermocouple measurement on voltage inputs.
 - *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.
 - *External Combined Probe 1* will acquire temperature from the Rotronic HC2 probe connected to specified serial interface.
 - *External Combined Probe 2* will acquire temperature from the Rotronic HCD probe connected to specified serial interface.
 - *External Chamber (SetPoint)* will acquire SetPoint temperature from the Kambič Metrology climatic chamber connected to specified serial interface. Note you must configure one measurement point with this option in order to enable chamber control feature.
 - *External Chamber (Value)* will acquire current temperature from the Kambič Metrology climatic chamber connected to specified serial interface.

- *Not Used* will not acquire any temperatures. Use this option if you would like to acquire only relative humidity.
- *RH Source* determines how the relative humidity is acquired or calculated. There are nine options available:
 - *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.
 - *External Combined Probe 1* will acquire relative humidity from the Rotronic HC2 probe connected to specified serial interface.
 - *External Combined Probe 2* will acquire relative humidity from the Rotronic HCD probe connected to specified serial interface.
 - *External Chamber (SetPoint)* will acquire SetPoint relative humidity from the Kambič Metrology climatic chamber connected to specified serial interface. Note that you must configure one measurement point with this option in order to enable setting RH setpoints with the chamber control feature.
 - *External Chamber (Value)* will acquire current relative humidity from the Kambič Metrology climatic chamber connected to specified serial interface.
 - *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.
 - *Not Used* will not acquire or calculate relative humidity. Use this option if you would like to acquire only temperature.
- *e and td source* determines how water vapour pressure and associated dew-point temperature are acquired or calculated. There are five options available:
 - *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.
 - *Not Used* will not acquire or calculate vapour pressure and dew-point temperature. Use this option if you would like to acquire only temperature.
- *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.

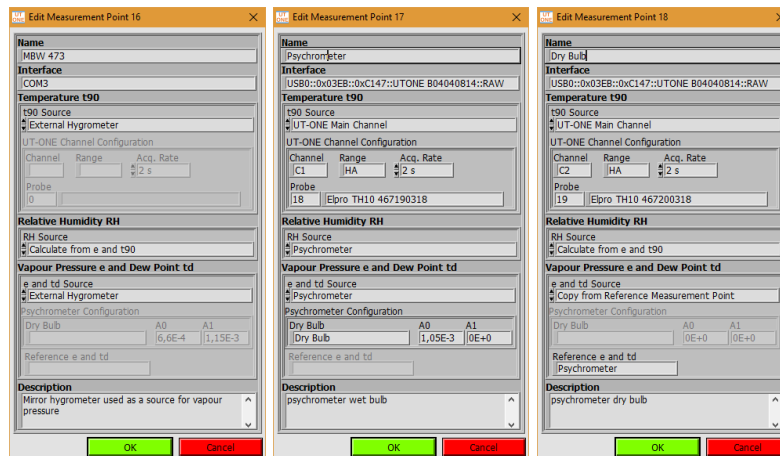


Figure 52: Examples of measurement point configuration

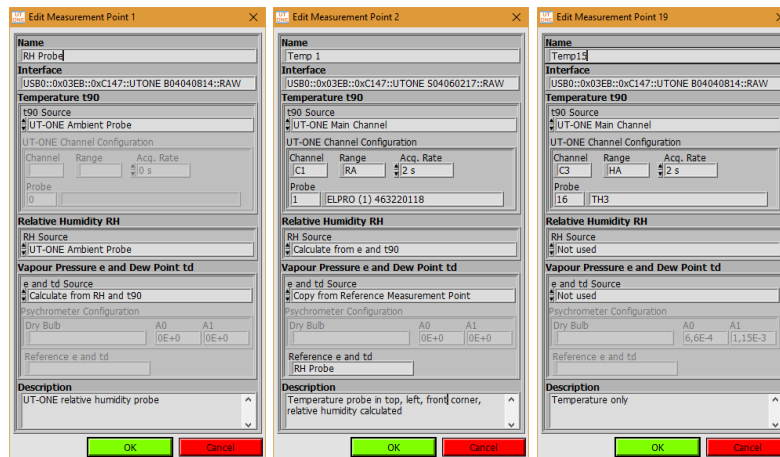


Figure 53: More examples of measurement point configuration

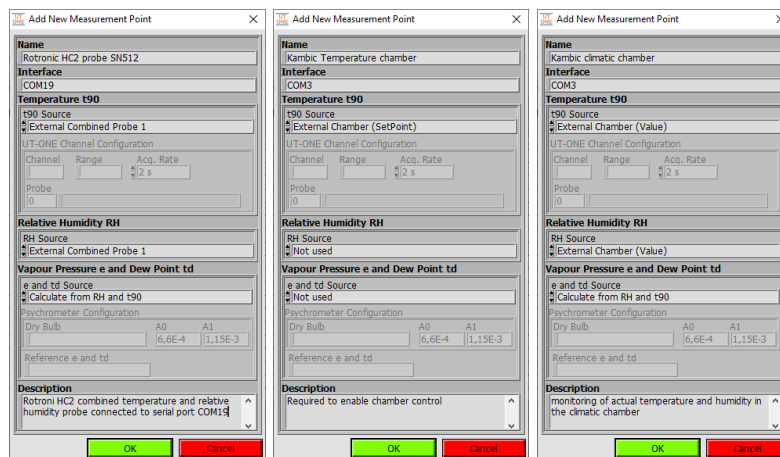


Figure 54: More examples of measurement point configuration

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.

If you would like to control the Kambič climatic chamber using the chamber control feature, you must configure one of the measurement points with the temperature source *External Chamber (SetPoint)* and specify the correct serial interface. This serial interface will be used to communicate with the chamber from the chamber control program. If you would like to set also the RH setpoint from the chamber control program, you must configure also the relative humidity source *External Chamber (SetPoint)*. This is not required if you are using temperature-only chamber.

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 Hygrome	COM3	External Hygrometer	Calculate from e and t90	External Hygrometer
2	Point 1	UTONE S04060217	UT-ONE (C1, ELPRO (1) 463220118)	Calculate from e and t90	Copy e from "Mirror Hygrometer"
3	Point 2	UTONE S04060217	UT-ONE (C2, ELPRO (2) 463230118)	Calculate from e and t90	Copy e from "Mirror Hygrometer"
4	Point 3	UTONE S04060217	UT-ONE (C3, ELPRO (3) 463250118)	Calculate from e and t90	Copy e from "Mirror Hygrometer"
5	Point 4	UTONE S04060217	UT-ONE (C4, ELPRO (4) 463250118)	Calculate from e and t90	Copy e from "Mirror Hygrometer"
6	Point 5	UTONE S04060217	UT-ONE (C5, ELPRO (5) 463260118)	Calculate from e and t90	Copy e from "Mirror Hygrometer"
7	Point 6	UTONE S04060217	UT-ONE (C6, ELPRO (6) 463270118)	Calculate from e and t90	Copy e from "Mirror Hygrometer"
8	Point 7	UTONE S04060217	UT-ONE (C7, ELPRO (7) 463280118)	Calculate from e and t90	Copy e from "Mirror Hygrometer"
9	Point 8	UTONE S04060217	UT-ONE (C8, ELPRO (8) 463290118)	Calculate from e and t90	Copy e from "Mirror Hygrometer"
10	Point 9	UTONE S04060217	UT-ONE (C9, ELPRO (9) 463300118)	Calculate from e and t90	Copy e from "Mirror Hygrometer"
11	Point 10	UTONE S04060217	UT-ONE (C10, ELPRO (10) 463310118)	Calculate from e and t90	Copy e from "Mirror Hygrometer"
12	Point 11	UTONE S04060217	UT-ONE (C11, ELPRO (11) 463320118)	Calculate from e and t90	Copy e from "Mirror Hygrometer"
13	Point 12	UTONE S04060217	UT-ONE (C12, ELPRO (12) 463330118)	Calculate from e and t90	Copy e from "Mirror Hygrometer"

