User Maintenance Manual

microK 2

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Issue 1.00

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1 Introduction

The microK^2 series of bridges replaces and builds on the success of the original microK launched in 2006.

The microK^2 works with all the three main thermometer types: RTDs/PRTs/SPRTs, thermocouples and thermistors. So, whether you are calibrating SPRTs or noble metal thermocouples in fixed points, calibrating industrial thermocouples or PRTs against a reference standard in a bath or making precision temperature measurements, the microK^2 is the only thermometry instrument you should need in your laboratory. The four measurement channels can be expanded up to 93 channels by using the companion scanner device: microsKanner-HC.

Despite its sophistication, microK^2 is very easy to use. The large, touch sensitive screen displays context sensitive menus that provide an intuitive user experience. Users can plug in a USB mouse and/or keyboard to make data-entry and instrument control even easier.

Readings can be displayed in resistance ratio, ohms, volts or temperature units (°C, °F or K). Algorithms for conversion to temperature include:

PRTs:	ITS-90
	Callendar-Van Dusen: IEC60751 (ASTM E1137) Callendar-Van Dusen: Custom coefficients
Thermocouples:	IEC584-1 (ASTM E230 & E1751) for type B, E, J, K, N, R, S, T
	Type L polynomial
	Au-Pt Reference Function Polynomial
	Pt-Pd Reference Function Polynomial
Thermistors:	Steinhart-Hart
	Polynomial (third order)

This manual provides a comprehensive guide to using the instrument and covers all the features of the microK^2 as well as the performance differences of the various models (as declared in the specification – section 10). You will probably not wish to read it through at this time, if so please read the safety section 1.3, take one of the tutorials in section 2 and then refer back to the manual using the list of contents to find additional information as required.

1.1 Migrating from Original microK

Users familiar with the original microK will notice a number of changes/improvements:

- Improved measurement performance (lower uncertainty)
- Lower measurement noise, especially with thermistors
- 2.5x larger screen (10.1” = 256 mm replaces 6.4” = 162 mm)
- 3.3x greater screen resolution (1280 x 800 WXGA replaces 640 x 480 VGA)
- Maximum sense current of 14.2 mA (increased from 10 mA)
- Display two channels on the same graph (instead of just one) allowing a DUT and reference to be viewed at the same time
- More responsive touch screen (PCT replaces 4-wire resistive)
- More channels (four instead of three)
- Channel 4 on rear for expansion instead of losing channel 1

- Three USB Host ports (increased from one) to allow connection to keyboard, mouse and flash drive without an external hub
- LEDs show which channel is being measured
- Power switch on front panel (previously on rear)
- Two RS232 ports (instead of one) allowing RS232 connectivity with microK^2 even when expanded using a microsKanner-HC
- Ethernet port on all models (previously only premium models)
- IP subnet mask now supported (previously fixed at 255.255.255.0)
- New binding posts with smoother action
- Improved processor (ARM Cortex A9 replaces ARM v5TE) giving faster measurement times
- Full access to measurements in temperature units and to the thermometer and resistors databases via SCPI commands on Ethernet, RS232 or GPIB interfaces
- Improved software update facility, now with roll-back feature
- Improved password recovery facility ("back-door" password eliminated)

1.2 Unpacking

Your microK^2 product should comprise the following items:

- microK^2 precision thermometry bridge
- Power cable suitable for your country
- This user manual

If any item is missing or damaged, please report this immediately to your supplier. If possible, we recommend that you retain the packaging material in case you need to return the instrument for calibration or service since it has been designed to ensure that your microK^2 is properly protected during transportation.

1.3 Safety ⚠

The microK^2 is a precision instrument, designed for use in a laboratory. It complies with the requirements of safety standard EN61010-1:2010 and is therefore safe to use in laboratory or light industrial environments. It is not intended for use outdoors or in extreme environments (refer to the specification in section 10).

The microK^2 is likely to be connected to thermometer sensors in use and the operator should take care to ensure that the complete system is safe. For example, metal sheathed thermometers may be connected to the microK^2 and then placed in a furnace powered from a 230 V electrical supply. Single fault conditions in such a furnace could lead to the thermometer wires and the front terminals of the microK^2 to which they are connected becoming electrically live and therefore hazardous to the operator. Suitable precautions should be taken, such as using an isolating transformer in the supply to such a furnace and/or residual-current circuit devices. **If you require further advice on safety issues, please contact Isotech or one of our appointed distributors - we have extensive experience of thermometry and can provide advice and equipment to help you.**

Retain these instructions. Use only as specified in these operating instructions or the intrinsic protection may be impaired.

Please observe the following safety precautions:

- Do not use your microK² if it is damaged
- Only connect to an earthed supply socket. THIS UNIT IS A CLASS 1 CONSTRUCTION AND MUST BE EARTHED!
- Only connect to a power supply with a voltage corresponding to that on the rating plate
- This equipment is for indoor use within an ambient temperature range of 5 °C to 40 °C with maximum relative humidity of 80% for temperatures up to 31 ºC decreasing linearly to 50% RH at 40 ºC
- Equipment is for operation at installation category II (transient voltages) and pollution degree 2 in accordance with IEC 606640-1:2020 at altitudes up to 2,000 metres
- Before replacing a fuse, DISCONNECT THE EQUIPMENT FROM THE ELECTRICAL SUPPLY
- The fuse is contained in the IEC socket on the rear panel. It must only be replaced with a similar HRC (high rupture current) fuse of the type and rating marked on the rear panel
- If a replacement fuse fails immediately, contact your local service agent. DO NOT replace with a higher value
- Always use the power cable supplied. Your sales outlet can provide a cable suitable for your country
- This equipment is for use in moderate climates only. NEVER use the equipment in damp or wet conditions
- Avoid excessive heat, humidity, dust & vibration
- Do not place liquid filled containers on the equipment
- Do not use where the equipment (or any associated accessories) may be subjected to dripping or splashing liquids
- Ensure that the power switch is easily accessible to allow the unit to be switched off
- The equipment weighs 13.5 kg (30 lb); use the handles provided. Always disconnect the equipment from the electrical supply and any ancillary units before moving
- Ensure that tabletop equipment is placed on a solid, level surface which can support its weight (and that of any attached accessories)
- Ensure all cables and wires are routed safely to avoid sharp bends and pinches. Also, avoid creating trip hazards with the cables/wires
- Clean only with a damp cloth. Do not wet or allow moisture to penetrate the unit. Do not use solvents. See section 5.3 for details of the cleaning procedure
- The product should be subjected to regular in-service inspections as required by local regulations; a yearly interval is suggested
- Verify that the power cable is undamaged and that the enclosure is bonded to protective earth. Do not apply earth test currents to any front panel terminal nor to the shrouds of the USB, RS232, GPIB or Ethernet connectors
- The product is designed to comply with EN 61010-1 and can be flash tested. It is fitted with radio frequency interference suppressors. Therefore, it is recommended that only a D.C. test be performed. Performing flash tests repeatedly can damage the insulation
- This equipment contains no user-serviceable parts. Refer all repairs to qualified service personnel. Contact Isotech or one of our appointed distributors for details of approved service outlets
- Before powering up your microK², check that any connected thermometers will not be damaged by the sense currents (which default to the last used values)

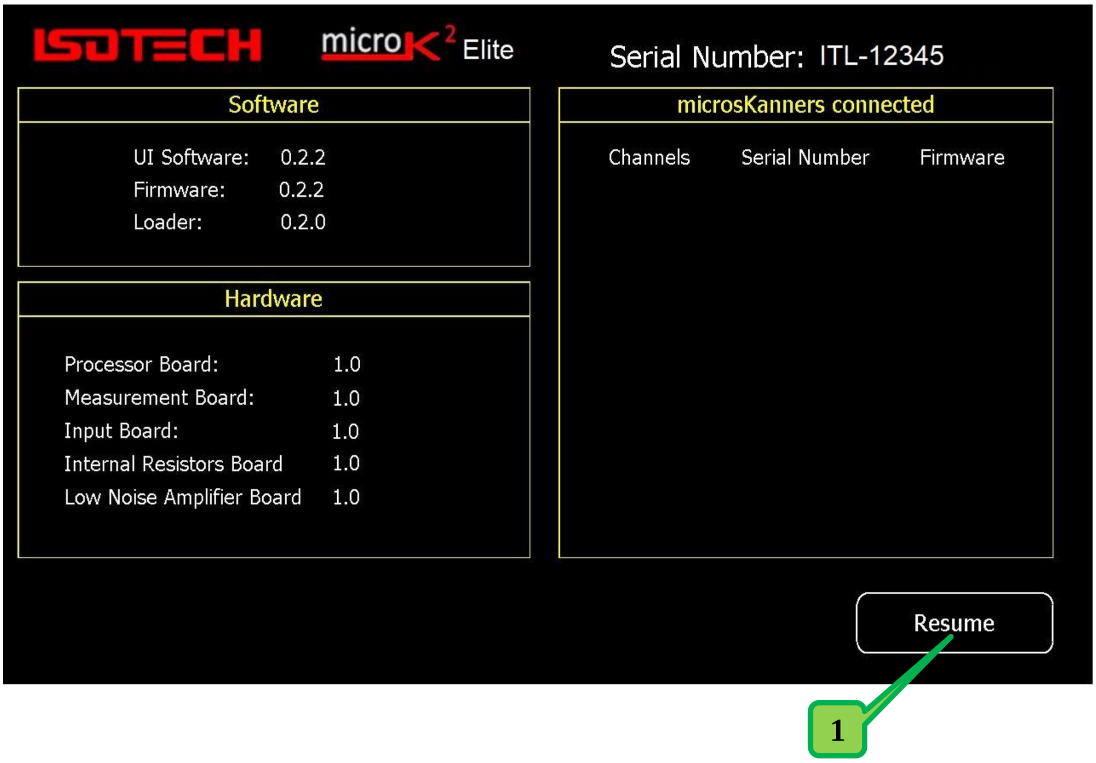
1.4 Powering Up Your microK²

The microK² operates on any standard AC electrical supply (88-264 V RMS at 47-63 Hz) so unless your supply is unusual you can simply use the power cable provided to connect your microK² to a suitable electrical outlet.

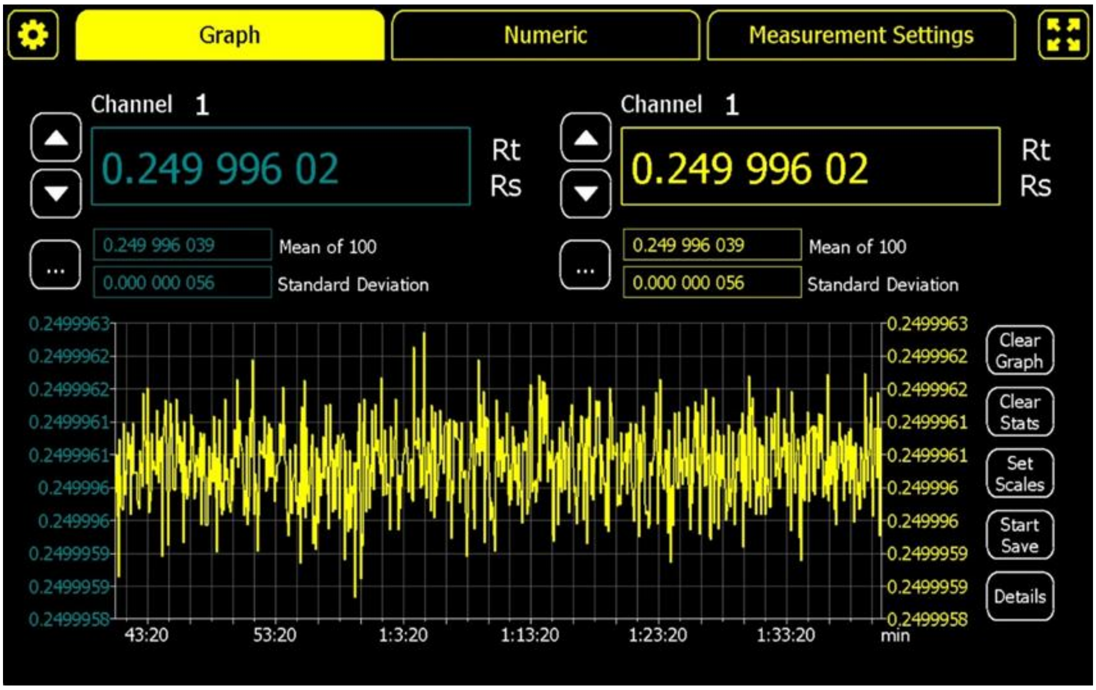
The power switch is located at the front (bottom right) of the instrument. When you turn your microK² on it will go through a boot sequence and (within 1 minute) will display a screen showing the status of the microK² with the *Resume* button.

Before pressing the *Resume* button, make sure that any thermometers attached will not be damaged by the sense currents that will be applied (the last values used). If in doubt, disconnect your sensors before proceeding and then reconnect them after changing the sense current to the required value.

Press *Resume [1]* to restart the microK² in the configuration it was in prior to the last power down:

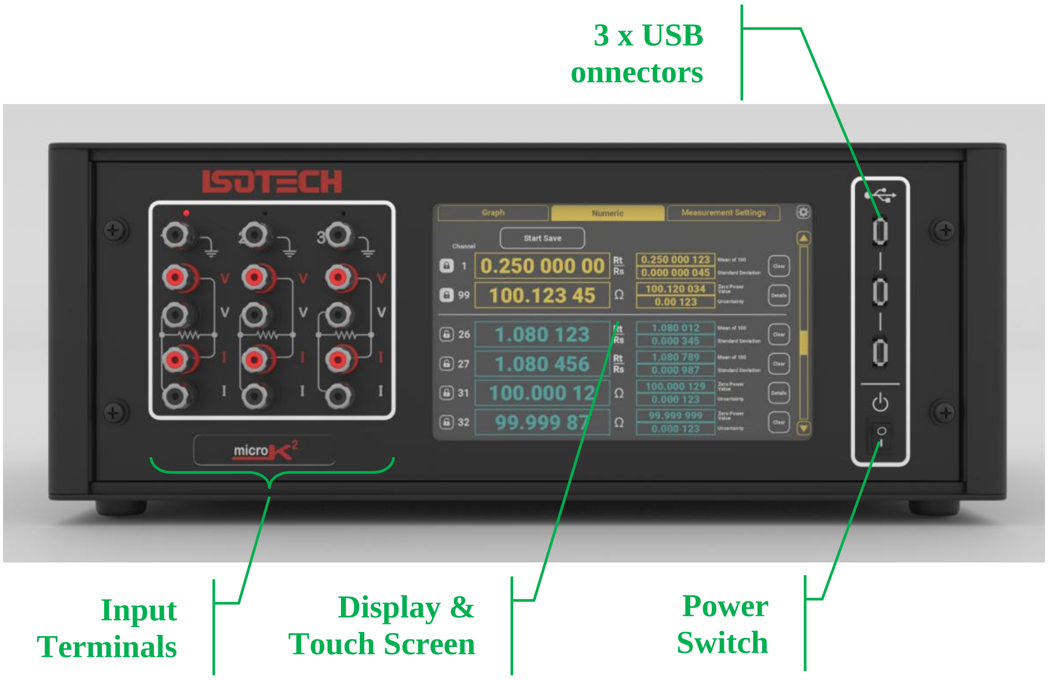


You will then see the main screen and be ready to operate your instrument:



1.5 A Quick Tour of Your microK^2

On the front panel of your microK^2 you will find the input terminals for three measurement channels (fourth channel is on the rear panel), the touch screen/colour display, three USB Host ports and the mains power switch:



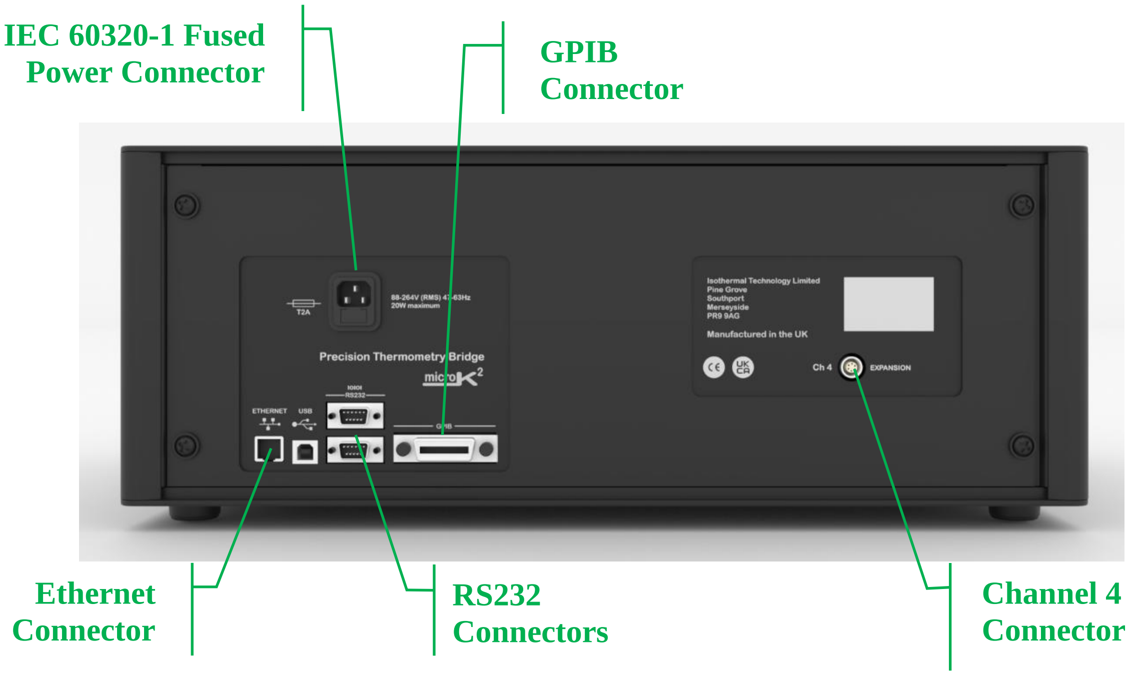
Input Terminals: The input terminals accept 4 mm plugs, spades or bare wires. The current (I) and voltage sense (V) terminals are spaced on ¾″ centres so that standard BNC to 4 mm adaptors (not supplied) can be used to connect to thermometer sensors that have BNC terminations.

The contact material for the connectors is gold plated tellurium-copper, offering extremely low thermal EMFs when connected to copper wires/connectors. This is essential when using precision thermocouples.

Display: The display is a colour TFT WXGA (1280 x 800) LCD with a long-life LED backlight and includes a PCT touch panel. PCT technology detects the presence of a conductive object (your finger) and does not work if you are wearing gloves (unless they are designed for use with PCT screens). Never use a sharp object with the touch panel as this may damage the surface - your finger is the best tool to use.

The USB Connectors: The three USB Host connectors allow you to connect a USB flash drive, keyboard and mouse simultaneously. The flash drive can be used to store measurement results and transfer these to a PC, backup the databases (of thermometers and reference resistors) and store instrument configurations for your microK^2.

On the rear panel of your microK^2 you will find the IEC power supply connector/ fuse module, the digital interface connectors and the Lemo connector for channel 4:



The digital interfaces (two RS232, Ethernet and GPIB ports) allow you to control the instrument and take measurements from a PC with your own software (see section 0). The command protocol employs the widely used SCPI format (Standard Commands for Programmable Instruments), as described in section 9. The USB-B peripheral device connector is used during manufacture and **should not be used during normal operation.**

2 Making a Measurement (Tutorials)

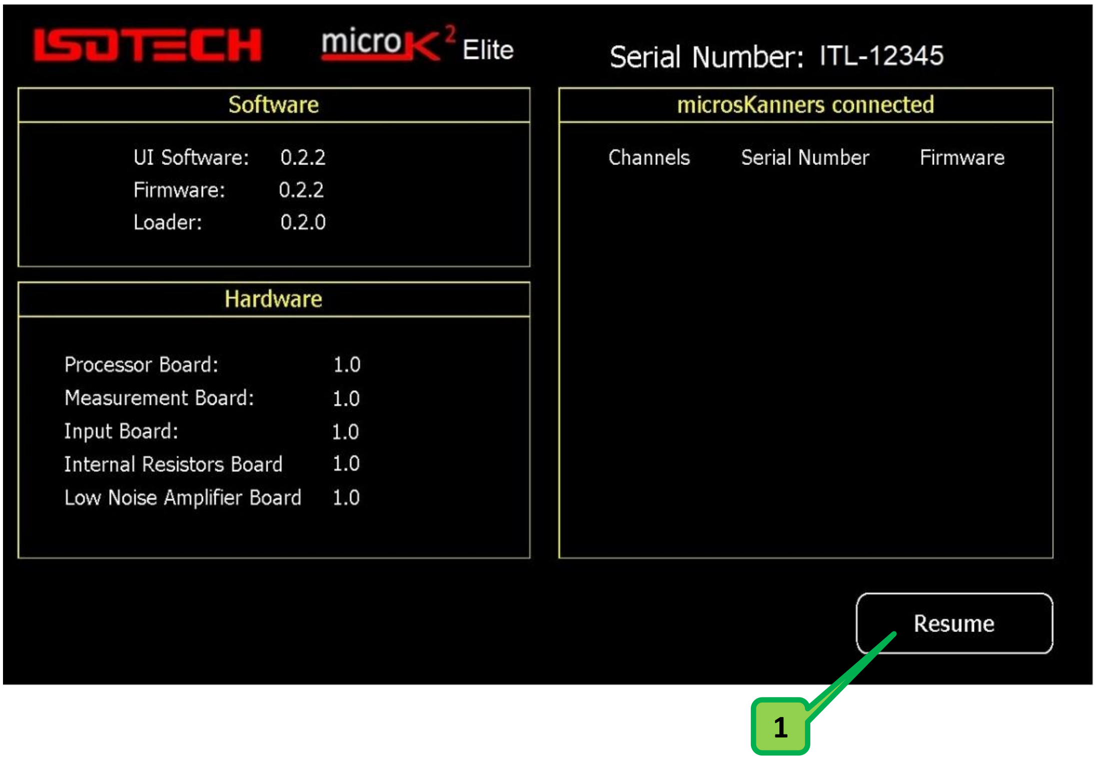
A traditional description showing how to access of all the features of the microK^2 through its user interface is given in section 3. This section provides a few tutorials that illustrate common applications as this is often an easier way to learn how to use an instrument. Even if these do not describe your application, it is worth working through one of them since it will provide you with a broad understanding of the extensive features available on your microK^2.

2.1 Fixed-Point Calibration of an SPRT Using Zero-Power Extrapolation

Calibrating an SPRT using fixed point cells offers the lowest possible calibration uncertainty. The process involves measuring the resistance of an SPRT with respect to an external reference resistor whilst at a number of known temperatures (by immersing it in fixed point cells) and then using that information to generate calibration data for the thermometer. The reference resistor should be a DC or AC/DC resistance reference standard maintained at a constant temperature in an oil bath or similar resistor maintenance system.

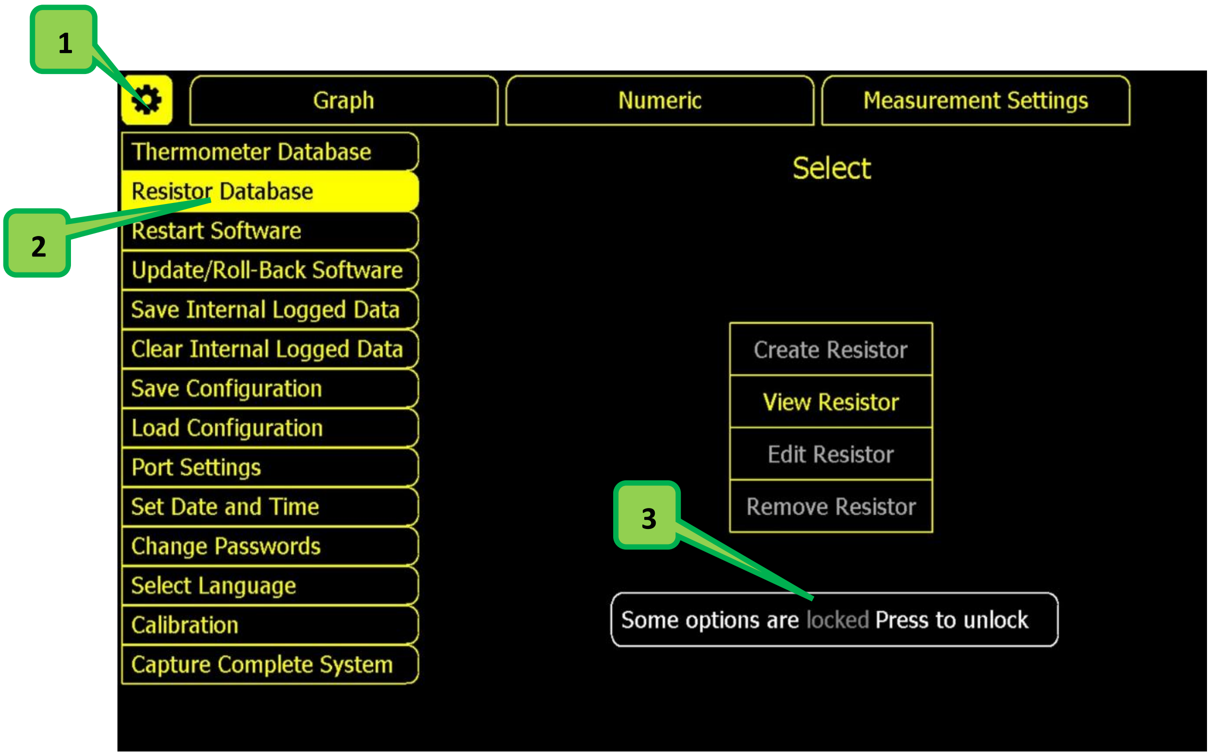
This tutorial describes how to make a zero-power corrected resistance measurement of an SPRT against an external reference resistor at a single temperature and logging all this information to files on a USB flash drive.

From start-up, press *Resume [1]* to restart your microK^2:

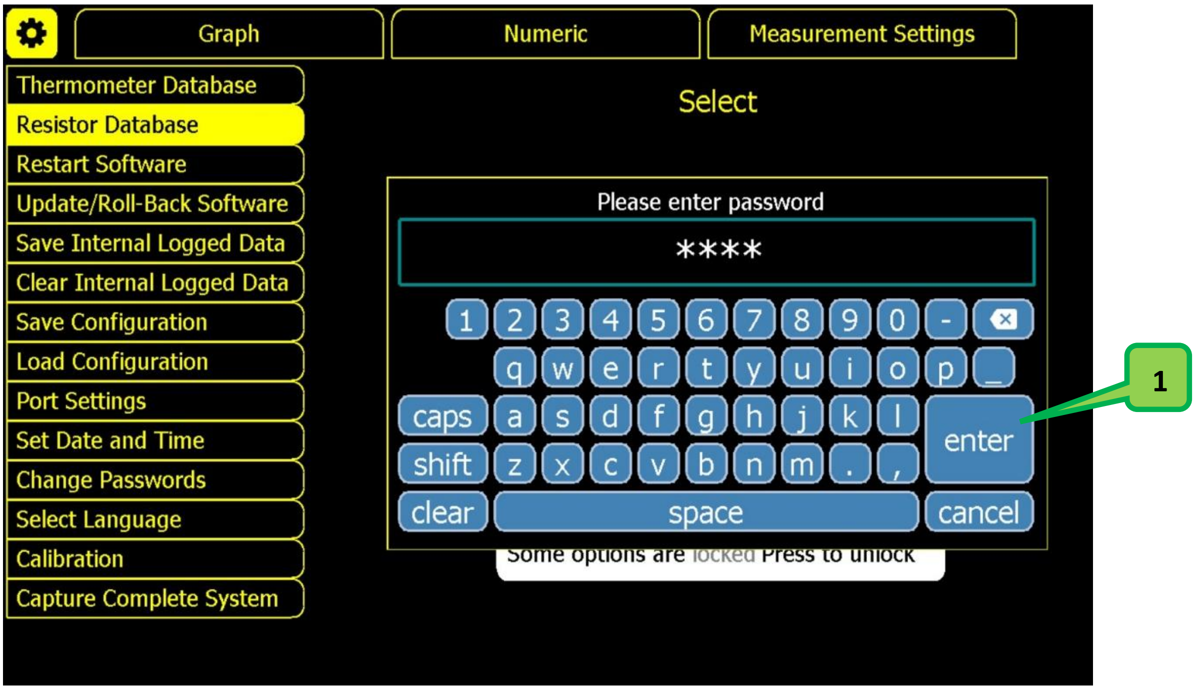


Before making any measurement, you will have to enter information about the reference resistor into the microK^2's database.

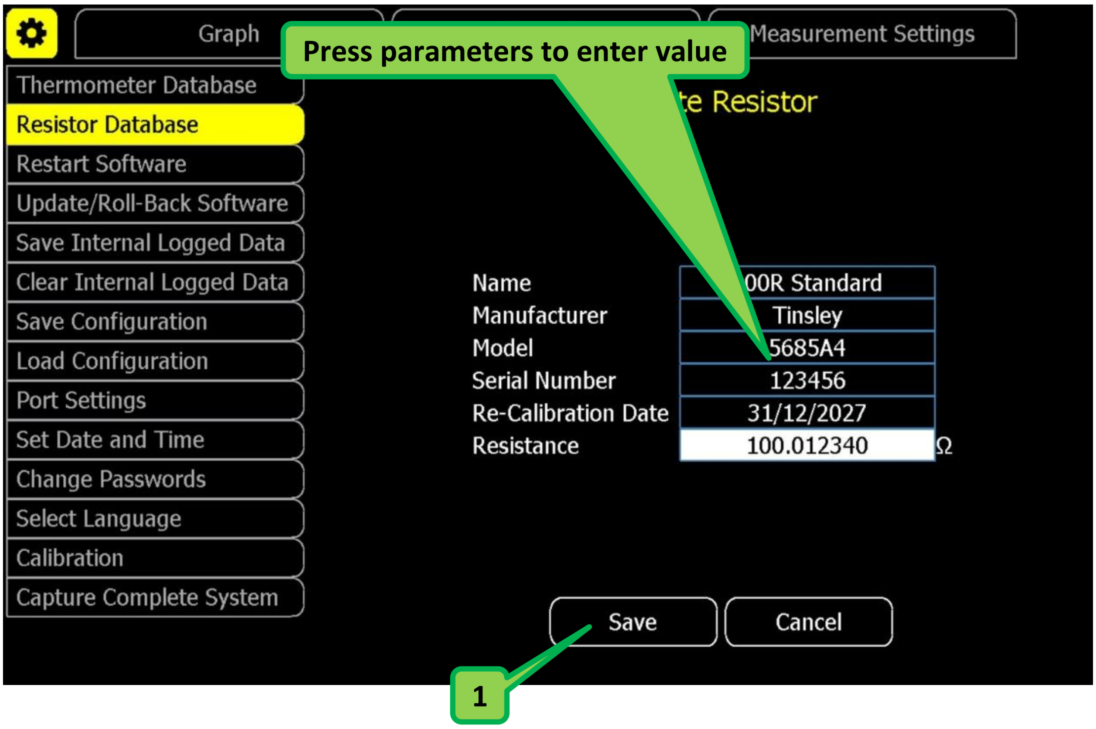
When the main screen opens, press the *Settings Cog [1]* button; the *Resistor Database [2]* button; and the *Some options are locked Press to unlock [3]* button:



In the pop-up window, enter the user password (set to "1234" initially, but this should be changed before using the microK^2 in a real measurement/calibration application to ensure security – see section 3.7.11). Then press *enter [1]*:



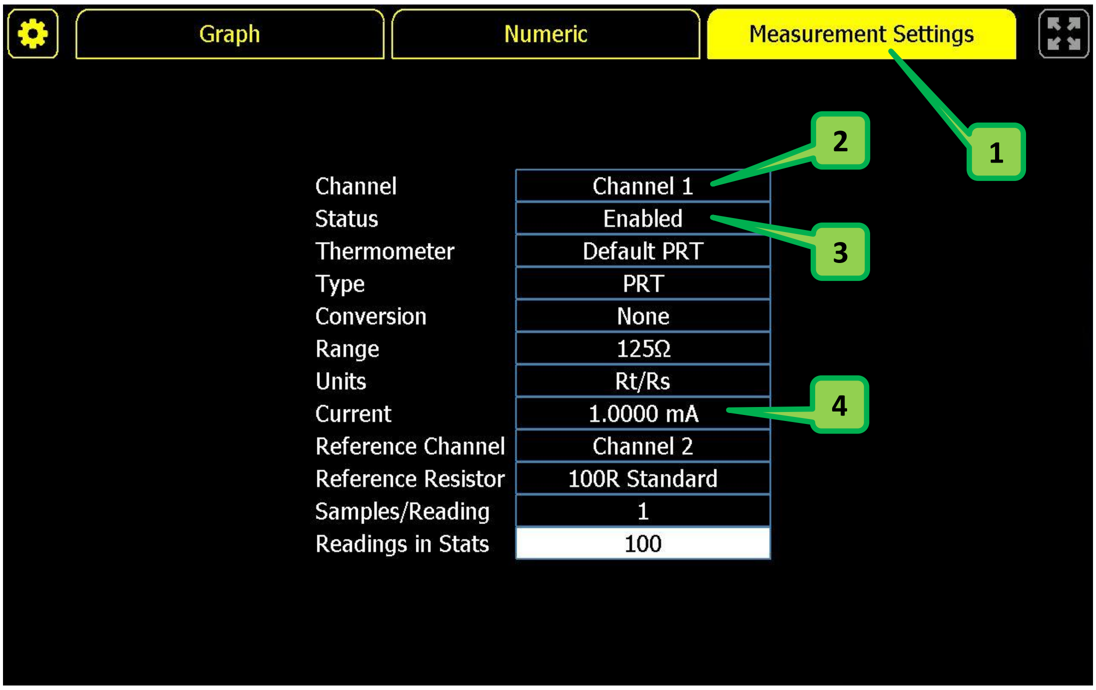
Press *Create Resistors* to open the 'Create Resistors' pop-up window. Enter the required data into the six parameter boxes using the associated pop-up windows. Press the *Save [1]* button:



Press the *Measurement Settings [1]* tab, then press the *Channel [2]* parameter box (to open the "Select Channel" pop-up window) and select channel 1.

Press the *Status [3]* parameter box to toggle channel 1 into the "Enabled" state. Repeat this process to disable the other channels (this will speed up the measurements by not wasting measurement time on unused channels).

Now press the other parameter boxes to enter the required data using the associated pop-up windows. Note: the "Type" box will be populated automatically when you select "Default PRT" and cannot be changed:



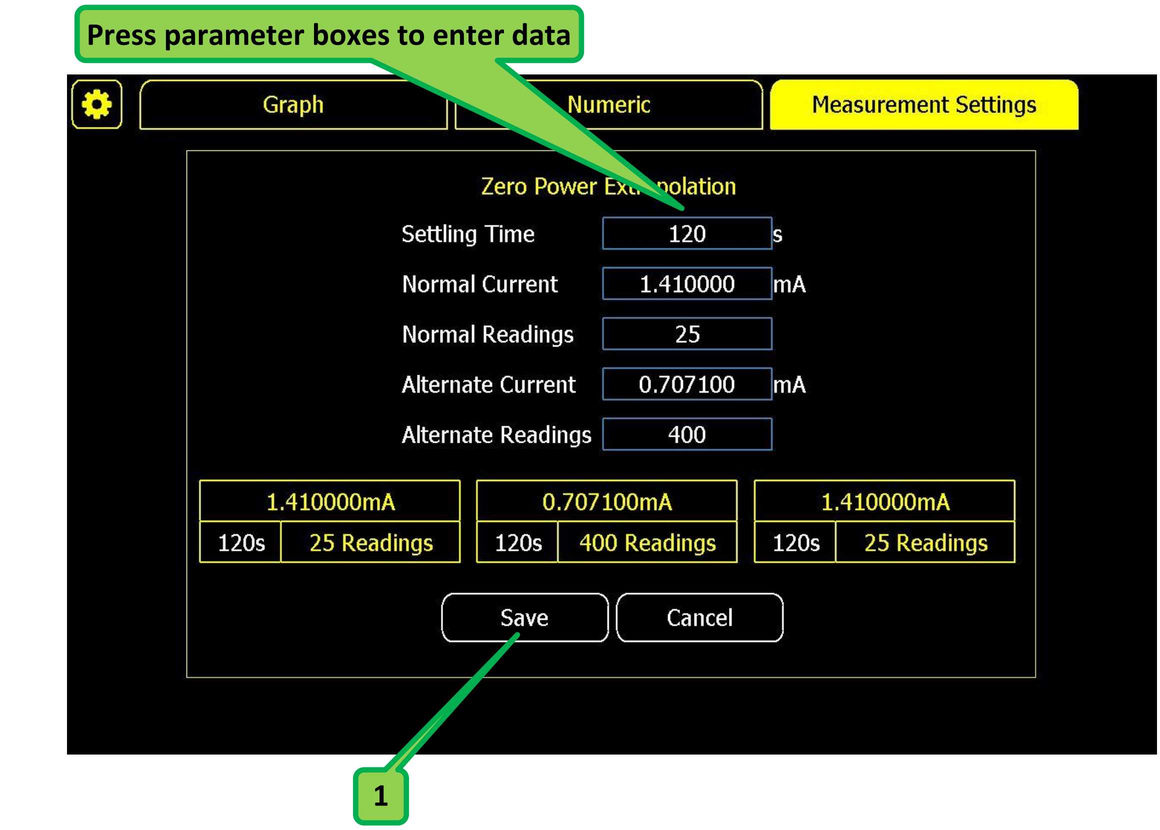
This configuration will perform resistance measurements on the SPRT at a fixed current (1 mA). The most accurate measurements are made using an extrapolation technique to determine the resistance at zero current (thereby eliminating self-heating errors) see section 6 for a detailed explanation.

Connect the SPRT to be calibrated to channel 1 and the reference resistor to channel 2 (see section 4.3 for details on how to connect 4-wire PRTs).

The original microK used the same number of readings per measurement at both currents. With microK^2 the user is able to input individual numbers for the readings taken at each current, so that the best (lowest uncertainty) measurements can be made automatically.

