MBW calibration

Thermometer T12

Operation and Maintenance Manual

V1.1

Warranty

MBW Calibration Ltd. (MBW) guarantees that its products are manufactured to the highest quality of material and workmanship specifications. MBW guarantees the reliability of its products for a period of 24 months from the date of initial shipment when operated in normal use and within the specified design limitations. Under this Warranty, MBW will, at its discretion, repair or replace any component that upon examination by MBW or its duly authorized representatives proves to be defective during the warranty period provided the system is returned to the factory for inspection and repair shipping prepaid. Improper or unauthorized maintenance, storage, repair, or alteration of any kind by personnel other than MBW or its duly authorized representatives may void all warranties. Warranty may also be voided for misuse, neglect, accident, corrosion, and improper installation. This Warranty is exclusive and in lieu of any and all other warranties of merchantability, fitness for a particular purpose, or any other warranty, expressed or implied, and all other liabilities and obligations on the part of MBW. MBW will not be liable for any other claims or damages, either direct, indirect, or consequential arising out of the use of its products.

Original manuals are prepared in English and German. Translations in other languages are available, but in the event of any discrepancy, the German or English versions will be considered as the official version.

Subject to change without notice.

For the latest version of this manual please visit our website.

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MBW Calibration Ltd.
Seminarstrasse 55/57
CH-5430 Wettingen
Switzerland

+41 56 437 28 30 Phone
+41 56 437 28 40 Fax
sales@mbw.ch

www.mbw.ch

Table of Contents

1 Safety Instructions

- The housing of the T12 may only be opened by MBW or an approved service center.
- If the instrument was dropped or otherwise damaged, disconnect the power. Do not use the instrument anymore and contact MBW or an approved service center

2 Introduction

2.1 Multi-Channel Reference Thermometer

T12 is a highly precise and stable platinum resistance thermometer (PRT) multichannel temperature measurement system. Using a custom designed high quality measurement circuit, 273 bit analogue to digital converters and multiplexor sampling; the T12 provides 12 channels of low uncertainty temperature data for validation and calibration.

With one of the three selectable currents the T12 checked again and again every twelve channels. Through the use of full reverse polarity power source, the T12-sensitive eliminates errors which are normally associated with DC measurement technique.

Accuracy is achieved by a high stability of the internal reference resistors.

The included software allows each channel individually with ITS-90 or Callendar-Van Dusen coefficients of direct resistance measurements in temperature to convert. The T12 is connected via the RS-232 interface to a PC.

- Twelve channel temperature measurement
- High precision, stability and reproducibility
- Internal reference resistors
- PC software for system control and data acquisition
- Simple to configure and use

Typical Applications

- Climatic chamber validation
- Calibration systems
- Temperature calibration

2.1.1 Internal Reference Resistors

To compensate for any thermal effects on the T12's measurement systems, two internal reference resistors are used.

During each sampling sequence, the T12 measures low and high range reference resistance values to quantify any thermal effects on the measurement circuit. This means that for all measurement and operational conditions, the uncertainty component for temperature coefficients is minimized.

2.2 Fast Sampling Rate

For applications where fast sampling rates are required, the T12 is the ideal choice. The system provides the ability to scan all twelve channels under five seconds.

3 Installation

3.1 Scope of Delivery

The T12 is supplied as standard in a robust carry case including accessories. This case should be retained for use when storing or transporting the instrument or when shipping for re-calibration.

Standard delivery contents:

- Thermometer T12
- 12V DC external power supply
- Serial cable for COM port
- RS-232 / USB converter
- MBW GeckoR2 Software
- Operation and Maintenance Manual
- Calibration certificate
- Transport case

Optional contents:

- External temperature probes (Pt-100)
- Lemo connectors 305 FGG.1B CLAD42 for customers to make their own temperature probes

Before starting, carefully remove these items from the packaging and check for any signs of damage. Check the packing list contents are all included, and **if you are missing any item or find something is damaged, please contact the manufacturer or your supplier immediately.** Make sure that the power rating on the 12VDC power adapter is compatible with your site power specification.

The instrument was successfully tested and calibrated in this setup.

3.2 Power supply and serial interface

On the back of the T12 is a 12V DC power connection and a serial port for connection to a computer.

3.2.1 Power Supply

The T12 requires a 12V DC power source. This is provided by the power adapter included. Connect the adapter to an AC power source and the to the 12V DC connector on the T12. A green control LED next to the power connection indicates that the device is correctly powered.

Power Adapter Specification:

Input voltage:	100 - 240 V AC, 50 - 60 Hz
Output voltage:	12 V DC
Current:	max. 500mA

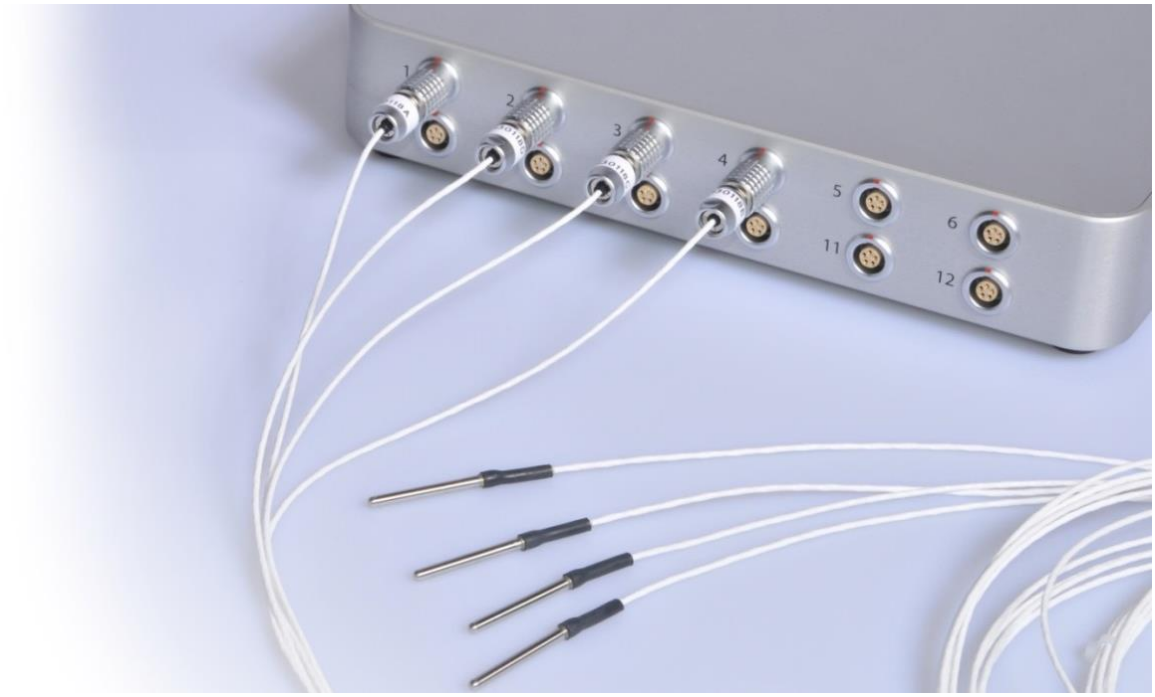
3.2.2 Serial Interface (COM)

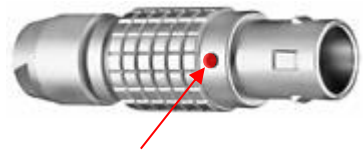
The T12 is controlled from the computer via an RS232 serial interface. Use the 9-pin serial cable supplied.

If your computer does not have an RS-232 port, you can use the supplied RS-232 / USB converter. The installation is described in chapter 'RS-232 / USB Adapter' on page 8.

3.3 Temperature Probe Connections

The T12 can measure up to twelve Pt100 temperature probes simultaneously. Probes are available from MBW or the user can fit their own. These are connected to the T12 using Lemo connectors as shown.

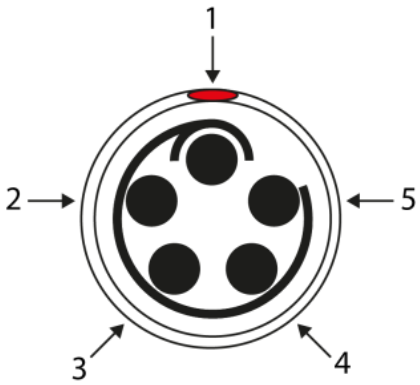




Red dot is aligned with pin 1

If you wish to connect your own temperature probe (PT-100), you need a 5-pin LEMO connector (www.lemo.ch), part number FGG 1B 305 CLAD 52.