Figure 55: 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	UTONE S04040814	UT-ONE Ambient Probe	Calculate from RH and t90	UT-ONE Relative humidity probe
2	Point 1	UTONE S04060217	UT-ONE (C7, ELPRO (1) 463220118)	Calculate from e and t90	Copy e from "RH Probe"
3	Point 2	UTONE S04060217	UT-ONE (C8, ELPRO (8) 463290118)	Calculate from e and t90	Copy e from "RH Probe"
4	Point 3	UTONE S04060217	UT-ONE (C9, ELPRO (9) 463300118)	Calculate from e and t90	Copy e from "RH Probe"
5	Point 4	UTONE S04060217	UT-ONE (C10, ELPRO (10) 463310118)	Calculate from e and t90	Copy e from "RH Probe"
6	Point 5	UTONE S04060217	UT-ONE (C11, ELPRO (11) 463320118)	Calculate from e and t90	Copy e from "RH Probe"
7	Point 6	UTONE S04060217	UT-ONE (C12, ELPRO (12) 463330118)	Calculate from e and t90	Copy e from "RH Probe"

Figure 56: 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	UTONE S04060217	UT-ONE (C1, Elpro TH10 467190318)	Psychrometer	Psychrometer (Dry Bulb= "Dry Bulb")
2	Dry Bulb	UTONE S04060217	UT-ONE (C2, Elpro TH10 467200318)	Calculate from e and t90	Copy e from "Wet Bulb"
3	Corner 1	UTONE S04060217	UT-ONE (C4, ELPRO (4) 463250118)	Calculate from e and t90	Copy e from "Wet Bulb"
4	Corner 2	UTONE S04060217	UT-ONE (C5, ELPRO (5) 463260118)	Calculate from e and t90	Copy e from "Wet Bulb"
5	Corner 3	UTONE S04060217	UT-ONE (C6, ELPRO (6) 463270118)	Calculate from e and t90	Copy e from "Wet Bulb"
6	Corner 4	UTONE S04060217	UT-ONE (C7, ELPRO (7) 463280118)	Calculate from e and t90	Copy e from "Wet Bulb"
7	Corner 5	UTONE S04060217	UT-ONE (C8, ELPRO (8) 463290118)	Calculate from e and t90	Copy e from "Wet Bulb"
8	Corner 6	UTONE S04060217	UT-ONE (C9, ELPRO (9) 463300118)	Calculate from e and t90	Copy e from "Wet Bulb"
9	Corner 7	UTONE S04060217	UT-ONE (C10, ELPRO (10) 463310118)	Calculate from e and t90	Copy e from "Wet Bulb"
10	Corner 8	UTONE S04060217	UT-ONE (C11, ELPRO (11) 463320118)	Calculate from e and t90	Copy e from "Wet Bulb"
11	Center	UTONE S04060217	UT-ONE (C3, ELPRO (3) 463240118)	Calculate from e and t90	Copy e from "Wet Bulb"

Figure 57: Configuration with psychrometer and 9 thermometers

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) 463220118)	NOT USED	Temperature in top left front corner
2	Temp 2	UTONE S04060217	UT-ONE (C2, ELPRO (2) 463230118)	NOT USED	Temperature in top left back corner
3	Temp 3	UTONE S04060217	UT-ONE (C3, ELPRO (3) 463240118)	NOT USED	Temperature in top right front corner
4	Temp 4	UTONE S04060217	UT-ONE (C4, ELPRO (4) 463250118)	NOT USED	Temperature in top right back corner
5	Temp 5	UTONE S04060217	UT-ONE (C5, ELPRO (5) 463260118)	NOT USED	Temperature in center
6	Temp 6	UTONE S04060217	UT-ONE (C6, ELPRO (6) 463270118)	NOT USED	Temperature in bottom left front corner
7	Temp 7	UTONE S04060217	UT-ONE (C7, ELPRO (7) 463280118)	NOT USED	Temperature in bottom left back corner
8	Temp 8	UTONE S04060217	UT-ONE (C8, ELPRO (8) 463290118)	NOT USED	Temperature in bottom right front corner
9	Temp 9	UTONE S04060217	UT-ONE (C9, ELPRO (9) 463300118)	NOT USED	Temperature in bottom right back corner

Figure 58: 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
2	Ambient Probe	UTONE B04040814	UT-ONE Ambient Probe	UT-ONE Ambient Probe	Calculate from RH and t90
3	Wet Bulb	UTONE B04040814	UT-ONE (C2, Elpro TH10 467190318)	Psychrometer	Psychrometer (Dry Bulb="Dry Bulb")
4	Dry Bulb	UTONE B04040814	UT-ONE (C3, Elpro TH10 467200318)	Calculate from e and t90	Copy e from "Wet Bulb"
5	Corner 1	UTONE S04060217	UT-ONE (C1, ELPRO (1) 463220118)	Calculate from e and t90	Copy e from "MBW 473"
6	Corner 2	UTONE S04060217	UT-ONE (C2, ELPRO (2) 463230118)	Calculate from e and t90	Copy e from "MBW 473"
7	Corner 3	UTONE S04060217	UT-ONE (C3, ELPRO (3) 463240118)	Calculate from e and t90	Copy e from "MBW 473"
8	Corner 4	UTONE S04060217	UT-ONE (C4, ELPRO (4) 463250118)	Calculate from e and t90	Copy e from "MBW 473"
9	Center	UTONE S04060217	UT-ONE (C5, ELPRO (5) 463260118)	Calculate from e and t90	Copy e from "Ambient Probe"
10	Corner 5	UTONE S04060217	UT-ONE (C6, ELPRO (6) 463270118)	Calculate from e and t90	Copy e from "Wet Bulb"
11	Corner 6	UTONE S04060217	UT-ONE (C7, ELPRO (7) 463280118)	Calculate from e and t90	Copy e from "Wet Bulb"
12	Corner 7	UTONE S04060217	UT-ONE (C8, ELPRO (8) 463290118)	Calculate from e and t90	Copy e from "Wet Bulb"
13	Corner 8	UTONE S04060217	UT-ONE (C9, ELPRO (9) 463300118)	Calculate from e and t90	Copy e from "Wet Bulb"
14	Aux 1	UTONE S04060217	UT-ONE (C10, ELPRO (10) 463310118)	NOT USED	NOT USED

Figure 59: Configuration with three different vapour-pressure sources, two UT-ONE units and 10 thermometers

Configuration List					
Name	Interface	Temperature Source	Relative Humidity Source	Vapour Pressure and Dewpoint Source	Description
1	Kambic Chamber	COM19	External Chamber (SetPoint)	External Chamber (SetPoint)	NOT USED
2	Kambic Chamber Value	COM19	External Chamber (Value)	External Chamber (Value)	Calculate from RH and t90
3	Probe 1	UTONE S15060217	UT-ONE (C1, Pt-100 ISO/IEC751)	NOT USED	NOT USED

Figure 60: Configuration with Kambic climatic chamber and one thermometer probe

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.

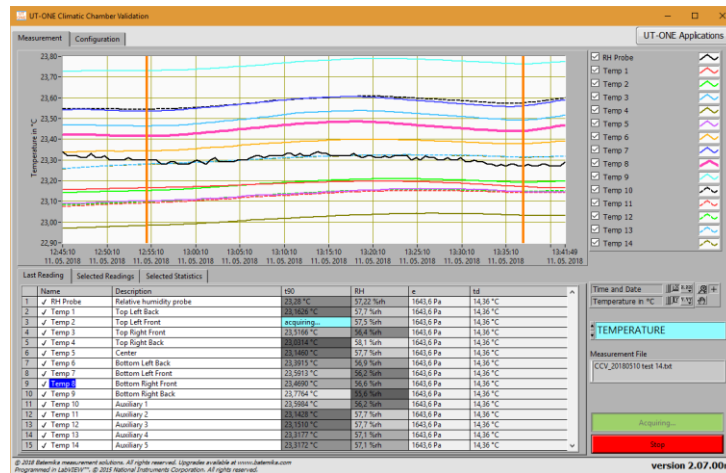


Figure 61: Measurement page with temperature display selected

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.