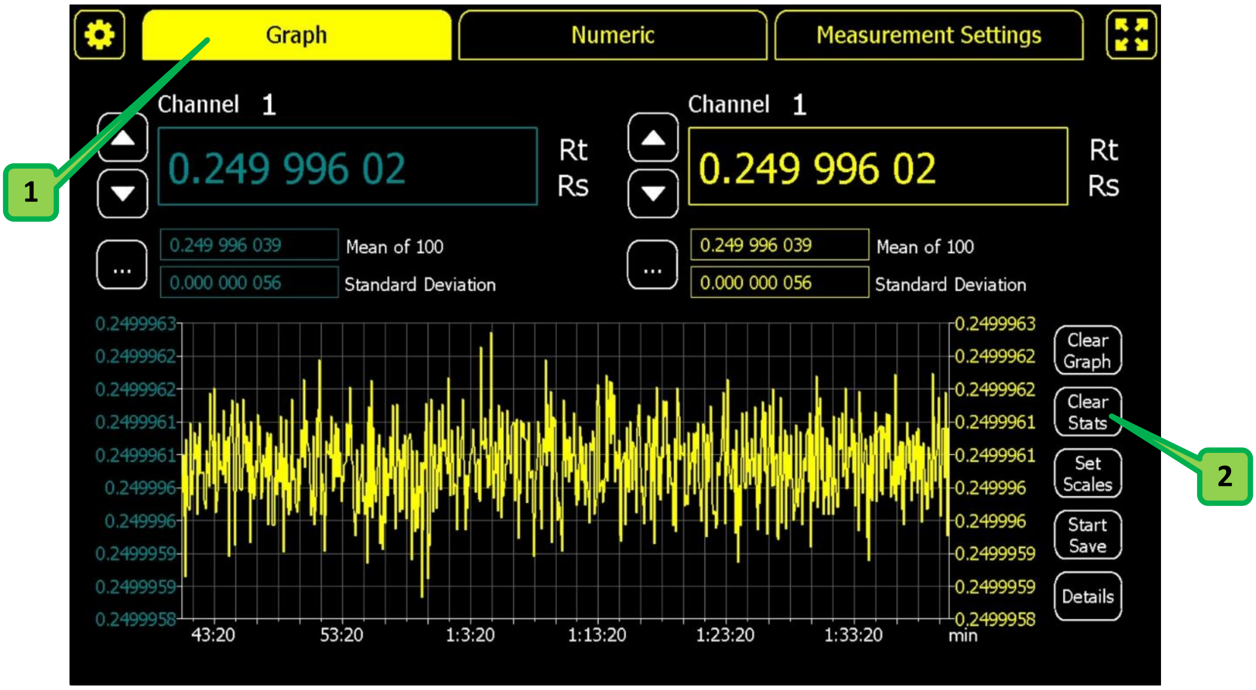
Press the *Current [4]* parameter box and then press the *Zero-Power Extrapolation* button to open the 'Zero Power Extrapolation' current sequence window. This window allows you to define the measurement sequence used to calculate the zero-power resistance. The measurement sequence comprises a measurement at the normal current followed by a measurement at the alternate current and then a final measurement at the original (normal) current.

Before each measurement, the microK^2 uses a defined settling time to ensure the thermometer reaches thermal equilibrium after a change in current. The optimum values will depend on the properties of the specific thermometer being used. In this example we assume that the thermometer will have reached thermal equilibrium within 120 s and that we wish to use the optimum 1:2 current ratio and 8:1 (400:25+25) between the number of readings at the lower and higher currents. Press the parameter boxes and enter the required values in the pop-up windows that appear. Then press *Save [1]*:



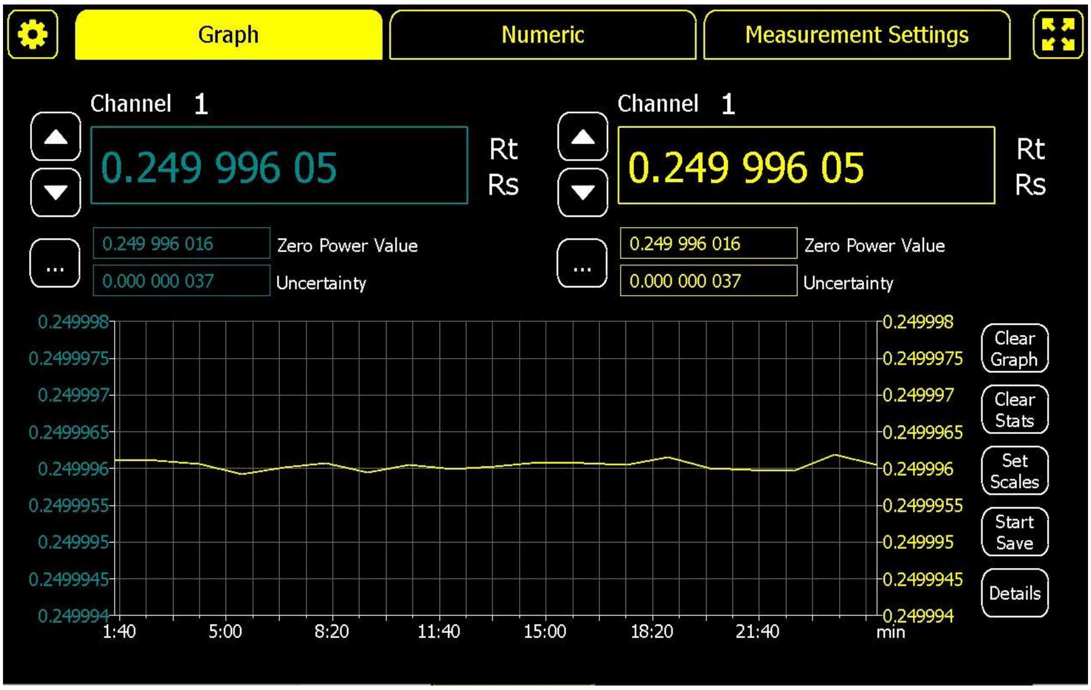
If the settling time for the thermometer is not known, it can be determined by measuring its resistance at the normal current and then manually changing this to the alternate current whilst monitoring the results with the microK^2 in the *'Graph'* tab. This will show the settling characteristics of the thermometer.

Press the *Graph [1]* tab to display the measurements graphically in real-time:

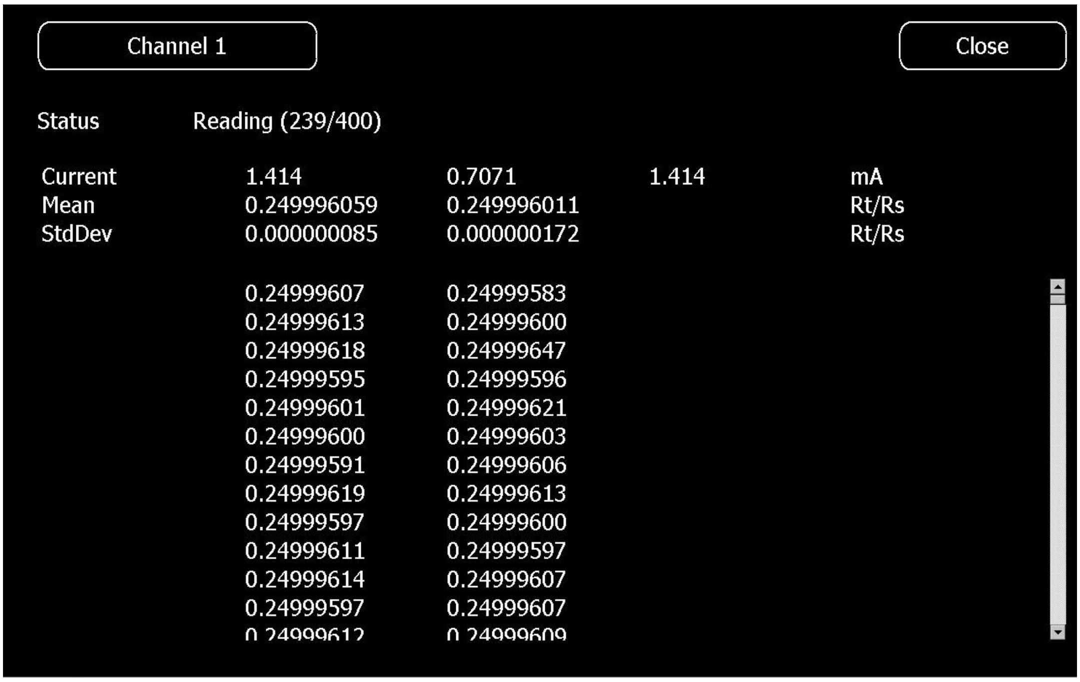


The *Mean of* and *Standard Deviation* boxes usually displayed in the *Graph* tab are replaced by the last calculated *Zero-Power Value* and its associated *Uncertainty* (calculated from the standard deviation of each set of measurement data). The measurements and associated statistics can be cleared/reset by the *Clear Stats [2]* button on this screen. In the *Numeric* tab, the statistics can be cleared for individual channels using the *Clear* buttons, or for all the channels using the *Clear* all button:

After enabling zero-power extrapolation, it can take several minutes before the first measurement data sets have been collected and the zero-power value calculated.



Press *Details* to open a window and see the individual readings used in each measurement as they are made:



Press *Close* to return to the main screen.

To save the data press *Start Save*, you will then be offered the choice of saving to an *External* USB flash drive (memory stick) or *Internal* memory. If you choose the internal memory, you can backup the data to an external USB flash drive later (see section 3.7.5 for details).

The 'raw' data is saved in a comma delimited ASCII file (together with the microK^2 settings information) with the extension ".dat".

The 'processed' zero-power measurements are saved in a comma delimited ASCII file (together with the microK^2 settings information) with the extension ".zpc".

These files can be transferred to a PC and analysed using Excel™.

Tip: You can connect a calibrated SPRT to channel 3 in order to monitor the temperature of the external reference resistor simultaneously. For lowest uncertainty, use the external reference resistor on channel 2 rather than the microK^2's internal resistance standards as the reference resistance for this SPRT.

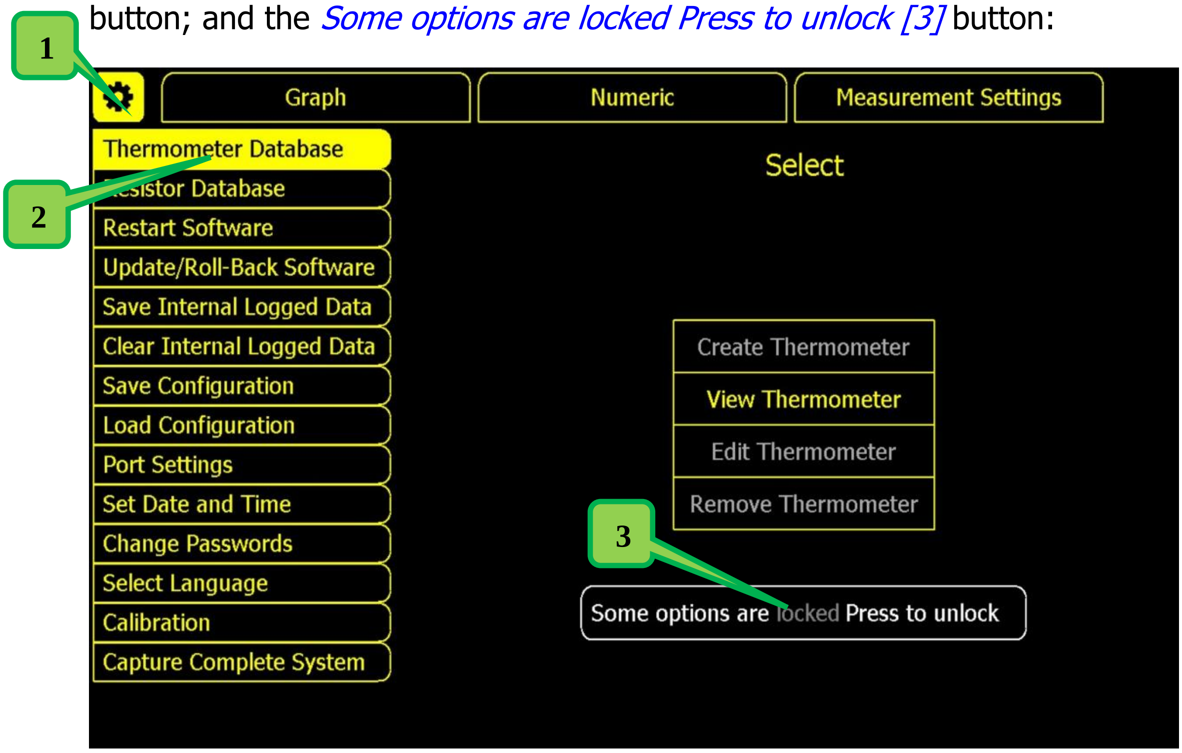
2.2 Measuring Temperature with an SPRT

The microK^2 can be used with a calibrated SPRT to measure temperature with extremely low uncertainty. For the lowest uncertainty, use an external DC or AC/DC resistance reference standard maintained at a constant temperature in an oil bath (or similar resistor maintenance system) as the reference resistor rather than the internal resistance standards.

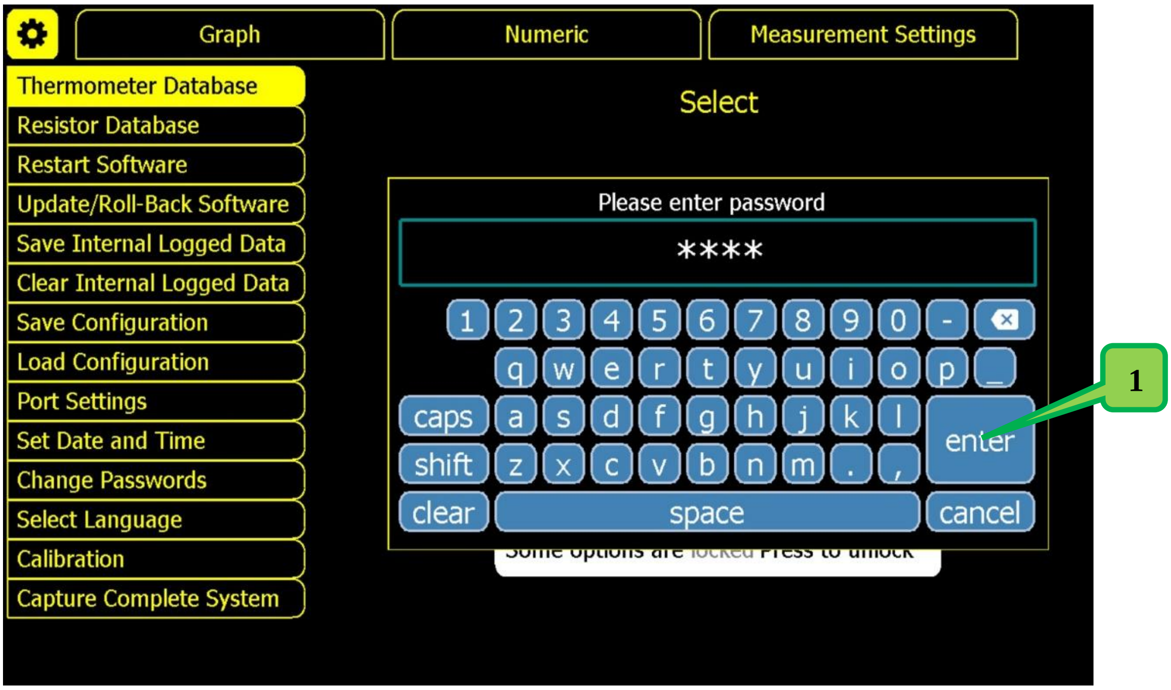
From start-up, press *Resume [1]* to restart your microK^2:

Before making any measurement, you will have to enter information about the SPRT and reference resistor into the microK^2's database.

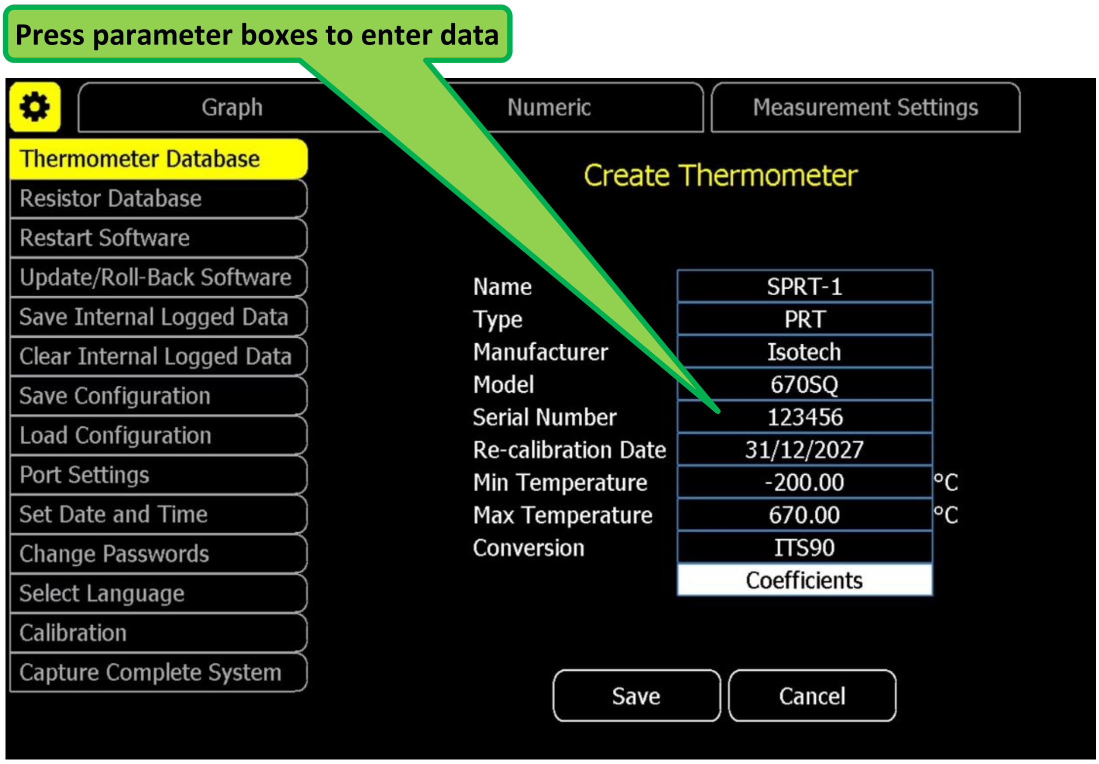
When the main screen opens, press the *Settings Cog [1]* button; the *Thermometer Database [2]* button; and the *Some options are locked Press to unlock [3]* button:



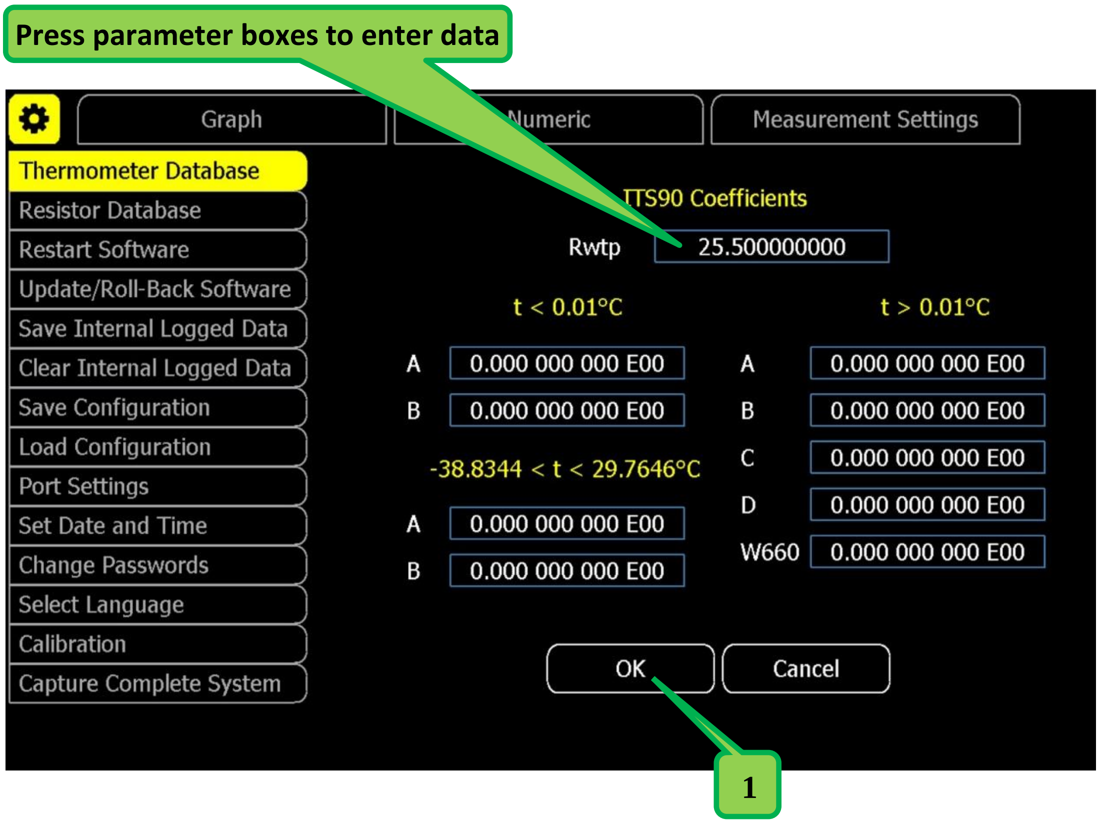
In the pop-up window, enter the user password (set to "1234" initially, but this should be changed before using the microK^2 in a real measurement/calibration application to ensure security – see section 3.7.11). Then press *enter [1]*:



Press *Create Thermometer* to open the 'Create Thermometer' window; press the parameter boxes to enter the required data using the associated pop-up windows:



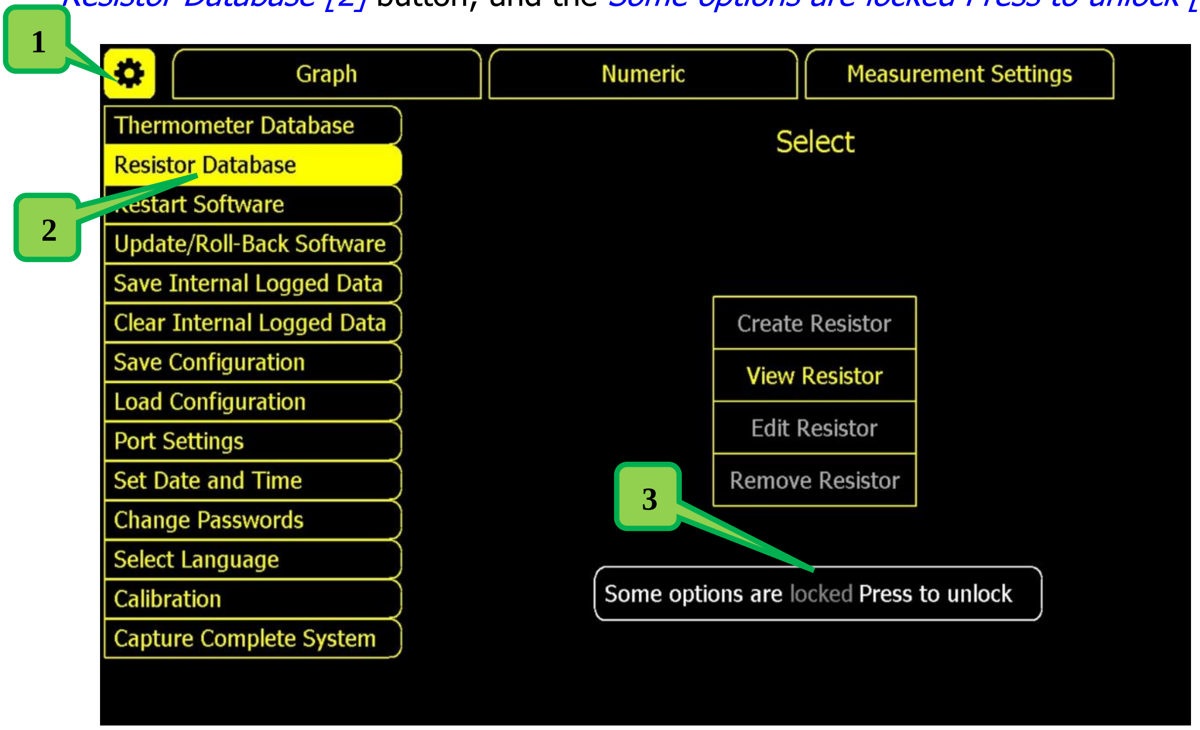
Press *Coefficients* and enter the calibration coefficients for the SPRT by pressing the parameter boxes, then press *OK [1]*:



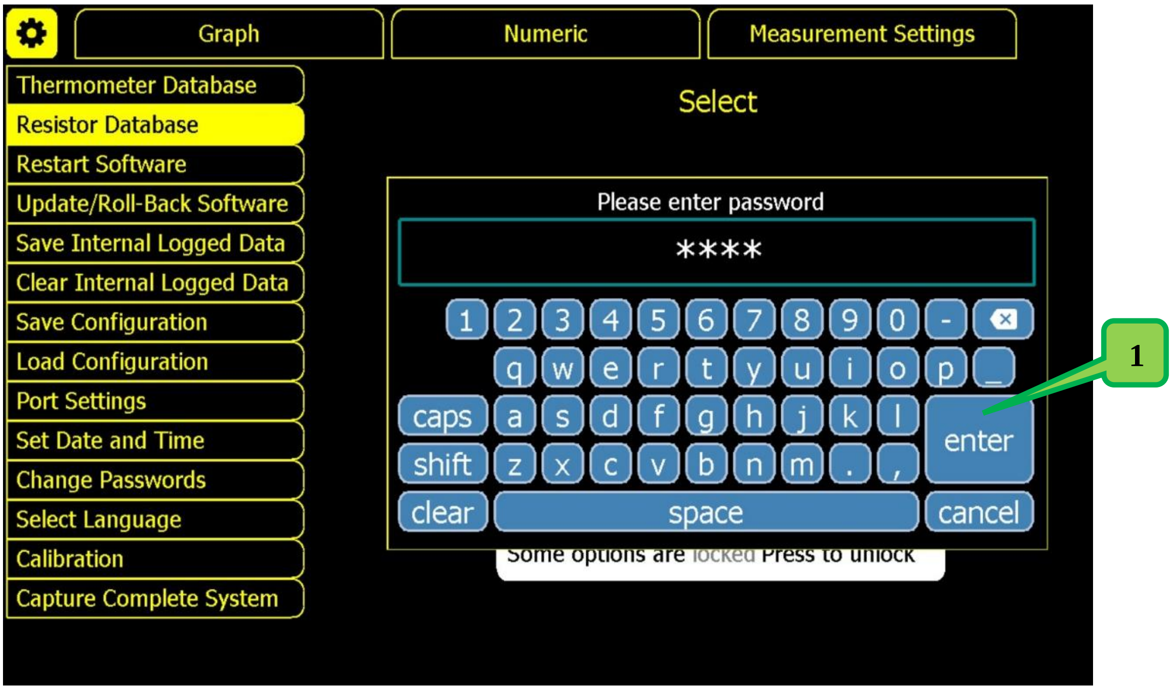
Press *Save* in the Create Thermometer window to save this information in the database.

As SPRTs/PRTs drift during use, the proportional change in resistance is similar at all temperatures. If you periodically measure the resistance of the SPRT at the water triple point (0.01 °C) and enter this value into the coefficients window, you will significantly improve the measurement uncertainty.

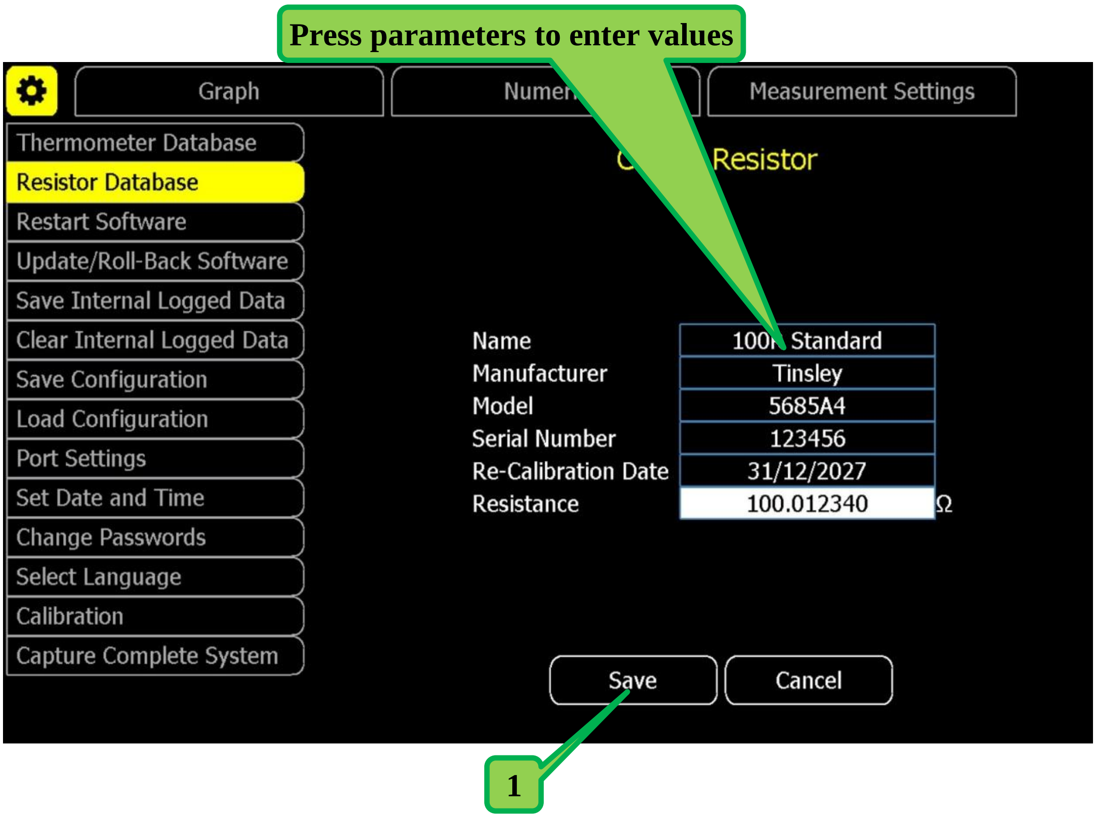
Now enter the details of the reference resistors by pressing the *Settings Cog [1]* button; the *Resistor Database [2]* button; and the *Some options are locked Press to unlock [3]* button:



In the pop-up window, enter the user password (set to "1234" initially, but this should be changed before using the microK^2 in a real measurement/calibration application to ensure security – see section 3.7.11). Then press *enter [1]*:



Press *Create Resistor* to open the 'Create Resistor' pop-up window. Enter the required data into the six parameter boxes using the associated pop-up windows. Press the *Save [1]* button:

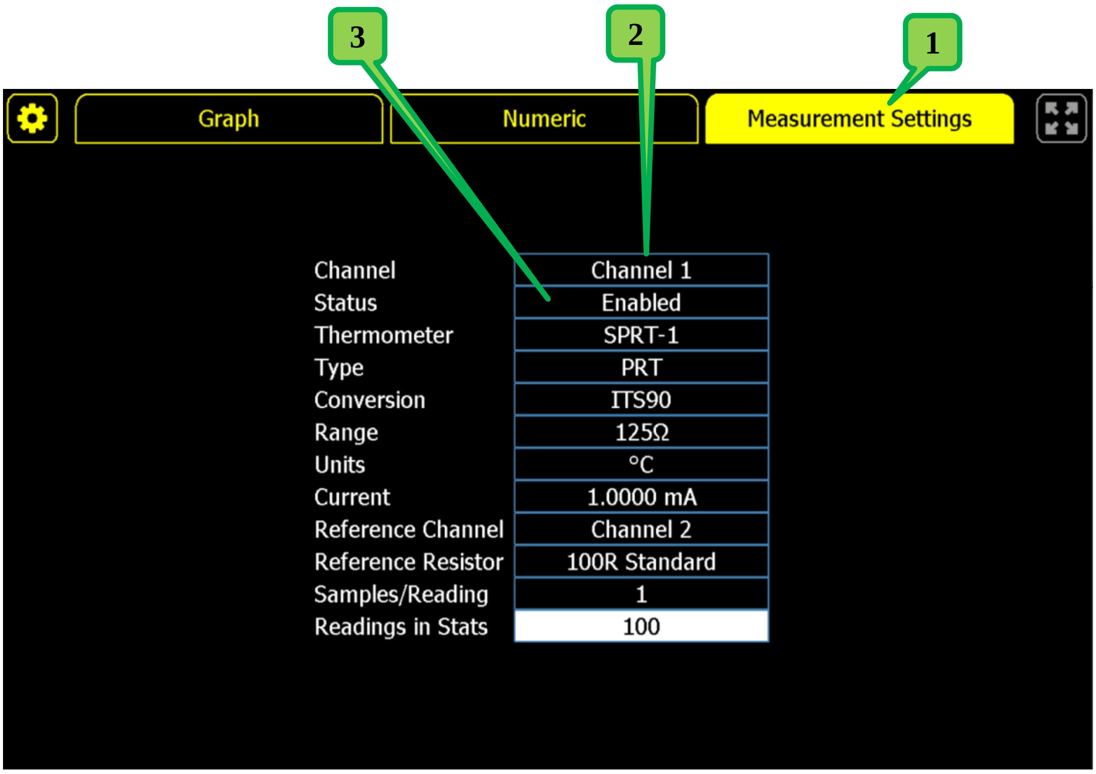


Connect the SPRT to be calibrated to channel 1 and the reference resistor to channel 2 (see section 4.3 for details on how to connect 4-wire PRTs).

Press the *Measurement Settings [1]* tab, then press the *Channel [2]* parameter box (to open the "Select Channel" pop-up window) and select channel 1.

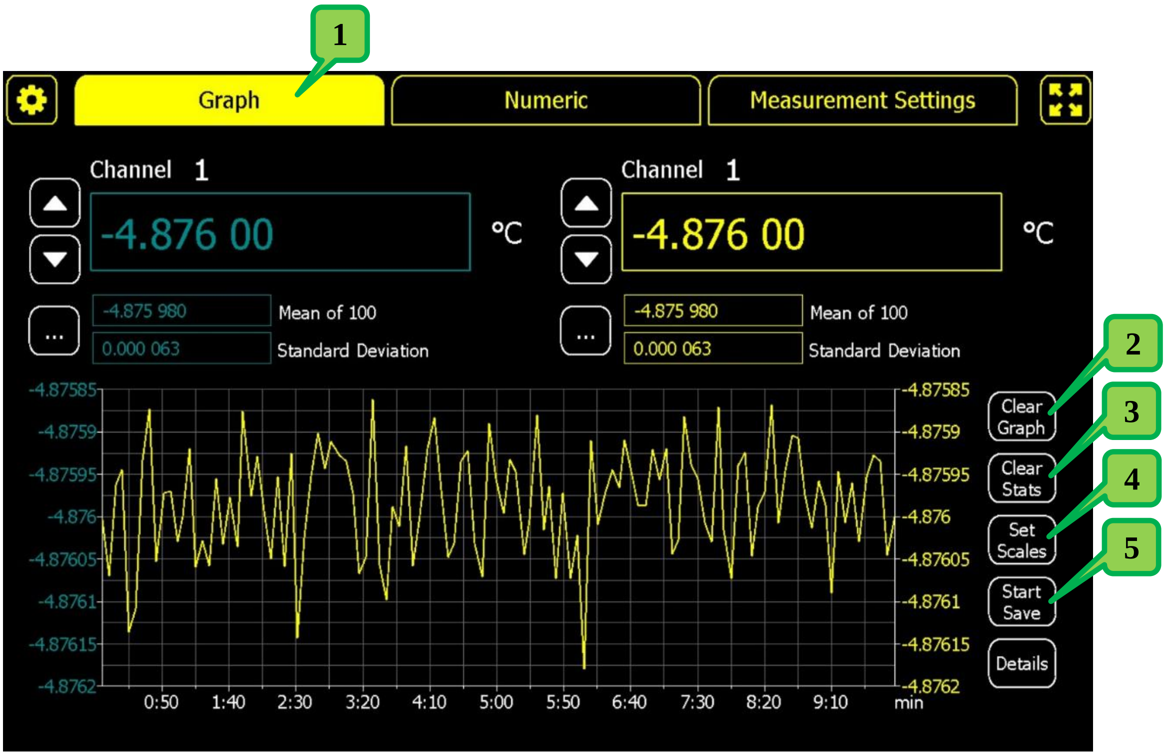
Press the *Status [3]* parameter box to toggle channel 1 into the "Enabled" state. Repeat this process to disable the other channels (this will speed up the measurements by not wasting measurement time on unused channels).

Now press the other parameter boxes to enter the required data using the associated pop-up windows. Note: the "Type" and "Conversion" boxes will be populated automatically when you select "SPRT-1" and cannot be changed:



This configuration will perform temperature measurements using the SPRT at a fixed current (1 mA). The most accurate measurements are made using an extrapolation technique to determine the resistance at zero current (thereby eliminating self-heating errors). See section 0 for further details.

Press the *Graph [1]* tab to display the measurements graphically in real-time:

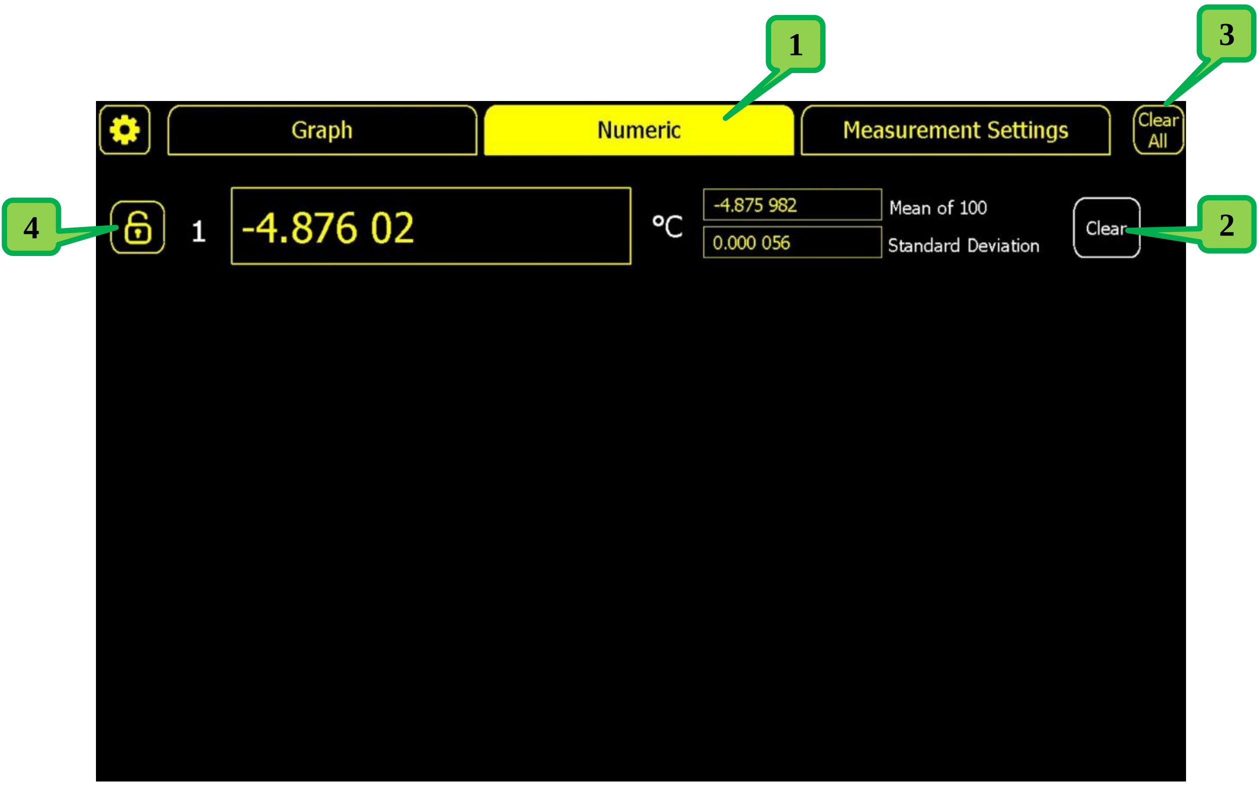


Press *Clear Graph [2]* to clear the graph; press *Clear Stats [3]* to clear the statistics for both channels on the graph; press *Set Scales [4]* to change the x-y scales of the graph.