After identifying pin 1, follow the line counter-clockwise from pin 1 to all other pins in succession. Wire the cable according to the following scheme:

Pin	Signal	Position	Description
1	Shield		When viewing the solder tubs of a disassembled 5-pin LEMO connector, pin 1 is usually identified with a full or partial circle drawn around it. Pin 5 should have no identifier. When wiring the cable, note that the pin numbering of the socket in the back panel of the instrument starts at the top left (pin 1) and goes counter-clockwise (as viewed from the rear of the unit).
2	+I		
3	+V		
4	-I		
5	-V		

3.4 Software Installation

3.4.1 GeckoR2 Software

MBW GeckoR2 software is supplied on a USB drive, CD-ROM, by email or download. This software does not require installation. Copy the file to the desired drive or folder on your computer. Gecko.exe can be run directly from this location. It is typical to copy Gecko the PC desktop and run from this location. Throughout this manual, a desktop location is the default used.

3.4.2 RS-232 / USB Adapter

The ES-U-1001-R10 / US232R-10 Serial/USB adapter is a standard accessory that goes with the T12.

This product is supported on multiple Operating Systems; Windows, MAC-OS, Linux, Android and WinCE 4.2 onwards.

In Windows 7, 8, 8.1 and 10 this adapter works without any driver installation (Plug and Play).

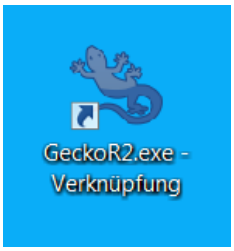
In other cases you will find the drivers here:
http://www.ftdichip.com/Drivers/VCP.htm

Installation instructions may be downloaded from:
http://www.ftdichip.com/US232R

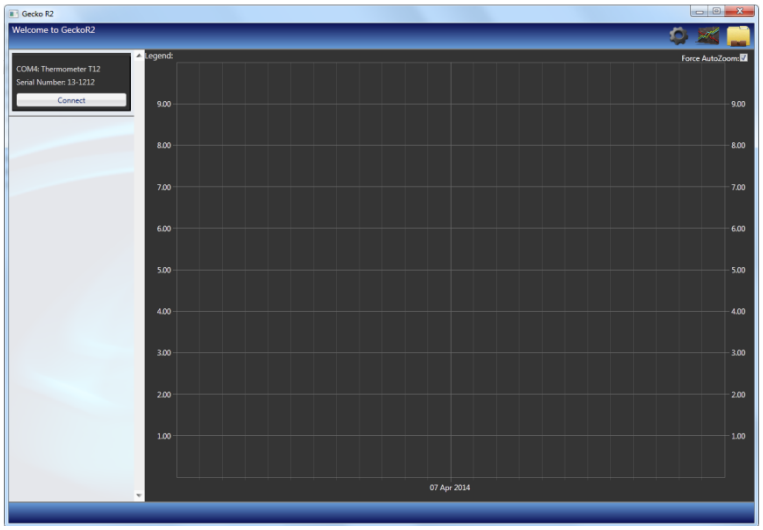
4 Operation

4.1 Start GeckoR2 and Connect T12

Make sure that the T12 is securely connected to the computer using an RS-232 cable and USB converter where needed. Gecko auto connects to the T12 via any COM port on the computer.

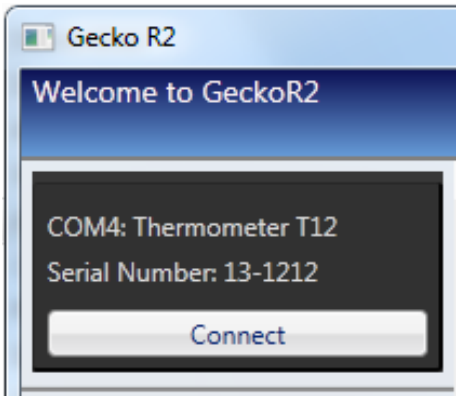


From the desktop there is an icon with the name 'GeckoR2'. Double-click this icon.



GeckoR2 software starts and the user interface of the software is displayed.

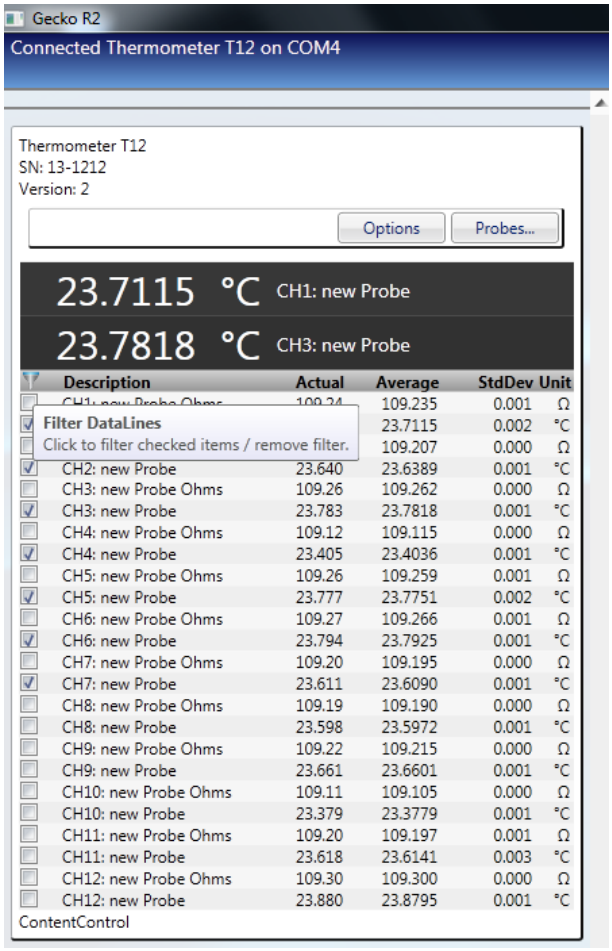
The attached T12 is auto-detected, connected and displayed at the top left. If you connect the T12 after starting the program, you must wait a few seconds for the software to recognize and connect the device. If T12 connection does not happen, check the power and interface connections.



Click on 'Connect' to complete the connection of the T12 to the GeckoR2 software.

4.2 Displaying Values

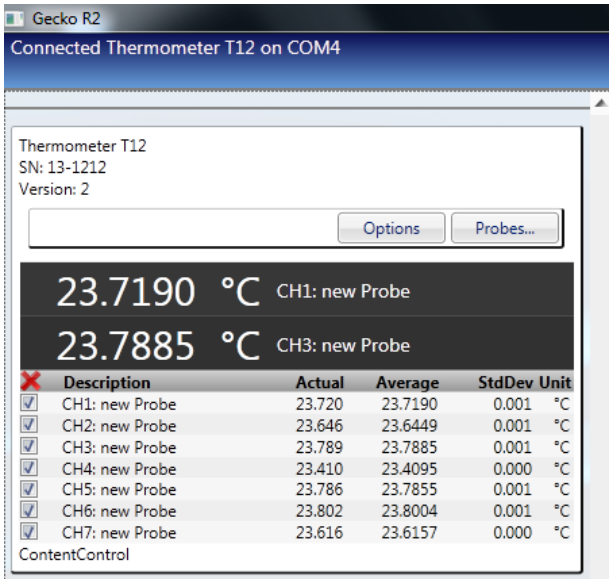
4.2.1 Hide and display channels



The software shows all channels of the Thermometer T12 in a table on the left-hand side.

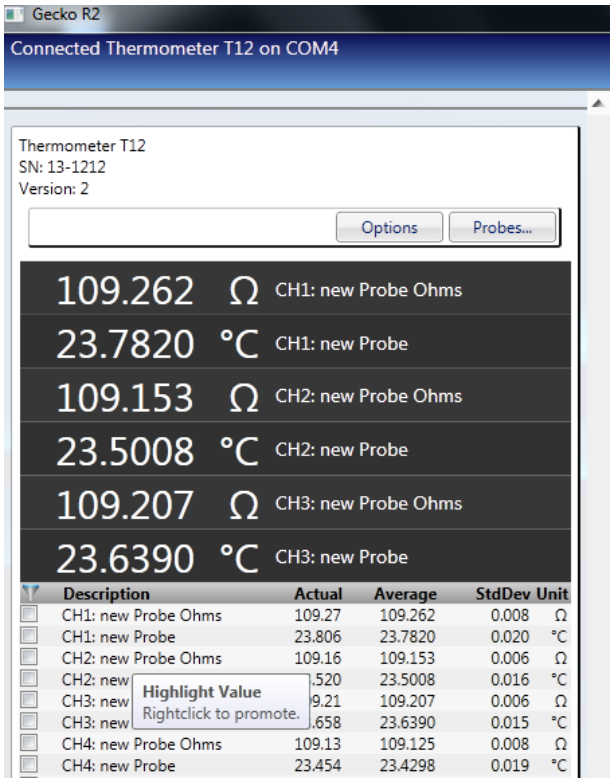
The table displays the channel number and probe description together with its resistance and temperature value. The current values are displayed beneath ***Actual***. ***Average*** shows you the average vaule at the given standard deviation ***StdDev*** and with its physical ***Unit***.