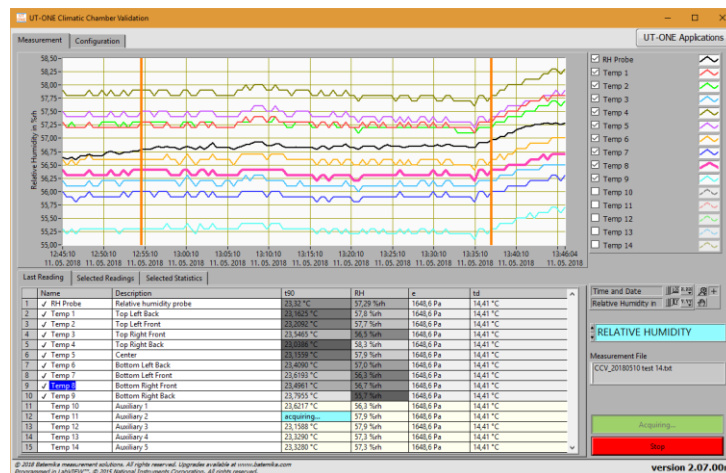


Figure 62: Measurement page with relative humidity display selected and auxiliary points excluded

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	t50	RH	e	td
1	RH Probe	23.40 °C	57.55 %rh	1663.1 Pa	14.55 °C
2	Temp 1	23.1168 °C	58.3 %rh	1663.1 Pa	14.55 °C
3	Temp 2	23.3308 °C	58.1 %rh	1663.1 Pa	14.55 °C
4	Temp 3	23.3804 °C	58.9 %rh	1663.1 Pa	14.55 °C
5	Temp 4	23.5988 °C	58.7 %rh	1663.1 Pa	14.55 °C
6	Temp 5	23.4200 °C	58.3 %rh	1663.1 Pa	14.55 °C
7	Temp 6	23.4367 °C	57.4 %rh	1663.1 Pa	14.55 °C
8	Temp 7	23.6511 °C	56.7 %rh	1663.1 Pa	14.55 °C
9	Temp 8	23.3278 °C	57.1 %rh	1663.1 Pa	14.55 °C
10	Temp 9	23.8188 °C	56.1 %rh	1663.1 Pa	14.55 °C
11	Temp 10	23.6490 °C	56.7 %rh	1663.1 Pa	14.55 °C
12	Temp 11	23.1682 °C	58.3 %rh	1663.1 Pa	14.55 °C
13	Temp 12	26.1795 °C	58.3 %rh	1663.1 Pa	14.55 °C
14	Temp 13	23.3622 °C	57.6 %rh	1663.1 Pa	14.55 °C
15	Temp 14	23.3812 °C	57.7 %rh	1663.1 Pa	14.55 °C

Figure 63: 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	t50 1	t50 2	t50 3	t50 4	t50 5	t50 6	t50 7	t50 8	t50 9	t50 10
11. 05. 2018 12:54:42	23.3000 °C	23.1648 °C	23.1509 °C	23.4403 °C	22.9838 °C	23.1027 °C	23.3437 °C	23.5353 °C	23.4143 °C	23.7905 °C
11. 05. 2018 12:55:14	23.3000 °C	23.1651 °C	23.1520 °C	23.4638 °C	22.9838 °C	23.1014 °C	23.3427 °C	23.5350 °C	23.4142 °C	23.7309 °C
11. 05. 2018 12:55:46	23.3000 °C	23.1656 °C	23.1526 °C	23.4636 °C	22.9843 °C	23.1021 °C	23.3429 °C	23.5356 °C	23.4150 °C	23.7311 °C
11. 05. 2018 12:56:16	23.2800 °C	23.1661 °C	23.1531 °C	23.4639 °C	22.9845 °C	23.1025 °C	23.3442 °C	23.5367 °C	23.4163 °C	23.7317 °C
11. 05. 2018 12:56:47	23.2800 °C	23.1670 °C	23.1544 °C	23.4644 °C	22.9858 °C	23.1038 °C	23.3448 °C	23.5372 °C	23.4165 °C	23.7319 °C
11. 05. 2018 12:57:17	23.2900 °C	23.1672 °C	23.1549 °C	23.4653 °C	22.9866 °C	23.1038 °C	23.3457 °C	23.5386 °C	23.4175 °C	23.7327 °C
11. 05. 2018 12:57:47	23.2900 °C	23.1679 °C	23.1562 °C	23.4658 °C	22.9877 °C	23.1054 °C	23.3470 °C	23.5400 °C	23.4192 °C	23.7327 °C
11. 05. 2018 12:58:17	23.2800 °C	23.1678 °C	23.1572 °C	23.4676 °C	22.9882 °C	23.1059 °C	23.3485 °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	23.4692 °C	22.9891 °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	22.9900 °C	23.1073 °C	23.3509 °C	23.5458 °C	23.4246 °C	23.7351 °C
11. 05. 2018 12:59:48	23.2900 °C	23.1701 °C	23.1614 °C	23.4730 °C	22.9914 °C	23.1079 °C	23.3528 °C	23.5473 °C	23.4265 °C	23.7367 °C

Figure 64: 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.

Name	Description	Mean	STD	Max	Min	Max-Min
Temp 1	Top Left Back	57.26 %rh	0.0940 %rh	57.40 %rh	57.10 %rh	0.300 %rh
Temp 2	Top Left Front	57.24 %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	57.83 %rh	0.0822 %rh	58.00 %rh	57.60 %rh	0.400 %rh
Temp 5	Center	57.42 %rh	0.0829 %rh	57.60 %rh	57.20 %rh	0.400 %rh
Temp 6	Bottom Left Back	56.59 %rh	0.0662 %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	55.38 %rh	0.0687 %rh	55.40 %rh	55.10 %rh	0.300 %rh
Temp 10	Auxiliary 1	55.90 %rh	0.0606 %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

Figure 65: 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.

8.8.7 Chamber control

Chamber Control feature enables the user to synchronize the chamber setpoints and temperature/relative humidity acquisition from a single application. This feature enables simple manual setting of temperature and relative humidity setpoints, as well as a more complex chamber program, which enables setting several setpoints with adjustable time intervals.

This feature currently support Kambič metrology climatic chambers with serial communication interface. Other chamber types may be included by integrating a suitable communication driver.

To enable chamber control feature, you must first configure one measurement point with the temperature source set to *External Chamber*. Make sure you select the correct serial communication interface. Climatic chamber must have the serial interface baud rate set to 19200 bauds.