To save the data press *Start Save [5]*, you will then be offered the choice of saving to an *External* USB flash drive ("memory stick") or *Internal* memory.

If you choose the internal memory, you can backup the data to an external USB flash drive later (see section 3.7.5 for details).

Press the *Numeric [1]* tab to display the measurements numerically:



Press *Clear [2]* to clear the statistics for an individual channel; press *Clear All [3]* to clear the statistics for all channels; press the *Lock [4]* button to toggle between locking and unlocking the channel. When locked (displayed information changes to blue) the channel will always be displayed in the tab as you scroll through the channels. This feature can be used to lock (always display) a channel that is being used as a reference.

Tip: You can perform a comparison calibration on a PRT by connecting it to channel 3 and measuring its resistance whilst also measuring the temperature of the above reference SPRT on channel 1. Immerse both in a number of temperature sources (fixed-point cells, liquid baths of block baths) and use the data to generate the calibration information for the PRT.

Tip: In comparison calibrations, any error in the value of the reference resistor causes an error in the measured resistance of the PRT being calibrated as well as a corresponding error in the temperature measured using the SPRT (provided that the same reference resistor is used for both thermometers). These correlated errors mean that the measured resistance-temperature point corresponds to a valid point further up or down the PRT's resistance-tempertaure characteristic and therefore does not cause a significant calibration error (provided that the slope of the resistance-temperature characteristic is the same for the PRT and SPRT). Any small difference between the slope of the PRT and SPRT will lead to an error, this is calculable and should be included in any uncertainty budget.

In effect, it is only necessary to know the temperature of the SPRT and the ratio of the resistance of the PRT to that of the SPRT in order to transfer the calibration from the SPRT to the PRT.

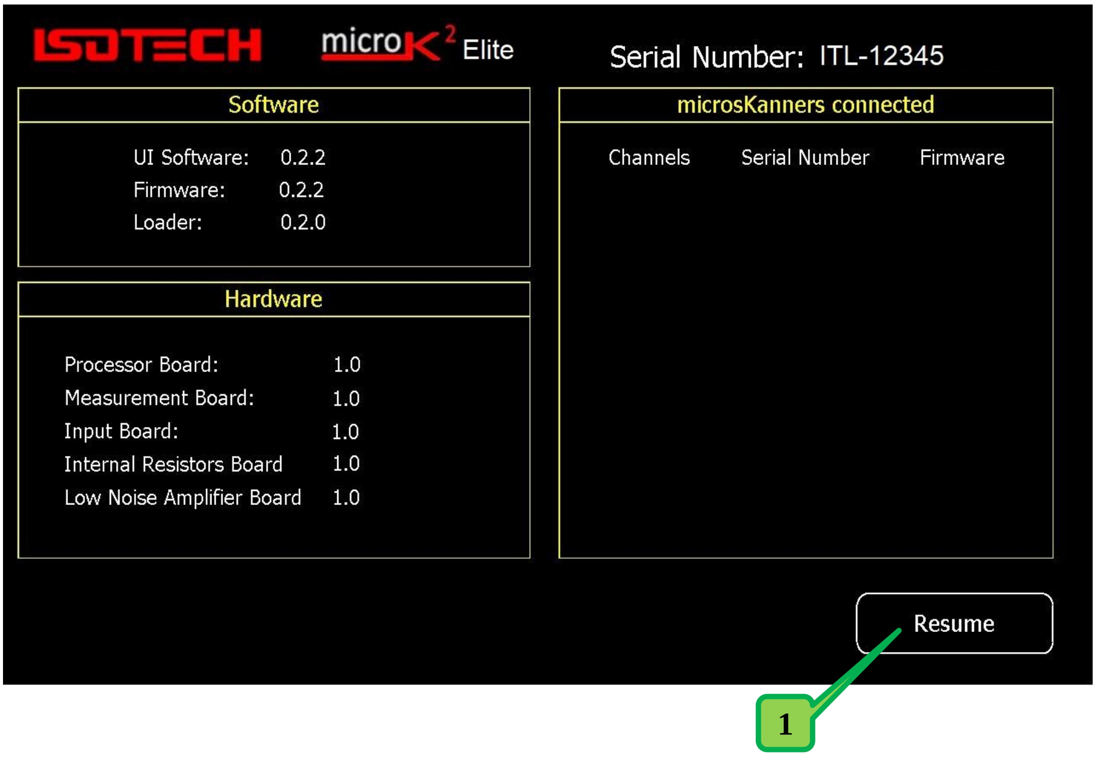
It is common practice to measure the ratio of the resistance of the two thermometers rather than measure their individual resistances in a comparison calibration. This has the advantage of reducing the calibration uncertainty by elimintating one of the measurements involved.

2.3 Measuring the Output from a Thermocouple

The microK^2 is capable of measuring temperature using a thermocouple, but a more common use would be to calibrate a thermocouple against another more accurate thermocouple or an SPRT.

This tutorial describes how to measure the output voltage from a thermocouple in volts.

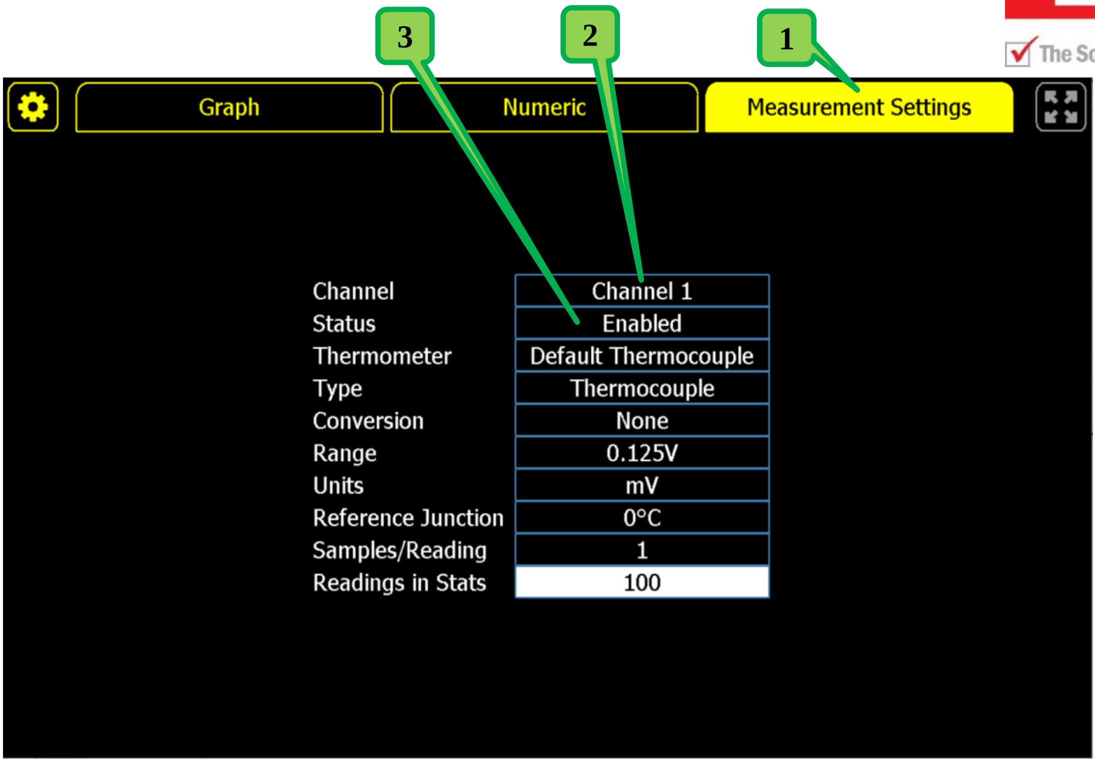
From start-up, press *Resume [1]* to restart your microK^2:



Connect the thermocouple to be calibrated to channel 1 and place the reference junction in an ice-point reference (see section 4.6 for details on how to connect thermocouples).

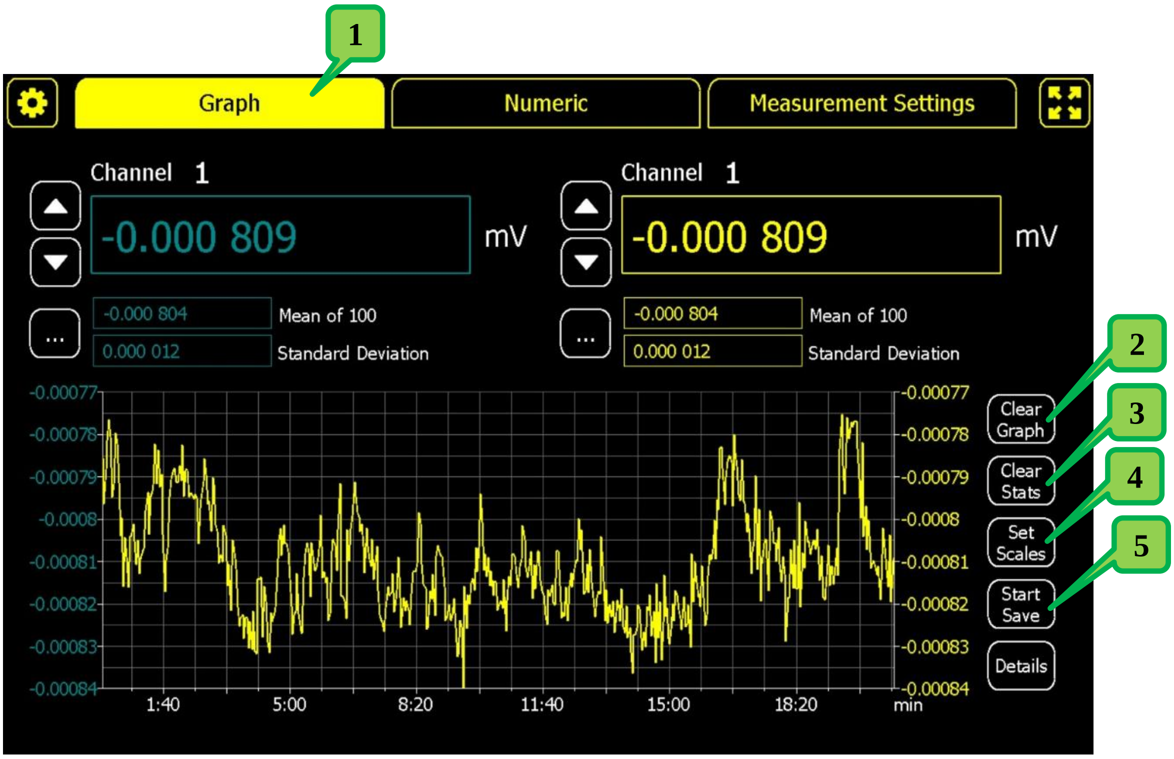
Press the *Measurement Settings [1]* tab, then press the *Channel [2]* parameter box (to open the "Select Channel" pop-up window) and select channel 1.

Press the *Status [3]* parameter box to toggle channel 1 into the "Enabled" state. Repeat this process to disable the other channels (this will speed up the measurements by not wasting measurement time on unused channels).



Now press the other parameter boxes to enter the required data using the associated pop-up windows. Note: the "Type" and "Range" boxes will be populated automatically when you select "Default Thermocouple" and cannot be changed. The 'Reference Junction' setting should be set to "0°C" otherwise the indicated voltage will be adjusted to compensate for the reference junction temperature.

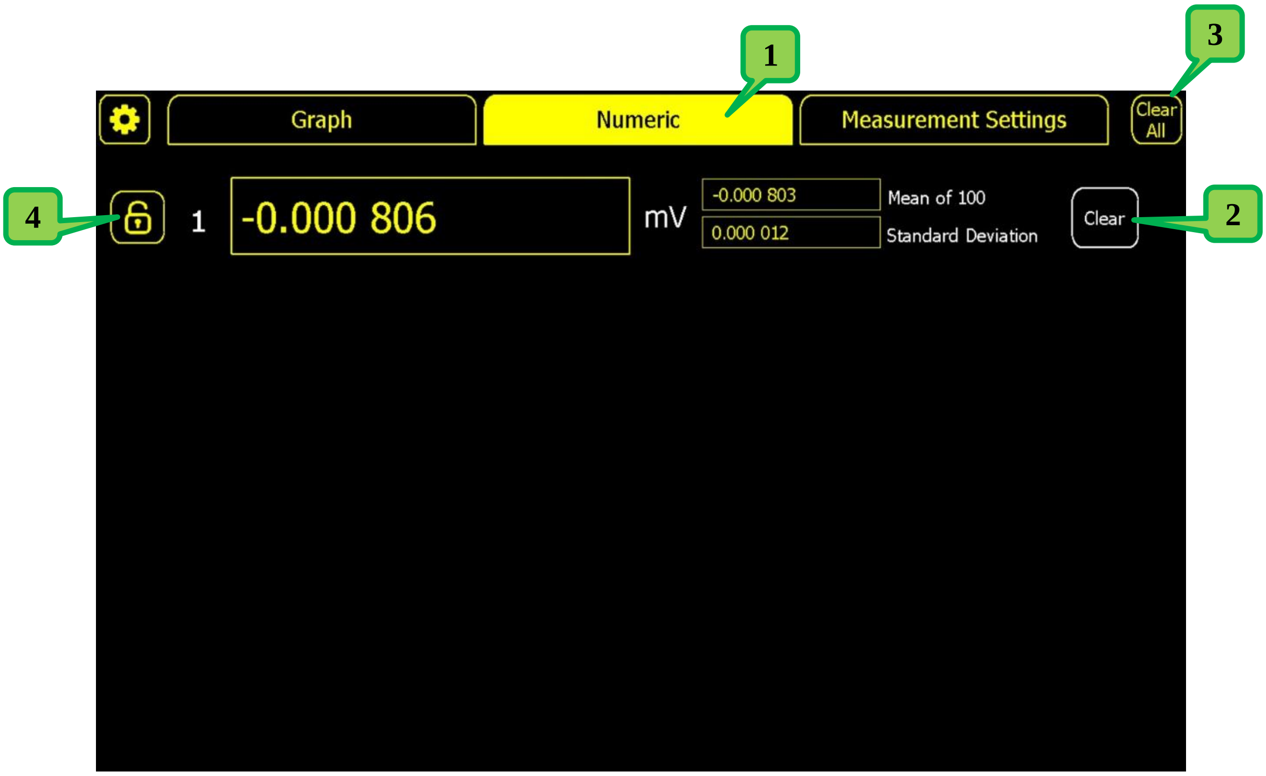
Press the *Graph [1]* tab to display the measurements graphically in real-time:



Press *Clear Graph [2]* to clear the graph; press *Clear Stats [3]* to clear the statistics for both channels on the graph; press *Set Scales [4]* to change the x-y scales of the graph.

To save the data press *Start Save [5]*, you will then be offered the choice of saving to an *External* USB flash drive ("memory stick") or *Internal* memory. If you choose the internal memory, you can backup the data to an external USB flash drive later (see section 3.7.5 for details).

Press the *Numeric [1]* tab to display the measurements numerically:



Press *Clear [2]* to clear the statistics for an individual channel; press *Clear All [3]* to clear the statistics for all channels; press the *Lock [4]* button to toggle between locking and unlocking the channel. When locked (displayed information changes to blue) the channel will always be displayed in the tab as you scroll through the channels. This feature can be used to lock (always display) a channel that is being used as a reference.

Tip: The microK^2 provides reference functions for standard thermocouples to convert the measured voltage to temperature. You can also enter a third-order polynomial as the individual deviation function for a calibrated thermocouple (see section 0).

3 Driving your microK^2

3.1 Introduction

The user interface for the microK^2 is provided through the WXGA resolution colour display with a PCT touch screen. It uses context sensitive buttons and menus to provide an easy-to-use interface that will feel familiar to users of other Isotech thermometry instruments.

The buttons in the microK^2 software have been sized and positioned to allow you to operate the instrument with your finger. If numeric or alphanumeric data needs to be entered, a pop-up keyboard window will appear. If you prefer to use a USB mouse or keyboard, you can simply plug these into the USB host connectors on the front panel. They will immediately become active provided they use the standard USB HID (human interface device) drivers.

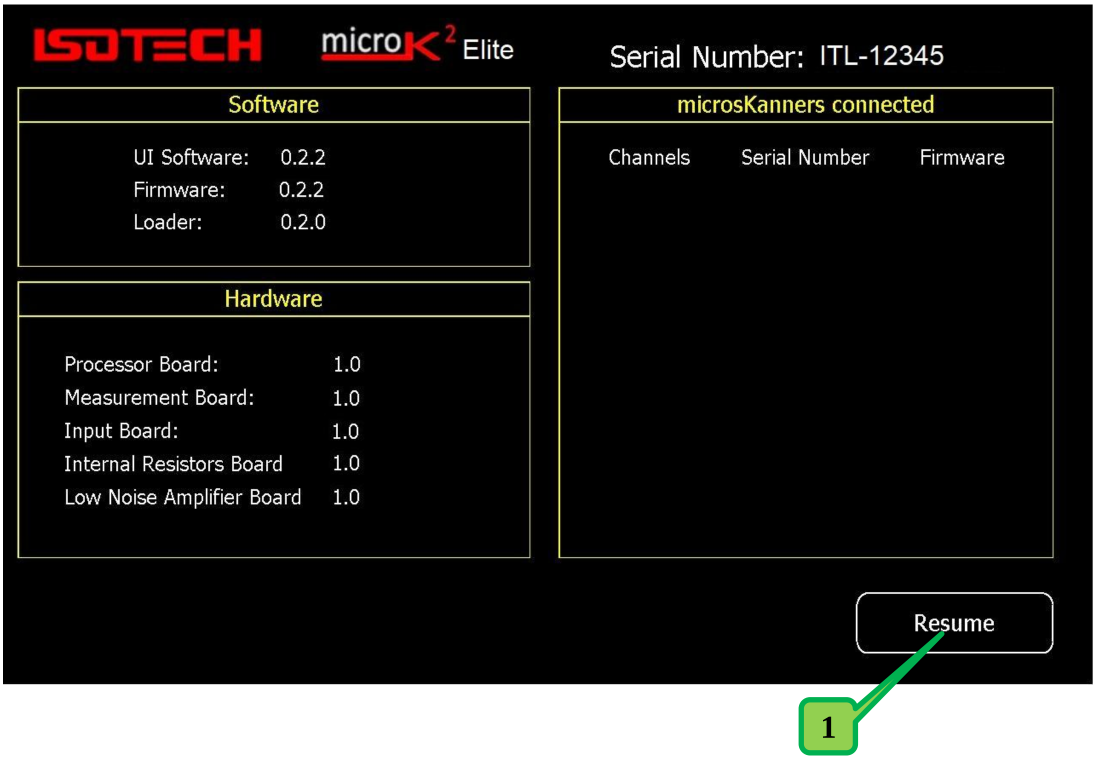
Calibration data for thermometers and reference resistors entered into the microK^2's database is password protected and includes recalibration dates. The microK^2 will alert you if you try to use a thermometer or reference resistor after its recalibration date with the option to ignore the warning (until the next restart). This feature ensures the integrity of your measurements and helps you to comply with the requirements of accreditation bodies.

The microK^2's internal resistance and voltage references can be calibrated by the user and are also protected by a separate calibration password. To provide total security for your measurement system, both passwords have a recovery mechanism that avoids the use of a 'backdoor' password.

3.2 The Start-up Screen

When the microK^2 is powered on, it goes through a boot sequence that loads the operating system and then starts the microK^2 application – this takes less than 1 minute. The start-up screen then appears showing: its serial number, the software and hardware used in your microK^2, and the details of any microsKanners used to expand channels on your microK^2.

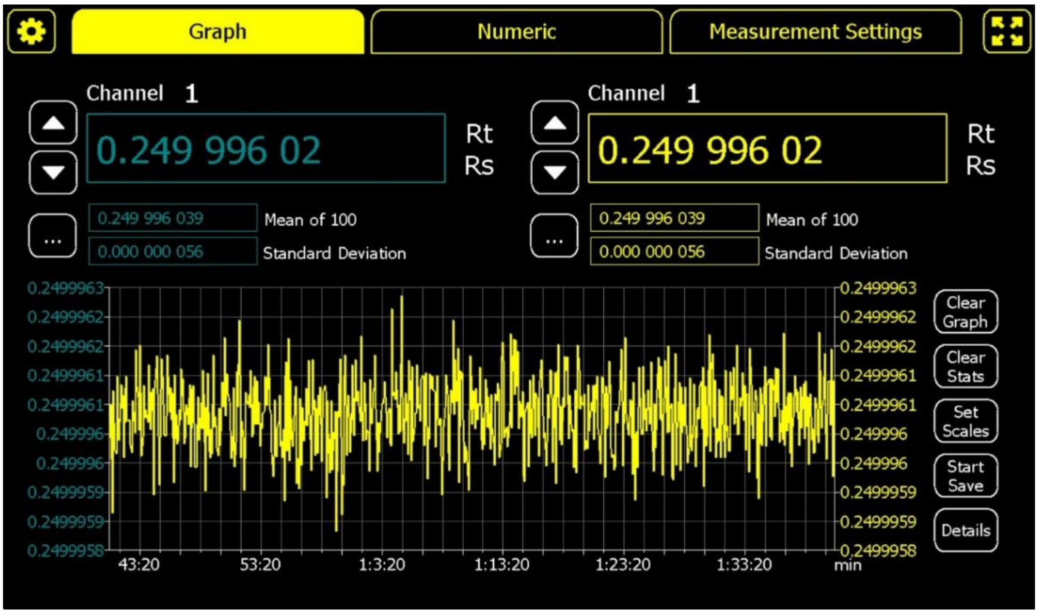
The start-up screen contains the *Resume [1]* button:



Resume: Pressing the *Resume [1]* button places the microK^2 in the state it was in prior to its last power down. **Before** pressing *Resume*, make sure that any thermometers attached will not be damaged by the sense currents that will be applied (the last values used). If in doubt, disconnect your sensors before proceeding and then reconnect them after changing the sense currents to the required value.

3.3 The Main Screen

Having pressed *Resume* in the start-up screen, you are presented with the main screen:



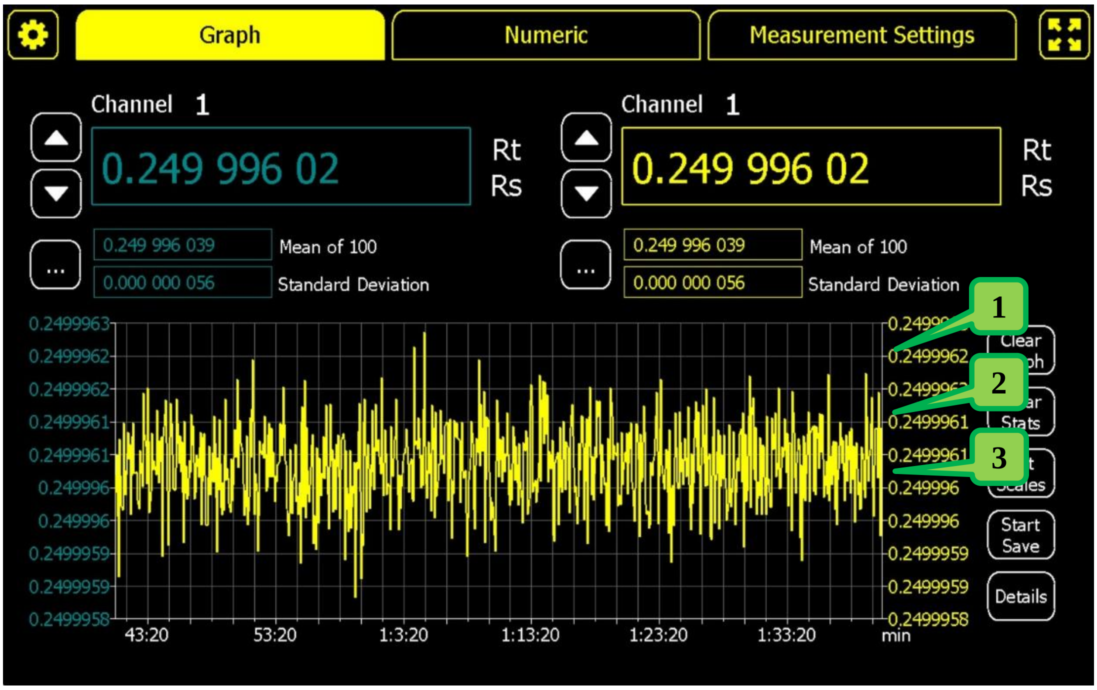
You will have access to all the functions that control the microK^2 through the three tabs and the Settings Cog in this screen:

Graph	Displays up to two channels in numeric and graphical form
Numeric	Displays all channels in numeric form
Measurement Settings	Allows you to configure the channels to perform the required measurements
(Settings Cog)	Allows you to enter information about the thermometers and reference resistors into the microK^2 database. It also allows you to save/load instrument configurations in the database, change instrument settings and perform calibration and maintenance functions

The main screen opens with the *Graph* tab selected.

3.4 The Graph Tab

Select this tab to see up to two channels in both numeric and graphical form:



The numeric part of the display shows the latest readings together with the mean and standard deviation of the most recent readings (the number of readings in the statistics is set in the *Measurement Settings* tab). If the zero-power extrapolation feature is being used, the mean and standard deviations are replaced by the "Zero-power Value" and "Uncertainty" values (see section 6).

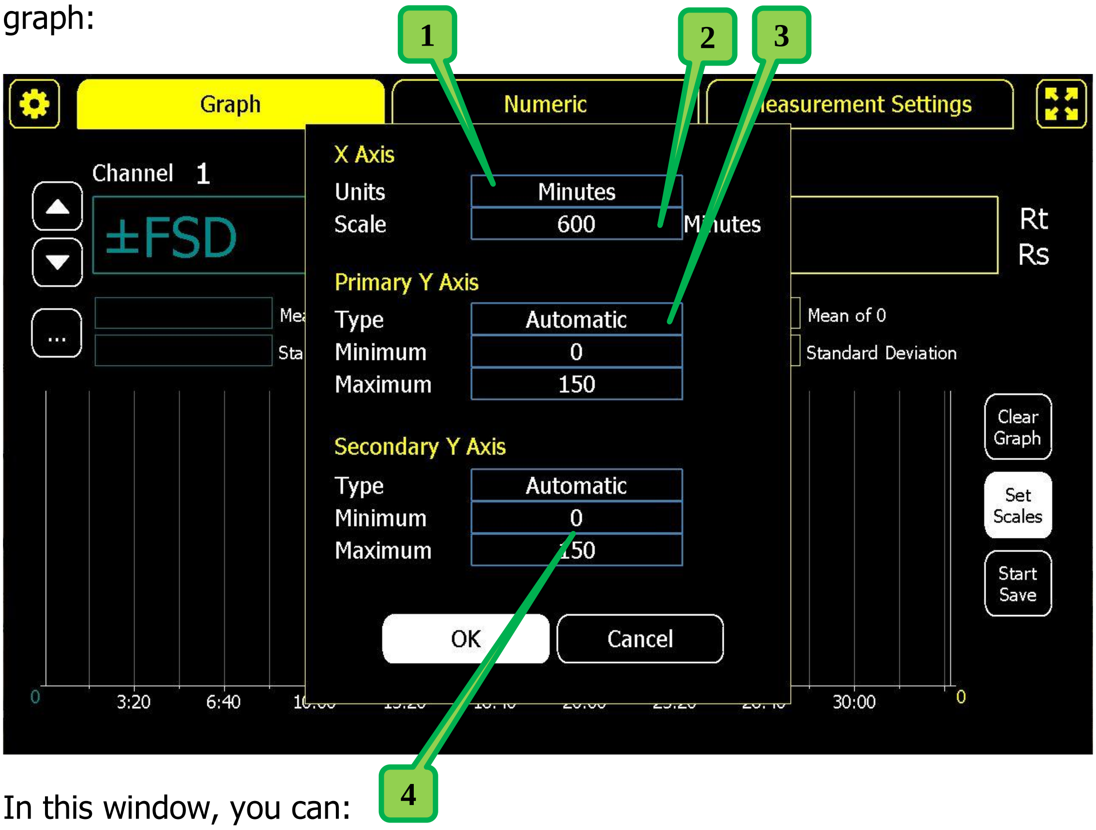
The numeric and graphical outputs are updated as new readings are made. The time between readings depends on the settings for that channel and any other channels that are also enabled. This can range from a few seconds to several minutes.

Channel parameter boxes: Use the *up/down* buttons by the *Channel* boxes to select the channel you wish to view. Alternatively press the *ellipses* button to open a numeric entry window and select the channel directly. The *ellipses* button is particularly useful when the microK^2 is used with microsKanner multiplexers, which can provide up to 90 external channels. You can only view channels that are enabled, so if a channel is disabled in the *Measurement Settings* tab, it will not appear in the sequence and will not be measured. This means that the *up/down* buttons have no effect if only one channel is enabled.

Clear Graph button: Press *Clear Graph [1]* to clear the graph and restart the autoscaling feature. This can be used to eliminate the effect of a large transient result (perhaps caused when changing connections to the thermometer).

Clear Stats button: Press *Clear Stats [2]* to clear (reset) the statistics on the channels being displayed. The statistics can also be cleared for individual channels using the *Clear* buttons in the *Numeric* tab. The statistics can be cleared for all channels using the *Clear All* button in the *Numeric* tab.

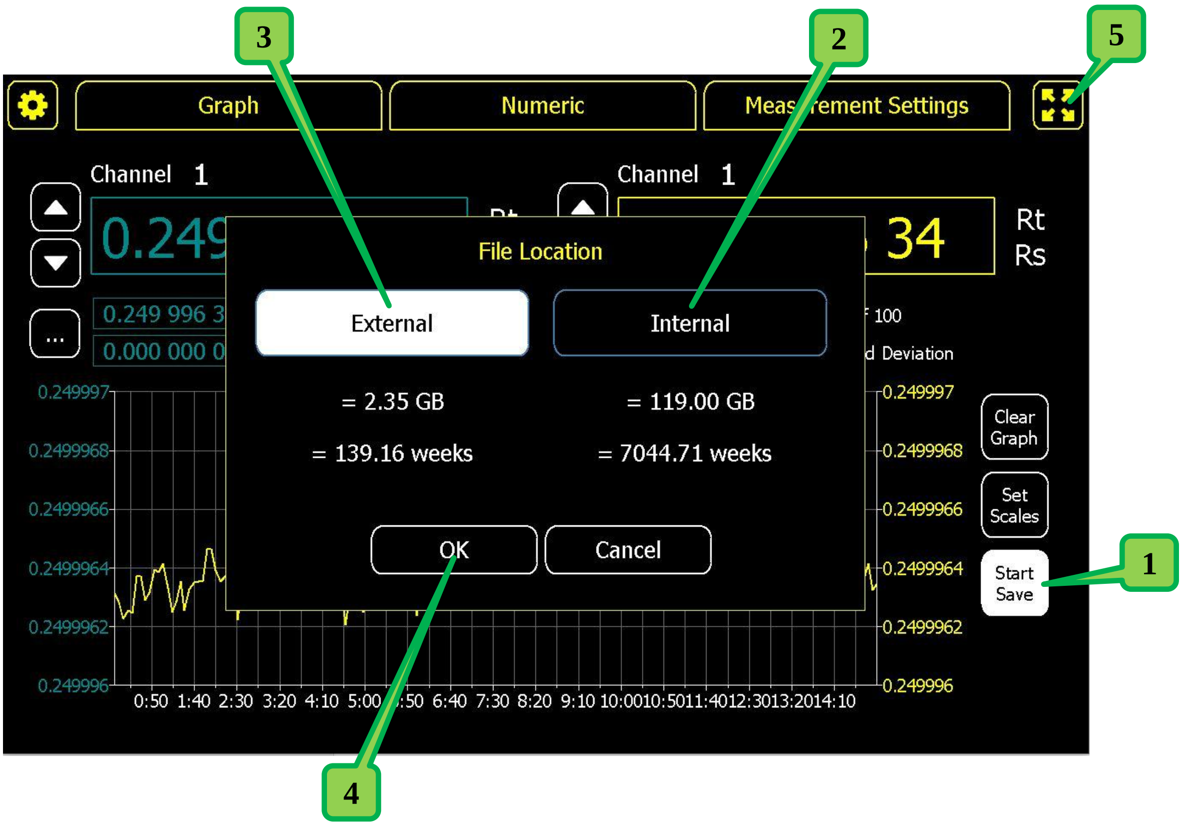
Set Scales button: Press *Set Scales [3]* to open a new window and set the x and y axes for the graph:



In this window, you can:

- Press the *Units [1]* parameter box to toggle between seconds and minutes
- Press the *Scale [2]* parameter box to set the x-axis scale in the associated pop-up window
- Press the *Type [3]* parameter box to toggle between 'Automatic' and 'Manual' modes. In 'Automatic' the scale adjusts to ensure all measurements are visible
- Press the *Minimum/Maximum [4]* parameter boxes (when in 'Manual' mode) to set the y-axis scale limits in the associated pop-up window

Start Save button: Press *Start Save [1]* to record all the measurements being made:



Press *Internal [2]* to store the measurements in internal memory (a solid-state drive) or *External [3]* to store the measurements on a USB flash drive plugged into the front panel. Data stored to the internal memory is preserved when power is removed and can subsequently be transferred to an external USB flash drive using the *Save Internal Logged Data* button in the *Settings Cog* (see section 3.7.5).

Select the destination for the data and then press *OK [4]* to open a pop-up window in which you can enter a filename. An automatically incrementing default name (based on the time and date) will appear in the entry box, press *enter* to accept this or use the soft keys to enter your preferred filename.

The *caps* key toggles the alpha keys between upper and lower case. The *shift* key toggles the alpha keys between upper and lower case for the next character only. If you try to use a filename that has already been used, you will have to enter the user password to proceed (see section 3.8 for details on password protection).

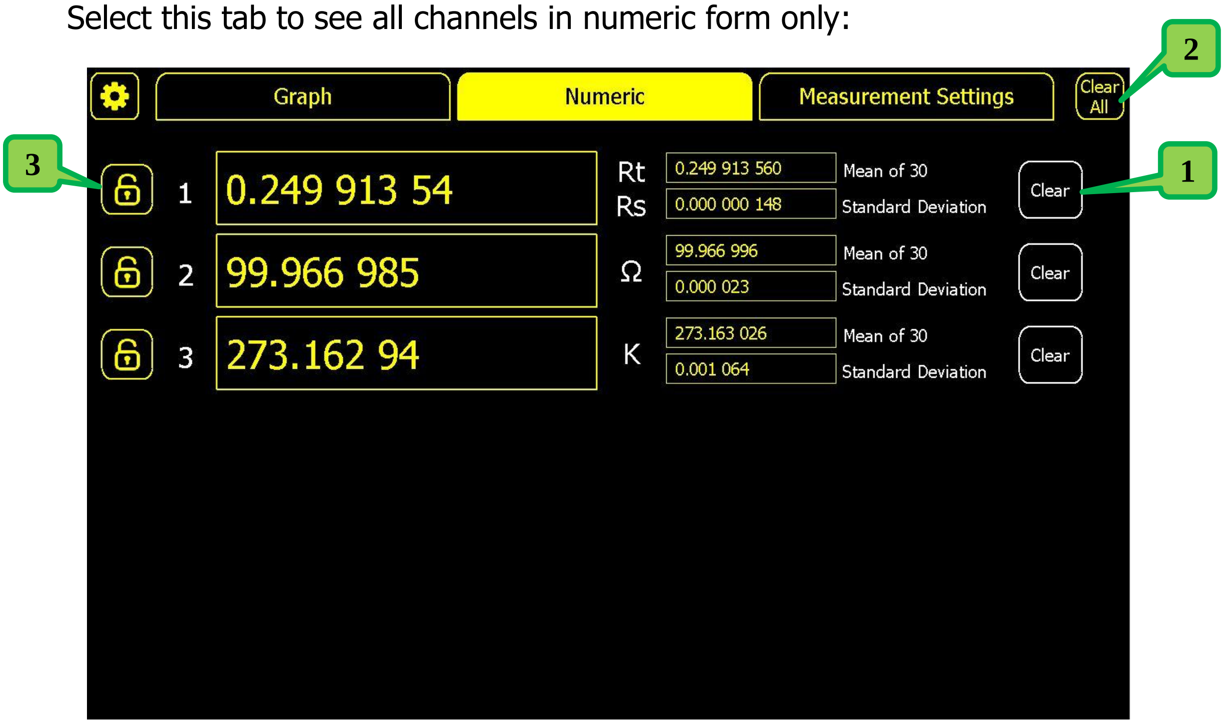
The measurements are written to the file in a comma delimited ASCII text form allowing easy importation into Microsoft Excel™ or other applications.

Press *Stop Save* to stop the recording of measurements.

Full Screen button: Press the *Full Screen [5]* button  to maximise the graph by removing the tabs and buttons. Press it again to return to the normal 'Graph' tab display

3.5 The Numeric Tab

Select this tab to see all channels in numeric form only:



The numeric display shows the latest reading together with the mean and standard deviation of the most recent readings for each of the channels that are enabled (the number of readings in the statistics is set in the *Measurement Settings* tab). If the zero-power extrapolation feature is being used, the mean and standard deviation values are replaced by the "Zero-Power Value" and "Uncertainty" values.

The displayed values are updated as new readings are taken. The time between readings depends on the settings for that channel and any other channels that are also enabled. This can range from a few seconds to several minutes.

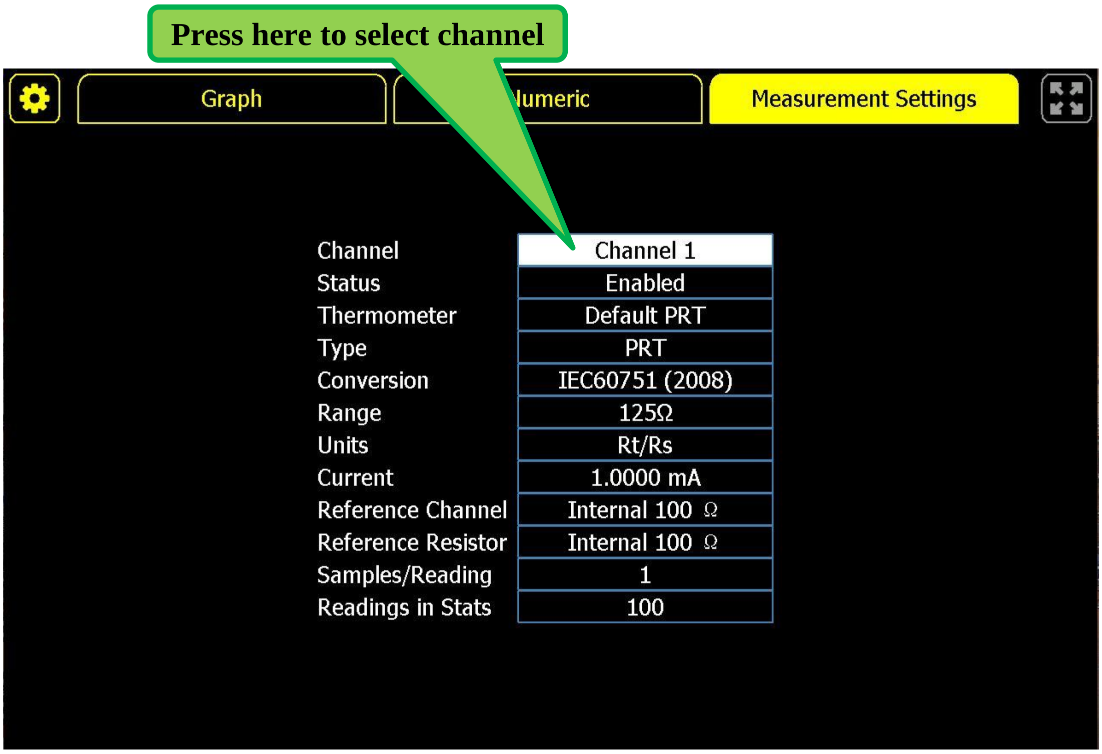
Clear buttons: Press the *Clear [1]* buttons to clear (reset) the statistics for the associated channel.