The software also provides a filter function. Tick the boxes of the channels you wish to display. Click on the Filter icon  and channels that are not required are hidden.



To reset and adjust the filter click on the red cross.

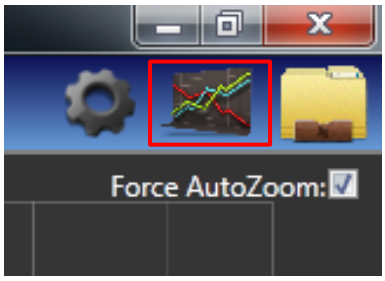
4.2.2 Highlight



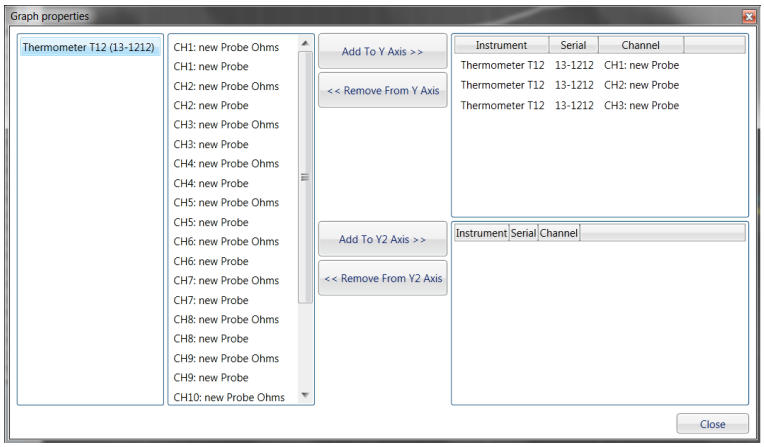
With a right click on a channel its average value will be displayed in large fonts above the table.

By a further right-click on highlighting the value disappears from the display.

4.2.3 Graphic Data Display



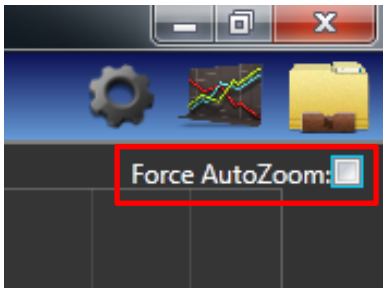
To display the values of a channel as a graph, click on the graphic symbol in the upper right hand corner.



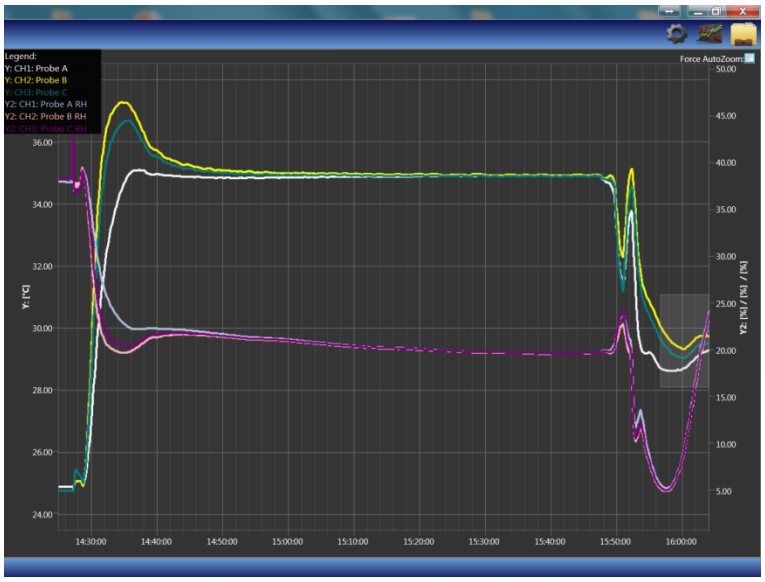
The first column on the left shows the connected instruments and the second column shows its channels. Mark the desired channel by clicking on it and assign it to the Y- or Y2-Axis by clicking on ***Add To Y Axis >>*** or on ***Add To Y2 Axis >>***.

To remove a channel from the graphic display, mark the respective channel in the right hand column and then click on ***<< Remove From Y Axis*** or ***<< Remove From Y2 Axis***.

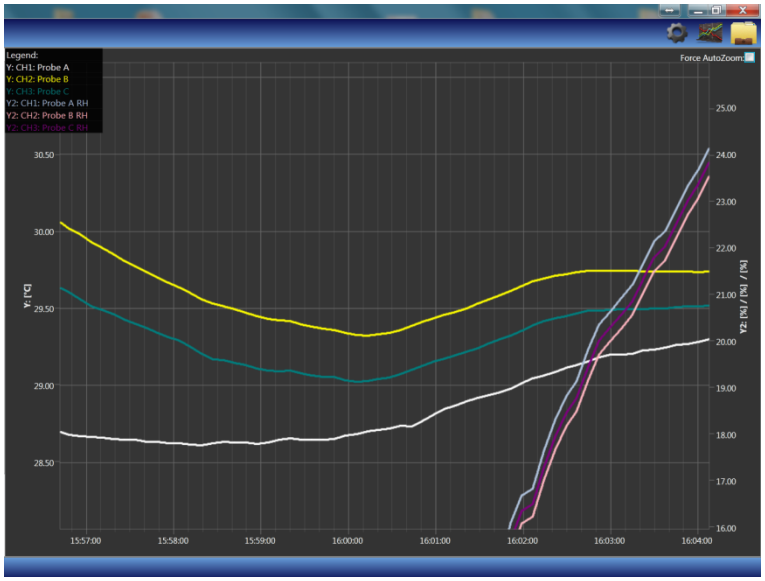
4.2.4 Zoom Function



Force AutoZoom must be deactivated to be able to manually adjust the zoom. Remove the tick next to ***Force AutoZoom*** to deactivate.



To enlarge an area of the graph, press and hold the left mouse button and drag a rectangle over the area you want to zoom in on.



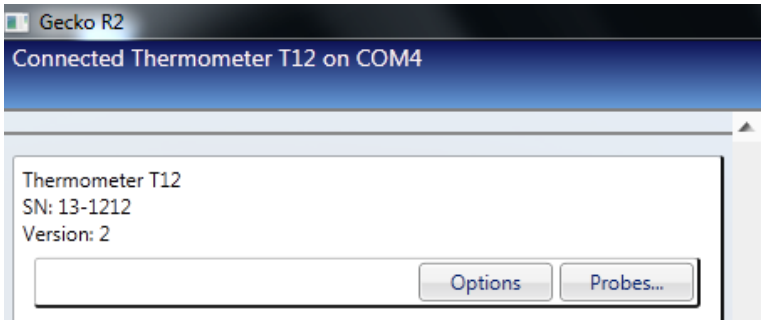
You can also zoom in or out on an area of the graph by using the scroll wheel of the mouse.

By positioning the cursor on the graph, holding the right mouse button and moving the cursor in any given direction you can move the current view.

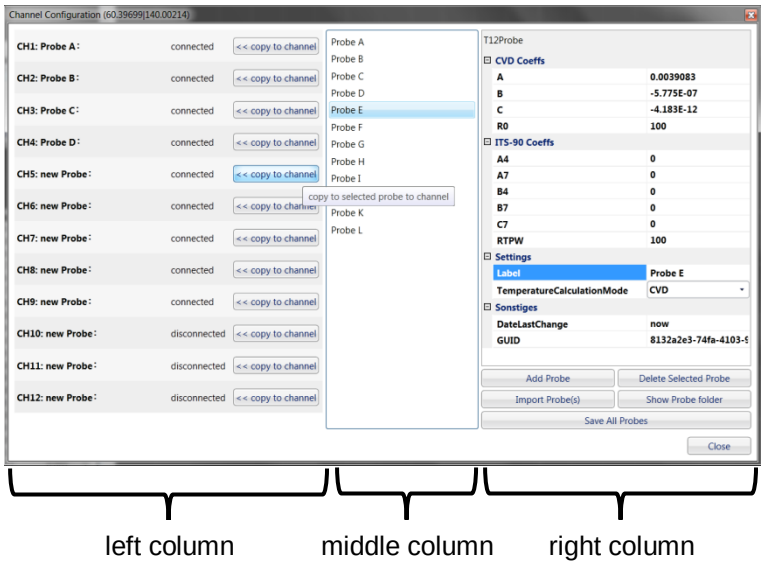
In order to make the entire graph visible again make a double click with the left mouse button.