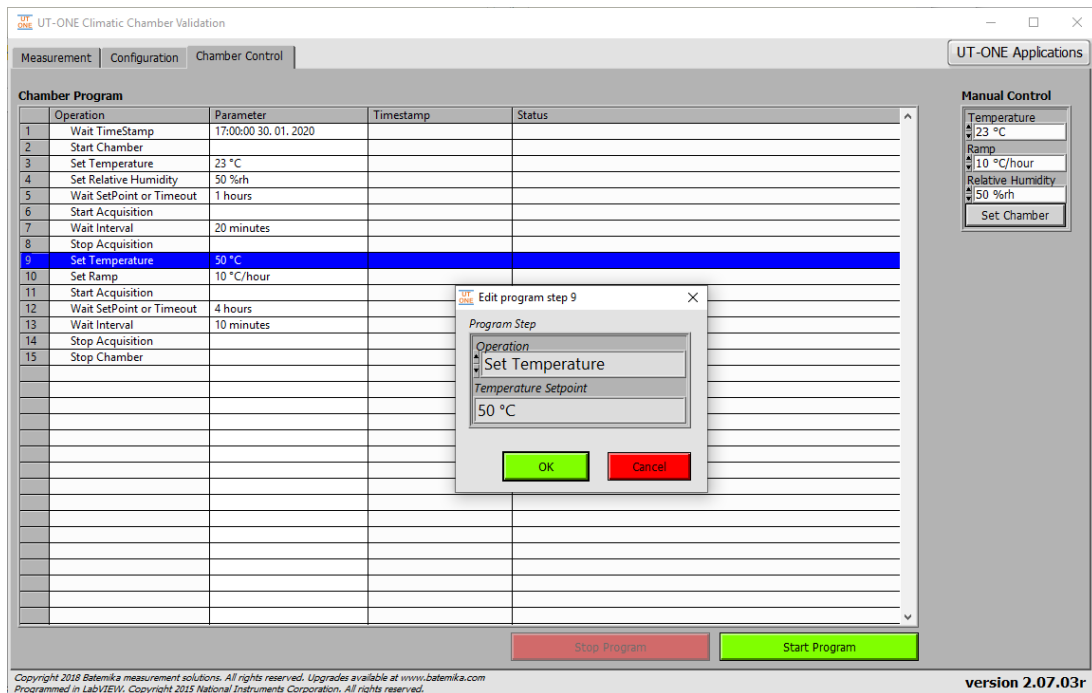


Figure 66: Chamber Control page

Chamber program consists of a set of program steps. A program step can be added by double-clicking an empty row. Alternatively, steps can be managed using commands from the popup menu.

Each program step consists of the operation and parameter, which can be edited in the Program Step dialog. The following operations are available:

- *Set Temperature* will send a new temperature setpoint to the chamber. Application will read the setpoint back from the chamber and compare it to the new setting. If there is a difference, a warning is displayed in the step status. Make sure that setpoints are within the temperature range of the particular climatic chamber, otherwise unexpected behaviour may occur.
- *Set Ramp* will send a new temperature ramp to the chamber. Application will read the ramp back from the chamber and compare it to the new setting. If there is a difference, a warning is displayed in the step status.
- *Set Relative Humidity* will send a new relative humidity setpoint to the chamber. Application will read the setpoint back from the chamber and compare it to the new setting. If there is a difference, a warning is displayed in the step status. Make sure that setpoints are within the relative humidity range of the particular climatic chamber, otherwise unexpected behaviour may occur. Note that relative humidity limits may vary with temperature setpoint for a specific chamber type.
- *Wait Interval* will wait for a specified fixed time interval, for example 30 minutes. After the time expires, the program will continue execution with the next step. If configured, the acquisition of measurement points will proceed normally during waiting period.
- *Wait TimeStamp* will wait until the specified absolute time. This command is especially useful for tests with a delayed start. For example, you may configure the application to start the program at midnight, so the chamber is already stable and ready for work in the morning.
- *Wait SetPoint or Timeout* will continuously monitor the chamber temperature setpoint and value, until they are the same for a period of 10 minutes. This gives a rough indication of a stable state. The application will allow some scatter in the temperature values by checking the median of readings and not the mean value. As a safeguard, you can set the timeout interval, which will allow the program to proceed to next program step after the timeout has elapsed. This is useful in cases when the stability criteria of the chamber is not met.
- *Start Chamber* will instruct chamber to start chamber operation.

- *Stop Chamber* will instruct chamber to stop chamber operation.
- *Start Acquisition* will start the main acquisition of configured measurement points. This is equivalent to clicking the green *Start* button on the *Measurement* page. This operation allows you to delay the start of acquisition and you can avoid storing irrelevant data (for example before the chamber is stable).
- *Stop Acquisition* will stop the main acquisition of configured measurement points. This is equivalent to clicking the red *Stop* button on the *Measurement* page.

Program is started by clicking the green *Start Program* button. Alternatively, you can use the command from the popup menu, which allows you also to start the program at any program step.

Program can be saved or loaded from the program file using the popup menu command. Also, after you start the program, the application will create an autosave copy of the program, which will be automatically loaded at next application start.

After the program is started, you can observe the status of the current and previous steps. In case of detected issues, the application will display a warning or error status.

Program steps can be skipped or paused using the command from the popup menu. You can also select any program step and use the popup menu command to continue program execution at selected step.

Note that chamber program execution is essentially independent of measurement acquisition. This allows you to start the program with or without measurement acquisition and start/stop measurement acquisition during program execution.

8.9 UT-ONE Parallel Acquisition

UT-ONE Parallel Acquisition is a specialised application that allows fast parallel acquisition from multiple UT-ONE units. It was primarily designed for use with UT-ONE S01A 1-channel units, but it can work normally with any UT-ONE thermometer readout.

This application is applicable for procedures where multiple temperature probes must be acquired at the same time and with a very short sampling time, so consecutive acquisition on a multi-channel device is not fast enough. This application allows acquisition rates of up to 2 samples per second on all probes.

Acquired readings are presented on the graph and stored in a measurement file.

The number of UT-ONE devices that can be acquired by this application is limited only with operating system resources. Note that USB standard allows the connection of up to 127 devices and some of them are already used by other computer peripherals. Available computer memory and processing power can also limit the total number of devices. The system was tested with 10 UT-ONE devices and performed flawlessly. A system with up to 30 devices should be able to work, but it would require some additional testing and optimization.