Clear All button: Press the *Clear All [2]* button to clear (reset) the statistics for all the channels.

Lock Channel buttons: Press the *Lock [3]* button to display a channel at the top of the screen permanently. Press the Unlock button to return it to the list below. Locked channels are displayed in blue. This feature is useful if you have many channels and want to have certain channel visible as you scroll through others (e.g. measurements from a reference thermometer).

3.6 The Measurement Settings Tab

Select this tab to configure each channel for the required measurement:



Press the parameter boxes (not the name) to change the setting/value as required.

Channel box: This opens a pop-up window containing all the channels, including any connected via microsKanners. Select the channel you wish to configure and then press *Select* to return to the Measurement Settings screen.

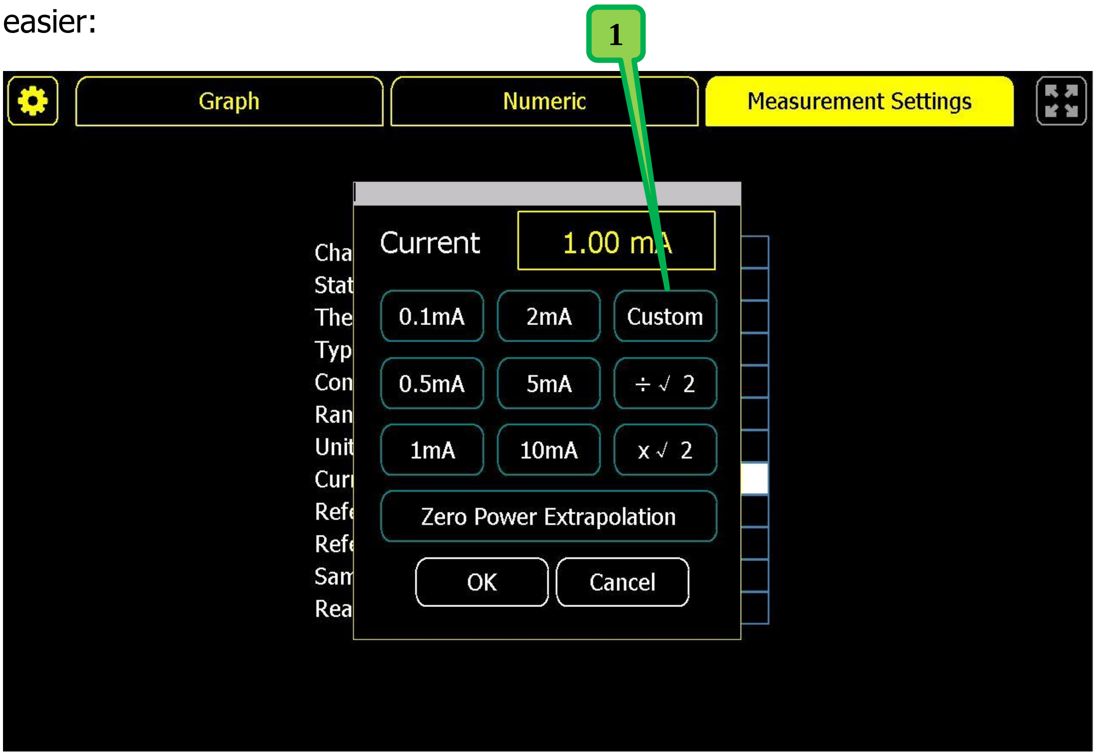
Status box: This toggles the channel between "Enabled" and "Disabled". Disable unused channels to skip measurements on that channel and reduce the cycle time through the channels.

Thermometer box: This opens a pop-up window listing all available thermometers. Initially this list will contain only "Default PRT", "Default Thermistor" and "Default Thermocouple"; these cannot be edited or deleted. You can use these entries for uncalibrated thermometer sensors. If you add thermometers to the microK^2's thermometer database (see section 3.7.1), these will also appear in the list. Select the thermometer you wish to use, and press *Select* to return to the Measurement Settings screen.

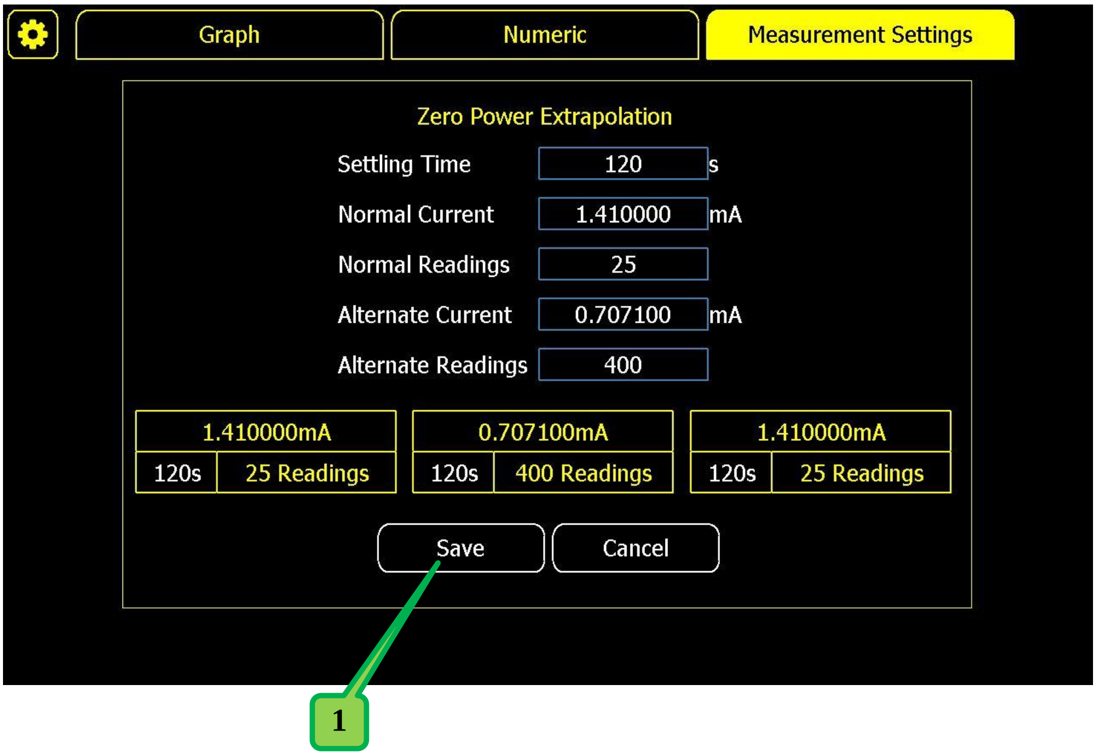
Type box: This displays the thermometer type and is defined when a thermometer is created. It cannot be edited here.

Conversion box: If the selected thermometer is one of the default types, you can press the box to open a pop-up window and select a standard polynomial function for converting the thermometer's base measurement to temperature. If the selected thermometer is one that you have created in the Thermometer Database, this box will be fixed and will be the conversion type defined for that thermometer.

Current box (PRTs and thermistors only): This opens the window in which the sense current for resistance measurements is set. The standard PRT sense currents are available directly through the buttons provided. Press the *Custom [1]* button to specify a different value (range 0 to 14.2 mA). Buttons for ÷√2 and ×√2 are included to make manual extrapolation to zero power easier:



Uniquely, the microK² can be configured to alternate the current between two values and extrapolate from these measurements to determine a zero-power resistance (see section 6). Press *Zero Power Extrapolation* to define the measurement sequence:



Press the parameter boxes to open pop-up windows and set the "Settling Time" (time for the thermometer to come to thermal equilibrium after a current change), "Normal Current", "Alternate Current" and the "Readings at Each Current" for each current setting. The resulting measurement sequence is displayed at the bottom of the window. The resistance is first measured at the normal current, then at the alternate current, and finally at the normal current again, with settling delays after each current change.

Press *Save [1]* to return to the 'Current' Window. The *Zero Power Extrapolation* button will have been replaced with the *Clear Zero Power Extrapolation* button. Press this button to disable this feature and return to using a single sense current.

Range box: This opens a window listing the available measurement ranges for PRTs and thermistors only. For thermocouples, the range is fixed at 0.125 V and cannot be changed (the pop-up function is disabled). Depending on your selected sense current, the microK^2 will offer you the choice of three resistance ranges corresponding to input voltages of 0.125, 0.5 and 2.5 V. Choose a resistance range that is greater than or equal to both the thermometer resistance and reference resistor value you intend to use.

Tip: Using the lowest suitable resistance range (but one that exceeds the resistance of the thermometer and reference resistor) will give the lowest possible measurement noise and therefore uncertainty. This simple precaution can halve the measurement uncertainty in a typical application.

Reference Channel box (PRTs and thermistors only): This opens a window listing the internal resistance standards and available channels to which a reference resistor can be connected. Select the reference resistance or channel and press *Select* to return to the Measurement Settings screen.

Reference Resistor box (PRTs and thermistors only): If an internal reference resistor was selected in the *Reference Channel* box, this box will show the name of that resistor which cannot be changed here. If one of the input channels was selected in the *Reference Channel* box, the *Reference Resistor* box will contain a list of the reference resistors in the microK^2's database (entered using the *Resistor Database* button in the *Settings Cog* – see section 3.7.2) as well as an *Uncalibrated* option. Select *Uncalibrated* if you only want to make a resistance ratio measurement between two channels. Otherwise, select the required reference resistor and press *Select* to return to the Measurement Settings screen.

Reference Junction box (thermocouples only): This opens the window listing 0 °C, 0.01 °C and any input channels that have been configured to measure temperature. Choose 0 °C or 0.01 °C if you are using an external reference junction in an ice-point bath or water triple point bath respectively. Choose one of the measurement channels if you want to measure the temperature of the reference junction with a thermometer on that channel. The software will not allow you to use a thermocouple channel as the reference junction sensor (to avoid circular dependencies). You must specify a thermometer sensor for the reference junction channel that includes temperature conversion, otherwise it will not appear in the *Reference Junction* box.

Units box: This opens a window listing the available units for the thermometer type. The base units are always available (resistance ratio "Rt/Rs" for PRTs and thermistors or "Volts" for thermocouples). "Ω" will also be available (only for PRTs and thermistors) if the value of the reference resistor is available (*Reference Resistor* not set to "Uncalibrated"). If the thermometer sensor chosen has a temperature conversion specified, then temperature units K, °C and °F are also available. Select the units you wish to use, and press *Select* to return to the Measurement Settings screen.

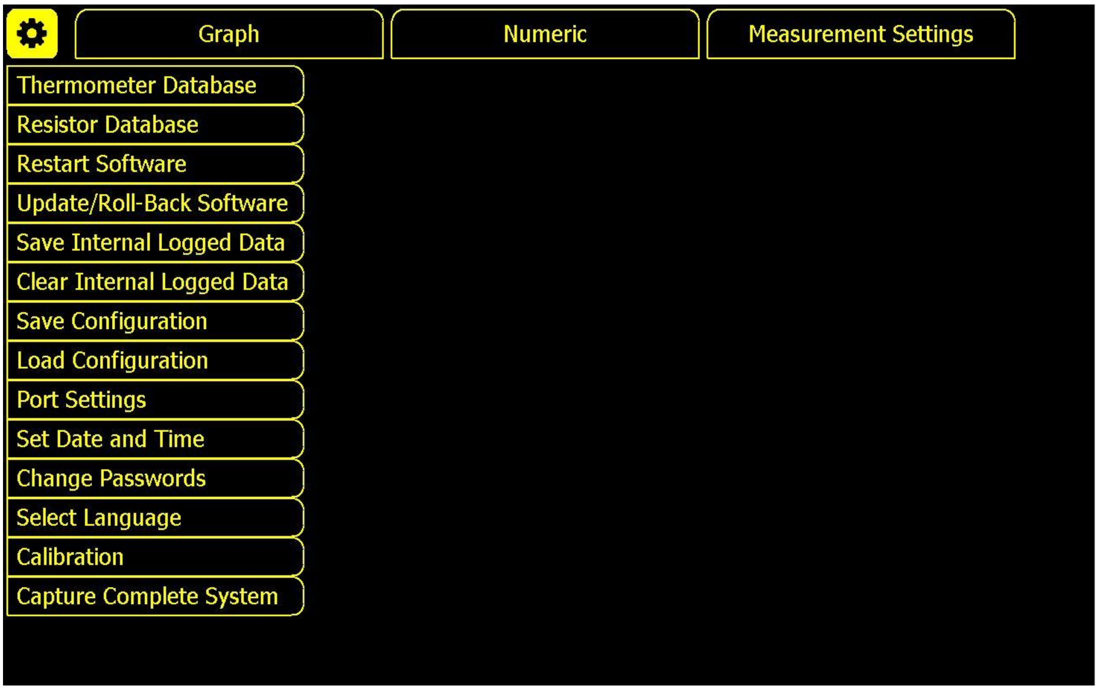
Samples per Reading box: This opens a numeric entry window to set the number of samples you want to average together to form a single reading. Values between 1 and 999 (inclusive) may be used.

Increasing the number of samples will slow down the rate at which readings are made, but this will reduce the uncertainty associated with these readings (as shown by the standard deviations reported in the *Graph* and *Numeric* tabs). This uncertainty reduction is proportional to the square-root of the number of samples. For example: selecting 16 samples per reading will reduce the uncertainty contribution from measurement noise by a factor of 4.

Readings in Rolling Statistics box: This opens a numeric entry window to set the number of samples in the rolling statistics. Values between 1 and 999 (inclusive) may be used.

3.7 The Settings Cog

Press the *Settings Cog* button to enter information into the microK^2's database (for thermometers and reference resistors), adjust system settings or perform other maintenance and calibration functions:

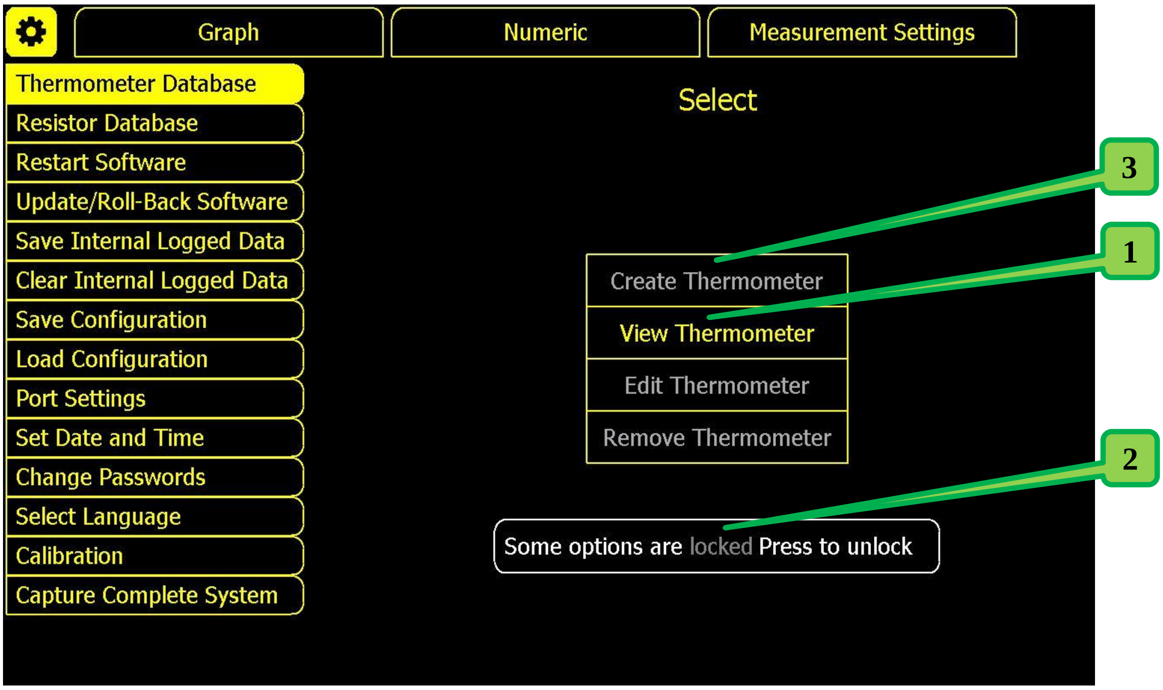


3.7.1 Thermometer Database

The microK^2 contains a database that allows you to enter, review, and edit information about the thermometers you use. You can then select a thermometer from this database, and all the parameters associated with it will be automatically loaded and used by the measurement system. This means that you do not need to manually enter information, such as the calibration coefficients, each time you use the thermometer, reducing the risk of data entry errors.

Information in the database is password protected to help you comply with the requirements of accreditation bodies.

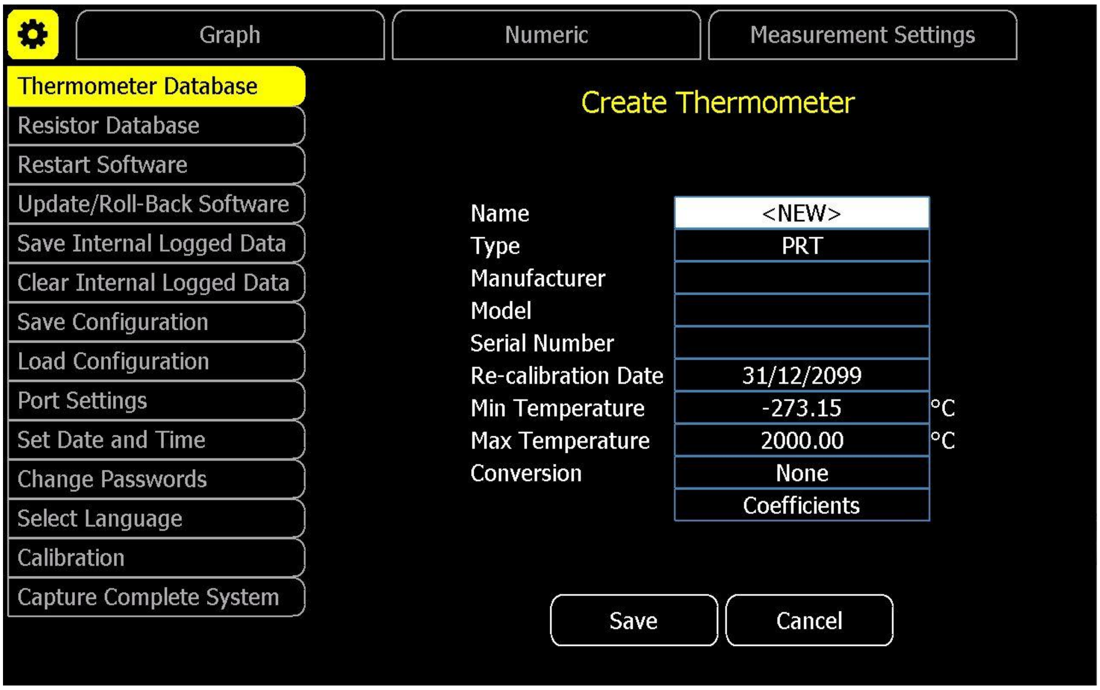
Press *Thermometer Database* to create, view, edit or remove (delete) thermometers in the database:



You can always view thermometers by pressing *View Thermometer [1]*. To create, edit or remove a thermometer you will need to enter the user password. Press *Some options are locked Press to unlock [2]* and enter the user password to proceed.

3.7.1.1 Create a Thermometer

Press *Create Thermometer [3]* to create a new thermometer in the database:



Press each parameter box in turn to enter the required information:

Name: This box opens a pop-up window in which you can enter a name for this thermometer. The *caps* key toggles the alpha keys between upper and lower case. The *shift* key toggles the alpha keys between upper and lower case for the next character only.

Type: This box opens a pop-up window. Select the required thermometer type from the list and press *Select* to return to the previous menu.

Manufacturer: This opens a pop-up window in which you can enter the name of the manufacturer.

Model: This opens a pop-up window in which you can enter the model number.

Serial Number: This opens a pop-up window in which you can enter the serial number.

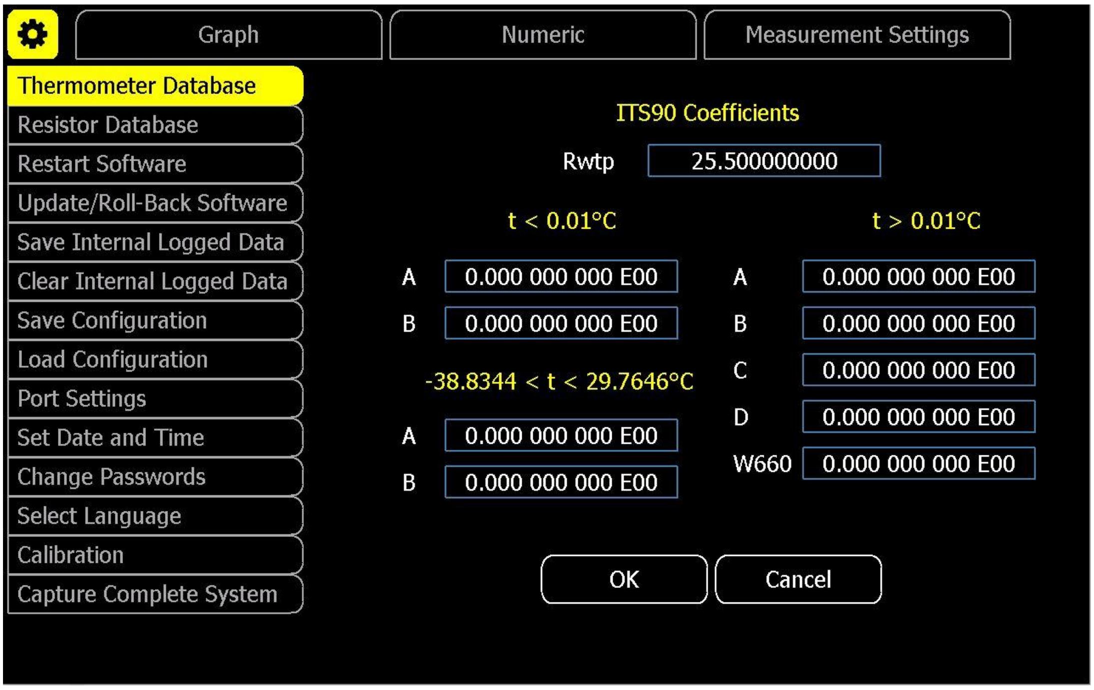
Recalibration Date: This opens a pop-up window in which you can enter a date for when the thermometer should be recalibrated. The microK^2 will warn you if you try to use a thermometer past its recalibration date. You will be given the option to ignore this warning, but it will continue to reappear every time the microK^2 is restarted until the recalibration issue is resolved.

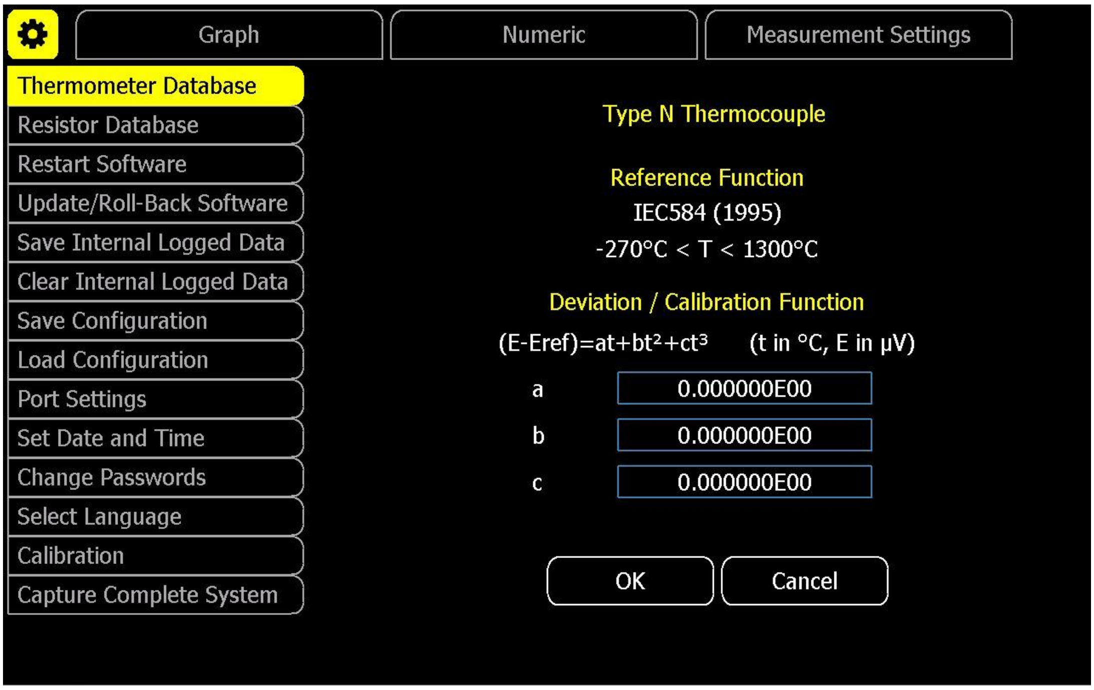
Min Temperature: This opens a pop-up window in which you can enter the minimum operating temperature for the thermometer.

Max Temperature: This opens a pop-up window in which you can enter the maximum operating temperature for the thermometer.

Conversion: This opens a pop-up window containing the temperature conversion algorithms for the selected thermometer type. Select the required conversion and press *Select* to return to the previous menu.

Coefficients: This opens a pop-up window in which you can enter the coefficients required for the selected temperature conversion. In the case of ITS-90 or thermocouples, these are the coefficients for the deviation function (the base conversion coefficients are fixed):





3.7.1.2 Edit a Thermometer

Press *Edit Thermometer* in the *Thermometer Database* menu to change the parameters for a thermometer. Press the parameter box you wish to change and enter the new value in the pop-up window.

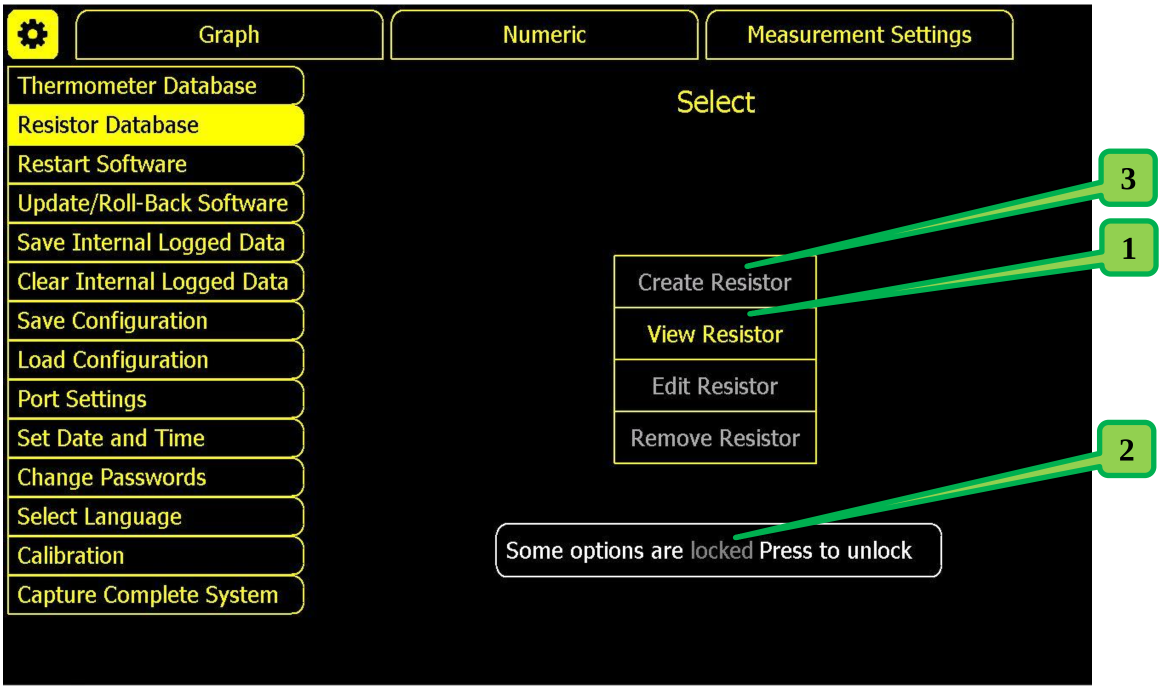
3.7.1.3 Delete a Thermometer

Press *Remove Thermometer* in the *Thermometer Database* menu to delete a thermometer from the database. Select the thermometer you wish to delete (details of the thermometer will appear) and then press the red "Remove" button.

3.7.2 Resistor Database

The microK^2 contains a database that allows you to enter, review, and edit information about the reference resistors you use. You can then select a reference resistor from this database, and all the parameters associated with it will be automatically loaded and used by the measurement system. This means that you do not need to manually enter information, such as the resistance value, each time you use the reference resistor, reducing the risk of data entry errors. Information in the database is password protected to help you comply with the requirements of accreditation bodies.

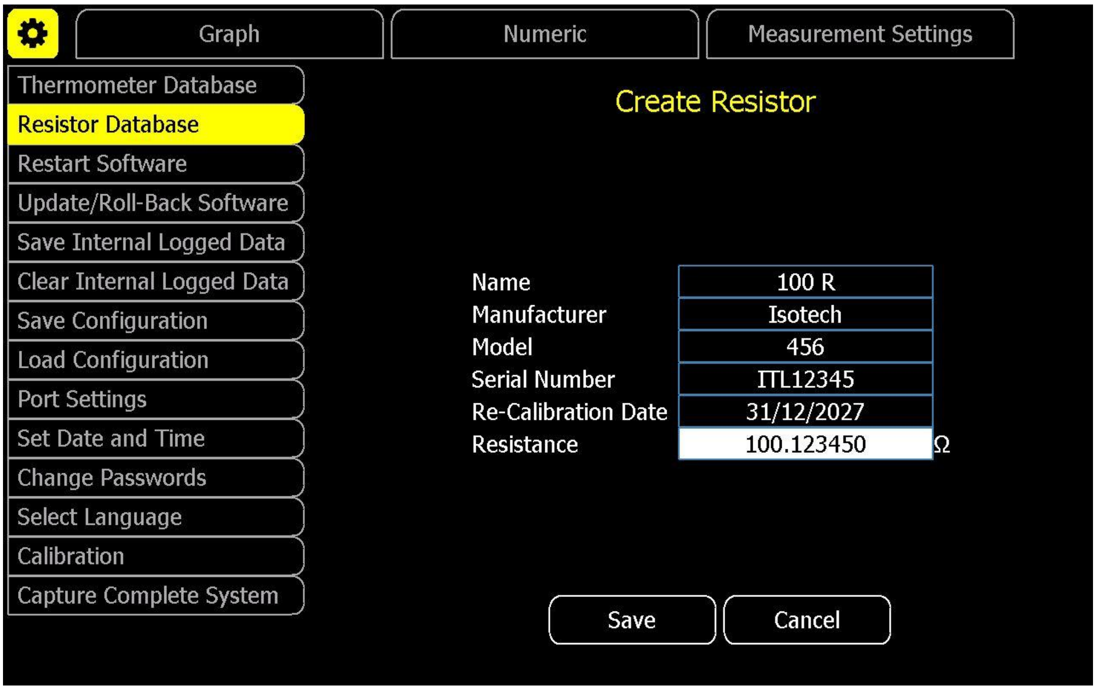
Press *Resistor Database* to create, view, edit or remove (delete) resistors in the database:



You can always view resistors by pressing *View Resistor [1]*. To create, edit or remove a resistor you will need to enter the user password. Press *Some options are locked Press to unlock [2]* and enter the user password to proceed.

3.7.2.1 Create a Resistor

Press *Create Resistor [3]* to create a new resistor in the database:



Press each parameter box in turn to enter the required information:

Name: This box opens a pop-up window in which you can enter a name for this resistor. The *caps* key toggles the alpha keys between upper and lower case. The *shift* key toggles the alpha keys between upper and lower case for the next character only.

Manufacturer: This opens a pop-up window in which you can enter the name of the manufacturer.

Model: This opens a pop-up window in which you can enter the model number.

Serial Number: This opens a pop-up window in which you can enter the serial number.

Recalibration Date: This opens a pop-up window in which you can enter a date when the resistor should be recalibrated. The microK^2 will warn you if you try to use a resistor past its recalibration date. You will be given the option to ignore this warning, but it will continue to reappear every time the microK^2 is restarted until the recalibration issue is resolved.

Resistance: This opens a pop-up window in which you can enter the calibrated value for the resistor.

3.7.2.2 Edit a Resistor

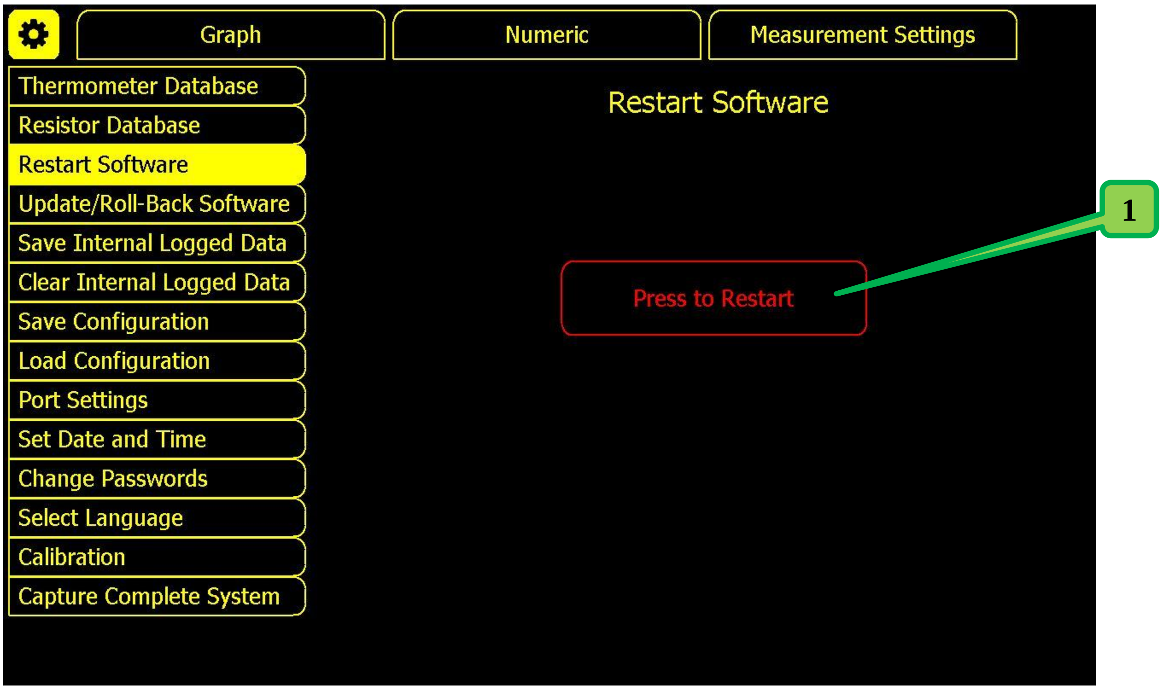
Press *Edit Resistor* in the *Resistor Database* menu to change the parameters for a resistor. Press the parameter box you wish to change and enter the new value in the pop-up window.

3.7.2.3 Delete a Resistor

Press *Remove Resistor* in the *Resistor Database* menu to delete a resistor from the database. Select the resistor you wish to delete (details of the resistors will appear) and then press the red "Remove" button.

3.7.3 Restart Software

Press *Restart Software* and then press the red *Press to Restart [1]* button to restart the microK^2 software:



This is useful if you have added or removed microsKanners and want to re-invoke the automatic discovery process without cycling the power.

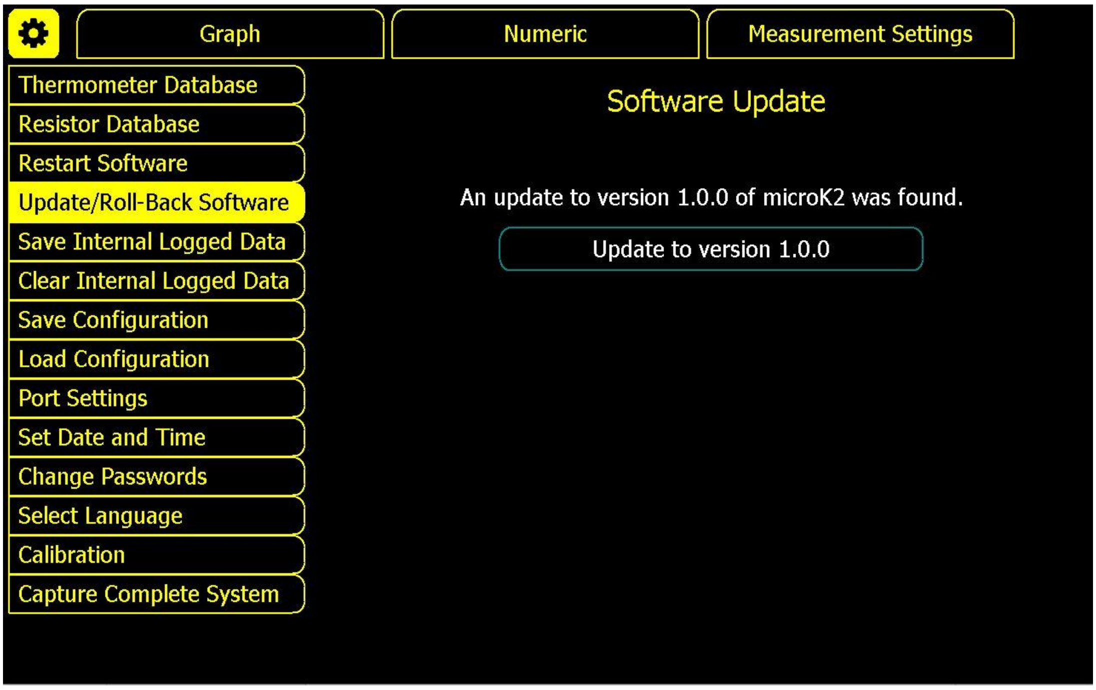
3.7.4 Update/Roll-Back Software

The software in the microK^2 provides the user interface and controls the instrument. It can easily be updated in-situ. Copies of all software versions installed on the microK^2 are archived so that it can be rolled back to any previous version.