4.3 Probe Settings

4.3.1 Configure a Probe Profile



To configure the temperature probes used with the T12, click on the ***Probes*** button.



A new window appears for the configuration of the probes. In the left column there is a list of the measuring channels with their assigned probes. In the middle column is a list of all previously saved probes to which a profile was configured. The right column displays the coefficients of the selected probe. For each probe used, a unique configuration must be created once. To do so, click on the button ***Add Probe***.

In the middle column a ***new Probe*** will appear. Click on this and enter the CVD or ITS-90 Coefficients in the right column.

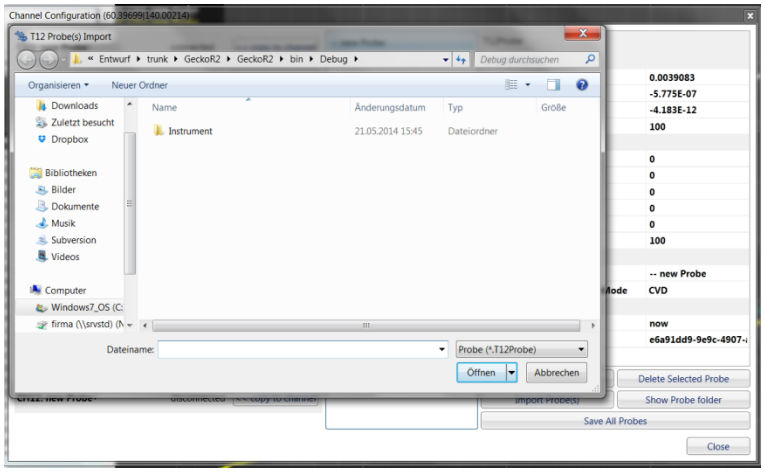
Under ***Label*** enter a name for the new profile to be able to unmistakably assign it to a probe.

By clicking on ***<< copy to channel*** you can assign the selected profile to a measurement channel and its connected probe.

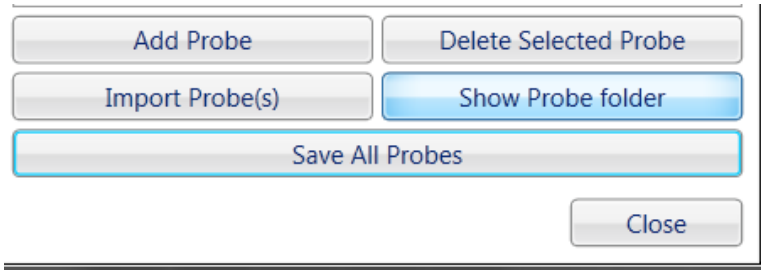
To save any changes click on ***Save All Probes***.

To delete a profile, select it in the middle column, and then click ***Delete Selected Probe***.

4.3.2 Import / Export



By clicking on ***Import Probe(s)*** you can import existing profiles (*.T12Probe). The imported profiles will appear in the list and you can assign them to a channel as described in the previous chapter.



By clicking on ***Show Probe folder*** you will be directed to the folder where the profiles of the probes are saved.

Use these files in case you would like to connect your probes to a different T12 or a different computer. These files can be imported by following the previously describes procedure.

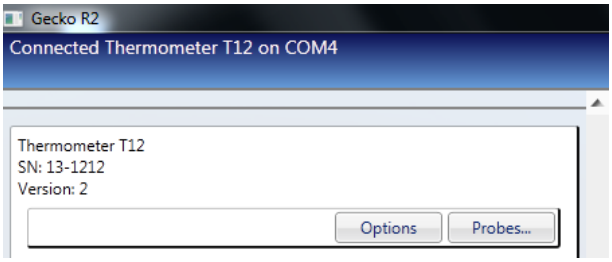
4.4 Climate Chamber Validation

4.4.1 Connecting a Dew Point Mirror

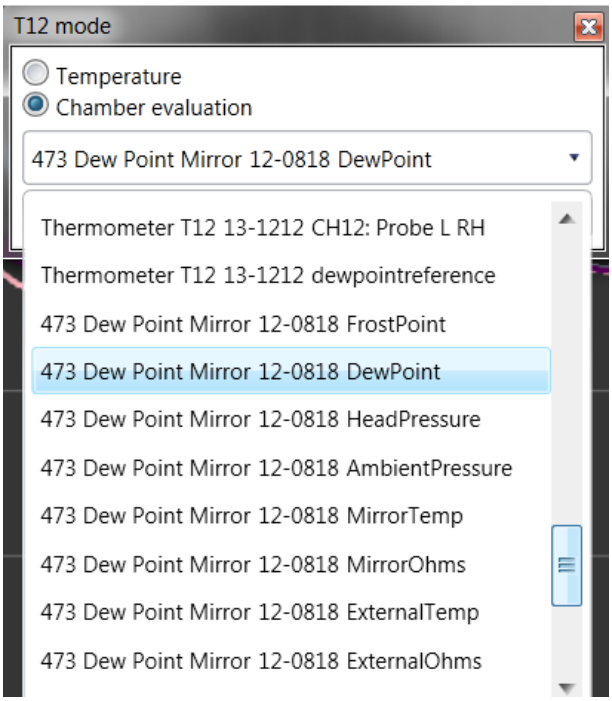
The GeckoR2 Software also recognizes connected dew point mirrors.

It may take a couple of seconds until the software recognizes the new instrument.

As soon as the connected instrument appears click on the ***Connect*** buttons of the instruments to connect them to the GeckoR2 Software.

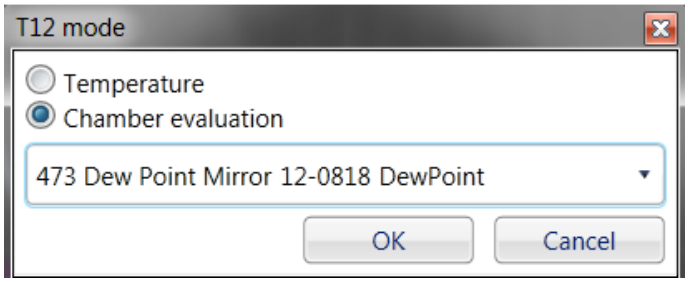


Click on the ***Options*** button.



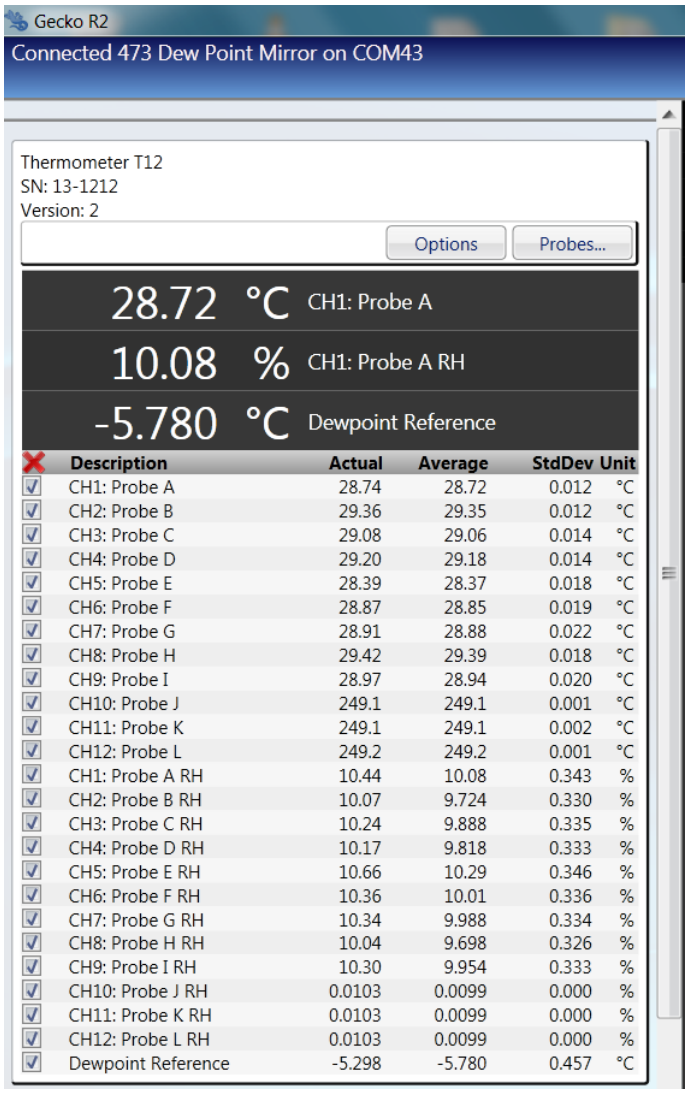
Change the T12 mode from ***Temperature*** to ***Chamber evaluation***.