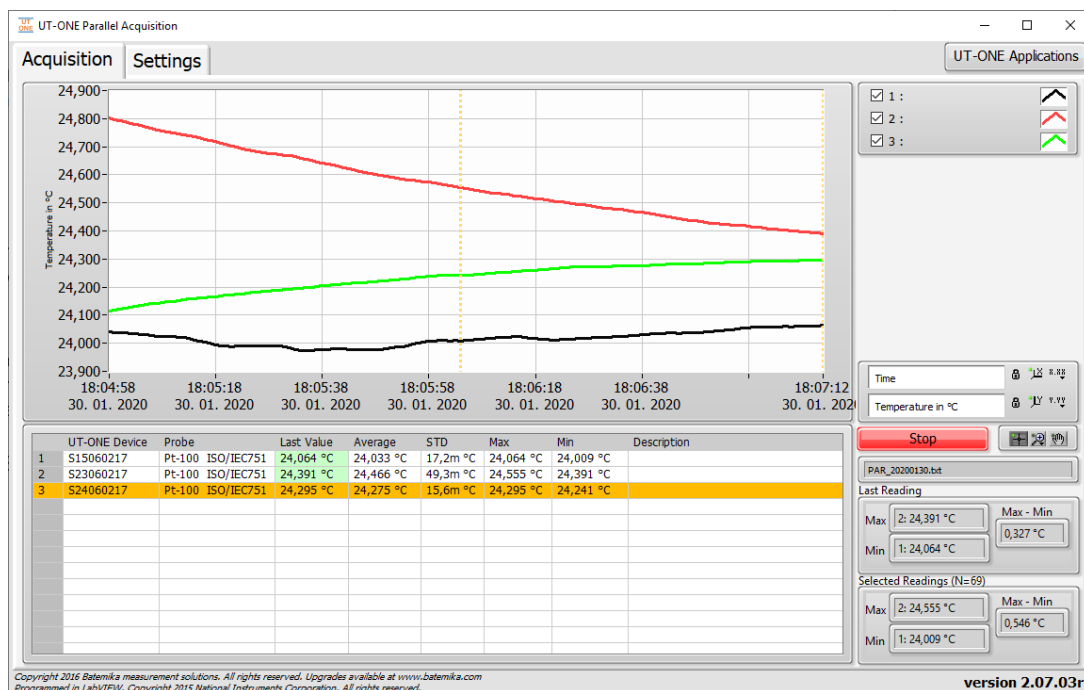


Figure 67: Parallel Acquisition application

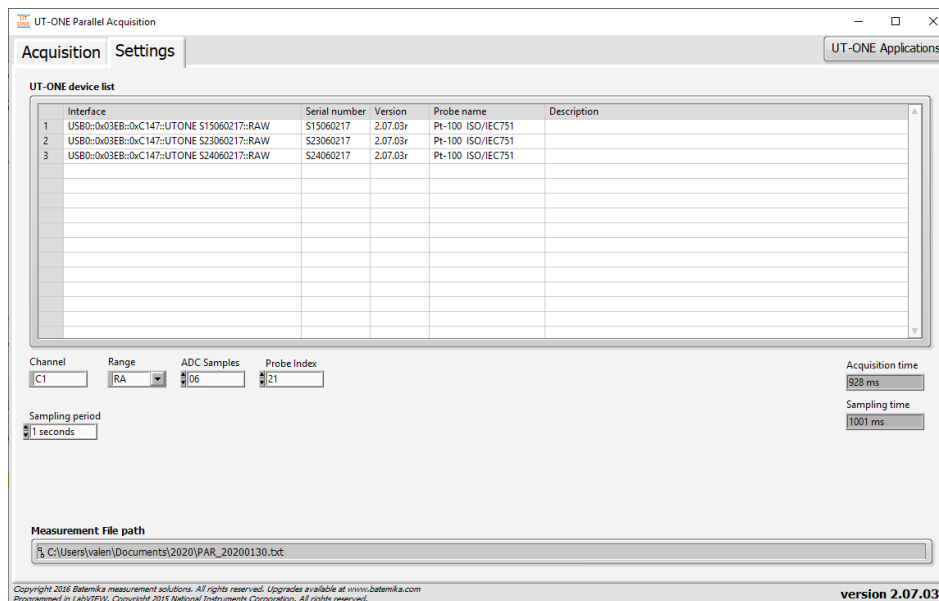


Figure 68: Settings page for Parallel Acquisition

To configure your parallel acquisition system, you must first add UT-ONE devices in the *UT-ONE device list* using the command from the popup menu. The system will autodetect all connected UT-ONE devices and display their USB addresses in a submenu. Note that you can only select a particular UT-ONE device once and use for acquisition on one main channel.

The acquisition settings are common for all UT-ONE devices. You can select channel (typically C1), measurement range (typically autorange RA for Pt-100 probes) and Probe Index used for conversion of acquired raw value to temperature. If you are using user-defined probe coefficients, make sure you store them under the same probe index on all UT-ONE devices.

Sampling rate is primarily determined by the *ADC Samples* parameter, which determines how many ADC samples are acquired and averaged to produce one temperature reading. You can between 1 and 40 samples. Recommended value is 6 samples, which will result in 1 temperature reading per second.

Sampling period parameter allows you to synchronize readings with computer clock. Make sure sampling time is larger than acquisition time, otherwise the acquisition rate will be determined by *ADC Samples parameter* and readings will be acquired asynchronously at maximum possible acquisition rate.

8.10 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. Always use 38400 baud rate setting, other baud rates are not supported by the upgrade application. If your UT-ONE unit is configured for another baud rate, change it to 38400 bauds first and then proceed with upgrade. Note that full upgrade takes about two hours at maximum baud rate for units with built-in display.

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

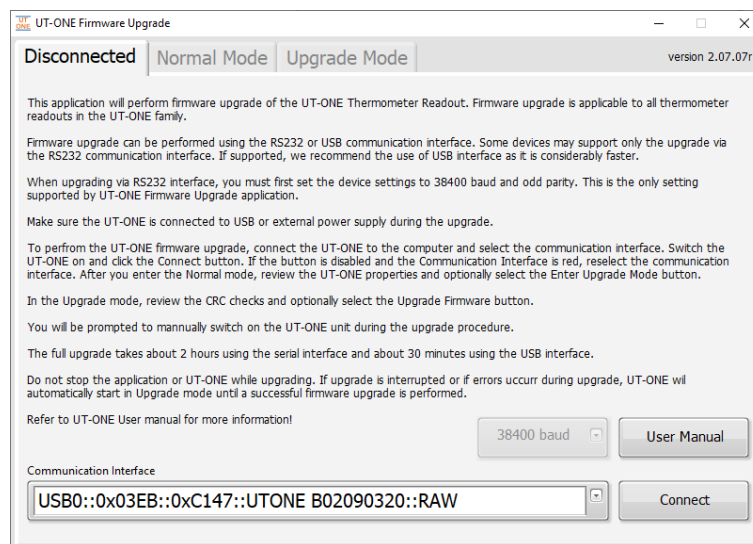


Figure 69: UT-ONE Firmware Upgrade

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.

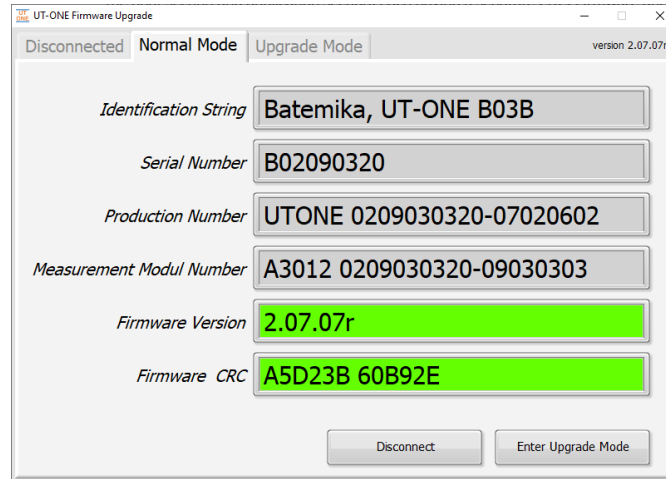


Figure 70: UT-ONE Firmware Upgrade in normal mode

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.

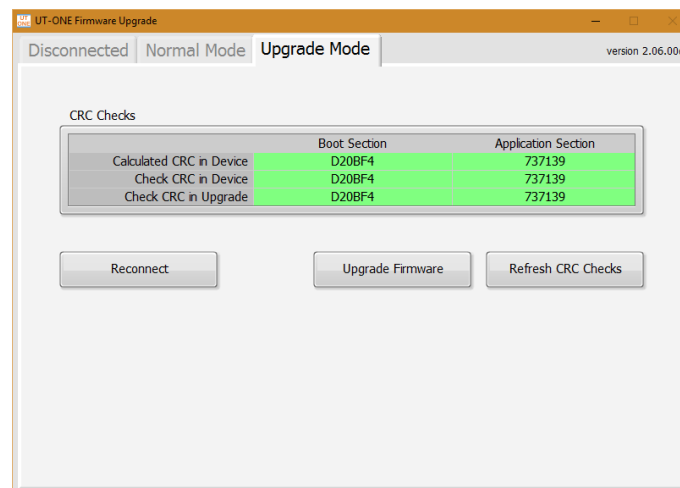


Figure 71: UT-ONE Firmware Upgrade during upgrade

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.