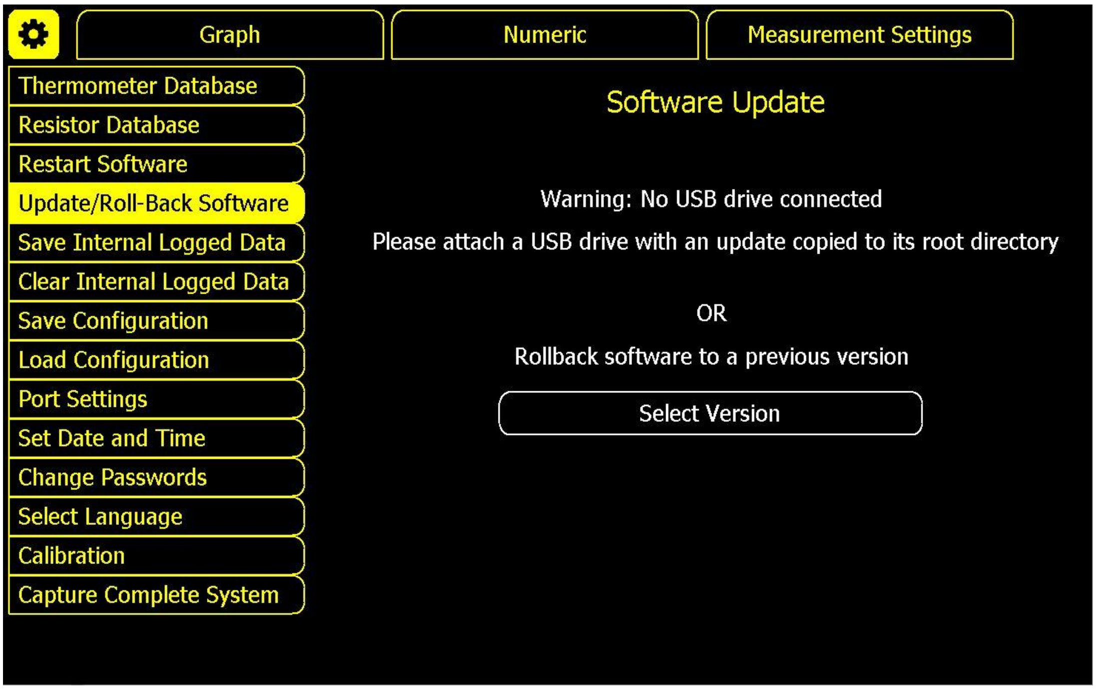
To update the software, save the update pack (supplied by Isotech as a zipped file) to the root directory of a USB flash drive and plug it into a USB port on the front of the microK^2.

Press *Update/Roll-Back Software* and enter the calibration password (initially set to 5678) to see the details of the update.

Press *Update to version x.y.z* to update the software:



To roll back the software to any previously installed version, simply press *Update/Roll-Back Software* and then *Select Version*. You will be offered a list of previous versions from which to make your selection:



3.7.5 Save Internal Logged Data to an External Storage Device

To save (backup) measurement data that was logged internally, insert a USB flash drive into the front panel and press *Save Internal Logged Data*. The file format is CSV (comma separated values) and can be viewed on an external PC using a suitable application such as Microsoft Excel™.

If a file with the same name is already present on the USB flash drive, you will be asked whether you wish to over-write it. To proceed, you will need to enter the user password.

Files are copied to the USB flash drive into the following directory:

\\microK2Data*serialnumber*\data

where "*serialnumber*" is the serial number of your microK^2. This means that you can use duplicate filenames for measurements, provided they are made with different instruments.

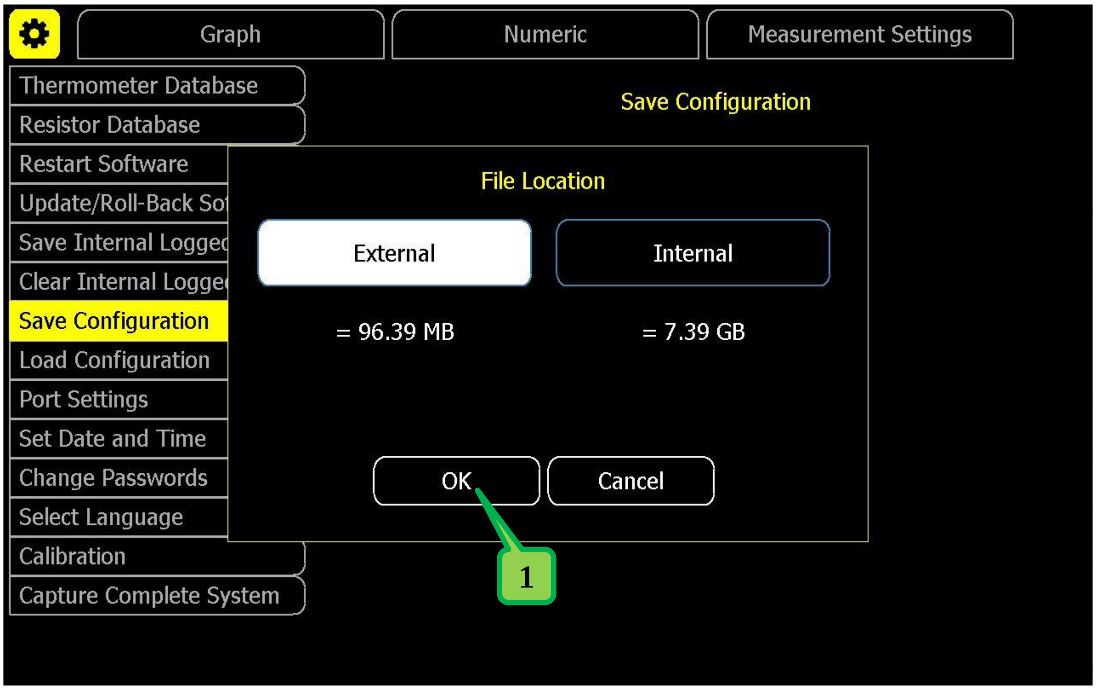
3.7.6 Clear Internal Logged Data

Press *Clear Internal Logged Data* to delete data files from the internal memory and free up space for new files to be recorded.

3.7.7 Save Configuration

Saving configurations is useful if you repeatedly use the microK^2 in a variety of different ways.

Press *Save Configuration* to save the microK^2's current Measurement Settings. You will then be offered the choice of storing the configuration on an *External* USB flash drive plugged into the front panel, or in the *Internal* memory (solid-state drive):



Press *OK [1]* to confirm your choice. This will open a pop-up window where you can enter a filename. An automatically incrementing default name (based on the time and date) will appear in the entry box, press *enter* to accept this or use the soft keys to enter your preferred filename. The *caps* key toggles the alpha keys between upper and lower case. The *shift* key toggles the alpha keys between upper and lower case for the next character only. If you try to use a filename that has already been used, you will have to enter the user password to proceed (see section 3.8 for details on password protection).

Configurations stored on a USB flash drive are in the following directory:

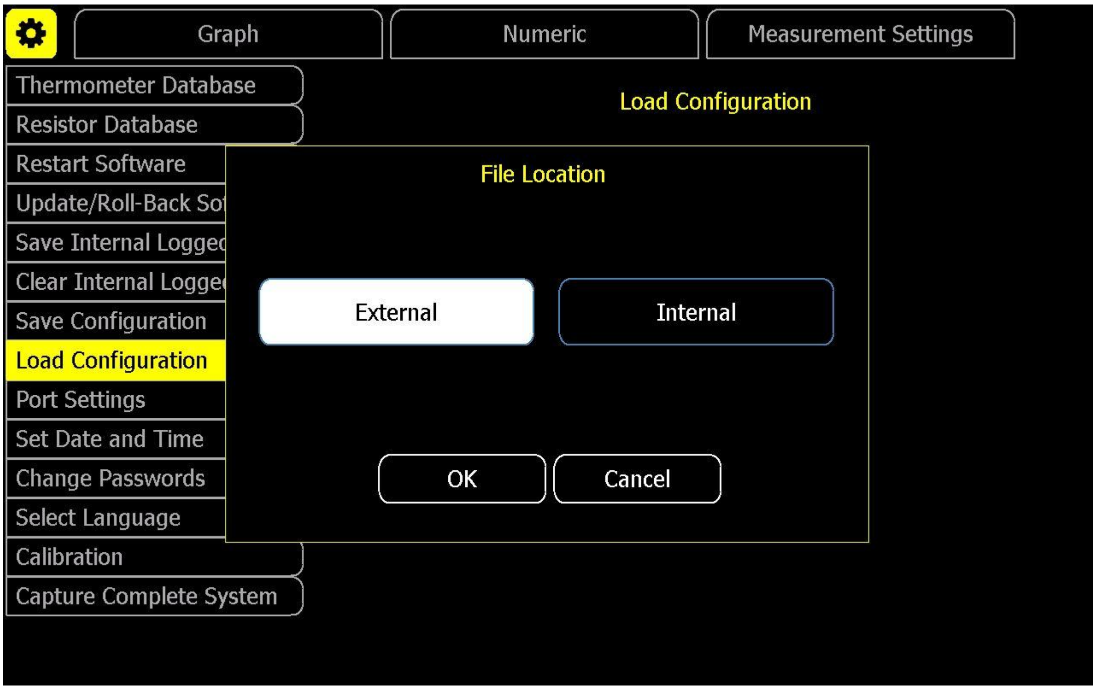
\\microK2Data*serialnumber*\backups

where "*serialnumber*" is the serial number if your microK^2. This means that you can use duplicate configuration names (filenames) provided they apply to different instruments. If you want to transfer a configuration from one microK^2 to another, you will need to move the configuration file manually on the USB flash drive between the sub-directories for the two microK^2's.

3.7.8 Load Configuration

You can load a pre-saved configuration rather than having to manually re-enter all the settings required for that particular measurement configuration.

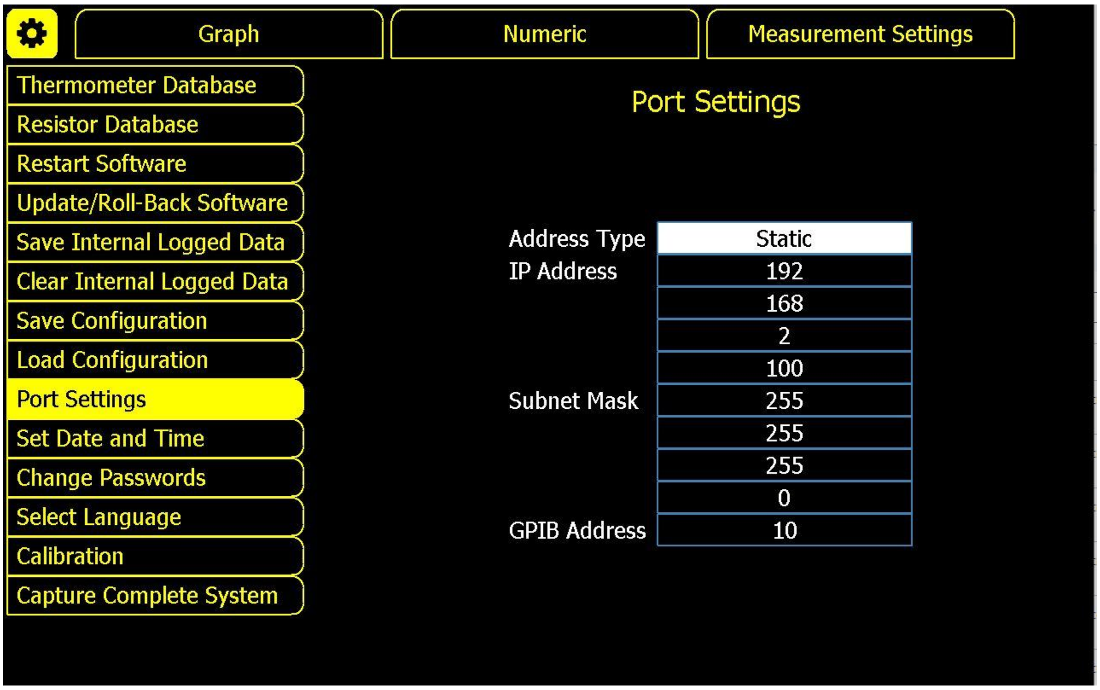
Press *Load Configuration* to load a Measurement Settings configuration onto the microK^2. You will then be offered the choice of loading the configuration from an *External* USB flash drive or the *Internal* memory (solid-state drive) – press *OK* to confirm your selection:



Choose the required configuration from the list in the pop-up window and then press *Select* to load that configuration.

3.7.9 Port Settings

Press *Port Settings* to view and change the microK^2's IP address, subnet mask and GPIB address (the RS232 baud rate is fixed and cannot be changed):

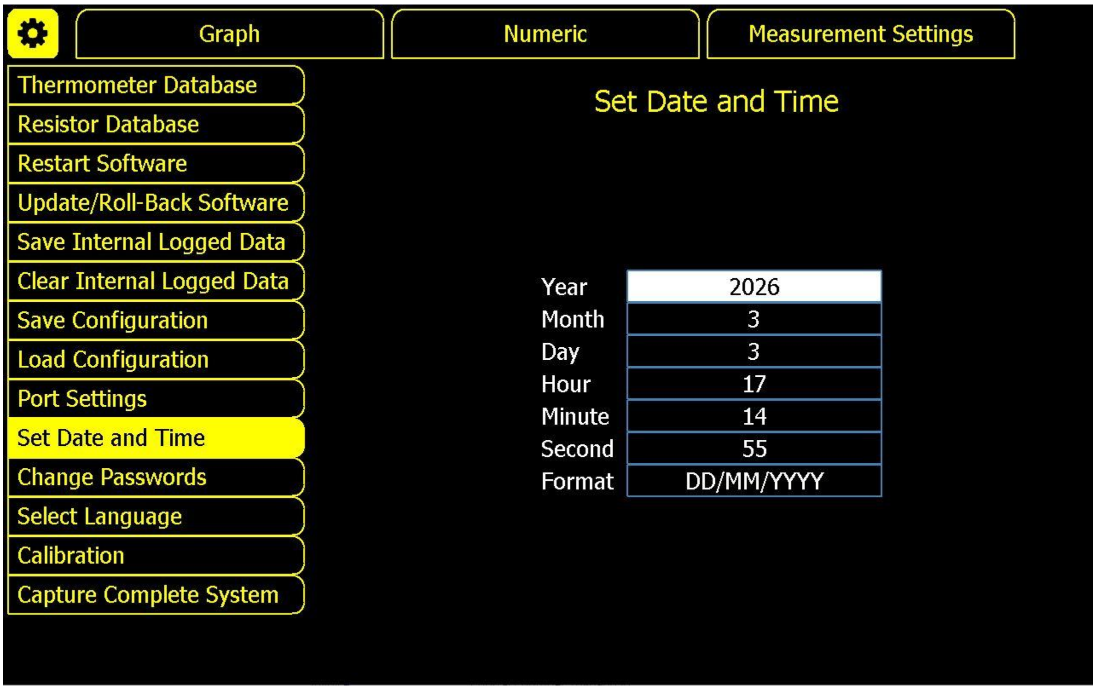


Press a parameter box if you wish to make a change.

Press the "Address Type" box to toggle the IP address between "Static" (a fixed IP address - specified in the parameter boxes here) or "Dynamic" (IP address assigned by a DHCP server on the network).

3.7.10 Set Time & Date

Press *Set Date and Time* to change the system's date and/or time. This opens a window where you can enter the current date and time, and select the date format used in the log files (DD/MM/YYYY or MM/DD/YYYY):

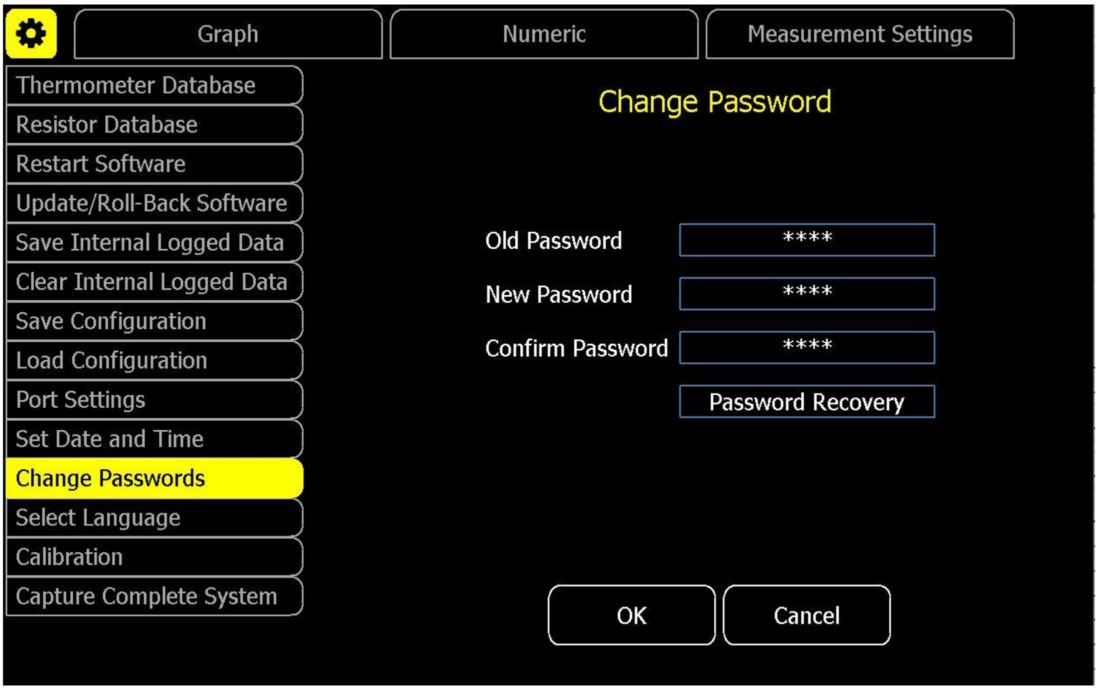


Press each box to open a numeric keypad window and enter the required value. Press the "Format" box to toggle between the date formats.

3.7.11 Change Passwords

The microK^2 uses two passwords. The "User Password" controls access to data that would affect the measurement results such as resistance values for resistors or temperature conversion coefficients for thermometers, these are stored in the microK^2's database. The "Calibration Password" controls access to the internal calibration data for the microK^2 itself. See section 3.8 for details of the settings protected by each password. The user password is initially set to "1234" and the calibration password is initially set to "5678". These should be changed before the microK^2 is used to protect the integrity of the measurements you make.

Press *Change Passwords* and select which password you wish to change. Enter the old password first, then enter the new password twice to confirm it has been entered correctly:

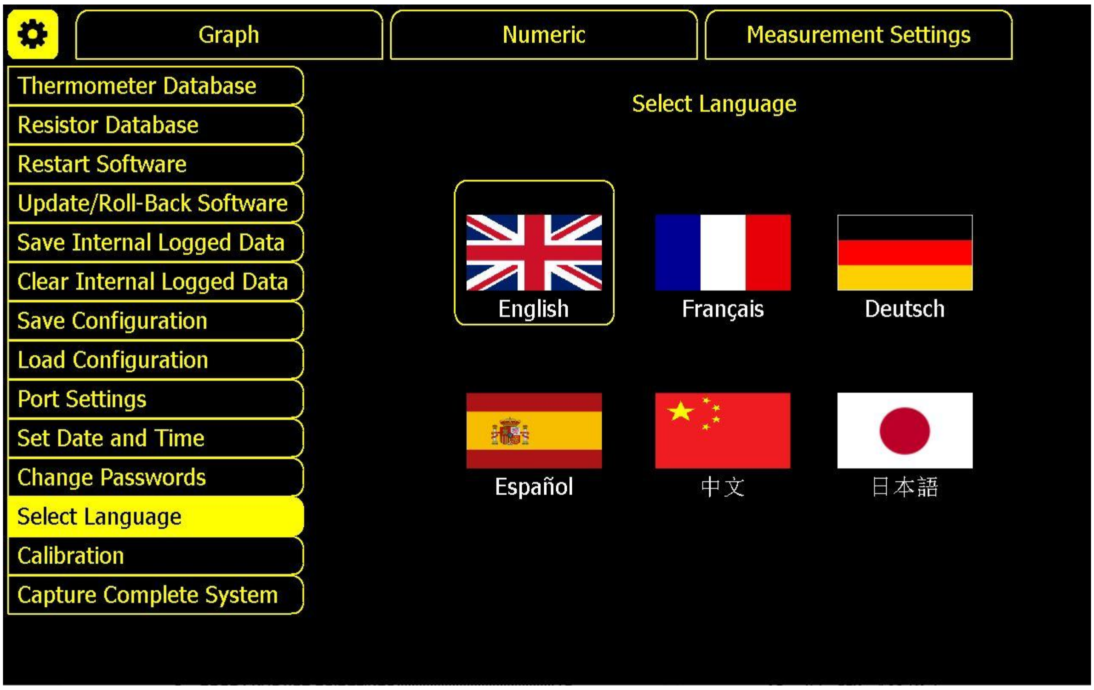


3.7.11.1 Password Recovery

If you have forgotten your password, press *Change Passwords* and then press *Password Recovery.* This will reveal a recovery "KEY" for you to send to Isotech, who will then supply you with a temporary password that can be entered as the "Old Password" and allow you to set a new password

3.7.12 Select Language

Press *Select Language* to change the language of the User Interface:



Press the flag for the required language, then press *OK* to implement the change.

3.7.13 Calibration

Press *Calibration* to adjust the settings that affect the accuracy of measurements made with the microK^2. For details see section 7.

3.7.14 Capture Complete System

This feature allows you to capture a complete image of your microK^2 (including the calibration, internal database and settings) if you require technical support. Isotech can then create a complete clone of your instrument and provide you with the support you need.

To capture the microK^2 system, plug a USB flash drive into a USB port on the front panel and press *Capture Complete System*. In the pop-up window, press the *Capture* button to start the process. When the capture is complete (this may take several minutes), remove the USB flash drive and send the resulting compressed .gz file to Isotech. The filename will begin with "Capture_", followed by a date and timestamp.

3.8 Password Protection of Key Settings

The microK^2 uses two separate passwords to ensure the integrity of your measurements.

3.8.1 The User Password

All settings and parameters that affect measurements (calibration data stored in the thermometer and resistor databases) are protected by a "user password". All actions that would lead to loss of data (such as clearing data logged to internal memory or overwriting files) are also protected by this "user password". This helps you establish working procedures that meet the requirements of accreditation bodies whilst alleviating some of their concerns about the integrity of measurements.

You need to enter the user password to perform the following tasks:

- Create/edit/delete a thermometer database entry
- Create/edit/delete a reference resistor database entry
- Overwrite a logged data file
- Overwrite a saved configuration file
- Delete internal data files
- Change the user password

The "user password" is initially set to "1234" but should be set to something more secure before using the microK^2 (see section 3.7.11).

3.8.2 The Calibration Password

A separate "calibration password" is used to protect the microK^2's calibration. You need to enter the calibration password to perform the following tasks:

- Adjust the calibration of the microK^2
- Adjust the value of the internal reference resistors
- Update or roll back the software
- Change the calibration password

The "calibration password" is initially set to "5678" but should be set to something more secure before using the microK^2 (see section 3.7.11).

4 Connecting Thermometer Sensors

4.1 The Binding Posts (Channel 1-3)

The binding posts used for channels 1 to 3 on the microK^2 are made of gold-plated tellurium-copper. They generate exceptionally low thermal EMFs when connected to the copper terminations used on standards-grade thermocouples.

The connectors accept 4 mm plugs, bare wires or spade terminations. The mechanism is designed so that the clamping surface does not rotate as it clamps the wire to prevent damaging it. Additionally, the connectors are spaced with a 19 mm (¾”) pitch to be compatible with standard 4 mm-to-BNC adaptors (not supplied) for connecting to BNC-terminated SPRTs.

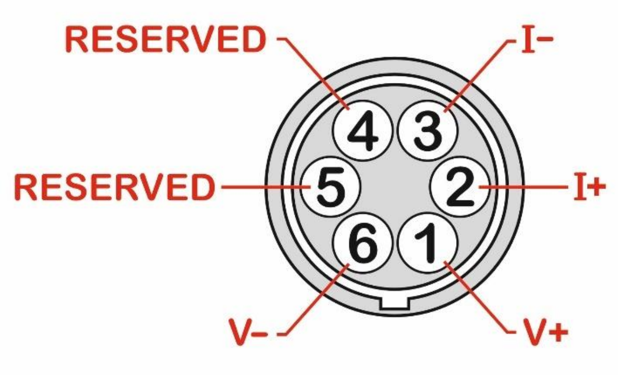
Tellurium-copper is a soft alloy and whilst the binding posts are designed to be robust under normal use, they can nonetheless be subject to mechanical damage if the connectors are over tightened. Please tighten the terminals to a light “finger-tight” level to ensure that they are not subject to undue wear or premature failure. This is all that is required electrically – do not try to use the connector to provide strain relief or tension a cable.

4.2 The Lemo Connector (Channel 4)

The connector for channel 4 is a high-reliability circular connector made by Lemo. It is located on the rear of the microK^2 and is a 6-pin circular connector from the Lemo B series (size 1: insert type 1B.306):

Lemo produce a comprehensive range of mating connectors. In choosing a mating connector, ensure that it is compatible with the 1B.306 insert. A suitable connector is the FGG.1B.306.CLAD62Z. These can be supplied by Isotech (part number: 935-16-101) or purchased from Lemo distributors.

The pin-out of the Lemo connector (looking into the microK²) is:



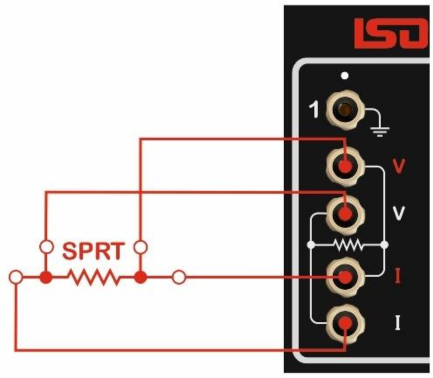
Channel 4 can be used with RTDs (SPRTs, PRTs, or thermistors), or as an expansion channel to increase the number of inputs available. You can connect up to nine microsKanners, each providing ten additional input channels. This allows a maximum of 93 input channels on a single microK².

Voltage measurements are disabled on this channel because the contacts are not made from low-thermal-EMF materials. This means that thermocouples cannot be used on channel 4.

Channel 4 is ideal for use with thermistors because the LEMO connector provides a fully screened connection, making it particularly immune to electromagnetic interference. It can also be used to connect to reference resistors.

4.3 Connecting PRTs (4-wire)

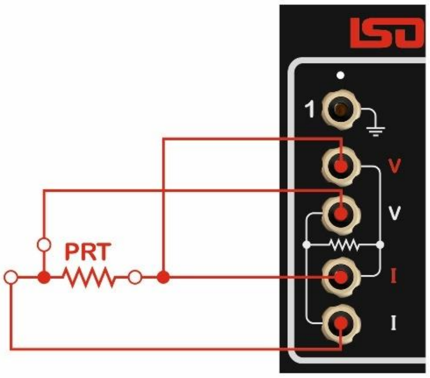
The microK²'s resistance measurement system is optimised for high accuracy, 4-wire resistance measurement.
The PRT should be connected to the chosen input channel in accordance with the schematic shown on the microK²'s front panel, as follows:



If your PRT has a screened lead, connect it to the top terminal (ground) to minimise the electrical noise picked up by the wires.

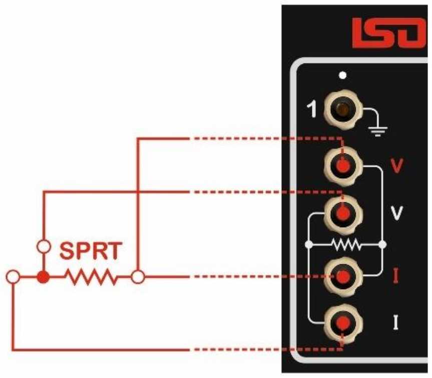
4.4 Connecting PRTs (3-wire)

The microK^2 can be connected to 3-wire PRTs, although it will not automatically compensate for cable resistance. The two red terminals should be connected together and then connected to the 'single' end of the 3-wire PRT as follows:



The connection to the 'single' end of the 3-wire PRT should be short (have a low resistance) to minimise the effect of lead resistance on the measurement.

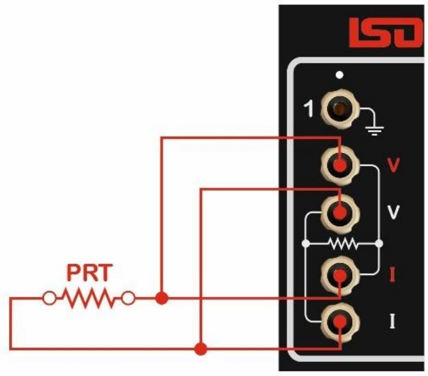
Alternatively, the connection to the 'single' end can use remote sensing (using the 4-wire measurement capability of the microK^2) to eliminate the effect of its lead resistance. In this arrangement, the current and voltage sense connections to the 'single' end are only joined close to the PRT.



If your PRT has a screened lead, connect it to the top terminal (ground) to minimise the electrical noise picked up by the wires.

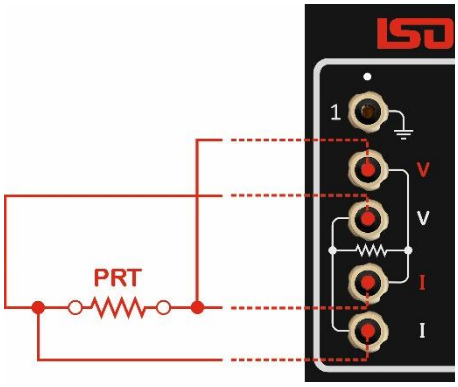
4.5 Connecting PRTs (2-wire)

The microK^2 can be connected to 2-wire PRTs. The two red and two black measurement terminals should be connected together and then connected to the PRT as follows:



The connections to the PRT should be short (low resistance) to minimise the effect of lead resistance on the measurement.

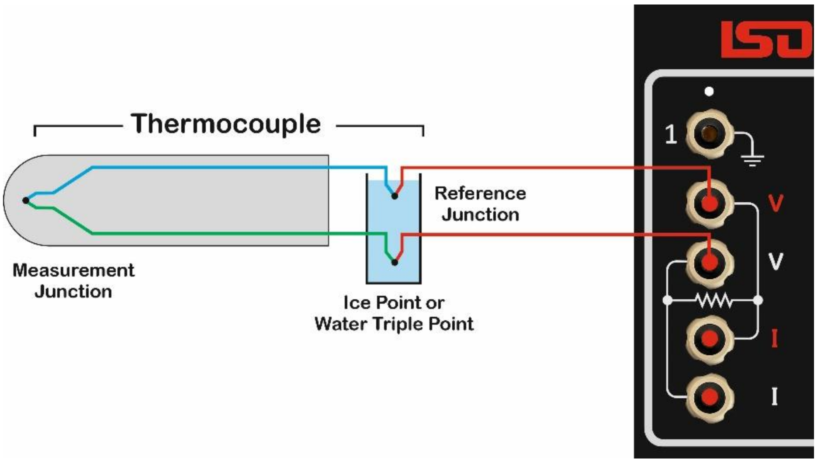
Alternatively, the connections can use remote sensing (using the 4-wire measurement capability of the microK^2) to eliminate the effect of lead resistance completely. In this arrangement, the current and voltage sense connections are kept separate and are only joined close to the PRT:



If your PRT has a screened lead, connect it to the top terminal (ground) to minimise the electrical noise picked up by the wires.

4.6 Connecting Thermocouples (external Ice Point or WTP)

Thermocouples can be connected directly to the voltage terminals of your microK^2:

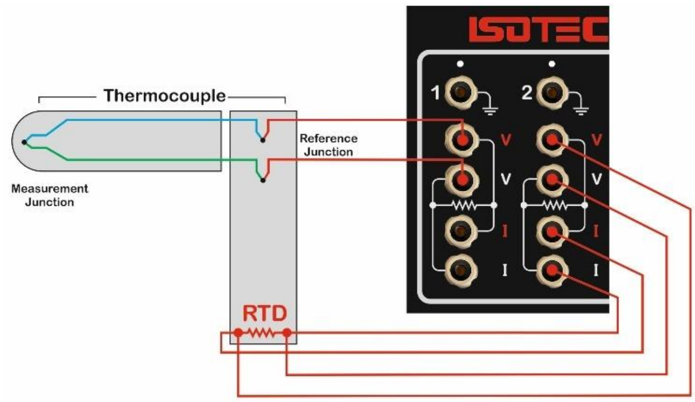


Note: with original microK it was necessary to connect the two current terminals to the positive voltage terminal for the active guarding system to work. This is not necessary with microK^2.

The most accurate thermocouple measurements are made with the reference junction immersed in an ice-point bath (or water-triple-point). The microK^2 supports this by allowing you to specify the temperature of the reference junction as 0 °C or 0.01 °C (see section 3.6).

4.7 Connecting Thermocouples (using reference junction compensation)

It is possible to measure the temperature of a thermocouple's reference junction and compensate for the associated EMF. The reference junction can be measured using a PRT or thermistor connected to another measurement channel:

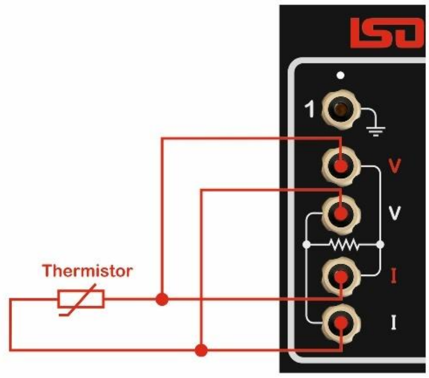


The microK^2 supports this by allowing you to use a temperature measured on another input channel as the reference junction temperature.

However, this technique is less accurate than using an ice-point (or water-triple-point) bath due to additional uncertainties from the PRT used to monitor the reference junction, as well as temperature gradients caused by the temperature difference between the PRT and reference junction.

4.8 Connecting Thermistors

The microK^2 can be connected to thermistors using the same arrangement as for 2-wire PRTs (see section 4.5):



Because the resistance of thermistors used for temperature measurement is much higher than for PRTs, lead resistance is not normally a problem.

Ideally, the value of the reference resistor should be similar to the thermistor's expected resistance range. Thermistors have much higher temperature coefficients than PRTs, so the tolerances on the reference resistor are correspondingly less demanding, making them relatively inexpensive.

The top terminal should be connected to the screen of the thermistor's lead to minimise electrical noise picked up by the wires. The high resistance of thermistors makes them more prone to picking up electrical noise. Compared to PRTs, it is even more important for thermistors to use a screened cable connected to the ground terminal on the microK^2.

5 Good Practice Guidelines

5.1 Using Internal/External Reference Resistors

The microK^2's internal reference resistors are the best commercially available foil resistors. However, they are not as stable as an external resistance standard maintained at a fixed temperature.

The microK^2 is capable of measuring resistance ratios to better than ± 0.03 ppm (depending on the model). To take advantage of this accuracy when performing resistance measurements, it is best to use a stable external reference resistor, such as a DC or AC/DC resistance reference standard, maintained at a constant temperature in an oil bath. You will not be able to measure resistance to ± 0.03 ppm using the internal resistors.

The internal resistors are useful for less accurate work (PRT measurements to a few mK) or in comparison calibrations where any error in the value of the reference resistor causes a corresponding error in the temperature measured by the reference thermometer – this largely cancels out the effect of the error in the resistance measurement.

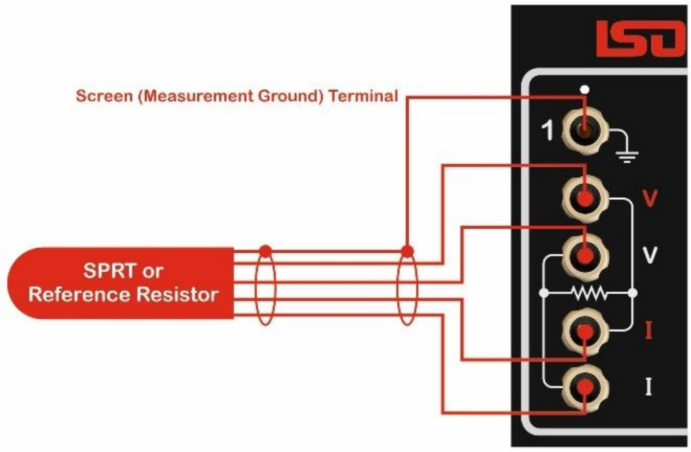
5.2 Making a Good Electrical Measurement

Although the microK^2 is intended for use in temperature metrology, its base measurements are electrical (resistance or voltage). The limited sensitivity of PRTs and thermocouples means that in order to achieve uncertainties at the mK level, we need to make electrical measurements that rival those of a good electrical metrology laboratory. For example, for a 25 Ω SPRT, a 0.03 mK temperature uncertainty corresponds to a 3 µΩ resistance uncertainty. With a 1 mA sense current, this would give a voltage uncertainty of 3 nV.

The microK^2 has been optimised for electromagnetic compatibility (minimising emissions and maximising immunity). However, it is still important to use good electrical measurement practices to optimise the microK^2's ability to measure very low signal levels.

Here are a few guidelines:

- The most sensitive points are the inputs to the microK^2 (measuring to a few nV). Whilst the microK^2 will work with just a four-wire connection to the PRT or reference resistor (using the voltage sense and current terminals marked "V" and "I" respectively), it is better to use a screened cable and to connect the screen to the measurement ground terminal above the input terminals:



The screen should also be connected to the outer sheath of the SPRT (if it is metal clad) or the case of the reference resistor. The use of screened cables is more important when the microK^2 is used with thermistors, which have a higher resistance than PRTs or thermocouples.

- Keep the cables to the microK^2 input terminals away from other cables that may be sources of electrical noise (for example electrical supplies to furnaces).
- The insulation in high temperature furnaces (any that 'glow') begins to conduct at higher temperatures. This can cause high common-mode voltages on any thermometer in the furnace. Whilst the microK^2 is designed to reject common-mode DC and AC signals (at both 50 and 60 Hz), it is good practice to minimise them. It is common practice to use a metal equalising block in a furnace when performing comparison calibrations. This should be connected to the safety earth of the electrical supply (most furnaces designed for temperature metrology applications are fitted with a device to 'earth' the equalising block). Do not 'earth' the equalising block to the screen/measurement ground terminals on the front panel of your microK^2 – they are not connected to the safety earth of the electrical supply.
- Provide a 'clean' electrical environment in your temperature laboratory. It may be useful to filter your electrical supply into the laboratory, especially if other heavy electrical machinery is being used nearby on the same supply (the microK^2 has very good immunity to electrical noise conducted along the electrical supply, but other equipment in your laboratory may be more sensitive). Avoid using sources of electrical signals or noise in your laboratory. Examples include furnaces with TRIAC controls (especially those that 'chop' the electrical supply part way through a cycle – better controllers switch only at the zero-crossing point to 'chop' only whole cycles) and mobile phones (the microK^2 is not significantly affected by mobile phones, but other equipment may be more sensitive).

5.3 Looking After Your microK^2

Your microK^2 is a precision electronic instrument intended for indoor use in a laboratory or office environment. Nonetheless, it has been designed to be as robust as possible and will provide many years of service if properly maintained.

We recommend returning your microK^2 to Isotech, or one of our approved service centres, annually for calibration. The microK^2 should require little maintenance between calibrations other than routine cleaning.

The display uses a PCT (Projected Capacitive Touch) system to detect your finger. It will not work if you are wearing gloves, unless they are very thin or have been designed for PCT use. Before using the touch screen, ensure that you have clean hands with no contaminants such as adhesives or solvents on your fingers, as these will be difficult to remove without damaging the screen.