In the Dropdown menu choose the reference value for the humidity measurement (dew point), which you need for the humidity calculation.



Confirm your selection by clicking ***OK***.

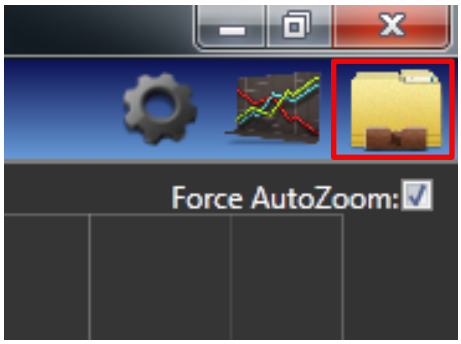
4.4.2 Measurement



Description	Actual	Average	StdDev	Unit
CH1: Probe A	28.74	28.72	0.012	°C
CH2: Probe B	29.36	29.35	0.012	°C
CH3: Probe C	29.08	29.06	0.014	°C
CH4: Probe D	29.20	29.18	0.014	°C
CH5: Probe E	28.39	28.37	0.018	°C
CH6: Probe F	28.87	28.85	0.019	°C
CH7: Probe G	28.91	28.88	0.022	°C
CH8: Probe H	29.42	29.39	0.018	°C
CH9: Probe I	28.97	28.94	0.020	°C
CH10: Probe J	249.1	249.1	0.001	°C
CH11: Probe K	249.1	249.1	0.002	°C
CH12: Probe L	249.2	249.2	0.001	°C
CH1: Probe A RH	10.44	10.08	0.343	%
CH2: Probe B RH	10.07	9.724	0.330	%
CH3: Probe C RH	10.24	9.888	0.335	%
CH4: Probe D RH	10.17	9.818	0.333	%
CH5: Probe E RH	10.66	10.29	0.346	%
CH6: Probe F RH	10.36	10.01	0.336	%
CH7: Probe G RH	10.34	9.988	0.334	%
CH8: Probe H RH	10.04	9.698	0.326	%
CH9: Probe I RH	10.30	9.954	0.333	%
CH10: Probe J RH	0.0103	0.0099	0.000	%
CH11: Probe K RH	0.0103	0.0099	0.000	%
CH12: Probe L RH	0.0103	0.0099	0.000	%
Dewpoint Reference	-5.298	-5.780	0.457	°C

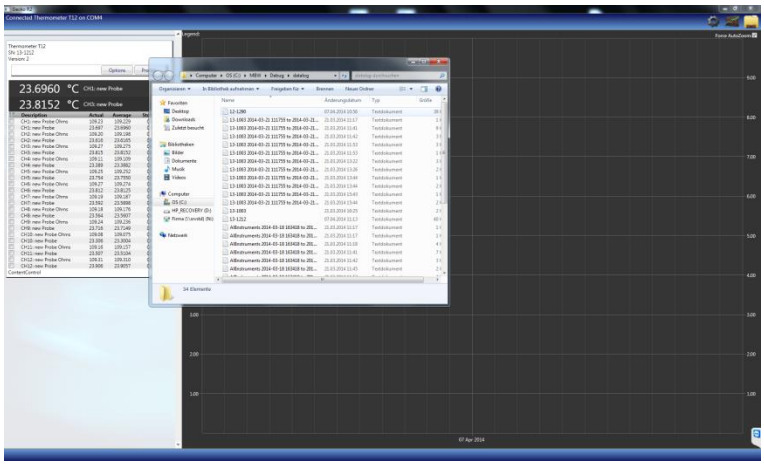
In this example we selected the dew point of a MBW Dew Point Mirror 473 as a reference. Now the relative humidity value for each temperature probe will be calculated automatically.

4.5 Log Files



Click on the folder icon in the upper right corner to open the directory containing the log files.

All log files are saved as a txt file.



The file name includes the instruments serial number for identification. When doing a new measurement, no new log file will be created but the data will be saved into the existing log file.

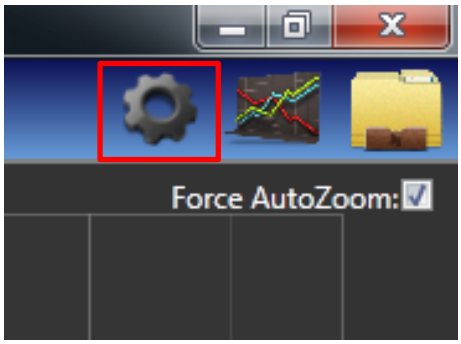
If several MBW devices are simultaneously connected to the computer, a combined log file may be useful. This file will also be created automatically and is named *AllInstruments.txt.*

After completion of the measurement a date and time stamp will be added to the file name:

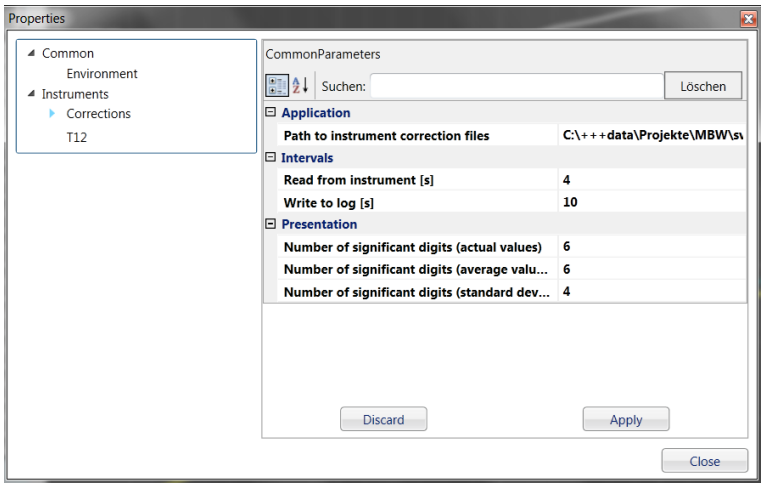
AllInstruments JJJJ-MM-DD Startzeit to JJJJ-MM-DD Stoppzeit.txt

Example:
AllInstruments 2013-12-04 161352 to 2013-12-04 163526.txt

4.6 Software Settings



To be able to change the software settings, click on the settings symbol in the top right corner.

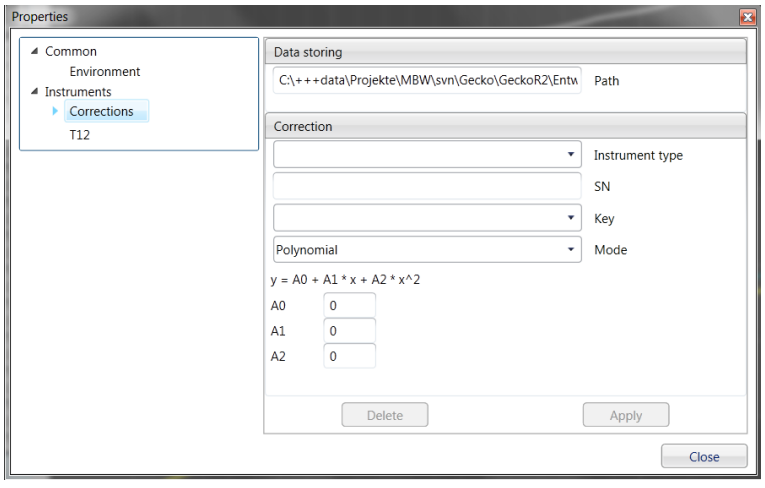


Under ***Environment*** you can change the software settings to suit your requirements.

Choose the number of significant digits you would like to be displayed.

You can also set the measurement and logging interval.