9 Specifications

This chapter provides detailed specifications for UT-ONE L01A 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>	1
<i>Thermometer probes</i>	platinum resistance thermometers (Pt100 option) thermistors (Thermistor option)
<i>Temperature range</i>	-273.15 °C to 2100 °C max, limited by the probe range
<i>Type of sampling</i>	single channel
<i>Sampling period</i>	1 to 240 seconds per enabled channel (continuous mode) 0.5 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, 10 µA / 7.07 µA for thermistors
<i>Keep-warm current</i>	Not applicable
<i>Measurement current accuracy</i>	0.5%
<i>Keep-warm current accuracy</i>	Not applicable
<i>Channel matching</i>	Not applicable
<i>Parasitic emf suppression</i>	full current reversal
<i>Communication interfaces</i>	RS232 (USB to RS232 converter included)
<i>Power supply</i>	5 V DC nominal supply voltage (4.5 V to 12 V acceptable)
<i>Power consumption</i>	0.1 W typical
<i>Weight</i>	0.2 kg
<i>External dimensions (HxD)</i>	90 x 44 mm (cylinder excluding connectors)
<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 10 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 $\mu\Omega$) is constant over particular measurement range.

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 thermometer 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.

9.2.1 Specifications for PRT subranges (Pt100 option)

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	5 ppm of value	10 ppm of value	0.25 ppm/ $^{\circ}\text{C}$
R2	50 Ω	35 $\mu\Omega$	1 ppm of range	5 ppm of value	10 ppm of value	0.25 ppm/ $^{\circ}\text{C}$
R3	100 Ω	70 $\mu\Omega$	1 ppm of range	5 ppm of value	10 ppm of value	0.25 ppm/ $^{\circ}\text{C}$
R4	200 Ω	120 $\mu\Omega$	1 ppm of range	5 ppm of value	10 ppm of value	0.25 ppm/ $^{\circ}\text{C}$
R5	400 Ω	200 $\mu\Omega$	1 ppm of range	5 ppm of value	10 ppm of value	0.25 ppm/ $^{\circ}\text{C}$
R6	800 Ω	500 $\mu\Omega$	1 ppm of range	5 ppm of value	10 ppm of value	0.25 ppm/ $^{\circ}\text{C}$

9.2.2 Specifications for thermistor subranges (Thermistor option)

Range name	Range limit	Effective resolution	Nonlinearity	Short-term drift	Long-term drift	Temperature coefficient
H1	2.5 k Ω	3 m Ω	2 ppm of range	15 ppm of value	25 ppm of value	1 ppm/ $^{\circ}\text{C}$
H2	5 k Ω	4 m Ω	2 ppm of range	15 ppm of value	25 ppm of value	1 ppm/ $^{\circ}\text{C}$
H3	10 k Ω	8 m Ω	2 ppm of range	15 ppm of value	25 ppm of value	1 ppm/ $^{\circ}\text{C}$
H4	20 k Ω	14 m Ω	2 ppm of range	15 ppm of value	25 ppm of value	1 ppm/ $^{\circ}\text{C}$
H5	40 k Ω	20 m Ω	3 ppm of range	15 ppm of value	25 ppm of value	1 ppm/ $^{\circ}\text{C}$
H6	80 k Ω	60 m Ω	5 ppm of range	15 ppm of value	25 ppm of value	1 ppm/ $^{\circ}\text{C}$

9.2.3 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, 2 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!

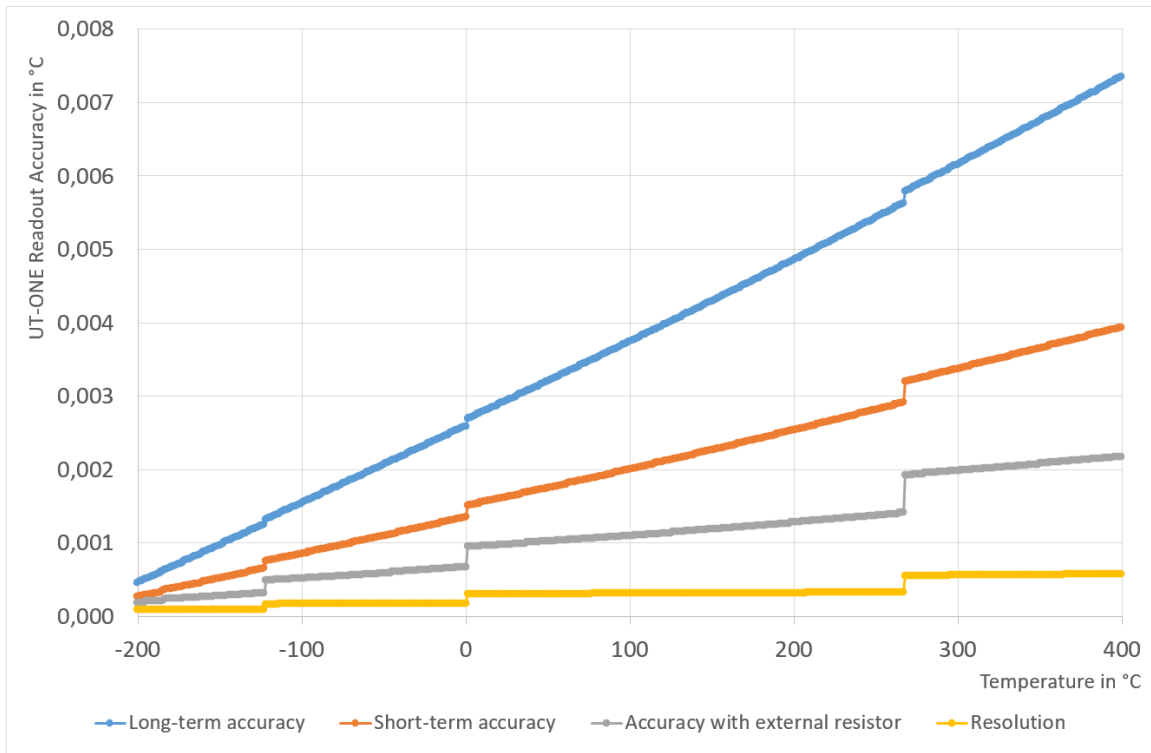


Figure 72: UT-ONE accuracy specification for Pt-100 probe

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.

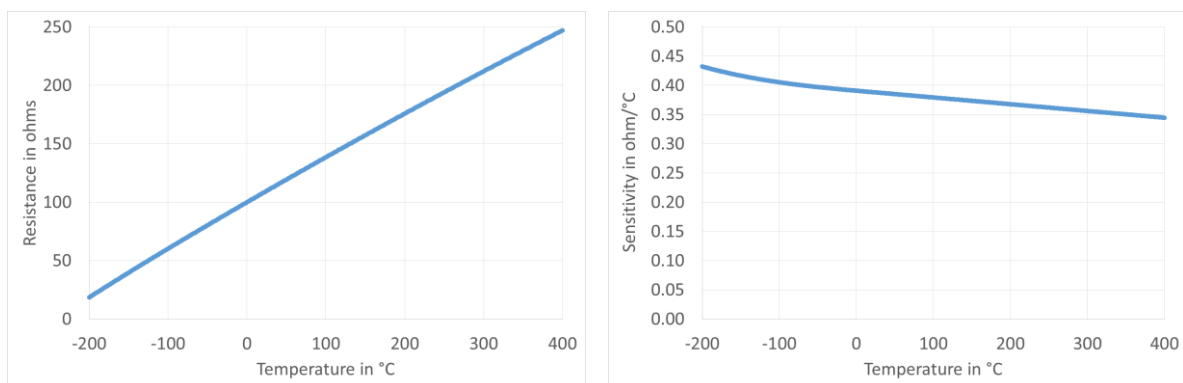


Figure 73: Resistance and sensitivity characteristic for Pt-100 probe

9.2.4 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, 2 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!