The touch screen can be cleaned using a screen cleaner (suitable for PC flat panel displays) or a damp (not wet) lint-free cloth to wipe the touch screen. Dry the screen immediately after cleaning with a lint-free cloth. The rest of the microK^2 can be cleaned in the same way and should not require cleaning as often as the display. Never use abrasive cleaners (such as 'cream' cleaners) on your microK^2.

6 Making Zero-Power Resistance Measurements

The sense current used to measure the resistance of a PRT (for example, a 1 mA current used with a 25 Ω SPRT) causes a small but significant amount of self-heating in the platinum element (generally a few mK). This offset is nominally constant under given conditions and is often ignored since it should affect the thermometer equally during calibration and use. However, the offset can vary (even when conditions are apparently identical) due to differences in the thermal contact between the thermometer and its environment. This means that the same thermometer may exhibit a slightly different resistance when used in two identical temperature sources (or even in the same temperature source after being removed and replaced). This effect is significant and should not be ignored in the most accurate thermometry work.

This uncertainty can be eliminated by determining the resistance of the SPRT at zero current (zero power). Whilst the resistance cannot be measured with zero current, it is possible to measure the resistance at two different currents and extrapolate back to determine the value at zero current. Historically, the most common way to do this was to make a measurement at the normal current and then to increase (or decrease) the current by a factor of $\sqrt{2}$ (≈ 1.414). This changes the power by a factor of 2 and allows easy determination of the zero-power resistance (by subtracting the change in resistance from the measurement at the lower current).

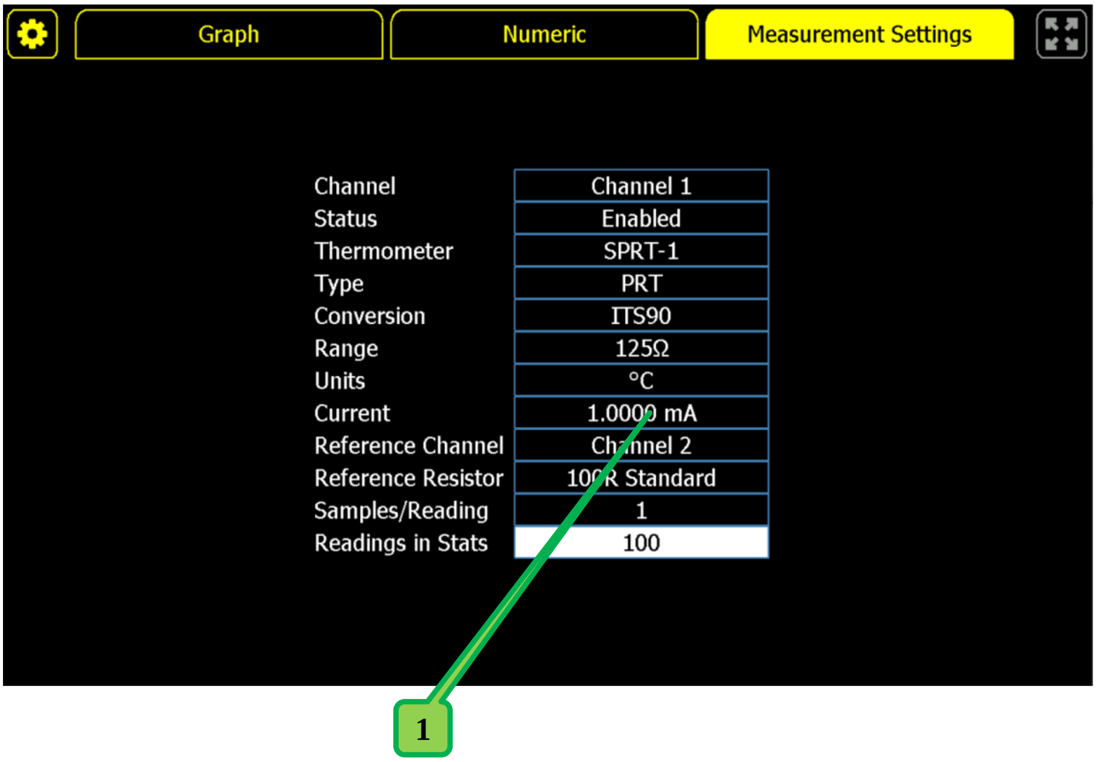
A better method is to make measurements at two currents that are in the ratio 1:2, taking 8 times as many readings at the lower current, and then extrapolating back to the zero-power value.

The microK^2 (in common with other thermometry bridges) supports the ability to vary the sense current in this way, allowing you to extrapolate back to the zero-power resistance. It has $\times\sqrt{2}$ and $\div\sqrt{2}$ buttons for scaling the current, since $\sqrt{2}$ is commonly used to simplify calculations, but any two currents can be used in the extrapolation process.

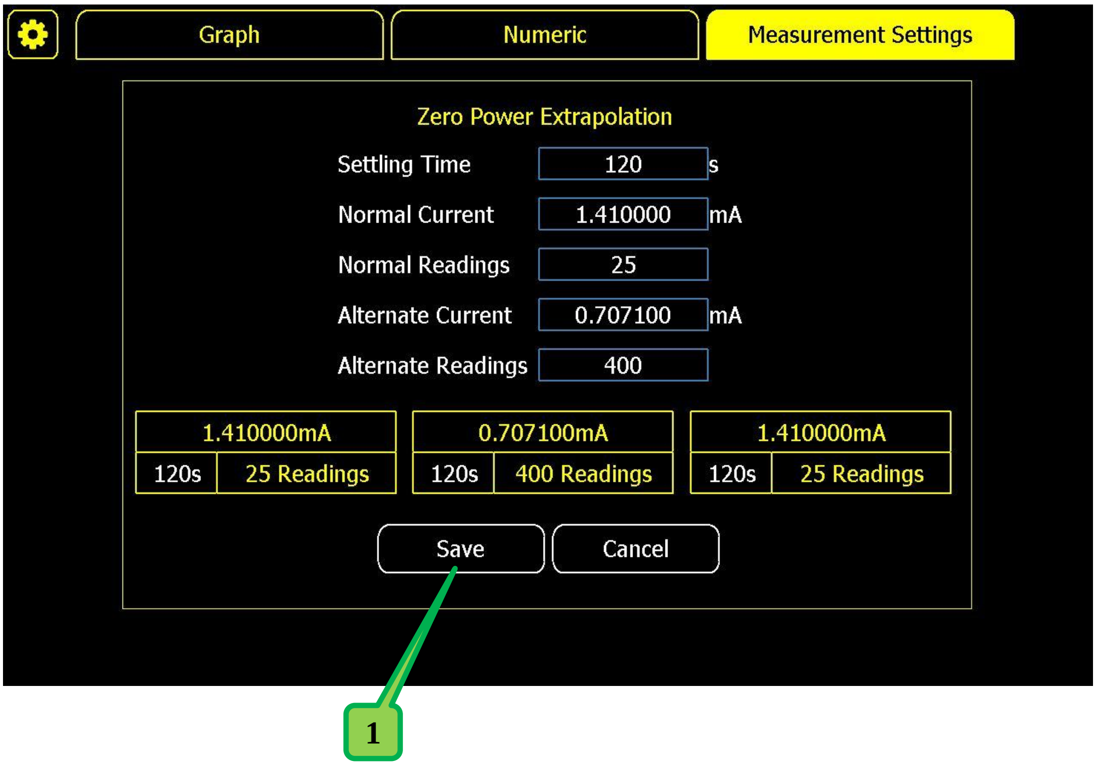
The microK^2 is unique in being able to sequence the current and generate a zero-power corrected value (including an uncertainty figure) without using any external software.

Each zero-power measurement consists of three sets of readings taken at the normal current, the alternate current and then the normal current again. The number of readings taken at each current and the settling time can be set as follows:

Press the *Measurement Settings* tab and then the *Current [1]* parameter box.



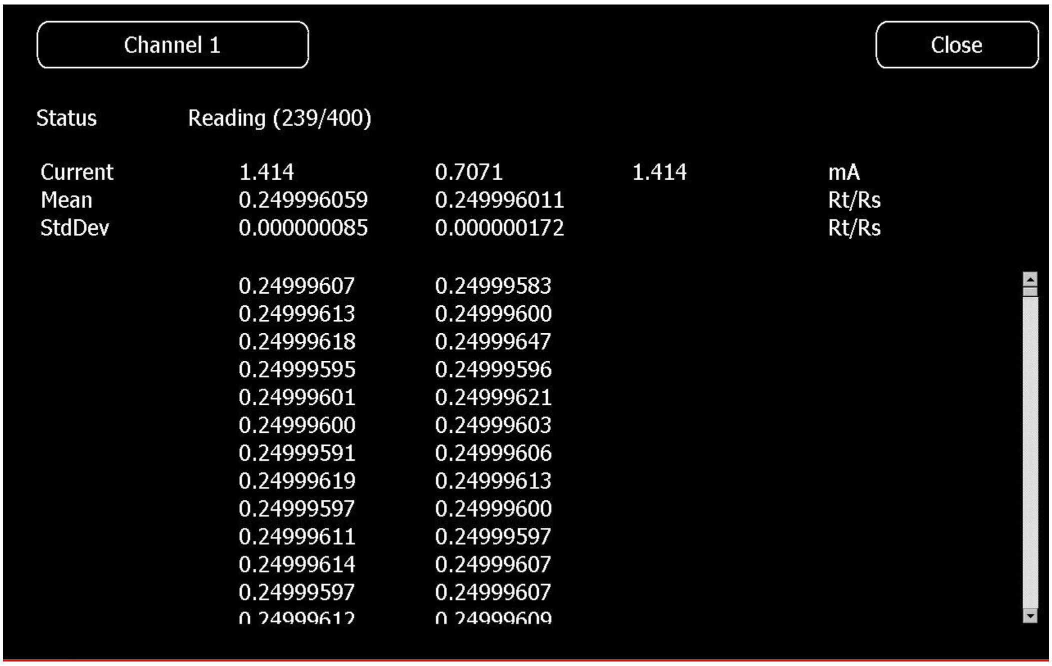
Press *Zero Power Extrapolation* to define the measurement sequence:



Press the parameter boxes to open pop-up windows and set the "Settling Time" (time for the thermometer to come to thermal equilibrium after a current change), "Normal Current", "Alternate Current" and "Readings at Each Current" for each current setting. The resulting measurement sequence is displayed at the bottom of the window. The resistance is first measured at the normal current, then at the alternate current, and finally at the normal current again, with settling delays after each current change.

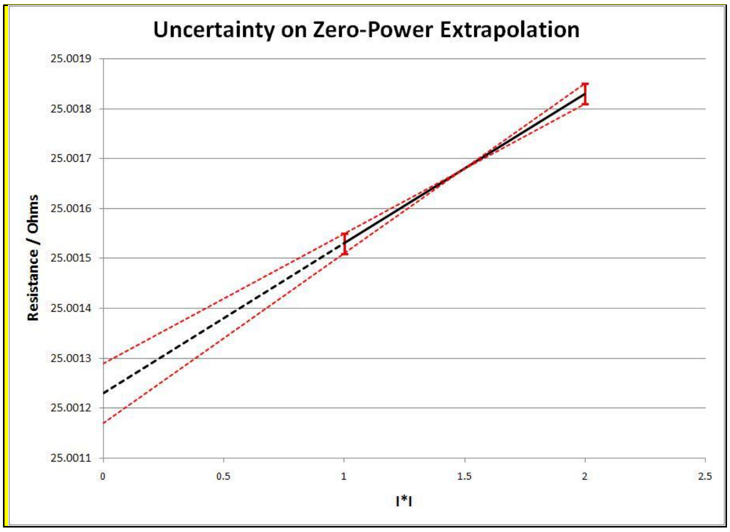
Press *Save [1]* to return to the 'Current' Window. The *Zero Power Extrapolation* button will have been replaced with the *Clear Zero Power Extrapolation* button. Press this button if you want to disable this feature and return to using a single sense current.

You can view the status of each measurement sequence and see the results appear by pressing *Details* in the 'Graph' tab. The 'Details' window shows the current status of the measurement:



6.1 Zero-Power Uncertainty Calculation

The software calculates the standard deviation for the three data sets in the measurement which are then used to determine the uncertainty of the mean for each data set. The two data sets for the normal current are combined to give a single mean and standard deviation. From this, the software can calculate the uncertainty of the zero-power extrapolated value:



The effect of self-heating is very small and can reasonably be regarded as linear with power. If the actual zero-power resistance is "R_0", and the measured resistance is "R_n" at current "i_n", then the measurements at the two currents will be:

$$R_1 = R_0 + \propto {i_1}^2$$
$$R_2 = R_0 + \propto {i_2}^2$$

where α is the (unknown) power coefficient.

The extrapolated (zero-power) value can easily be determined by eliminating α from these 2 equations:

$$R_0 = \frac{R_1 i_2^2 - R_2 i_1^2}{i_2^2 - i_1^2}$$

The combined mean of the results for the first and last (normal current) sets of readings are used for R_1. The mean of the second (alternate current) set of readings are be used for R_2.

The uncertainty in the zero-power value is determined by:

1. Calculating the uncertainties (the standard deviation of the data set divided by the square root of the data set size) u_1 and u_2 for the two data sets used to calculate R_1 and R_2
2. Calculating the propagation of these uncertainties to the extrapolated value R_0 by differentiating the above equation for R_0 with respect to R_1 or R_2
3. Combining the effect of these two uncertainties u_1 and u_2 using the root sum of squares

The uncertainty in the extrapolated value R_0 arising from the noise (defined by the standard deviation calculations) associated with the data sets is:

$$u'_1 = \frac{dR_0}{dR_1} u_1 = \frac{i_2^2}{i_2^2 - i_1^2} u_1$$

$$u'_2 = \frac{dR_0}{dxR_2} u_2 = \frac{-i_1^2}{i_2^2 - i_1^2} u_2$$

The combined uncertainty (reported by the microK^2) is therefore:

$$u = \left| \frac{1}{i_2^2 - i_1^2} \sqrt{i_2^4 u_1^2 + i_1^4 u_2^2} \right|$$

As we would expect, the above equation predicts that the uncertainty of the extrapolated result increases as i_2 approaches i_1. The equation allows us to investigate the optimum ratio between i_1 and i_2. For a resistance bridge such as the microK^2, the noise and therefore the uncertainty of measurement will be inversely proportional to the sense current used. So, if we let $i_2 = ki_1$, then $u_2 = u_1/k$. Substituting into our uncertainty equation we get:

$$u = \left| \frac{u_1}{k^2 - 1} \sqrt{k^4 + \frac{1}{k^2}} \right|$$

If we differentiate this with respect to k and set this equal to zero, we can find a value for k that gives the minimum of u:

$$2k^6 + 3k^2 - 1 = 0$$

The relevant solution to this equation is k = 0.55938. This means that the optimum ratio between the alternate and normal current is not 0.707 (1/√2), but 0.56. This applies to all resistance bridges, not just the microK^2. The improvement in uncertainty in going for 1/√2 to 0.56 is only 13% because u is fairly insensitive to k for values near to 0.56. For convenience, a ratio of 0.5 is a sensible choice as there is less than a 2% degradation in uncertainty between this and the optimum value.

The above proposed technique for optimising zero-power measurements has been further improved by NPL. Their approach was to vary the number of measurements at each current as well as the value.

The conclusion is that the optimum (lowest uncertainty due to noise in a given time) settings are use:

1. Ratio of the currents = 2:1
2. Ratio of the number of readings (low:high current) = 8:1

The derivation of this measurement protocol was published (24 June 2013) in Metrologia Volume 50, Number 4: "The optimization of self-heating corrections in resistance thermometry" J V Pearce, R L Rusby, P M Harris and L Wright

7 Calibration

The ADC and measurement topology used in the microK^2 are inherently very stable with both time and temperature. The stability of the microK^2 is primarily determined by its internal standards (a buried Zener reference for voltage, and bulk metal foil resistors for resistance and current). We have used the best available components for these internal standards. To keep your microK^2 operating within its specification, it should be recalibrated annually. Please contact Isotech to arrange this calibration.

The microK^2 includes features that allow you to calibrate the microK^2 yourself, provided you have correctly calibrated instruments and suitable reference standards. The adjustable calibration parameters and the instruments/reference standards required are as follows:

Parameter	**Equipment Required**	**Equipment Uncertainty**
Master Current Source	Ammeter to measure 1 mA	< ± 1.5 nA
Internal Resistors	100 Ω standard resistor	< ± 1 ppm
Voltage Offset	Low thermal EMF cable	< ± 0.04 nV
Voltage Range	Voltage reference	< ± 0.04 nV

The above uncertainties are 4 times lower than the uncertainty capability of the microK^2. This is regarded as the minimum margin for transferring a calibration. A better margin would be 10 times lower (so 40% of the above figures).

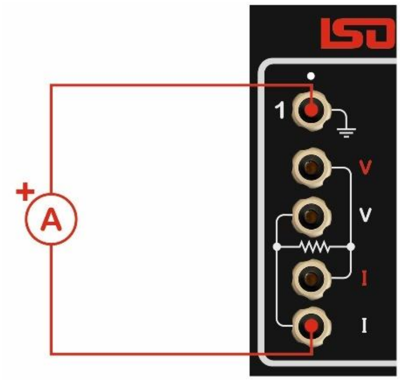
7.1 Checking Calibration

The calibration can be checked by measuring known standards with the microK^2. It should be performed in a temperature-controlled environment similar to the one in which the instrument will be used (typically 20 °C or 23 °C ± 1 °C). The microK^2 should be powered on and left to stabilise in the calibration environment for at least four hours before checking or adjusting its calibration.

7.1.1 Checking the Master Current Source

The microK^2 current source has three ranges (0-100 µA, 0-1.42 mA and 0-14.2 mA). These ranges share a common reference and feedback circuit, so do not need to be recalibrated separately. The most accurate temperature measurements use SPRTs, and these typically require a 1 mA sense current; it is therefore recommended that you check and adjust the 1.42 mA range near to its full scale.

Check the master current source by connecting a calibrated ammeter (or DMM) between the ground terminal and the negative current terminal of channel 1:



Note: connecting the ammeter between the ± current terminals will not work.

To check the master current source, connect a PC to your microK^2 via one of the RS232, Ethernet, or GPIB ports and send SCPI commands to it using a terminal emulation application such as PuTTY. For further details of how to connect a PC to your microK^2 see section 8.

Restart the microK^2, but **DO NOT** press the 'Resume' button (to ensure measurements are not being made). Once you have established communication with your microK^2, type in the following commands and check that the measured current is within the given limits:

command	current limits
TEST:CURR1 0.1	0.09944 to 0.10056 mA
TEST:CURR1 1	0.9944 to 1.0056 mA
TEST:CURR1 10	9.944 to 10.056 mA
TEST:CURR1 -0.1	-0.09944 to -0.10056 mA
TEST:CURR1 -1	-0.9944 to -1.0056 mA
TEST:CURR1 -10	-9.944 to -10.056 mA

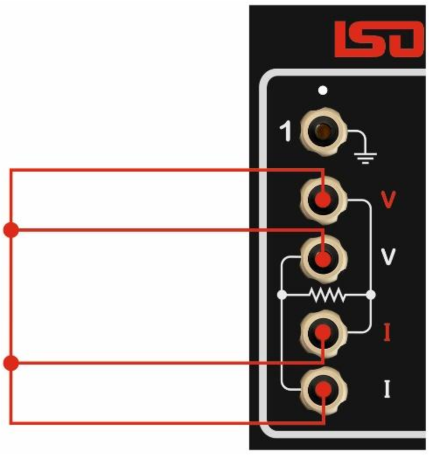
Section 7.2.1 describes how to adjust the master current source.

7.1.2 Checking Resistance Measurements

The current reversal used by the microK^2 to eliminate the effect of thermal EMFs means that it has an inherently stable zero for resistance measurements. The zero ohms test does not form part of the calibration process, but it is used to confirm correct operation of the measurement system. It only needs to be checked on one channel.

7.1.2.1 Zero Ohms Check

Start by applying a four terminal short-circuit to channel 1. This involves shorting out the voltage sense terminals (marked "V") and the current terminals (marked "I") and then making a single connection between these two sets of terminals. The objective is to ensure that none of the sense current passes along the wire between the voltage sense terminals. This can easily be achieved by using a single piece of un-insulated wire:



Configure the microK^2 to measure a Default PRT at 1 mA against the internal 100 Ω reference on channel 1 (with all other channels disabled) and select the 125 Ω range. Set the units to Ohms and use 1 sample per reading and 100 readings in the rolling statistics (see section 3.6). Select the *Graph* tab and clear the statistics. After the microK^2 has collected at least 100 readings (shown as *Mean of last…* in the *Graph* tab), check that the *Mean* is less than 0.000 004
(4 µΩ i.e. 0.032 ppm of the 125 Ω range).

7.1.2.2 Checking the 400 Ω Internal Reference Resistor

Connect a stable external resistance standard with a nominal value of 100 Ω to channel 1. Ideally, this should be a DC or AC/DC resistance reference standard with a recent (traceable) calibration certificate maintained at a constant temperature in an oil bath. Configure the microK^2 to measure a Default PRT at
1 mA against the internal 400 Ω reference on channel 1 (with all other channels disabled) and select the 500 Ω range. Set the units to Ω and use 1 sample per reading and 100 readings in the rolling statistics (see section 3.6). Select the *Graph* tab and press *Clear Stats* to clear the statistics. After the microK^2 has collected at least 100 readings (shown as *Mean of x…* in the *Graph* tab), check that the *Mean* agrees with the expected value within ± 1 ppm of value.

7.1.2.3 Checking the 100 Ω Internal Reference Resistor

Repeat the procedure for checking the 400 Ω internal reference (see section 7.1.2.2), but instead configure the microK^2 to measure a Default PRT at 1 mA against the internal 100 Ω reference on channel 1, setting the range to 125 Ω. The *Mean* should agree with the expected value within ± 1 ppm of value.

7.1.2.4 Checking the 25 Ω Internal Reference Resistor

Repeat the procedure for checking the 400 Ω internal reference (see section 7.1.2.2), but instead configure the microK^2 to measure a Default PRT at 1 mA against the internal 25 Ω reference on channel 1, setting the range to 125 Ω. The *Mean* should agree with the expected value within ± 1 ppm of value.

7.1.3 Checking the Other Internal Resistors

The microK^2 can optionally be fitted with up to eight internal reference resistors. Typical non-standard values include 1 Ω, 10 Ω and 10 kΩ. These can be checked in a similar way to the 400 Ω internal reference (see section 7.1.2.2).

7.1.4 Checking the Voltage Measurements

The automatic input reversal used by the microK^2 when measuring voltage provides good zero stability. However, small differences between the thermal EMFs generated by the devices used to make these reversals on each channel mean that the zero offset needs to be checked for each channel. Once the zero offsets have been checked/adjusted, it is only necessary to check the range on one channel since this part of the measurement system is common to all the channels.

7.1.4.1 Checking the Zero Voltage Offsets

Short out the two potential measurement terminals on all three channels using a piece of un-insulated copper wire for each channel:

Configure the microK^2 to measure a Default Thermocouple with units set to mV (for all three channels) and the reference junction set to 0°C. Use 1 sample per reading and 100 readings in the rolling statistics (see section 3.6). Select the *Numeric* tab and clear the statistics for all three channels. After the microK^2 has collected at least 100 readings (shown as *Mean of x…* in the *Numeric* tab), check that the *Mean* for each channel is less than 0.000 150 (0.15 μV).

7.1.4.2 Checking the milli-Volt Range

Connect a stable, low-noise voltage source with a nominal value of 50 mV to channel 1 of the microK^2 using low thermal EMF wire and connectors (use copper or an alloy such as tellurium–copper that still has a high copper content and low thermal EMF. Brass connectors must NOT be used):

Configure the microK² to measure a Default Thermocouple with units set to mV and the reference junction set to 0°C. Use 1 sample per reading and 100 readings in the rolling statistics (see section 3.6). Select the *Graph* tab and clear the statistics. After the microK² has collected at least 100 readings (shown as *Mean of x…* in the *Graph* tab), check that the *Mean* value agrees with the applied voltage to within 0.000 150 V (0.15 μV).

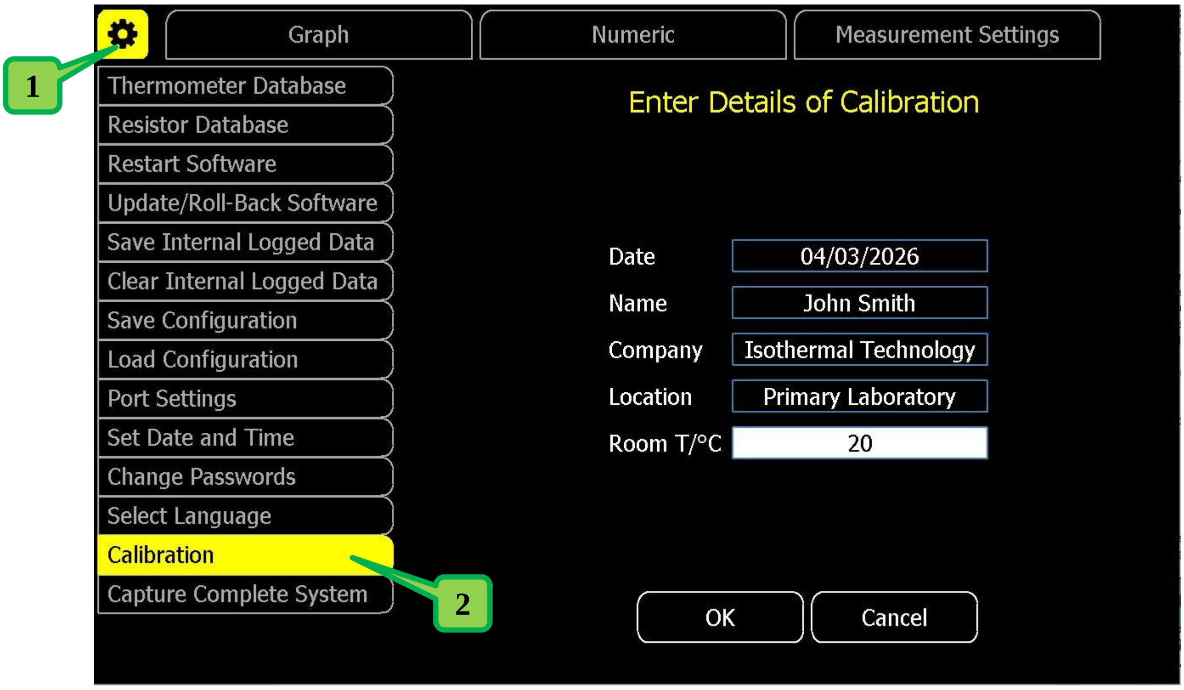
Repeat the procedure with the voltage source set to -50 mV.

7.2 Adjusting Calibration

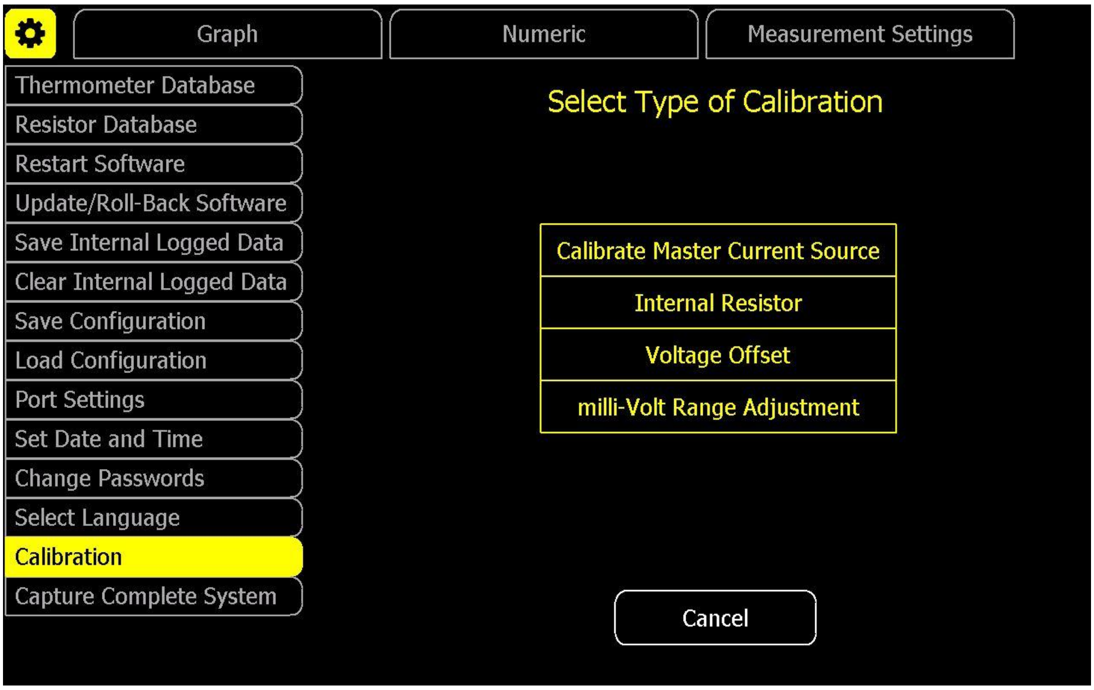
This section describes the procedures for adjusting the internal reference standards and the input offset voltages. These can be performed by the user or a third-party calibration provider, subject to the availability of suitable instruments and standards. Isotech additionally checks the temperature coefficient of the Zener reference and the linearity of the microK² against an ARBC (Automatic Resistance Bridge Calibrator) with an uncertainty of 0.01 ppm. We therefore recommend that you return your microK² to Isotech or one of our appointed service centres annually for a comprehensive instrument calibration.

There are no potentiometers to adjust inside the microK², calibration is implemented in software so can be performed without removing the cover from your microK².

The calibration is adjusted using the internal calibration facility: press the *Settings Cog [1]* and then *Calibration [2]*. Press *Calibration is locked Press to unlock* in the pop-up window and enter the password in order to proceed (note: this is a separate password from the normal user password - see section 3.8 for information on passwords). You will then be asked to enter details of the calibration (you will not be able to proceed until this is done). Then press OK:



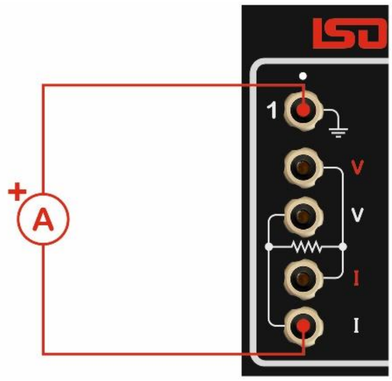
You can then select the calibration you wish to adjust from the list:



7.2.1 Calibrate Master Current Source

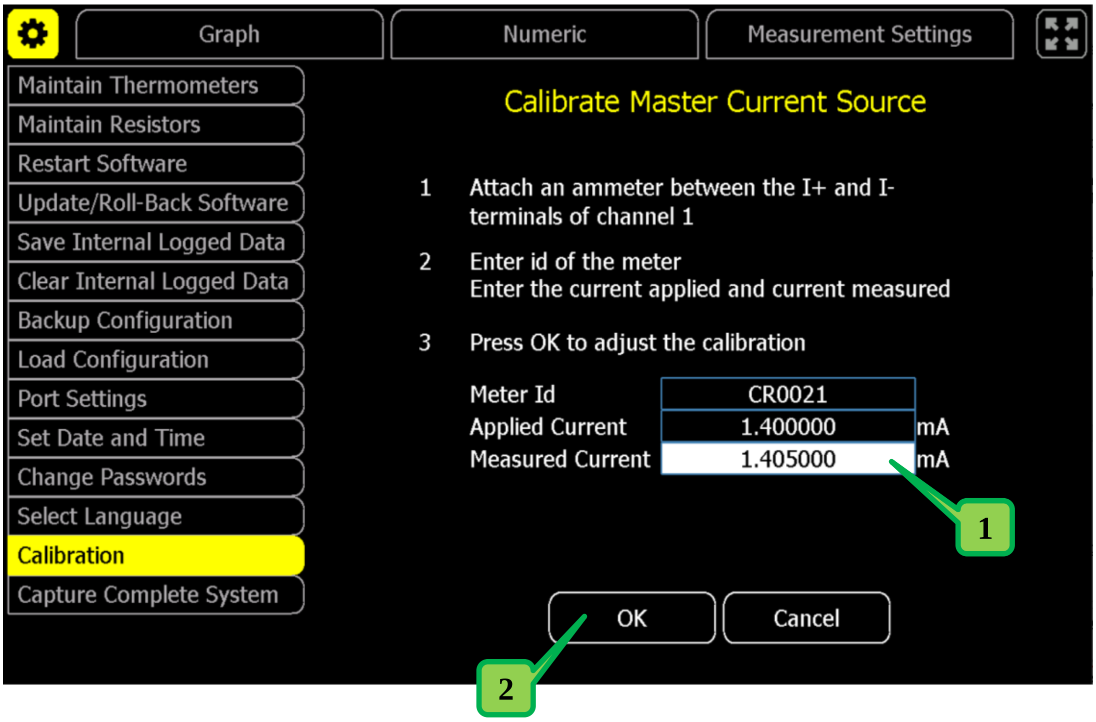
The microK² 's current source has three ranges (0-100 µA, 0-1.42 mA and 0-14.2 mA). These share a common reference and the tolerance between the ranges is sufficiently small that it is only necessary to calibrate the 1.42 mA range in order to achieve the full performance specification. The current is controlled by a DAC, so adjustments are made in the software by scaling the DAC value as required.

Connect a calibrated ammeter (or DMM) between the ground terminal and the negative current terminal of channel 1:



⚠ Note: connecting the ammeter between the ± current terminals will not work.

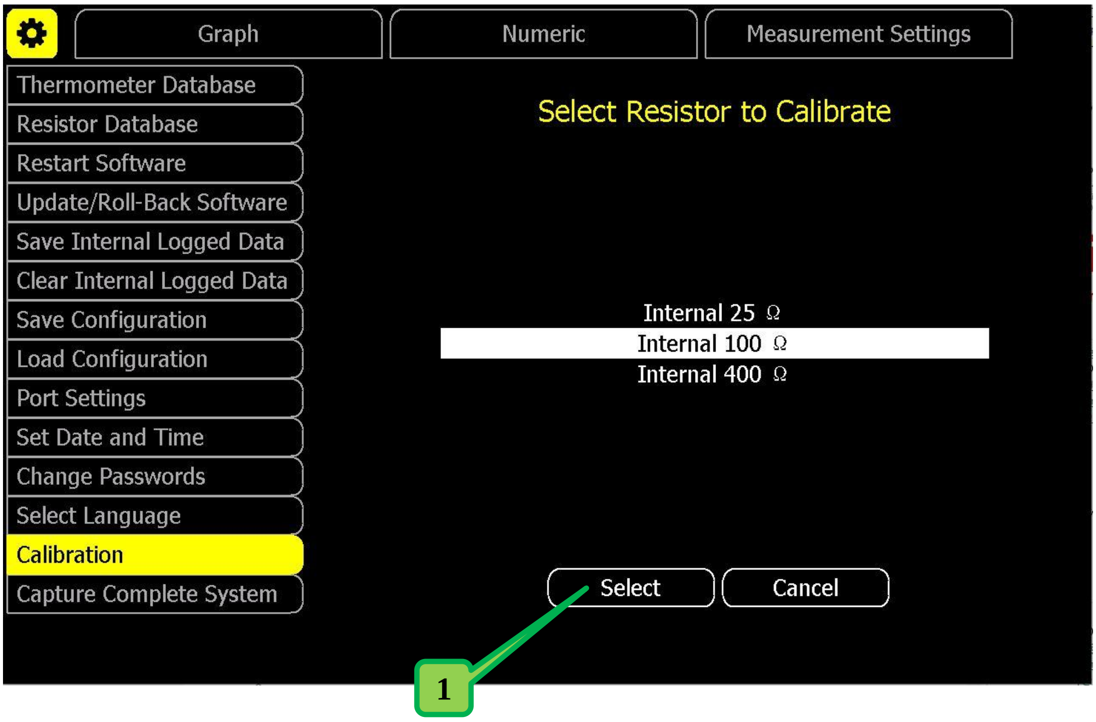
Press the *Calibrate Master Current Source* button from the *Select Type of Calibration* menu. Enter the Meter Id (e.g. its serial number) and the test current (1.4 mA) in the pop-up window. At this point the ammeter will then start reading the requested current. Enter value indicated on the ammeter into the *Measured Current [1]* box and press *OK [2]* to apply the adjustment:



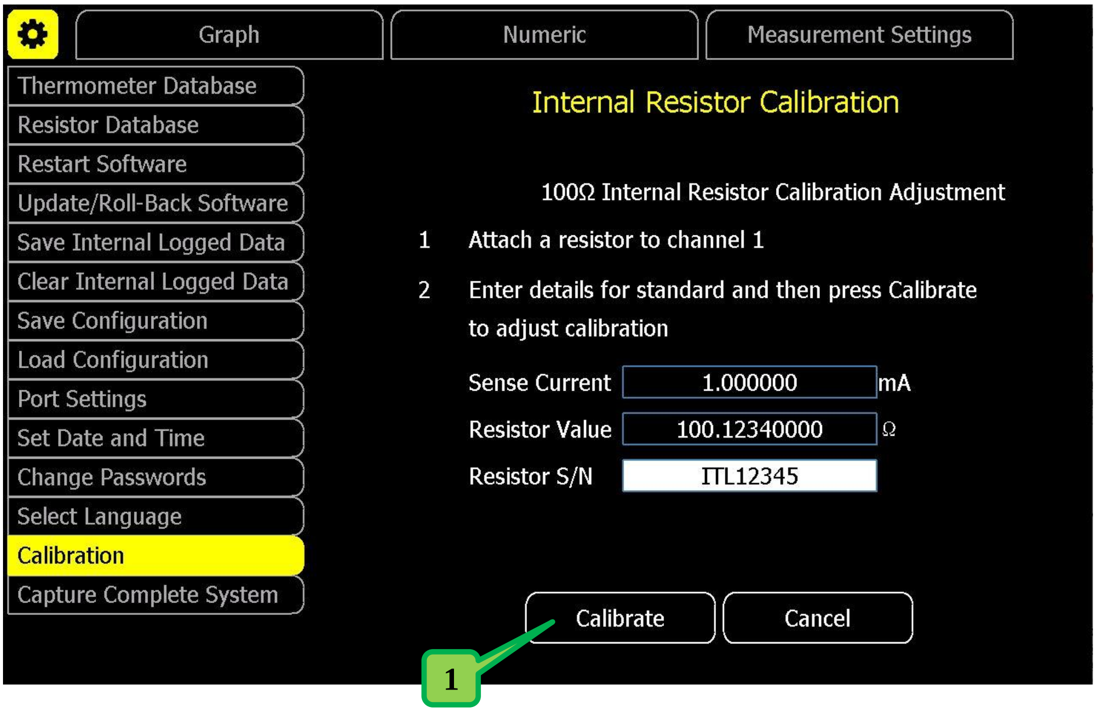
After adjustment, check that the ammeter now reads the correct current within the specified tolerance.