4.6.1 Correction

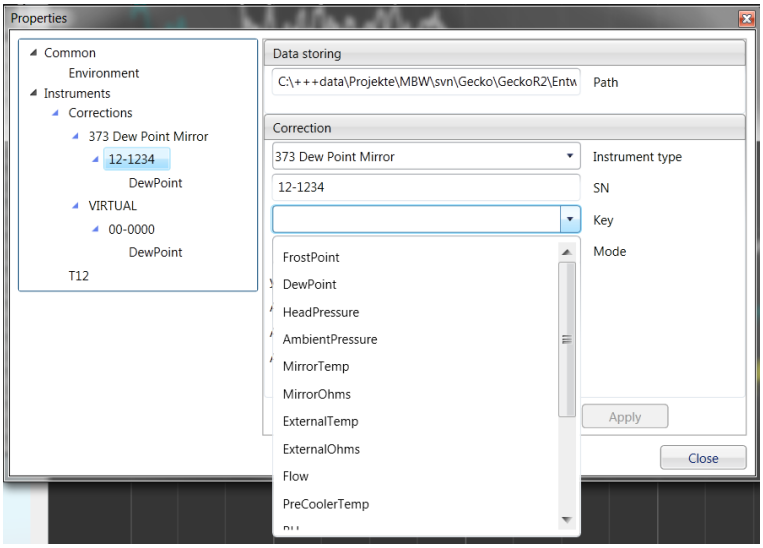


You have the possibility to correct the data of the dew point mirrors with new coefficients.

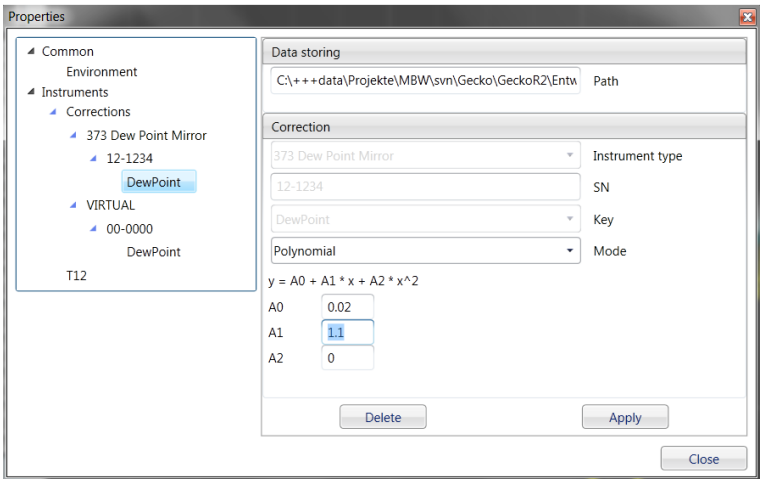
The certificate of the dew point mirror shows the deviation that may be corrected.

Calculated values like relative humidity can be generated using the corrected measurement data.

Use the dropdown-menu ***Instrument type*** to choose the instrument of which you would like to correct the data and enter the respective serial number in the ***SN*** field.

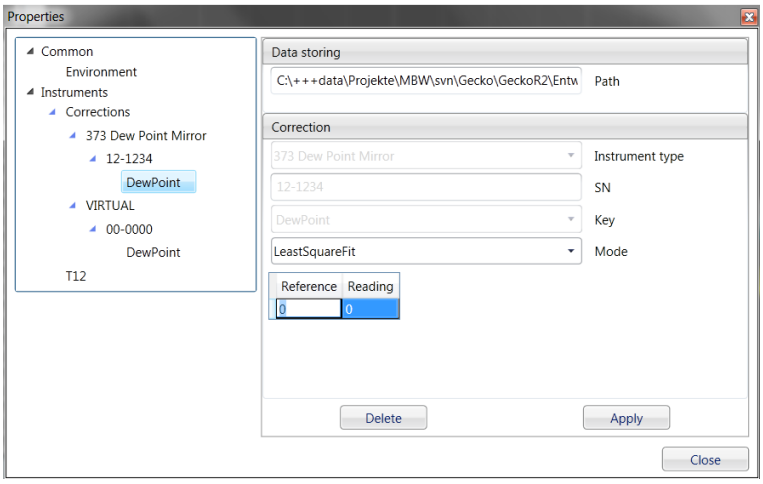


Choose the parameter to be corrected from the dropdown menu ***Key***.



By choosing the ***Mode Polynomial*** you can directly enter the new coefficients (A0, A1 and A2).

Confirm the correction by pressing ***Apply***.



By choosing the ***Mode LeastSquareFit*** you can enter multiple measuring points of the instrument to be corrected and of its reference in form of a table.

Confirm the correction by pressing ***Apply***.

When connecting the instrument to the software anew after entering the corrections, you will see two values for all the corrected parameters, for example:

DewPoint - unchanged as read by the instrument

DewPoint_Corrected – new value with applied correction

5 Application Examples

5.1 Ice Test for Temperature Sensor Calibration

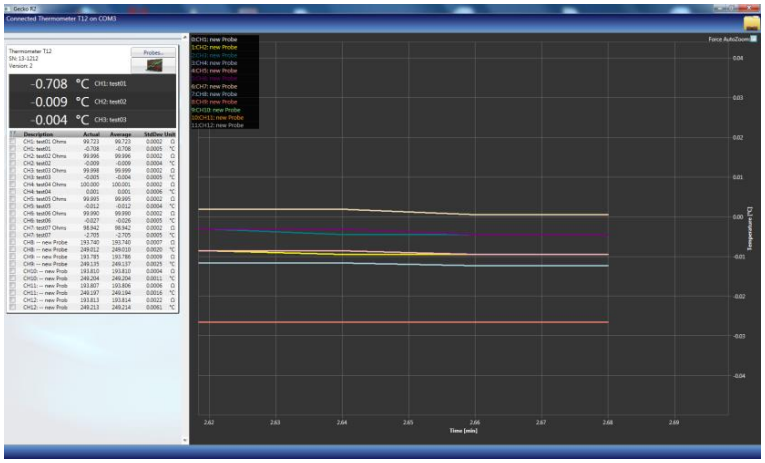
The ice test provides an easy-to-implement method to check temperature probe stability. Use the thermometer T12 to read the values of your temperature sensors and display them using the MBW GeckoR2 software. Dewar

In preparation, distilled water is frozen and then shredded using for example an ice crusher. Then, a Dewar flask is filled with the crushed ice and topped up with distilled water. It is important to ensure that sufficient ice is present in the flask, so that the ice reached down to the bottom and does not float.

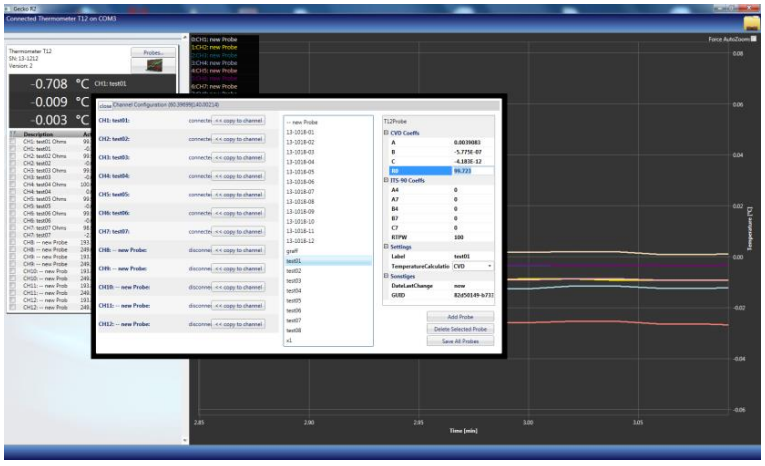
Connect your temperature sensor to the T12 and insert it into the ice/water mixture. The temperature sensors must not touch each other or the wall of the flask. Then the Dewar flask should be insulated as best as possible to keep the ambient influences to a minimum.

Connect the T12 via serial port to your computer and start the MBW GeckoR2 software. After successfully connecting the instrument by clicking on ***Connect***, the software starts displaying the measurement data in tabular form (left) and as a graph (right). In addition, the measured data is automatically stored in a log file and accessible at all times.

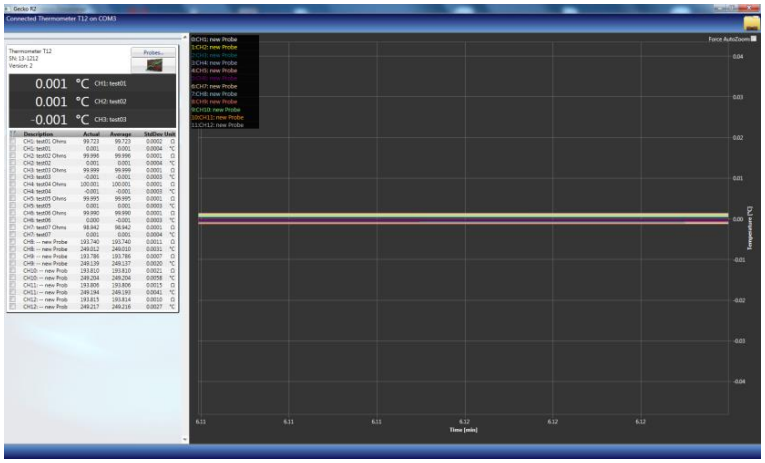
For further information on the MBW GeckoR2 software, go to the chapter 4 ‘Operation’ on page 9.