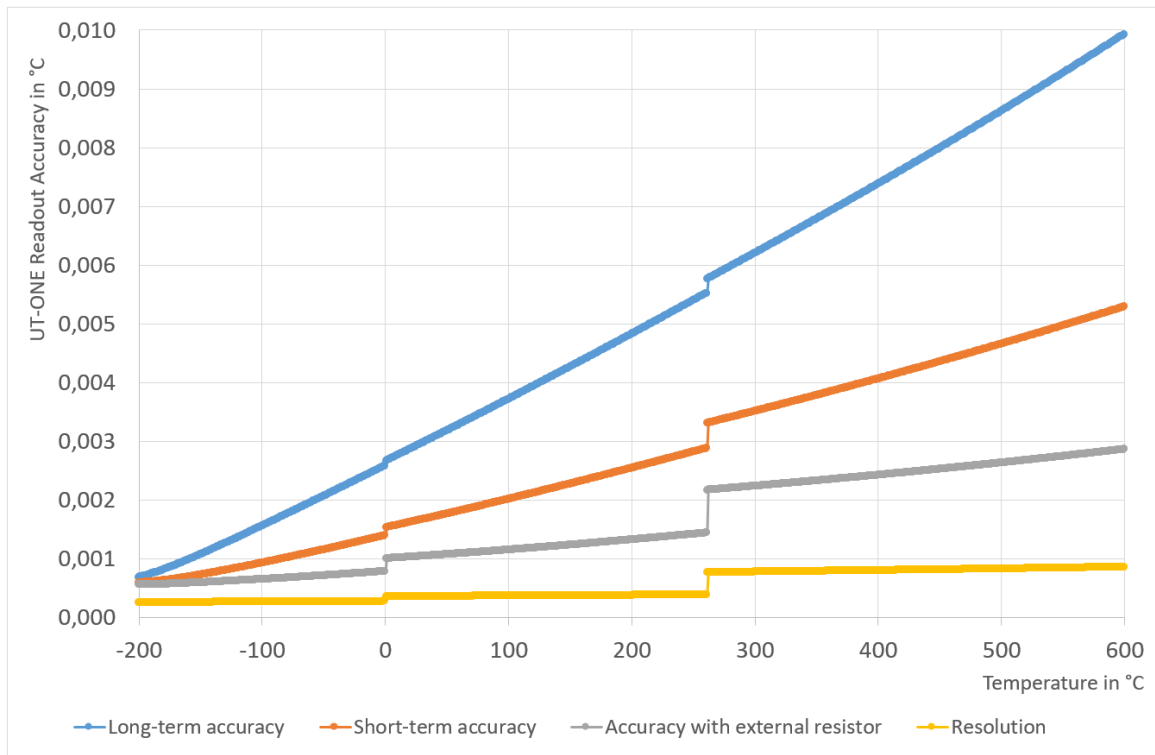


Figure 74: UT-ONE accuracy specification for Pt-25 probe

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.

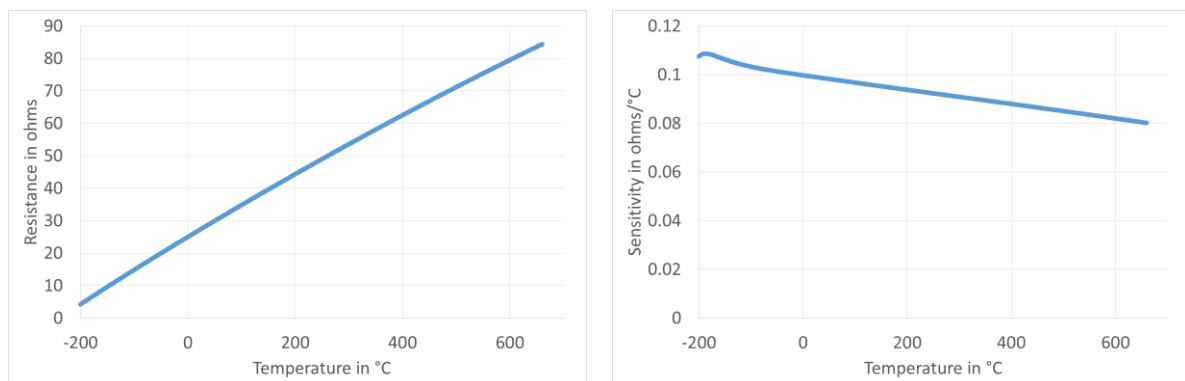


Figure 75: Resistance and sensitivity characteristic for Pt-25 probe

9.2.5 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 (10 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!

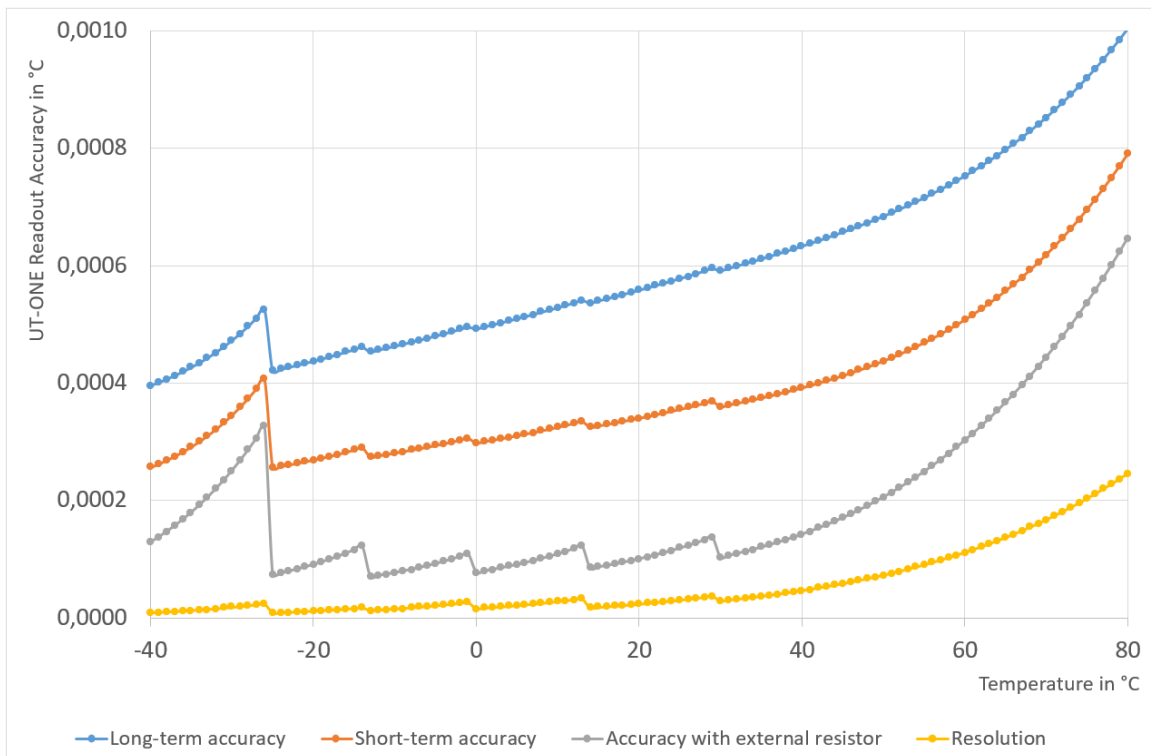


Figure 76: UT-ONE accuracy specification for 3K3A thermistor probe

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.