7.2.1.1 Calibrating the Internal Reference Resistors

Connect a stable external resistance standard with a nominal value of 100 Ω to channel 1. Ideally, this should be a DC or AC/DC resistance reference standard with a recent (traceable) calibration certificate maintained at a constant temperature in an oil bath. Press the *Internal Resistor* button in the *Select Type of Calibration* menu. Select the resistor you wish to recalibrate. Press *Select [1]*:



Enter the required information and press *Calibrate [1]* to start the calibration process:



Repeat the calibration adjustment process for the 25 and 400 Ω resistors. These can reasonably be calibrated against the external 100 Ω external reference resistor. However, if you have access to 25 and 400 Ω external reference resistors, these should be used.

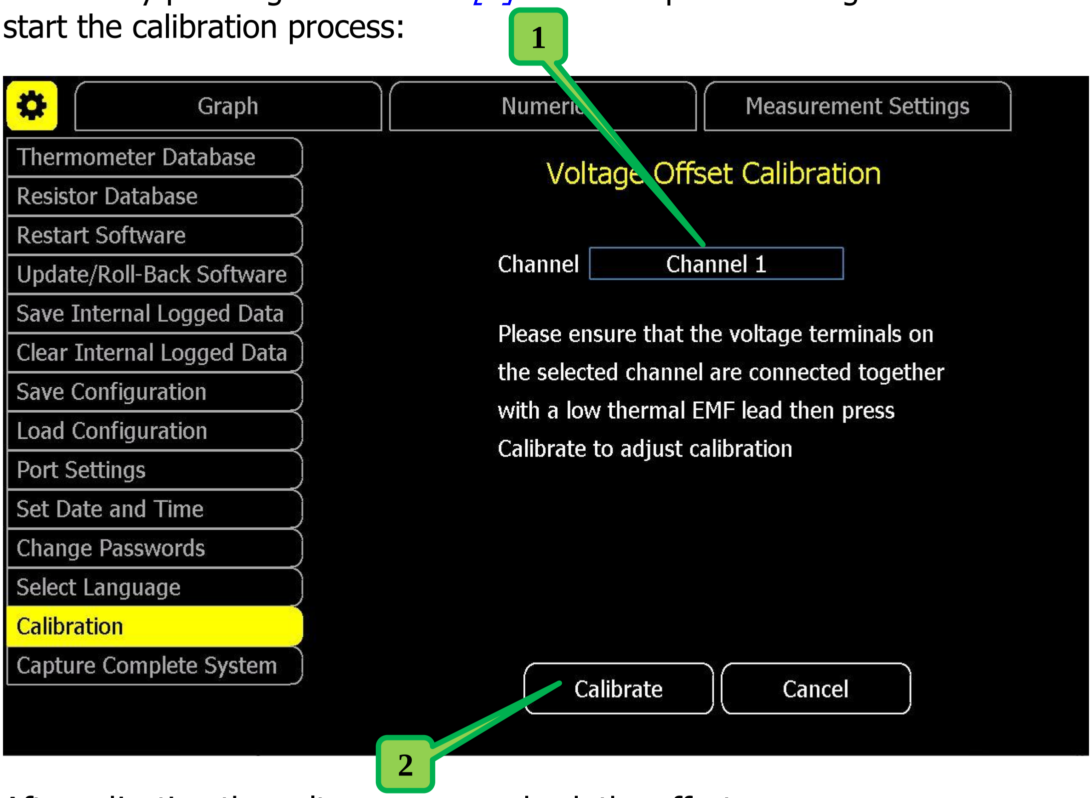
The microK^2 can optionally be fitted with up to eight internal reference resistors. Typical non-standard values include 1 Ω, 10 Ω and 10 kΩ. These can be adjusted in a similar way to the standard internal reference resistors provided you have a suitable external standard

After adjusting the internal resistors, re-check them against the external, calibrated resistor(s).

7.2.2 Removing Voltage Offsets

Short out the voltage terminals on all three channels using a piece of un-insulated copper wire for each channel:

Press the *Voltage Offset* button in the *Select Type of Calibration* menu and select the required channel by pressing the *Channel [1]* box to sequence through the channels. Press *Calibrate [2]* to start the calibration process:

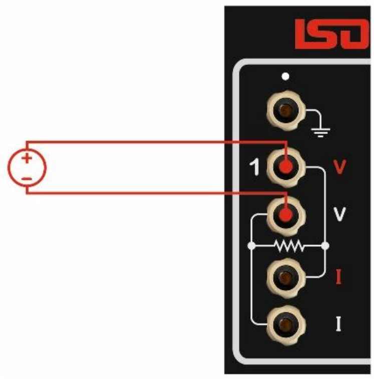


After adjusting the voltage zero, re-check the offset.

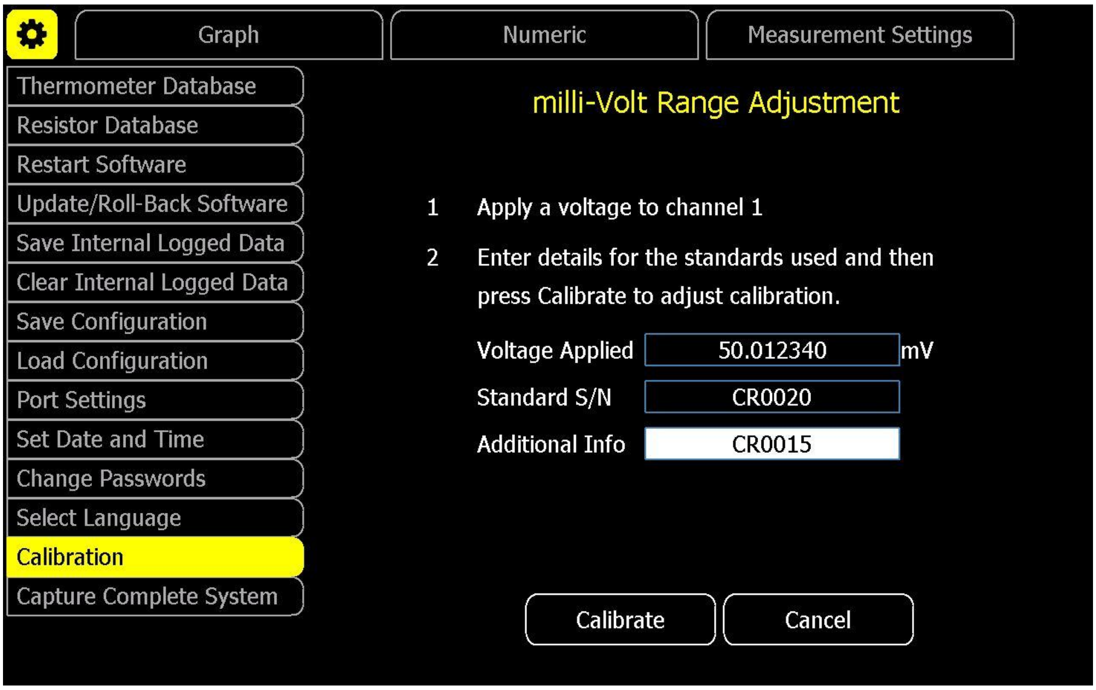
7.2.3 Calibrating Voltage Range

The offset voltage on channel 1 **MUST** be checked and if necessary adjusted to be within specification **BEFORE** adjusting the milli-Volt range.

The milli-Volt range adjustment is common to all channels, so the calibration only needs to be adjusted on one channel. Connect a stable, low noise voltage source with a nominal value of 50 mV to channel 1 using low thermal EMF wire and connectors (use copper or an alloy such as tellurium–copper that has a high copper content and low thermal EMF. Brass connectors must NOT be used):



Press the *milli-Volt Range Adjustment* button in the *Select Type of Calibration* menu and enter the required information into the pop-up window:



Press *Calibrate* to start the calibration process. After adjusting the milli-Voltage range, re-check the indicated value.

8 Digital Interfaces

The microK^2 is equipped with the following digital interfaces:

- Two RS232 ports
- GPIB port (IEEE-488)
- Ethernet Port (IEEE 802.3u: 100Base-TX / 10Base-T)

The connectors are located on the rear panel (see section 1.5). All three interfaces can be used to control the microK^2 using SCPI commands (Standard Commands for Programmable Instruments). Additionally, one of the RS232 ports can be used to control a microsKanner attached to your microK^2 to provide additional input channels.
The microK^2 treats the two RS232 ports, the GPIB port, the Ethernet port and the user interface as separate input streams so that they do not interact with each other.

8.1 RS232 Interface

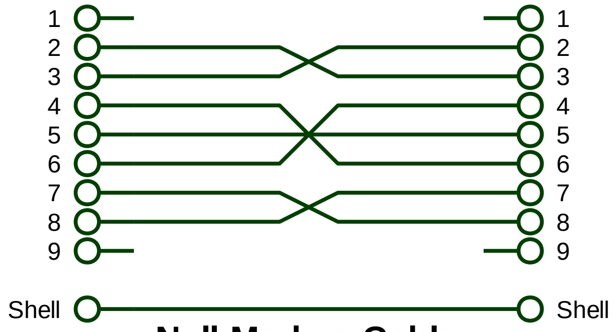
The microK^2 is equipped with two RS232 ports. These can be used to control the microK^2 or to communicate with microsKanners attached to it. When the microK^2 starts (or is restarted using the "Restart Software" function – see section 3.7.3) it looks for microsKanners attached to both ports. If found, that port is thereafter assigned to controlling microsKanners. Both ports are identical and can be used independently. The command set uses the SCPI protocol (Standard Commands for Programmable Instruments). See section 9 for details.

8.1.1 Establishing an RS232 Connection

The RS232 connectors are located on the rear of your microK^2 (see section 1.5). The connector is a 9-way (male) D-type configured as a standard DTE device:

Pin	Name	Function
1	CD	carrier detect (not connected)
2	RD	receive data
3	TD	transmit data
4	DTR	data terminal ready (fixed high)
5	SG	signal ground
6	DSR	data set ready (not connected)
7	RTS	request to send
8	CTS	clear to send
9	-	not used (not connected)
Shell	FG	frame ground (screen)

Connect your microK^2 to a PC using a standard null-modem cable:



Null-Modem Cable

The format for the RS232 interface is fixed and is as follows:

Baud Rate	9,600
Start Bits	1
Stop Bits	1
Parity Bit	none

You can use a terminal emulator application, such as "PuTTY", to communicate with the microK^2 via the RS232 connection, or you can write your own software.

Send *IDN? to your microK^2 (terminated with a carriage return). The microK^2 should then respond with a string in the form:

Isothermal Technology,microK2 Elite,25-P3456,1.0.0

Where:

- microK2 Elite is the model
- 25-P3456 is the serial number
- 1.0.0 is the firmware version

This confirms that you have successfully established an RS232 connection with your microK^2.

8.2 GPIB Interface

The microK^2 is equipped with an IEEE-488 GPIB (General Purpose Interface Bus) port. This can be used to control the microK^2. The command set uses the SCPI protocol (Standard Commands for Programmable Instruments). See section 9 for details.

The GPIB connector is located on the rear of your microK^2 (see section 1.5). The connector is the standard IEEE-488 connector (24-way):

Pin	Name	Function
1	DIO1	Data Input/Output bit
2	DIO2	Data Input/Output bit
3	DIO3	Data Input/Output bit
4	DIO4	Data Input/Output bit
5	#EOI	End or Identify
6	#DAV	Data Valid
7	NRFD	Not Ready for Data
8	NDAC	Not Data Accepted
9	#IFC	Interface Clear
10	#SRQ	Service Request
11	#ATN	Attention
12	GND	Shield
Shell	-	Frame Ground (cable screen)
13	DIO5	Data Input/Output bit
14	DIO6	Data Input/Output bit
15	DIO7	Data Input/Output bit
16	DIO8	Data Input/Output bit
17	#REN	Remote Enable
18	GND	Ground (paired with #DAV)
19	GND	Ground (paired with NRFD)
20	GND	Ground (paired with NDAC)
21	GND	Ground (paired with #IFC)
22	GND	Ground (paired with #SRQ)
23	GND	Ground (paired with #ATN)
24	GND	Logic Ground

Unlike the RS232 interface (which is full duplex) the GPIB is inherently half-duplex (data can only be transferred between the microK^2 and the GPIB Controller in one direction at any given time - the direction is determined by the controller). If a response is expected from the microK^2, the GPIB Controller must address the microK^2 as a Talker so that it can transmit this information. The microK^2 will try to send information on the GPIB for 2 seconds, after which time it will abandon attempts to respond and revert to being a Listener in order to receive further commands on the GPIB. This 2 second window will start as soon as the microK^2 is ready to respond. There will be a delay between the microK^2 receiving a command and attempting to respond to it. The length of the delay depends on the command (requesting data involves a short delay, but requesting a measurement may take up to 2 seconds) and whether the microK^2 is busy processing other commands (for example, if measurements are being requested via the front panel operator interface or via the RS232 interface).

8.2.1 GPIB Address

The microK^2 behaves as a GPIB Peripheral and can have an address in the range 1 to 30 (inclusive). The factory default address is 10, but this can be changed using the *Port Settings* function in the *Settings Cog* (see section 3.7.9).

8.2.2 Establishing a GPIB Connection

Connect your microK^2 to a GPIB Controller using a standard (straight through) GPIB cable. Send *IDN? to the GPIB address of the microK^2 (see section 8.2.1) terminated with a Line Feed (see section 9.1 for acceptable terminators), the microK^2 should then respond with a string in the form:

Isothermal Technology,microK2 Elite,25-P3456,1.0.0

Where:

- microK2 Elite is the model
- 25-P3456 is the serial number
- 1.0.0 is the firmware version

This confirms that you have successfully established a GPIB connection with your microK^2.

8.3 Ethernet Interface

The microK^2 is equipped with an Ethernet interface. There are two ways to use the Ethernet interface: you can use the Microsoft CerHost™ remote desktop facility to control the microK^2 from a PC, or you can send SCPI commands (see section 9 for details) to the microK^2 in the same way as using the RS232 or GPIB interfaces. Both ways of controlling the microK^2 using the Ethernet interface can be used at the same time.

8.3.1 Establishing an Ethernet Connection

Connect the RJ45 connector on the rear of your microK^2 to your LAN (Local Area Network); a braid screened cable is recommended. Alternatively, you can connect your microK^2 directly to the ethernet port on a PC. The microK^2 uses auto-MDIX to detect the type of cable used (straight-though or crossover) - so it will work with any ethernet cable.

The microK^2 can be used with a fixed IP address or acquire its IP address from a DHCP server on the network. See section 3.7.9 for further details.

Check that the PC can communicate with the microK^2 by opening a Command Prompt window. Type “ping” followed by the IP address of the microK^2 into the Command Prompt window. For example, in the case of a microK^2 with IP address 192.168.2.100, send “ping 192.168.2.100”. The connection test results will be reported in the ‘Command Prompt’ window.

The microk^2 and PC must be in the same subnet range. The Subnet Mask and IP Address can be set in the *Port Settings* function in the *Settings Cog*, see section 3.7.9.

9 SCPI Command Set

The command format and protocol used by the microK^2 is based on the SCPI (Standard Commands for Programmable Instruments) standard. This was developed to provide a consistent command language for all types of programmable instruments. The objective was to reduce the development time required by users of these instruments by providing a consistent programming environment using pre-defined: messages, instrument responses, and data formats. Further information on SCPI can be obtained from the SCPI Consortium (https://www.ivifoundation.org/About-IVI/scpi.html).

9.1 Command Terminators

SCPI commands are ASCII (American Standard Code for Information Interchange) character strings. If sent to the microK^2's RS232 interface, these should be terminated with a Carriage Return character (ASCII character 13). Responses from the microK^2 on the RS232 interface are always terminated by a Carriage Return character.

If commands are sent to the microK^2's GPIB port, they can be terminated by a Line Feed character (ASCII character 10), Carriage Return character (ASCII character 13), EOI condition (by pulling the #EOI line low during the last character of the ASCII string) or any combination of these. Responses from the microK^2 on the GPIB interface are always terminated by a Line Feed character (the microK^2 does not assert EOI at the end of a response).

9.2 SCPI Command Structure

Commands are arranged in a hierarchical tree, similar to directory trees used in personal computers. SCPI uses a defined notation to represent the command tree structure. Each node in the tree structure is a command keyword with keywords being separated by colons (:). To simplify the description of the SCPI commands, the notation represents levels in the tree using horizontal indentations with the root node being the left most column. For example, the microK^2 includes the following command structure:

```
SENSe
    :UNITs
    :CHANnel
    :FRESistance
        :REFerence:CHANnel
        :REFerence:CHANnel?
READ?
*IDN?
CALibrate
    :UNLock
    :LOCK
```

A valid command is formed by following the tree structure from a root node until a node is reached with no further nodes below it, for example in the above command tree we may use:

SENSe:FRESistance:REFerence:CHANnel?

Keywords can be shortened to the first four letters (or 3 if the fourth letter is a vowel). To indicate this, the notation uses upper-case to indicate required letters and lower-case to indicate optional letters (NB: all commands are case-insensitive). For example, valid forms of the above command include:

Sense:Fresistance:Reference:Channel?
SENS:FRES:REF:CHAN?
Sense:fresistance:REF:ChAnNel?

To shorten the commands, default (optional) keywords are enclosed in square brackets and may be omitted. For example, in the case of the command:

CALibrate:GPIB[:ADDRess]?

Valid forms of this command include:

CAL:GPIB?
calibrate:gpib:address?

9.3 SCPI Numeric Suffixes

In order to support multiple input channels, commands can include numeric suffixes. These are represented by a hash (#) in the command notation, for example:

MEASure[:SCALar]:RATio#<channel>:REFerence#<reference>?

In addition to the four input channels (which are assigned the suffixes 1, 2, 3 and 4), the internal reference resistors are specified using numeric suffixes as follows:

channel#	Internal reference resistor
201	1 Ω (Optional fit)
202	10 Ω (Optional fit)
203	25 Ω
204	100 Ω
205	400 Ω
206	Custom value (Optional fit)
207	Custom value (Optional fit)
208	10 kΩ (Optional fit)

In order to measure the ratio of the resistance on channel 1 against the internal 100 Ω reference resistor up to a maximum of 130 Ω with a 1 mA sense current, the command used would be:

MEAS:RAT1:REF204? 130,1

9.4 Parameters

If a command requires parameter(s), these follow the command and are separated from it by white space. If more than one parameter is required, each parameter is separated by a comma. For example, the command to measure the ratio of a resistor on channel 1 against a reference resistor on channel 2 using the 100 Ω range and a sense current of 1 mA would be:

MEAS:RAT1:REF2? 100,1

9.5 Concatenating Commands

Instead of sending multiple command strings (terminated with carriage returns i.e. on separate lines), you can join them together into a single command string separated by semi-colons. So:

```
SENS:FUNC  RAT
SENS:CHAN  1
SENS:RAT:REF 2
SENS:CURR 1
READ?
```

Can be replaced with:

```
SENS:FUNC  RAT;SENS:CHAN  1;SENS:RAT:REF 2;SENS:CURR 1;READ?
```

9.6 Units

Numeric parameters may optionally include units. The standard multiplying prefixes may also be used to indicate decimal multiples or fractions. For example, for current the default units are milli-amps, so the following are all equivalent.

```
CURRENT    1
CURRENT    0.001 A
CURRENT    1 mA
CURRENT    1000 UA
```

The following prefixes are available:

prefix	*name*	*factor*
N or n	nano	10^{-9}
U or u	micro	10^{-6}
M or m	milli	10^{-3}
K or k	kilo	10^{+3}
MA or ma	mega	10^{+6}

9.7 Using REMote/LOCal Modes

There is only one measurement system in the microK². The firmware makes no distinction between requests for a measurement received on digital interfaces (RS232, GPIB and Ethernet) or the UI (user interface) and will process these in the order in which they are received. If a response is expected, it will always be returned on the interface on which the request was made.

There is no direct interference between measurements made using the front panel operator interface and measurements requested using SCPI commands in the digital interface. However, measurements take some time to complete so there may be a delay in responses to SCPI commands if measurements are also being made for the UI. To avoid unnecessary delays to responses to SCPI commands, you can stop all measurements requested via the front panel operator interface by either sending the SCPI command *REMote* or not pressing the *Resume* button at startup. The microK² can be returned to normal operation by sending the SCPI command *LOCal* or pressing the *Local* button in the pop-up window that appears in REMote mode.

Placing the microK² in REMote mode is required for some SCPI commands. In order to use any information in the database (thermometer or resistor data) the microK² MUST be placed in REMote mode.

9.7.1 Measuring Resistance Ratio using SCPI Commands

To measure the resistance of a PRT, you need to:

- Set the microK² to measure resistance ratio
- Set the sense current
- Select the measurement range
- Select the measurement channel
- Select the reference channel
- Make the measurement

If you want to measure the resistance ratio of a 25.5 Ω SPRT on channel 1 up to a maximum resistance of 30 Ω against a 100 Ω reference resistor on channel 2, the maximum resistance that the measurement system sees is 100 Ω. To make this measurement using a 1 mA sense current, you can use the following command sequence:

```
REM
SENS:FUNC RAT
SENS:CURR 1
SENS:RAT:RANG 100,1
SENS:CHAN 1
SENS:RAT:REF 2
READ?
```

The microK² will then report the measured resistance, for example "2.500123456E-001".

The following short-form command performs the same measurement:

```
REM;MEAS:RAT1:REF2? 100,1
```

9.7.2 Measuring Resistance using SCPI Commands

In order to measure the resistance of a PRT, you need to:

- Set the microK^2 to measure resistance
- Set the sense current
- Select the measurement range
- Select the measurement channel
- Select the reference resistor
- Make the measurement

If you want to measure a 25.5 Ω SPRT up to a maximum resistance of 30 Ω against the internal 100 Ω reference, the maximum resistance that the measurement system sees is 100 Ω. To make this measurement using a 1 mA sense current, you can use the following command sequence:

```
REM
SENS:FUNC FRES
SENS:CURR 1
SENS:FRES:RANG 100,1
SENS:CHAN 1
SENS:FRES:REF:CHAN 204
READ?
```

The microK^2 will then report the measured resistance, for example "2.500123456E001".

The following short-form command performs the same measurement:

```
REM;MEAS:FRES1:REF204? 100,1
```

9.7.3 Measuring Voltage using SCPI Commands

In order to measure the voltage from a thermocouple, you need to:

- Set the microK^2 to measure voltage
- Select the measurement channel
- Make the measurement

If you want to measure the voltage from a thermocouple, you can use the following command sequence:

```
SENS:FUNC VOLT
SENS:CHAN 1
READ?
```

The microK^2 will then report the measured voltage, for example "0.000000023". The result is in volts, so in the above example the reading is 23 nV.

The following short-form command performs the same measurement:

REM;MEAS:VOLT1?

9.7.4 Measuring Temperature using SCPI Commands

In order to measure temperature with a PRT or thermistor, you need to:

- Set the microK^2 to measure temperature
- Select the measurement channel
- Select the reference resistor channel used to measure the resistance of the measurement PRTs/thermistors (or the PRT/thermistor used for RJC)
- Select the units (°C, °F or K)
- Specify the thermometer conversion by selecting a thermometer in the database with a conversion, or a generic conversion e.g. "type K" or "IEC60751"
- Specify the resistance range used to measure the resistance of the measurement PRT/thermistor (or the PRT/thermistor used for RJC)
- Set the sense current used to measure the resistance of the measurement PRT/thermistor (or the PRT/thermistor used for RJC)
- Select the reference resistor in the database used to measure the resistance of the measurement PRTs/thermistors (or the PRT/thermistor used for RJC)
- Specify the RJC to be used if measuring with a thermocouple (None, 0.01°C or a channel used to measure the reference junction temperature)
- Specify the thermometer conversion used for RJC by selecting a thermometer in the database with a conversion, or generic conversion "IEC60751"
- Make and report the measurement

These parameters can be defined using the SENS commands followed by READ? or the MEAS:TEMP#:REF#? command (see section 0).

The feature is best explained by looking at examples:

9.7.4.1 Using a PRT With An Internal Reference Resistor

To measure temperature in °C on channel 1 with a Pt100 using the generic IEC60751 conversion against the internal 100 Ω reference resistor (channel 204) up to a maximum resistance of 400 Ω with a sense current of 1 mA, you can use the following SCPI commands:

```
REM
SENS:FUNC  TEMP
SENS:UNIT C
SENS:CHAN  1
SENS:THER  IEC60751
SENS:FRES:REF:CHAN  204
SENS:FRES:RANG  400,1
SENS:CURR  1
READ?
```

Alternatively, the shorter form SCPI commands can be used:

```
REM
MEAS:TEMP1:REF204? C,IEC60751,400,1,0,0,0
```

In response to the above SCPI commands, a Pt100 with resistance 101 Ω would report "2.55963".

9.7.4.2 Using an SPRT With An External Reference Resistor

To measure temperature in °C on channel 1 with an SPRT defined as thermometer 2 in the database against an external reference resistor connected to channel 3 and defined as resistor 4 on the database up to a maximum resistance of 100 Ω and a sense current of 1 mA, you can use the following SCPI commands:

```
REM
SENS:FUNC  TEMP
SENS:UNIT C
SENS:CHAN  1
SENS:THER  2
SENS:FRES:REF:CHAN  3
SENS:FRES:REF:RES 4
SENS:FRES:RANG  100,1
SENS:CURR  1
READ?
```

Alternatively, the shorter form SCPI commands can be used:

```
REM
MEAS:TEMP1:REF3? C,2,100,1,4,0,0
```

In response to the above SCPI commands, an SPRT with ITS-90 conversion (all deviation function coefficients = 0) with WTP resistance of 25.5 Ω and a resistance of 50 Ω would report "250.29265".

9.7.4.3 Using a Thermocouple With No RJC

To measure temperature in °C on channel 1 with a Type S thermocouple using the generic Type S conversion and no RJC (reference junction compensation), you can use the following SCPI commands:

```
REM
SENS:FUNC  TEMP
SENS:CHAN  1
SENS:UNIT C
SENS:THER TYPE S
SENS:RJC:CHAN NON
READ?
```

Alternatively, the shorter form SCPI commands can be used:

```
REM
MEAS:TEMP1:REF1? C,TYP S,400,1,0,NON,0
```

9.7.4.4 Using a Thermocouple With RJC

To measure temperature in °C on channel 1 with thermocouple defined as thermometer 4 in the database and RJC (reference junction compensation) using a PRT on channel 2 defined as thermometer 5 in the database against external reference resistor connected to channel 3 and defined as resistor 6 in the database up to a maximum resistance of 100 Ω and a sense current of 1 mA, you can use the following SCPI commands:

```
REM
SENS:FUNC  TEMP
SENS:UNIT C
SENS:CHAN  1
SENS:THER 4
SENS:RJC:CHAN 2
SENS:RJC:THER  5
SENS:FRES:REF:CHAN  3
SENS:FRES:REF:RES 6
SENS:FRES:RANG  100,1
SENS:CURR 1
READ?
```

Alternatively, the shorter form SCPI commands can be used:

```
REM
MEAS:TEMP1:REF2? C,4,100,1,5,3,6
```

9.7.5 SCPI Commands

The microK2 supports the following SCPI commands:

```
*IDN?
SENSe
    :FUNCtion[:ON]      <function>
    :FUNCtion[:ON]?
    :UNITs      <units>
    :UNITs?
    :CHANnel    <channel>
    :CHANnel?
    :RATio
        :REFerence          <denominator channel>
        :REFerence?
        :RANGe[:UPPer]  <resistance range>,<current>
        :RANGe[:UPPer]?
    :FRESistance
```

```
        :REFerence
            :CHANNel        <reference channel>
            :CHANNel?
            :RESistor       <reference resistor>
            :RESistor?
        :RANGe[:UPPer]  <resistance range>,<current>
        :RANGe[:UPPer]?
    :CURRent    <current>
    :CURRent?
    :THERmometer        <thermometer>
    :THERmometer?
    :RJC
        :CHANNel        <channel>
        :CHANNel?
    :RJC
        :THERmometer        <thermometer>
        :THERmometer?
[MICRok2]
    :REMote
    :LOCal
INITiate[:IMMediate][:ALL]
FETCh[:SCALar]?
READ[:SCALar]?
MEASure[:SCALar]
    :RATio# <channel>
        :REFerence# <refence>?   <resistance range>,<current>[,<readings>]
    :FRESistance# <channel>
            :REFerence# <reference>?   <resistance range>,<current>[,<readings>]
    :VOLTage[:DC]# <channel>   [<Thermocouple Type>][,RJC channel] [,readings>]
    :TEMPerature# <channel>
        :REFerence#<reference>?   <units>,<thermometer>,<range>,<current>,
                                   <reference>,<RJC channel>,<RJC reference>
CALibrate
    :UNLock     <calibration password>
    :LOCK
    :NAMe       <name>
    :NAMe?
    :COMPany  <company>
    :COMPany?
    :LOCation       <location>
    :LOCation?
    :TEMPerature  <temperature>
    :TEMPerature?
    :IDENtification     <name>,<company>,<location>,<temperature>
    :IDENtification?
    :IDENtification
        :LAST?
    :CURRent[:GAIN] <current>,<measured current>[,<standard>]
    :CURRent[:GAIN]?
    [:VOLTage]
        :OFFSet# <channel>     <offset>
        :OFFSet# <channel>?
```

```
        :GAIN    <adjustment>[,<standard 1>][,<standard 2>]
        :GAIN?
    :REFerence
        [:RESistor]# <reference> <nominal resistance>,<actual resistance>[,<standard>]
    :REFerence[:RESistor]# <reference>?
    :GPIB[:ADDRess] <gpib address>
    :GPIB[:ADDRess]?
    :STATus?
    :PASSword <old password,< password>,< password>,<which password>
PASSword
    :RECovery
        :KEY?
DATabase
    :UNLock     <password>
    :LOCK
THERmometer
    :COUNt?
    :NAMe# < thermometer> <name>
    :NAMe?
    :TYPe    <type>
    :TYPe?
    :MANufacturer     <manufacturer>
    :MANufacturer?
    :MODel  <model>
    :MODel?
    :SERial# <thermometer> <serial number>
    :SERial# < thermometer >
    :DATe# < thermometer > <date>
    :DATe?
    :MINimum      <minimum temperature>
    :MINimum?
    :MAXimum      <maximum temperature>
    :MAXimum?
    :CONVersion   <temperature conversion>
    :CONVersion?
    :COEFficient   <coefficient>,<value>
    :COEFficient?
    :CVD
        :FORM      <form>
        :FORM?
    :ITS
        :FORM# <thermometer>      < form>
        :FORM# <thermometer>?
    :CREate     <name>
    :DELete# <thermometer>
    :FIND?   <name>
RESistor:
    :COUNt?
    :NAMe# <probe> <name>
    :NAMe?
    :MANufacturer     <manufacturer>
    :MANufacturer?
```

:MODel *<model>*
:MODel?
:SERial# *<probe>* *<serial number>*
:SERial# *<probe>*
:DATe# *<probe>* *<date>*
:DATe?
:VALue *<resistance >*
:VALue?
:CREate <name>
:DELete# *<probe>*
:FIND? *<name>*
MICRoskanner
:FIND
:COUNt?
:LIST?
:SERialnumber# *<microsKanner>*?
:VERSion# *<microsKanner>*?
:PORT?
MICRosckanner10
:COUNt?
PASSword
:RECovery
:KEY?

A detailed description of each command follows:

9.7.6 Command *IDN?

Format: *IDN?

Reports information on the microK^2 in four comma separated fields:

- Manufacturer
- Model
- Serial number
- Firmware version

Example: for a microK^2 60 with serial number ITL12345-6 using firmware version 1.23, the microK^2 responds to *IDN? with:

Isothermal Technology,microK2 60,ITL12345-6,1.23

9.7.7 Command SENSe:FUNCtion

Format: SENSe:FUNCtion[:ON] *<function>*

Selects the measurement function. The parameter *<function>* must be one of the following valid SCPI parameters:

- RATio
- FRESistance
- VOLTage[:DC]
- TEMPerature

Example: to set the microK^2 to measure ratio, use: SENS:FUNC RAT

9.7.8 Command SENSe:FUNCtion?

Format: SENSe:FUNCtion[:ON]?

Reports the current measurement function.

Example: a microK^2 set to measure voltage will respond to SENS:FUNC? with "VOLTAGE".

9.7.9 Command SENSe:UNITs

Format: SENSe:UNITs *<units>*

Selects the units for temperature measurements. The parameter *<units>* must be one of K, C or F.

Example: to set the microK^2 to report temperature in °C, use: SENS:UNIT C

9.7.10 Command SENSe:UNITs?

Format: SENSe:UNITs?

Reports the units used for temperature measurements.

Example: a microK^2 set to measure temperature in °C will respond to SENS:UNIT? with "C".

9.7.11 Command SENSe:CHANnel

Format: SENSe:CHANnel *<channel>*

Selects the channel for the next measurement. The channel is not actually selected until a measurement is started using either the INITiate or READ? commands.

Example: to select channel 2 for the next measurement, use: SENS:CHAN 2

9.7.12 Command SENSe:CHANnel?

Format: SENSe:CHANnel?

Reports the channel selected for the next measurement.

Example: a microK^2 set to measure channel 1 on the next measurement will respond to SENS:CHAN? with: "1".

9.7.13 Command SENSe:RATio:REFerence

Format: SENSe:RATio:REFerence *<denominator channel>*

Selects the denominator (reference) channel for the next resistance ratio measurement. The channel is not actually selected until a measurement is started using either the INITiate or READ? commands. The channel numbers used for the internal reference resistors are:

- Channel 201 = 1 Ω (Optional fit)
- Channel 202 = 10 Ω (Optional fit)
- Channel 203 = 25 Ω
- Channel 204 = 100 Ω
- Channel 205 = 400 Ω
- Channel 206 = Custom value (Optional fit)
- Channel 207 = Custom value (Optional fit)
- Channel 208 = 10 kΩ (Optional fit)

Example: to select channel 2 as the denominator channel for the next resistance ratio measurement, use: SENS:RAT:REF 2

9.7.14 Command SENSe:RATio:REFerence?

Format: SENSe:RATio:REFerence?

Reports the channel selected as the denominator (reference) channel for the next resistance ratio measurement.

Example: a microK^2 set to use channel 2 as the denominator in the next resistance ratio measurement will respond to the command SENS:RAT:REF? with: "2".

9.7.15 Command SENSe:RATio:RANGe

Format: SENSe:RATio:RANGe[:UPPer] *<resistance range>,<current>*

Sets the range for the next resistance ratio measurement. The range is determined by the voltage range of the measurement system (0.125, 0.5 or 2.5 V) and depends on the sense current used. The *current* parameter is the current you intend to use in the measurement; this may not be the same as the present value of sense current that is set with the SENSe:CURRent command. The 3 resistance ranges available with the microK^2 are:

- *resistance range 1 = 0.125 V / current*
- *resistance range 2 = 0.5 V / current*
- *resistance range 3 = 2.5 V / current*

The resistance range specified should be the higher of the maximum PRT/thermistor resistance and reference resistor since the measurement system has to measure the signal across both to determine their ratio.

Example: to set the microK^2 to measure the resistance ratio of a PRT that has a maximum resistance of 130 Ω (with a 100 Ω reference resistor) with a 1 mA sense current, use: SENS:RAT:RANG 130,1. This will set the microK^2 to the 0.5 V range.

9.7.16 Command SENSe:RATio:RANGe?

Format: SENSe:RATio:RANGe[:UPPer]?

Reports the range for the next resistance ratio measurement at the present sense current (set using the SENSe:CURRent command). The current used to calculate the range may be different from that specified when the range was set using the SENSe:RATio:RANGe command. The reported range is the actual range for the measurement system at the present sense current.

Example: a microK^2 that has had its resistance ratio range set using the command shown in section 9.7.15 but has its sense current set to 0.5 mA would respond to the command: SENS:RAT:RANG? with: "1000".

9.7.17 Command SENSe:FRESistance:REFerence:CHANnel

Format: SENSe:FRESistance:REFerence:CHANnel *<reference channel>*

Selects the reference channel for the next resistance measurement made. This command is also used to select the reference resistor channel used for a thermocouples RJC (reference junction correction) sensor. The channel is not actually selected until a measurement is started using either the INITiate or READ? Commands. The channel numbers used for the internal reference resistors are:

- Channel 201 = 1 Ω (Optional fit)
- Channel 202 = 10 Ω (Optional fit)
- Channel 203 = 25 Ω
- Channel 204 = 100 Ω
- Channel 205 = 400 Ω
- Channel 206 = Custom value (Optional fit)
- Channel 207 = Custom value (Optional fit)
- Channel 208 = 10 kΩ (Optional fit)

Example: to select channel 204 (100 Ω) as the reference channel for the next resistance measurement, use: SENS:FRES:REF:CHAN 204

9.7.18 Command SENSe:FRESistance:REFerence:CHANnel?

Format: SENSe:FRESistance:REFerence:CHANnel?

Reports the channel selected as the reference channel for the next resistance measurement.

Example: a microK^2 set to use channel 204 as the reference in the next resistance measurement will respond to the command SENS:FRES:REF:CHAN? with: "204".

9.7.19 Command SENSe:FRESistance:REFerence:RESistor

Format: SENSe:FRESistance:REFerence:RESistor *<reference resistor>*

Selects the reference resistor used for the next resistance measurement made. This command is also used to select the reference resistor used for a thermocouples RJC (reference junction correction) sensor.

Example: to select the second reference resistor in the resistor database as the reference resistor for the next resistance measurement, use: SENS:FRES:REF:RES 2

9.7.20 Command SENSe:FRESistance:REFerence:RESistor?

Format: SENSe:FRESistance:REFerence:RESistor?

Reports the reference resistor selected as the reference resistor for the next resistance measurement.

Example: a microK^2 set to use the second reference resistor in the database as the reference resistor for the next resistance measurement will respond to the command SENS:FRES:REF:RES? with: "2".

9.7.21 Command SENSe:FRESistance:RANGe

Format: SENSe:FRESistance:RANGe[:UPPer] *<resistance range>,<current>*

Sets the range for the next resistance measurement. The range is determined by the voltage range of the measurement system (0.125, 0.5 or 2.5 V) and depends on the sense current used. The *current* parameter is the current you intend to use in the measurement; this may not be the same as the present value of sense current that is set with the SENSe:CURRent command. The three resistance ranges available with the microK^2 are:

- *resistance range 1 = 0.125 V / current*
- *resistance range 2 = 0.5 V / current*
- *resistance range 3 = 2.5 V / current*

The resistance range specified should be the higher of the maximum PRT/thermistor resistance and reference resistor since the measurement system must measure the signal across both to determine the resistance of the device under test.

Example: to set the microK^2 to measure a PRT that has a maximum resistance of 130 Ω (using a 100 Ω reference resistor) with a 1 mA sense current, use: SENS:FRES:RANG 130,1. This will set the microK^2 to the 0.5 V range.

9.7.22 Command SENSe:FRESistance:RANGe?

Format: SENSe:FRESistance:RANGe[:UPPer]?

Reports the range for the next resistance measurement at the present sense current (set using the SENSe:CURRent command). The current used to calculate the range may be different from that specified when the range was set using the SENSe:FRESistance:RANGe command. The reported range is the actual range for the measurement system at the present sense current.

Example: a microK^2 that has had its resistance range set using the command shown in section 9.7.21 has its sense current set to 0.5 mA would respond to the command: SENS:FRES:RANG? with: "1000".

9.7.23 Command [SENSe:]CURRent

Format: [SENSe:]CURRent *<current>*

Sets the sense current for the next resistance or ratio measurement to *<current>*. The current is not changed until a measurement is started using either the INITiate or READ? commands.