To verify drift and stability of the temperature sensors, they have to stay in the ice/water mixture for at least 15 minutes, until the average temperature is approx. 0 °C and the standard deviation is less than 1/100.



Deviations can be corrected directly in the software. Click on ***Probes…*** to change the sensor parameters. Please enter the average resistance value (for Pt-100 approx. 100Ω) in the entry field next to ***R0***.



After changing the parameters click ***Save All probes*** and the values will be adjusted immediately.

5.2 Climatic Chamber Calibration

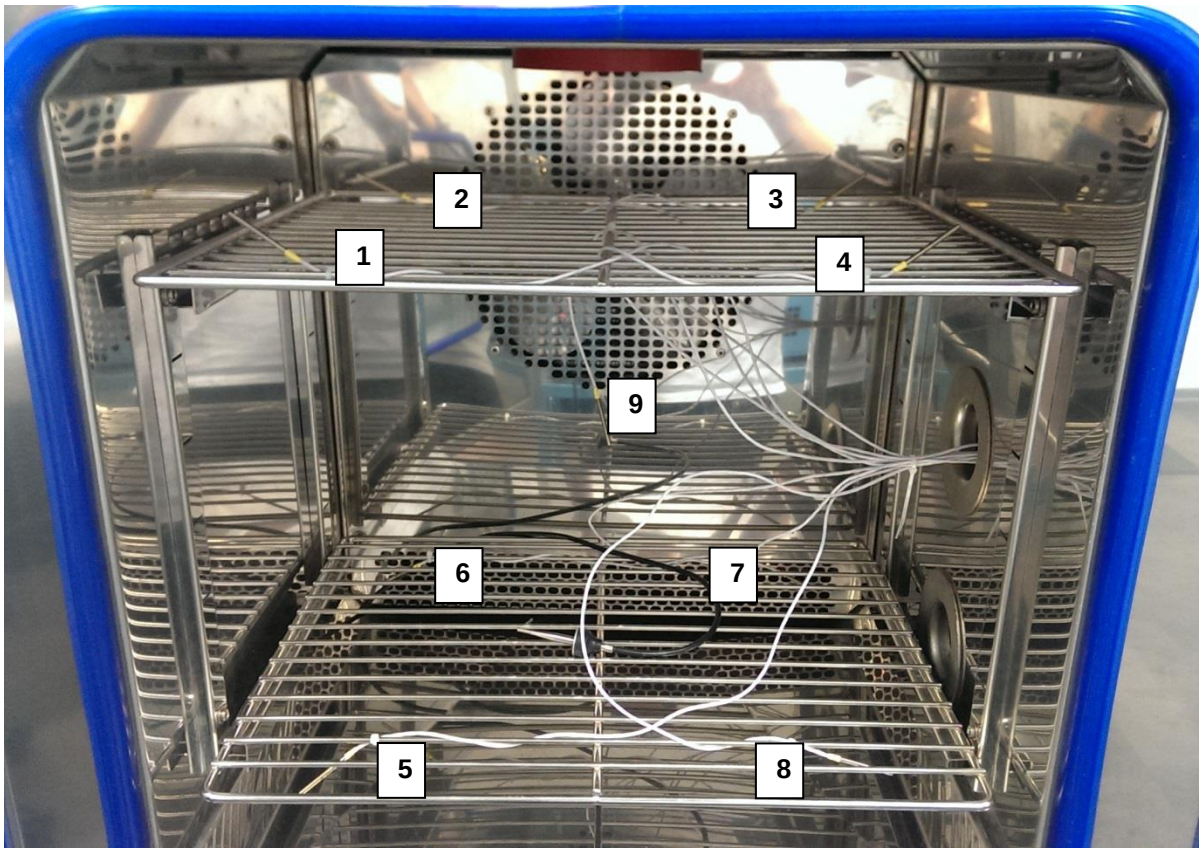
To obtain the relative humidity, the method of using a chilled mirror for dew point measurement in combination with the temperature measurement is widespread. To achieve the required specifications and to comply with governmental or laboratory standards, a periodic validation of the climatic chambers is necessary. The chamber can be tested loaded or unloaded. Evaluating temperature and relative humidity in a climatic chamber is part of the IEC 60068, and requires nine sensors for temperature measurement, which are essential for the determination of the relative humidity. The T12 is particularly suitable for this application because with this multi-channel thermometer you can evaluate up to 12 probes simultaneously. Temperature

5.2.1 Temperature

In this example a CTS climate chamber is being validated. To measure temperature a thermometer T12 is being used with nine temperature probes.

If you purchase the temperature sensor as a set with the T12, then the set is calibrated and certified by the MBW SCS accredited calibration laboratory. Therefore there is only one uncertainty for the complete set which is lower than for equipment purchased separately.

In each corner and in the center of the chamber, a temperature sensor is mounted and connected to the T12.



The T12 is connected to a computer via the serial interface and the values are collected and displayed by the software. The measurement values are automatically saved in a log file.

A complete result of a temperature calibration should contain following information:

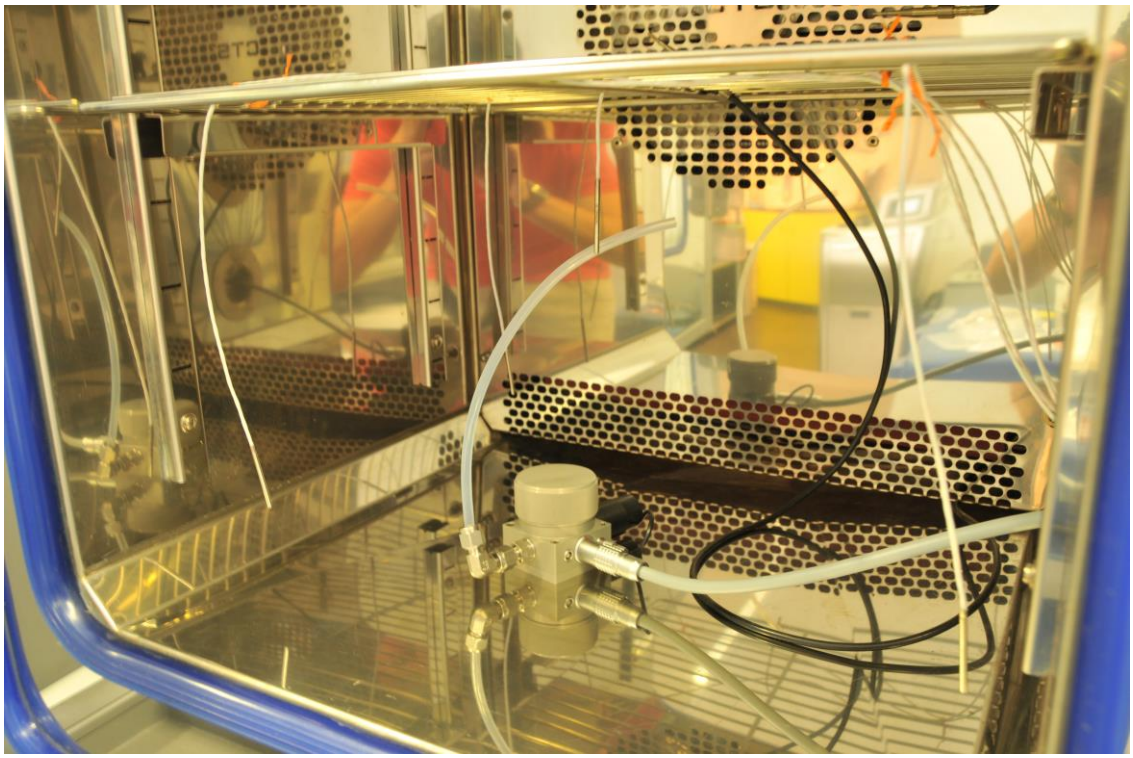
- Correction or deviation of the temperature measurement
- Uncertainty of the temperature measurement
- Detailed uncertainty budget including influence of chamber homogeneity, stability, radiation, wall temperature, etc.
- Environmental conditions

(For more detailed definitions you may refer to the guidelines DKD DKD-R 5-7 and DIN EN 60068-3-5:2002).

5.2.2 Relative Humidity

A widely used method for validation or calibration of the working volume of a climatic chamber is based on the use of a chilled mirror to measure the dew point temperature of the chamber environment. In combination with the temperature measurement, the relative humidity can be calculated.

In this example we also use a CTS chamber. To measure the dew point we use a MBW 473-SH2 with an external chilled mirror and a thermometer T12 with nine temperature probes.