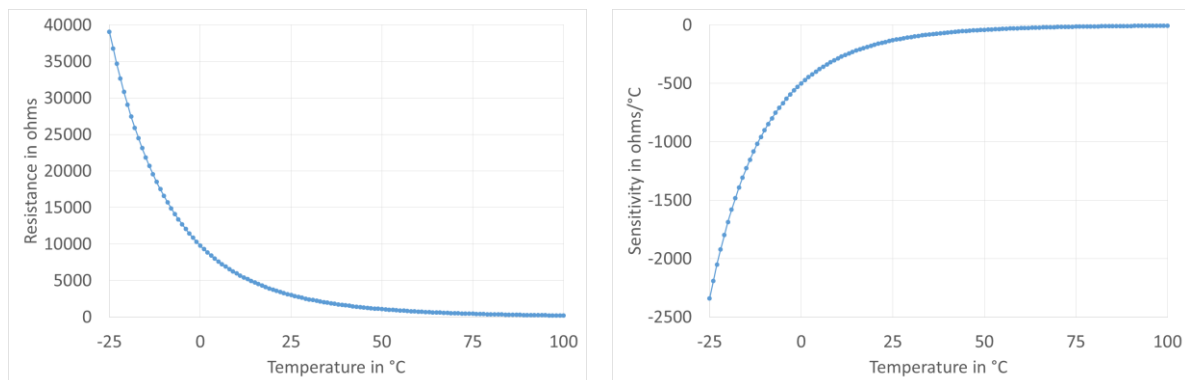


Figure 77: Resistance and sensitivity characteristic for 3K3A thermistor probe

9.2.6 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 (10 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!

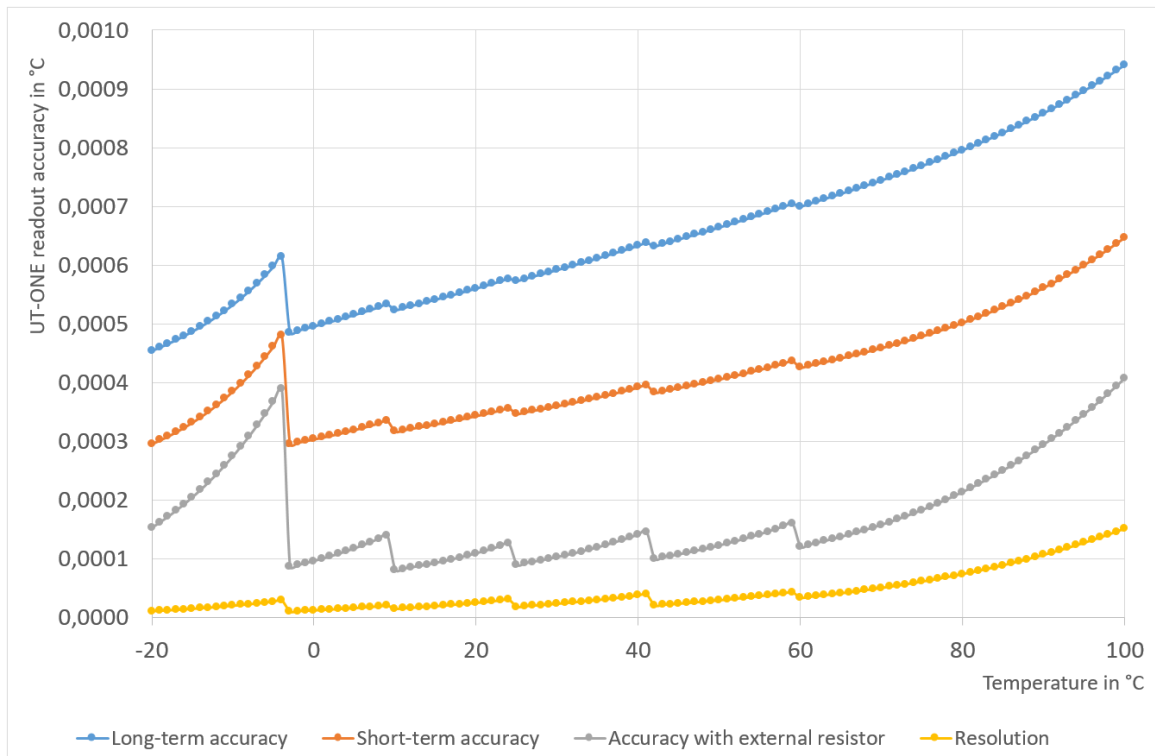


Figure 78: UT-ONE accuracy specification for 10K3A thermistor probe

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.

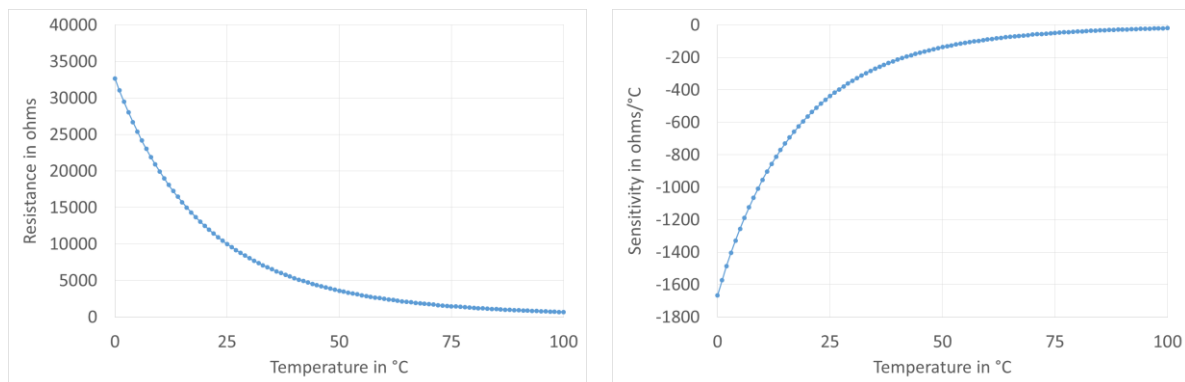


Figure 79: Resistance and sensitivity characteristic for 10K3A thermistor probe

9.3 Auxiliary channels

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>	-30 to 60 °C
<i>Temperature resolution</i>	0.01 °C
<i>Temperature accuracy</i>	±1 °C

9.4 Environmental specifications

Operating environment:	harsh environments, outdoor and indoor use, wet environments, laboratory and industrial environment
Operating temperature:	-30 °C to 60 °C
Operating relative humidity:	0 %rh to 100 %rh
Storage temperature:	-30 °C to 80 °C
Storage relative humidity:	0 %rh to 100 %rh
Ingress protection rating:	IP68 (with connectors or sealing caps attached)

10 Troubleshooting

1. *The communication with the device can't be established.*
Connect the device to a computer using the provided USB to RS232 converter. Start UT-ONE Applications software, UT-ONE Interface application. Select the correct COM port and try communication with different baud rates until you select the correct one (the software will display the device information after the communication is established).
2. *The device works with the provided USB to RS232 converter, but not in the actual measurement system.*
Check the power supply.
Check the baud rate setting.
If you are using long cables, try reducing the baud rate.
3. *The acquisition was started in continuous mode, but no results are returned.*
Check the averaging time. The maximum averaging time is 240 seconds per channel, which require up to 48 minutes before the first reading of all channels is returned.
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. *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.

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 and a thermistor with the same UT-ONE L01A device?*
No. Each UT-ONE L01A device is configured with either Pt100 or thermistor option during manufacturing. You must specify the correct option when ordering.
3. *Can I open the UT-ONE L01A housing?*
No. There are no serviceable parts inside the UT-ONE L01A housing. The interior is potted with the encapsulating resin, which completely seals the PCB and provides additional protection from water and contaminants. Trying to force-open the housing will break the connector cables and permanently destroy the device. Damage caused by force-opening the device is not covered by warranty.
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.

9. *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.

10. *Do I have to calibrate the UT-ONE resistance and voltage ranges in regular intervals?*

UT-ONE resistance and voltage ranges are factory adjusted to correct values within specified accuracy. However, as for any instrument, UT-ONE calibration values are subject to drift and regular calibration is recommended.

However, if UT-ONE is used only with a fixed set of non-interchangeable thermometer probes for measurement of temperature, the combination of UT-ONE and thermometer probes can be calibrated as single measurement instrument. This requires only temperature calibration (no voltage and resistance calibrations) and will generally produce best accuracy. The disadvantage of this approach is that the thermometer probes calibrations are linked to the particular UT-ONE unit and the readings of resistance and emf are irrelevant.