Following MBW products are suitable for external sampling of a climate chamber:

- 373H, 373HX and 573H for dew points up to +95 ° C
- 373S, 573S, 973 for dew points up to ambient temperature

The external chilled mirror is mounted in the center of the climate chamber and connected to the 473-SH2 with a cable. As previously described the temperature sensors are mounted one in each corner and one in the center of the chamber and connected with the thermometer T12.

The T12 as well as the 473-SH2 is connected to a computer via serial port. The software included in the standard delivery set of the T12 allows to simultaneous operate and read the data of both instruments. The software calculates the relative humidity based on the measured dew point and temperature values.

A complete temperature calibration for temperature and relative humidity should contain following information:

- Correction or deviation of the temperature measurement
- Correction or deviation of the humidity measurement
- Uncertainty of the temperature measurement
- Uncertainty of the humidity measurement
- Detailed uncertainty budget including influence of chamber homogeneity, stability, radiation, wall temperature, etc.
- Environmental conditions

(For more detailed definitions you may refer to the guidelines DKD DKD-R 5-7 and DIN EN 60068-3-5:2002).

6 Maintenance & Calibration

6.1 Maintenance and Calibration Intervals

Do not operate the instrument in an excessively wet, oily, dusty, or dirty environment. A dirty instrument housing may easily be cleaned with a damp cloth. Please handle the instrument with care. Do drop the instrument, bang it against other objects or expose it to vibration.

The T12 is factory tested and calibrated. Nevertheless, it is recommended to regularly check and calibrate the reference resistors and the temperature sensors in use.

Recommended maintenance and calibration interval:

Operation	Interval	Resources required	By whom
Calibration of the temperature probes	Monthly or when needed	Insulated dewar, double distilled water, crushed ice, reference thermometer	User
Calibration of internal reference resistors	12 months	Calibrated reference resistor	User or MBW
Adjustment of the T12	Only if internal reference resistor deviation is out of specification		MBW

6.2 Calibration

6.2.1 Internal Reference Resistors

The T12 including the internal reference resistors is built using high quality components which have proven to be very stable over a long period of time. Nevertheless, it is important that you perform the calibration and maintenance as suggested in the previous chapter. To perform such a calibration use known reference resistors and connect them to the LEMO connections of the T12. In the appendix you will find an example of a MBW calibration certificate in which the used reference resistors are listed.

If the measurement data show large deviations contact MBW or an authorized representative to perform an adjustment.

Do not perform any adjustment on the T12 by yourself! This may lead to the loss of the warranty.

6.2.2 Temperature Probes

The temperature probes which are used in combination with the T12 must be calibrated regularly, regardless of whether the temperature sensors were obtained from MBW or another supplier. The recommended calibration interval is described in chapter 6.1 'Maintenance' on page 27.

For such a calibration, the ice-test described in chapter 5.1 'Ice Test for Temperature Sensor Calibration' on page 21 is suitable.

7 Specifications

Specifications	Thermometer T12	
Measuring Ranges		
Temperature	-200...800 °C (PRT Pt-100)	
Resistance	0…380 Ω	
Performance	**for the range of -200…250 °C**	
Resolution	0.1 mK	
Accuracy (T12 only)	≤ ± 2 mK @ 23 °C (95% confidence level, 1 year)	
Temperature coefficient	0.1 mK/ °C	
Standard Features		
Available inputs	12 channels	
Temperature sensors	Pt-100 Platinum Resistance Thermometer (PRT), 4-wire, shielded	
Supported coefficients	ITS-90, Callendar-Van Dusen	
Excitation current	0.33, 0.66 und 1 mA (range dependent), reversing DC	
Reference resistors	2 internal	
Data output	RS-232 (incl. USB adapter)	
Control and data acquisition	MBW GeckoR2 Software	
Logging interval	User programmable from 5 seconds to 60 minutes	
Sampling rate	< 5 seconds for all channels	
Enclosure type	Aluminum, IP65	
Power supply	External AC/DC power supply with 1.5 m cable (indoor use only)	
Operating instructions	English / German	
Calibration certificate	Resistance calibration	
CE compliance	Safety and EMC	
Accessories		
Temperature probes	Calibrated and uncalibrated PRT's available	
Connectors	LEMO plugs (305 FGG.1B.CLAD42)	
Additional Information		
Digital I/O	Bi-directional RS-232	
AC power	100-240 V, 50/60 Hz	
DC power	12 V, 0.3 A / Max. 5W	
Maximum operating conditions	0 °C…+50 °C, max. 98 %rh, non-condensing	
Storage temperature	-20 °C…+50 °C	
Weight & Dimensions	**Instrument**	**Instrument in transport case**
Dimensions (L x W x H)	190 x 235 x 45 mm	430 x 500 x 180 mm
Weight	2 kg	5 kg

We reserve the right to change design or technical data without notice.

8 Appendix

MBW Calibration Ltd.
Seminarstrasse 55/57
CH-5430 Wettingen
Schweiz

Telefon +41 56 437 28 30
Fax +41 56 437 28 40

www.mbw.ch
calibration@mbw.ch

Kalibrierzertifikat (Beispiel)
Calibration Certificate (Example)

Zertifikat Nr: Certificate No.:	XXXXMBW2013
Prüfling: Unit under Test:	Thermometer
Hersteller: Manufacturer:	MBW Calibration AG
Typ: Type:	T12
Serien-Nr.: Serial No.:	00-0000
Datum der Kalibrierung: Date of Calibration:	XX.XX.XXXX
Unterschrift: Signature:	

Messverfahren
Measurement Method

1. Justieren der internen Referenzwiderstände.
   Check of internal reference resistors.
   Referenz 1 / reference 1: 60.39508 Ω
   Referenz 2 / reference 2: 140.00536 Ω
2. Anschluss von Bezugswiderständen.
   Comparison with Reference resistance values.

Messbedingungen
Measurement Conditions

Während den Messungen befand sich das Gerät in einer Umgebungstemperatur von (23 ± 3)°C. Alle Messwerte des Prüflings wurden über die serielle Schnittstelle RS-232 ausgelesen und mit der mitgelieferten Software zum T12 / Gecko dargestellt. Alle in diesem Zertifikat ausgewiesenen Messwerte sind Mittelwerte, welche über eine Zeitspanne von mindestens 10 Minuten aus min-

destens 30 Werten ermittelt wurden.

During the measurement the instrument was exposed to ambient temperature of (23 ± 3) °C.
All measurement values of the test object were read through the serial interface RS-232 and displayed with the supplied T12 / Gecko software. All the measurement values reported in this certificate are the arithmetic averages calculated based on at least 30 values measured over a time period of at least 10 minutes.

Messresultate
Measurement Results

Referenzwert Reference value	Wert des Prüflings Reading of unit under test	Abweichung zum Referenzwert Deviation from reference value	Erweiterte Messunsicherheit Extended measurment uncertainty
Ω	Ω	Ω	Ω
4.9996	4.9997	0.0001	0.00037
24.9994	24.9997	0.0003	0.00045
50.0009	50.0005	-0.0004	0.00062
59.9985	59.9984	-0.0001	0.00071
70.0003	70.0003	0.0000	0.00079
80.0036	80.0037	0.0001	0.00088
90.0000	89.9999	-0.0001	0.00097
99.9985	99.9986	0.0001	0.00107
109.9992	109.9995	0.0003	0.00116
119.9975	119.9978	0.0003	0.00126
129.9979	129.9981	0.0002	0.00135
140.0013	140.0015	0.0002	0.00145
150.0059	150.0058	-0.0001	0.00155

Rückführbarkeit
Traceability

Präzisionswiderstände Vishay / Precision Resistors Vishay
Kalibrierzertifikat Nr. 212-04581, METAS, 07.08.2012

Messunsicherheit
Measurement uncertainty

Die angegebene Messunsicherheit ist das Produkt der kombinierten Standardunsicherheit mit einem Erweiterungsfaktor von k=2. Dies entspricht einem Vertrauensinterval von etwa 95%. Die Unsicherheit wurde in Übereinstimmung mit den Richtlinien „International Guide to the Expression of Uncertainty in Measurement“ (GUM:1995) ermittelt und beinhaltet die Messunsicherheiten des Prüflings. Die angegebenen Messunsicherheiten beziehen sich nur auf die hier aufgeführten Messungen und machen keine Aussage über die Langzeitstabilität des Prüflings.

The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor k=2, providing a level of confidence of approximately 95%. The uncertainty evaluation has been carried out in accordance with the “International Guide to the Expression of Uncertainty in Measurement” and is inclusive of the unit under test. The uncertainties relate only to the measured values and do not carry any implication regarding the long term stability of the instrument.