Example: to set the sense current for the next resistance measurement to 2 mA use: CURR 2

9.7.24 Command [SENSe:]CURRent?

Format: [SENSe:]CURRent?

Reports the sense current for the next resistance or ratio measurement.

Example: a microK^2 that has had its sense current set using the command shown in section 9.7.23 would respond to the command SENS:CURR? with : "2.000000E-003"

9.7.25 Command SENSe:THERmometer

Format: SENSe:THERmometer *<thermometer>*

Specifies the thermometer to be used in the next a measurement of temperature (see section 9.7.4), *<thermometer>* can be either an index to a thermometer in the microK^2's database or a standard thermometer type, such as:

NONe
IEC60751
TYPe B
TYPe E
TYPe J
TYPe K

TYPe L
TYPe N
TYPe R
TYPe S
TYPe T
TYPe AU-PT
TYPe PT-PD

Examples: send SENS:THER 2 to select the second probe in the microK²'s database for use in a temperature measurement. Send SENS:THER TYP K to select a type K thermocouple for use in a temperature measurement.

9.7.26 Command SENSe:THERmometer?

Format: SENSe:THERmometer?

Reports the thermometer probe to be used in the next a measurement of temperature (see section 9.7.4). this will be either an index to a thermometer in the microK²'s database or a standard thermometer type (see section 9.7.25).

Example: a microK² set to measure temperature using a type N thermometer will respond to the command SENS:THER? by returning "Type N".

9.7.27 Command SENSe:RJC:CHANnel

Format: SENSe:RJC:CHANnel *<channel>*

Sets the channel used to measure the reference junction temperature, or a fixed temperature; either 0°C (*<channel> = NONe*) or 0.01° C (*<channel = WTP*). The 0.01° C option is provided as WTP (water tripe point) cells are often available in a temperature laboratory, whereas ice points are less often used.

Example: send SENS:RJC:CHAN 2 to set channel 2 as the channel used to measure the reference junction temperature.

9.7.28 Command SENSe:RJC:CHANnel?

Format: SENSe:RJC:CHANnel?

Reports the channel used to measure the reference junction temperature, or the fixed-point temperature ("None" for 0° C and "WTP" for 0.01° C).

Example: a microK² configured to use a WTP as the reference junction will respond to SENS:RJC:CHAN? by returning "WTP".

9.7.29 Command SENSe:RJC:THERmometer

Format: SENSe:RJC:THERmometer *<thermometer>*

Specifies the thermometer to be used to measure the reference junction temperature, *<thermometer>* can be either an index to a thermometer in the microK2's database or IEC60751. Typed thermocouples cannot be used as the thermometer since this could lead to circular dependencies.

Example: send SENS:RJC:THER 1 to select the first thermometer in the database as the thermometer used to measure the reference junction.

9.7.30 Command SENSe:RJC:THERmometer?

Format: SENSe:RJC:THERmometer?

Reports the thermometer used to measure the reference junction temperature.

Example: a microK^2 configured to use a PRT with an IEC60751 temperature conversion to as the reference junction thermometer will respond to SENS:RJC:THER? by returning "IEC60751".

9.7.31 Command INITiate

Format: INITiate[:IMMediate][:ALL]

Initiates a measurement using the conditions defined by previous SENSe commands. The measurement is made immediately but not reported.

Example: to initiate a voltage measurement that has been defined with SENSe commands (such as SENS:CHAN 1 and SENS:FUNC volt) use: INIT

9.7.32 Command FETCh?

Format: FETCh[:SCALar]?

Reports the result of the last measurement made.

Example: a microK^2 that has made a measurement on a short circuit connected to channel 1 using the commands shown in the example in section 9.7.3 will respond to FETC? with something similar to : "0.0000123".

9.7.33 Command READ?

Format: READ[:SCALar]? *<readings>*

Initiates and reports measurements (repeated *<readings>* times) using the conditions defined by previous SENSe commands. This is similar to INIT followed by FETCh? but can be used to make multiple measurements with the same settings.

Example: a microK^2 that is connected to a short circuit on channel 1 and has been configured to make a voltage measurement using SENSe commands (such as SENS:CHAN 1 and SENS:FUNC volt) will respond to READ? with something similar to: "0.0000123".

9.7.34 Command MEASure:RAT#:REF#?

Format: MEASure[:SCALar]:RATio#<channel>:REFerence#<reference>?

<resistance range>,<current>

Initiates and reports a resistance ratio measurement on <channel> against a reference on channel *<reference>* using *<resistance range>* with sense *<current>* (note that there is no gap between the command and the channel numbers as this command makes use of the numeric suffixes feature of SCPI described in section 9.3). This command is equivalent SENS:FUNC rat, SENS:CHAN *<channel>*, SENS:RAT:REF *<reference>*, SENS:RAT:*RANG <resistance range>,<current>*,SENS:CURR *<current>* and READ?

Example: to set the microK^2 to measure the resistance ratio of a PRT on channel 1 that has a maximum resistance of 130 Ω against a 100 Ω reference resistor on channel 2 with a 1 mA sense current, use: MEAS:RAT1:REF2? 130,1

9.7.35 Command MEASure:FRES#:REF#?

Format: MEASure[:SCALar]:FRESistance#*<channel>*:REFerence#*<reference>*?

<resistance range>,<current>

Initiates and reports a resistance measurement on *<channel>* against a reference channel *<reference>* using *<resistance range>* with sense *<current>*.

The reference channel must be selected from the range of internal reference resistor channels (201–208). See section 9.3 for details.

Note that there is no gap between the command and the channel numbers as this command makes use of the numeric suffixes feature of SCPI – see section 9.3.

This command is equivalent to SENS:FUNC fres, SENS:CHAN *<channel>,* SENS:FRES:REF:CHAN *<reference>*, SENS:FRES:RANG *<resistance range>,<current>*, SENS:CURR *<current>* and READ?

Example: to set the microK^2 to measure a PRT on channel 1 that has a maximum resistance of 130 Ω using the 100 Ω internal reference resistor (channel 204) with a 1 mA sense current, use: MEAS:FRES1:REF204? 130,1

9.7.36 Command MEASure:VOLTage?

Format: MEASure[:SCALar]:VOLTage[:DC]#*<channel>*?

Initiates and reports a voltage measurement on *<channel>* (note that there is no gap between the command and the channel number as this command makes use of the numeric suffixes feature of SCPI described in section 9.3). This command is equivalent to SENS:FUNC volt, SENS:CHAN *<channel>* and READ?

Example: to initiate a voltage measurement on channel 3 use: MEAS:VOLT3?

9.7.37 Command MEASure:TEMPerature?

Format: MEASure[:SCALar]:TEMPerature#*<channel>*:REFerence#*<reference>*?

<units>,<thermometer>,<range>,<current>,<reference resistor>,<rjc>,<rjc thermometer>

Initiates and reports a measurement of temperature on *<channel>* using a reference on channel *<reference>* with the specified measurement parameters (note that there is no gap between the command and the channel numbers as this command makes use of the numeric suffixes feature of SCPI described in section 9.3). This command supports both RTDs (PRTs and thermistors) and thermocouples, internal and external reference resistors (in the resistor database), generic conversions (e.g. IEC60751, Type K) or thermometers in the database and RJC (for thermocouples) using temperature measurements made with RTDs connected to *<rjc>* channel or a fixed temperature (0 or 0.01 °C). Examples of how to use this command are given in section 9.7.4.

Although the command is common to all thermometer types, the syntax for this command is best understood by considering its use with RTDs and thermocouples separately.

9.7.37.1 Command MEASure:TEMPerature? With RTDs

Format: MEASure[:SCALar]:TEMPerature#*<channel>*:REFerence#*<reference>*?

<units>,<thermometer>,<range>,<current>,<reference resistor>,0,0

Where:

<channel> = the channel to which the RTD thermometer is connected

<reference> = the channel to which the reference resistor is connected. This can be in internal reference resistor channel (201 to 208), an external channel (1 to 4) or an expansion channel on a microsKanner (10-99).

<units> = the temperature units (F, C or K)

<thermometer> = the thermometer whose definition is used to convert the resistance measurement to temperature. This can be the index number of a thermometer in the database or generic conversion IEC60751

<range> = the maximum resistance (in Ω) of the thermometer or reference resistor

<current> = the sense current (in mA)

<reference resistor> = the database index number of the reference resistor, or “0” if an internal resistor is being used

The last 2 parameters are unused as they are only required for thermocouples, so can be set to 0.

Examples are given in sections 9.7.4.1 and 9.7.4.2.

9.7.37.2 Command MEASure:TEMPerature? With Thermocouples

Format: MEASure[:SCALar]:TEMPerature# *<channel>*:REFerence#*<reference>*?

<units>,<thermometer>,<range>,<current>,<reference resistor>,<rjc>,<rjc thermometer>

Where:

<channel> = the channel to which the thermocouple is connected. Channel 4 is not permitted

<reference> = the channel to which the reference resistor used with the RJC thermometer is connected. This can be an internal reference resistor channel (201 to 208), an external channel (1 to 4) or an expansion channel on a microsKanner (10-99).

<units> = the temperature units (F, C or K)

<thermometer> = the thermometer whose definition is used to convert the voltage measurement to temperature. This can be the index number of a thermometer in the database or a generic conversion such as "Type S"

<range> = the maximum resistance (in Ω) of the thermometer or reference resistor used to measure the temperature of the reference junction (if required for RJC)

<current> = the sense current (in mA) used with the RJC sensor

<reference resistor> = the index number of the reference resistor used with the RJC thermometer to measure the reference junction temperature, or "0" if an internal resistor is being used

<rjc> = reference junction compensation applied. This can be "None" (reference junction 0 °), "WTP" (reference junction in a water triple-point at 0.01°C) or the channel to which the RJC sensor is connected

<rjc thermometer> = the thermometer whose definition is used to convert the resistance measurement to temperature to measure the reference junction temperature in order to apply RJC. This can be the index number of a thermometer in the database or generic conversion IEC60751

Examples are given in sections 9.7.4.3 and 9.7.4.4.

9.7.38 Command TEST:CURRent

Format: TEST:CURRent*[#<channel>] <current>*

Immediately sets the sense current on channel *<channel>* to *<current>*. If *<channel>* is omitted, it defaults to channel 1. This command can be used to test/calibrate the master current source (see section 7.1.1 and section 7.2.1).

Example: to set the sense current on channel 1 to 1.4 mA use: TEST:CURR1 1.4

9.7.39 Using CALibrate Commands

The calibration of your microK^2 can easily be performed via the user interface (see section 7). However, the following SCPI commands perform the same function.

All CALibrate commands that adjust a calibration parameter (e.g. CALibrate:VOLTage:OFFset# *<channel>* *<offset>*) only apply an adjustment if the calibration has been unlocked using the CALibrate:UNLock command (see section 9.7.40), otherwise it will just report "Calibration Locked".

A complete record of all calibration adjustments is maintained in the microK^2, including a record of the name of the calibration engineer, the calibration organisation, the location and room temperature at which it was made, provided that this is entered using the relevant SCPI commands (see sections 9.7.42 to 9.7.52). This information should be supplied when adjusting the calibration to provide a full audit trail for the microK^2.

The details for the last calibration adjustment made can be accessed using the CALibrate:IDENtification:LAST? Command (see section 9.7.52).

9.7.40 Command CALibrate:UNLock

Format: CALibrate:UNLock *<password>*

Unlocks the microK^2 to allow calibration adjustment. The microK^2 always powers up in the locked state. Calibration can be re-locked by cycling the power or using CAL:LOCK (see section 9.7.41).

Example: to unlock (enable) the calibration adjustment on a microK^2 with the default password (see section 3.8.2), use: CAL:UNL 5678

9.7.41 Command CALibrate:LOCK

Format: CALibrate:LOCK

Locks the microK^2 to prevent calibration adjustment.

Example: to lock the calibration of a microK^2 after adjustment, use: CAL:LOCK

9.7.42 Command CALibrate:NAMe

Format: CALibrate:NAMe *<name>*

Sets the 'name' parameter recorded for any calibrations made after this command, until the microK^2 is restarted or 'name' is changed using this SCPI command or CALibrate:IDENtification (see section 9.7.50). This information would typically be used to store the name of the calibration engineer.

Example: for calibrations made by John Smith, send CAL:NAM John Smith

9.7.43 Command CALibrate:NAMe?

Format: CALibrate:NAMe?

Reports the 'name' parameter that will be recorded for any subsequent calibrations.

Example: a microK^2 that has been set to record "John Smith" as the 'name' for calibrations (see section 9.7.42 or section 9.7.50) would respond to CAL:NAM? with: "John Smith".

9.7.44 Command CALibrate:COMPany

Format: CALibrate:COMPany *<company>*

Sets the 'company' parameter recorded for any calibrations made after this command, until the microK^2 is restarted or 'company' is changed using this SCPI command or CALibrate:IDENtification (see section 9.7.50). This information would typically be used to store the name of the calibration organisation.

Example: for calibrations made by Isotech, send CAL:COMP Isothermal Technology

9.7.45 Command CALibrate: COMPany?

Format: CALibrate: COMPany?

Reports the 'company' parameter that will be recorded for any subsequent calibrations.

Example: a microK^2 that has been set to record "Isothermal Technology" as the 'company' for calibrations (see section 9.7.44 or section 9.7.50) would respond to CAL:COMP? with: "Isothermal Technology".

9.7.46 Command CALibrate:LOCation

Format: CALibrate:LOCation *<location >*

Sets the 'location' parameter recorded for any calibrations made after this command, until the microK^2 is restarted or 'location' is changed using this SCPI command of CALibrate:IDENtification (see section 9.7.50). This information would typically be used to store the location where the calibration was performed.

Example: for calibrations made in Isotech's primary standards laboratory, send CAL:LOC Primary Laboratory

9.7.47 Command CALibrate:LOCation?

Format: CALibrate:LOCation?

Reports the 'location' parameter that will be recorded for any subsequent calibrations.

Example: a microK^2 that has been set to record "Primary Laboratory" as the 'location' for calibrations (see section 9.7.46 or section 9.7.50) would respond to CAL:LOC? with: "Primary Laboratory".

9.7.48 Command CALibrate:TEMPerature

Format: CALibrate:TEMPerature *<temperature>*

Sets the 'temperature' parameter recorded for any calibrations made after this command, until the microK^2 is restarted or 'temperature' is changed using this SCPI command of CALibrate:IDENtification (see section 9.7.50). This information would typically be used to store the temperature of the laboratory in which the calibration was made.

Example: for calibrations made at 20 °C ± 1 °C, send CAL:TEMP 19-21C

9.7.49 Command CALibrate: TEMPerature?

Format: CALibrate:TEMPerature?

Reports the 'temperature' parameter that will be recorded for any subsequent calibrations.

Example: a microK^2 that has been set to record "19-21 degrees C" as the 'temperature' for calibrations (see section 9.7.48 or section 9.7.50) would respond to CAL:TEMP? with: "19-21 degrees C".

9.7.50 Command CALibrate:IDENtification

Format: CALibrate:IDENtification *<name>,<company>,<location>,<temperature>*

Sets all the identification parameters recorded for any calibrations that are made after this command, until the microK^2 is restarted or these parameters are changed using this SCPI command or the other commands used to set these parameters (see section 9.7.42, section 9.7.44, section 9.7.46 and section 9.7.48). This information would typically be used to store the name of the calibration engineer; the calibration organisation; the location and environment of the calibration.

Example: for calibrations made by John Smith at Isotech at Isotech's primary standards laboratory operating at 20 °C ± 1 °C, send CAL:IDEN John Smith,Isothermal Technology Limited,Primary Laboratory,19-21 C

9.7.51 Command CALibrate:IDENtification?

Format: CALibrate:IDENtification?

Reports all the identification parameters that will be recorded for any subsequent calibrations.

Example: a microK^2 that has had the identification information set using the example in section 9.7.50, would respond to CAL:IDEN? with: "John Smith,Isothermal Technology Limited,Primary Laboratory,19-21 C".

9.7.52 Command CALibrate:IDENtification:LAST?

Format: CALibrate:IDENtification:LAST?

Reports the calibration information for the last calibration adjustment made to the microK^2.

Example: for a microK^2 that had been calibrated by John Smith of Isothermal Technology in their Secondary Laboratory at 20 °C ±1 °C and had not had any calibration adjustment applied since might respond to CAL:IDEN:LAST? with: "John Smith,Isothermal Technology,Secondary Laboratory,19-21 C".

9.7.53 Command CALibrate:CURRent

Follow the instructions in section 9.7.40 before using this command

Format: CALibrate:CURRent[:GAIN] *<current>,<measured current>[<standard]*

The gain of the master current source is most easily adjusted using the internal calibration facility (see section 7.2.1). This command provides an alternative method for setting the master current source gain after using the TEST:CURR 1 command (see section 9.7.38) and measuring the current on channel 1 (see section 7.1.1). It uses the actual current measured to adjust the master current source to the correct current. The optional *<standard>* parameter can be used to record a reference, such as the serial number of the ammeter used to measure the current. This will be recorded in the calibration logfile of the microK^2 to maintain a full calibration audit trail.

Example: if after sending the command TEST:CURR 1, the current measured between the I- and ground terminals of channel 1 was 1.00123 mA, the master current source gain can be adjusted using: CAL:CURR 1,1.00123

Note: The measured current will not change until the TEST:CURR command is resent.

9.7.54 Command CALibrate:CURRent?

Format: CALibrate:CURRent[:GAIN]?

Reports the current gain (range 0.9 to 1.1) for the master current source system.

Example: microK^2 with an initial current gain of 1 and adjusted as per the example in section 9.7.53 would respond to TEST:CURR? with: "9.9877151E-001"

9.7.55 Command CALibrate:REFerence

Follow the instructions in section 9.7.40 before using this command

Format: CALibrate:REFerence# *<reference> <nominal resistance>,<actual resistance>[,<standard>]*

The calibration of internal resistors is most easily adjusted using the internal calibration facility (see section 7.2.1.1). This command provides an alternative method for adjusting the calibration of the internal resistor on channel *<reference>* with *<nominal resistance>*, by assigning a new *<actual resistance>* to it. The optional *<standard>* parameter can be used to record a reference, such as the serial number, of the resistor against which it was calibrated. This information will be recorded in the calibration logfile of the microK^2 to maintain a full calibration audit trail.

The channel numbers (numeric suffixes) used for the internal resistor are given in section 9.3. The calibrated value is stored as a floating-point number and will therefore be subject to some rounding (less than 0.12 ppm of value)

Example: if the value of the internal 100 Ω reference has been measured as 100.00123, the new value can be assigned to it using: CAL:REF204 100,100.00123

9.7.56 Command CALibrate:REFerence?

Format: CALibrate:REFerence# *<reference>*?

Reports the nominal and calibrated value of the internal resistor on channel *<reference>*.

Example: a microK^2 with an internal 100 Ω reference resistors having a calibrated value of 100.00123 will respond to CAL:REF204? with "100,1.00001230E+002".

9.7.57 Command CALibrate:OFFSet

Follow the instructions in section 9.7.40 before using this command

Format: CALibrate[:VOLTage]:OFFSet# *<channel> <offset>*

The voltage offsets on each channel are most easily adjusted (nulled out) using the internal calibration facility (see section 7.2.2). This command provides an alternative method for adjusting the voltage offset for a *<channel>*. The voltage offsets have no effect on resistance or resistance ratio measurements. The offset range is limited, attempts to apply an offset greater than this will just return an error message.

The *<offset>* parameter is **SUBTRACTED** from the measured voltage to correct for the offset. It should therefore be the measured offset.

Example: if the measured offset on channel 3 is 0.123 μV use: CAL:OFFS3 1.23E-7

9.7.58 Command CALibrate:OFFSet?

Format: CALibrate[:VOLTage]:OFFSet<channel#>?

Reports the offset **SUBTRACTED** from voltage measurements on a *<channel>*

Example: a microK^2 that has been calibrated to correct for a measured 0.123 μV offset on channel 3 will respond to CAL:OFFS3? with "-0.000000123".

9.7.59 Command CALibrate:GAIN

Follow the instructions in section 9.7.40 before using this command. It is essential that the offset errors are nulled out before making the measurements used to calculate the gain adjustment.

Format: CALibrate[:VOLTage]:GAIN *<adjustment>,<standard 1>,<standard 2>*

The voltage gain (common to all channels) is most easily adjusted using the internal calibration facility (see section 7.2.3). This command provides an alternative method for adjusting the voltage gain by the factor *<adjustment>*. The optional parameters *<standard 1> and <standard2>* can be used to record references, such as the serial numbers, of the devices used to implement the calibration. This information will be recorded in the calibration logfile of the microK^2 to maintain a full calibration audit trail.

Example: for a microK^2 that has been found to have a voltage gain that is low by a factor of 1/1.000123 (see section 7.1.4.2), the gain can be corrected using: CAL:GAIN 1.000123

9.7.60 Command CALibrate:GAIN?

Format: CALibrate[:VOLTage]:GAIN?

Reports the total gain adjustment applied to the measurement system's voltage measurements.

Example: a microK^2 that has had a number of gain adjustments causing a total ratio adjustment of 1.000123 will respond to CAL:GAIN? POS with "1.0001230E+000"

9.7.61 Command CALibrate:GPIB

Follow the instructions in section 9.7.40 before using this command.

Format: CALibrate:GPIB[:ADDRess] *<gpib address>*

Sets the GPIB address to *<gpib address>.* The address must be in the range 1-30 (inclusive).

Example: to set the GPIB address to 21 use: CAL:GPIB 21

9.7.62 Command CALibrate:GPIB?

Format: CALibrate:GPIB[:ADDRess]?

Reports the GPIB address.

Example: a microK^2 with GPIB address 10 will respond to CAL:GPIB? with: "10"

9.7.63 Command CALibrate:PASSword

Follow the instructions in section 9.7.40 before using this command.

Format: CALibrate:PASSword *<old password>,<password>,<password>*

Changes the calibration password used to lock (protect) the calibration of the microK^2's measurement system. This is initially set to "5678" but should be changed before using the microK^2 for any critical or traceable measurement or calibration work. The new password must be at least 4 characters in length and must be typed in identically twice in order to effect the change. Passwords are case sensitive.

Example: to change the password from 5678 to ABCD use: CAL:PASS 5678,ABCD,ABCD

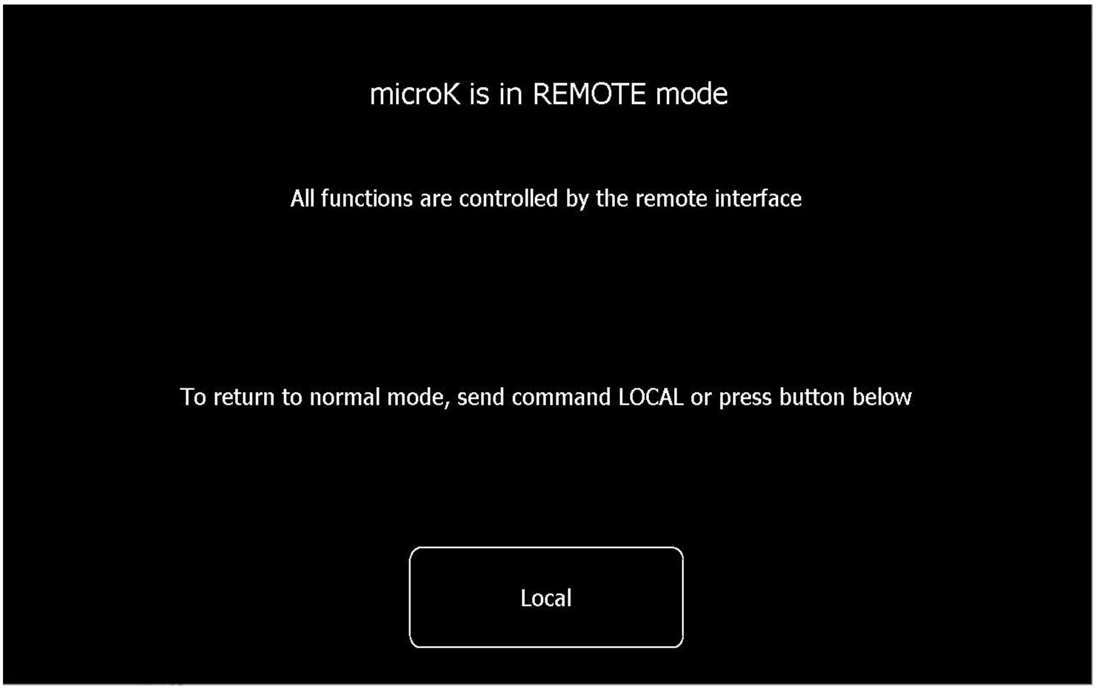
9.7.64 Command REMote

Format: [MICRok:]REMote

Puts the microK^2 into 'REMote' mode (see section 9.7). This stops all measurement activity via the user interface (which will speed up responses to SCPI commands) and allows all SCPI commands (including those that require access to the database of thermometers and resistors) to respond.

N.B. The optional keyword [MICRok:] is included in the command for use in systems in which microsKanners are used with the microK^2. In such systems, the PC may be connected to the end of the "daisy-chain" of microsKanners. In this case, the command REMote would be intercepted and acted on by the microsKanner to which the PC is connected. Conversely, the full command MICRok:REMote is passed along the "daisy-chain" of microsKanners to the microK^2. We therefore recommend that you always use MICRok:REMote to put the microK^2 into 'remote' mode as this works wherever you choose to connect your PC.

Example: send MICR:REM to put the microK^2 into 'remote' mode, the screen will then display:



Pressing the *Local* button on the screen or sending MICRok:LOCal (see section 9.7.65) returns the microK^2 to normal, 'local' operation.

9.7.65 Command LOCal

Format: [MICRok:]LOCal

Returns the microK^2 in 'remote' operation (see section 9.7.64) to normal, 'local' operation in which it is controlled via the user interface.

N.B. The optional keyword [MICRok:] is included in the command for use in systems in which microsKanners are used with a microK^2. In such systems, the PC may be connected to the end of the "daisy-chain" of microsKanners. In this case, the command LOCal would be intercepted and acted on by the microsKanner to which the PC is connected. In contrast, the full command MICRok:LOCal is passed along the "daisy-chain" of microsKanners to the microK^2. We therefore recommend that you always use MICRok:LOCal to exit 'remote' mode as this works wherever you choose to connect your PC.

Example: send MICR:LOC to return the microK^2 to normal, 'local' mode.

9.7.66 Command DATabase:UNLock

Format: DATabase:UNLock *<password>*

Unlocks the database to allow thermometer and resistor entries to be created, edited and deleted.

Example: send DAT:UNL 1234 to unlock the thermometer and resistor database (with the factory default user password).

9.7.67 Command DATabase:LOCK

Format: DATabase:LOCK

Locks the database to prevent thermometer and resistor entries being created, edited or deleted.

Example: send DAT:LOCK to lock the thermometer and resistor database.

9.7.68 Command THERmometer:COUNt?

Format: THERmometer:COUNt?

Returns the number of thermometers in the database.

Example: send THER:COUN? to request the number of thermometers in the database.

9.7.69 Command THERmometer:NAMe#<thermometer>

Format: THERmometer:NAMe# *<thermometer>* *<name>*

Sets the 'Name' field in the database of thermometers with index *<thermometer>* to *<name>*.

Example: send THER:NAM3 my third probe to set the 'Name' field of the third thermometer in the database to "my third probe".

N.B. Changing the name of the probe causes the database to be reindexed, so you will have to rediscover the *<thermometer>* index for this thermometer.

9.7.70 Command THERmometer:NAMe#<thermometer>?

Format: THERmometer:NAMe# *<thermometer>*?

Returns the 'Name' field in the database for thermometers with index *<thermometer>.*

Example: send THER:NAM4? to request the 'Name' of the fourth thermometer in the database.

9.7.71 Command THERmometer:MANufacturer#<thermometer>

Format: THERmometer:MANufacturer# *<thermometer>* *<manufacturer>*

Sets the 'Manufacturer' field in the database of thermometers with index *<thermometer>* to *<manufacturer>*.

Example: send THER:MAN3 Isothermal Technology to set the 'Manufacturer' field of the third thermometer in the database to "Isothermal Technology".

9.7.72 Command THERmometer:MANufacturer#<thermometer>?

Format: THERmometer:MANufacturer# *<thermometer>*?

Returns the 'Manufacturer' field in the database of thermometers with index *<thermometer>*.

Example: send THER:MAN4? to request the 'Manufacturer' of the fourth thermometer in the database.

9.7.73 Command THERmometer:MODel#<thermometer>

Format: THERmometer: MODel#*<thermometer>* *<model>*

Sets the 'Model' field in the database of thermometers with index *<thermometer>* to *<model>.*

Example: send THER:MOD3 96178 to set the 'Model' field of the third thermometer in the database to "96178".

9.7.74 Command THERmometer:MODel#<thermometer>?

Format: THERmometer:MODel# *<thermometer>*?

Returns the 'Model' field in the database of thermometers with index *<thermometer>.*

Example: send THER:MOD4? to request the 'Model' of the fourth thermometer in the database.

9.7.75 Command THERmometer:SERial#<thermometer>

Format: THERmometer:SERial# *<thermometer>* *<serial number>*

Sets the 'Serial Number' field in the database of thermometers with index *<thermometer>* to *<serial number>.*

Example: send THER:SER3 35583 to set the 'Serial Number' field of the third thermometer in the database to "35583".

9.7.76 Command THERmometer:SERial#<thermometer>?

Format: THERmometer:SERial# *<thermometer>*?

Returns the 'Serial Number' field in the database of thermometers with index *<thermometer>*.

Example: send THER:SER4? to request the 'Serial Number' of the fourth thermometer in the database.

9.7.77 Command THERmometer:DATe<thermometer#>

Format: THERmometer:DATe<thermometer#> *<date>*

Sets the 'Recalibration Date' field in the database of thermometers with index <thermometer#> to <date >. The format of the date must be "dd/mm/yyyy" (leading zeros in the day or month may be omitted).

Example: send THER:DAT3 21/4/2020 to set the 'Recalibration Date' field of the third thermometer in the database to "25/04/2020" (25th April 2020).

9.7.78 Command THERmometer:DATe#<thermometer>?

Format: THERmometer:DATe# *<thermometer>*?

Returns the 'Recalibration Date' field in the database of thermometers with index *<thermometer>.* The format is always "dd/mm/yyyy".

Example: send THER:DAT4? to request the 'Recalibration Date' of the fourth thermometer in the database.

9.7.79 Command THERmometer:MINimum<thermometer#>

Format: THERmometer:MINimum# *<thermometer>* *<minimum>*

Sets the 'Min Temperature' field in the database of thermometer with index *<thermometer>* to *<minimum>*, where the temperature units are °C.

Example: send THER:MIN3 -40 to set the 'Min Temperature' field of the third thermometer in the database to -40 °C.

9.7.80 Command THERmometer:MINimum#<thermometer>?

Format: THERmometer:MINimum# *<thermometer>*?

Returns the 'Min Temperature' field in the database of thermometers with index *<thermometer>*. The temperature units are °C.

Example: send THER:MIN4? to request the 'Min Temperature' field of the fourth thermometer in the database.

9.7.81 Command THERmometer:MAXimum#<thermometer>

Format: THERmometer:MAXimum# *<thermometer>* *<maximum>*

Sets the 'Max Temperature' field in the database of thermometer with index *<thermometer>* to *<maximum>*, where the temperature units are °C.

Example: send THER:MAX3 1000 to set the 'Max Temperature' field of the third thermometer in the database to 1000 °C.

9.7.82 Command THERmometer:MAXimum#<thermometer>?

Format: THERmometer:MAXimum# *<thermometer>*?

Returns the 'Max Temperature' field in the database of thermometers with index *<thermometer>*. The temperature units are °C.

Example: send THER:MAX4? to request the 'Max Temperature' field of the fourth thermometer in the database.

9.7.83 Command THERmometer:TYPe#<thermometer>

Format: THERmometer:TYPe# *<thermometer>* *<type>*

Sets the 'Type field in the database of thermometers with index *<thermometer>* to *<type>*, where conversion must be one of: PRT, THERMOcouple or THERMIstor.

Example: send THER:TYP4 PRT to set the 'Type' of the fourth thermometer in the database to "PRT".

9.7.84 Command THERmometer:TYPe#<thermometer>?

Format: THERmometer:TYPe# *<thermometer>*?

Returns the 'Type' field in the database for thermometer index *<thermometer>*. The returned string will be "PRT", "Thermocouple" or "Thermistor". The

Example: send THER:TYP4? to request the 'Type' of the fourth thermometer in the database.

9.7.85 Command THERmometer:CONVersion#<thermometer>

Format: THERmometer:CONVersion# *<thermometer>* *<conversion>*

Sets the 'Conversion' field in the database of thermometers with index *<thermometer>* to <conversion>, where conversion must be one of:

<conversion>	**Thermometer Type**
IEC60751	PRT
CallendarVanDusen	PRT
ITS90	PRT
TYPe B	Thermocouple
TYPe E	Thermocouple
TYPe J	Thermocouple
TYPe K	Thermocouple
TYPe L	Thermocouple
TYPe N	Thermocouple
TYPe R	Thermocouple

TYPe S	Thermocouple
TYPe T	Thermocouple
TYPe AU-PT	Thermocouple
TYPe PT-PD	Thermocouple
Steinhart-Hart	Thermistor
POLYnomial	Thermistor
NONe	

The conversion must be applicable to the **Thermometer Type** of the thermometer (see table above), which is determined by the "Type" field in the database and must be set (using THER:TYP#<thermometer> *<type>* see section 9.7.83) before using this command (otherwise the conversion will be set to "None").

Example: send THER:CONV3 CVD to set the 'Conversion' field of the third thermometer in the database (a PRT) to CallendarVanDusen.

9.7.86 Command THERmometer:CONVersion#<thermometer>?

Format: THERmometer:CONVersion# *<thermometer>*?

Returns the 'Conversion' field in the database of thermometers with index *<thermometer>*. The returned value will be one of:

IEC60751 (2022)
Callendar-Van Dusen
ITS90
Type B
Type E
Type J
Type K
Type L
Type N
Type R
Type S
Type T
Type Au-Pt
Type Pt-Pd
Steinhart-Hart
Polynomial
None

Example: send THER:CONV4? to request the 'Conversion' field of the fourth thermometer in the database.

9.7.87 Command THERmometer:COEFficient#<thermometer>

Format: THERmometer:COEFficient# *<thermometer>* *<coefficient#>,<value>*

Sets the specified *<coefficient#>* in the database of thermometers with index *<thermometer>* to <value>. The <coefficient> field specifies which coefficient to set and depends on the 'Conversion' (and therefore the 'Type') field of the thermometer:

coefficient#	CvD & IEC60751	ITS90	Typed Thermocouple	Steinhart Hart	Polynomial
1	Ro	R (0.01)	a	A	C0
2	a	a (negative)	b	B	C1
3	b	b (negative)	c	C	C2
4	c	a (positive)	N/A	N/A	C3
5	N/A	b (positive)	N/A	N/A	N/A
6	N/A	c (positive)	N/A	N/A	N/A
7	N/A	d (positive)	N/A	N/A	N/A
8	N/A	W660.323 °C			

The 'Type' and 'Conversion' must be set before using this command (see section 9.7.84 and section 9.7.85).

Example: send THER:COEF3 1,99.999 to set the Ro value of the third thermometer in the database (a PRT using Callendar-van Dusen conversion) to 99.999 Ω.

9.7.88 Command THERmometer:COEFficient#<thermometer>?

Format: THERmometer:COEFficient# *<thermometer>*? *<coefficient#>*

Returns the specified *<coefficient#>* in the database of thermometers with index *<thermometer>*. The *<coefficient>* field specifies the coefficient and depends on the 'Conversion' field of the thermometer (see table in section 0 above).

Example: send THER:COEF4? 4 to request the ITS90 'a (positive)' coefficient for the fourth thermometer in the database (a PRT using ITS90 conversion).

9.7.89 Command THERmometer:CVD:FORM

Format: THERmometer:CVD:FORM *<form>*

Sets the 'Eqn Form' to be used in Callendar-van Dusen conversions. The form used is determined by *<form>* which must be "ABC" or "ABD":

<form>	CvD Equation Form
abc	abc
abd	αβδ

Example: send THER:CVD:FORM ABD to set the Callendar-van Dusen equation form to αβδ.

9.7.90 Command THERmometer:CVD:FORM?

Format: THERmometer:CVD:FORM?

Returns the form of the Callendar-van Dusen equation used. The returned value will be either "abc" or "abd".

Example: send THER:CVD:FORM? to request the form of the Callendar-Van Dusen equation used.

9.7.91 Command THERmometer:CREate

Format: THERmometer:CREate *<name>*

Creates a new entry in the thermometer database with name <name>. N.B. This command causes the thermometer database to be re-indexed and the order of the thermometers is indeterminate. The order of the thermometers can, of course, be re-determined using the THERmometer:NAMe# *<thermometer>*? command (see section 9.7.70). Alternatively, thermometer index numbers for thermometer names can be re-determined using the THERmometer:FIND? *<name>* command (see section 9.7.93).

Example: send THER:CRE my new thermometer to create a new thermometer in the database called "my new thermometer".

9.7.92 Command THERmometer:DELete#<thermometer>

Format: THERmometer:DELete# *<thermometer>*

Deletes the thermometer in the database with index *<thermometer>*. N.B. after a thermometer is deleted from the database, the database is re-indexed and the order of the thermometers is indeterminate. The order of the thermometers can, of course, be re-determined using the THERmometer:NAMe# *<thermometer>*? command (see section 9.7.70). Alternatively, thermometer index numbers for thermometer names can be re-determined using the THERmometer:FIND? *<name>* command (see section 9.7.93).

Example: send THER:DEL5 to delete the fifth thermometer in the database.

9.7.93 Command THERmometer:FIND?

Format: THERmometer:FIND? *<name>*

Finds the database index number for a thermometer with the field 'Name' set to *<name>.*

Example: send THER:FIND? SPRT-1 to find the index number of the thermometer named "SPRT-1".

9.7.94 Command RESistor:COUNt?

Format: RESistor:COUNt?

Returns the number of resistors in the database.

Example: send RES:COUN? to request the number of resistors in the database.

9.7.95 Command RESistor:NAMe#<resistor>

Format: RESistor:NAMe# *<resistor>* *<name>*

Sets the 'Name' field in the database of resistors with index *<resistor>* to *<name>*.

Example: send RES:NAM3 100R to set the 'Name' field of the third resistor in the database to "100R".

N.B. Changing the name of the probe causes the database to be reindexed, so you will have to rediscover the *<resistor>* index for this resistor.

9.7.96 Command RESistor:NAMe#<resistor>?

Format: RESistor:NAMe# *<resistor>*?

Returns the 'Name' field in the database for resistor with index *<resistor>.*

Example: send RES:NAM4? to request the 'Name' of the fourth resistor in the database.

9.7.97 Command RESistor:MANufacturer#<resistor>

Format: RESistor:MANufacturer# *<resistor>* *<manufacturer>*

Sets the 'Manufacturer' field in the database of resistors with index *<resistor>* to *<manufacturer>*.

Example: send RES:MAN3 Isothermal Technology to set the 'Manufacturer' field of the third resistor in the database to "Isothermal Technology".

9.7.98 Command RESistor:MANufacturer#<resistor>?

Format: RESistor:MANufacturer# *<resistor>*?

Returns the 'Manufacturer' field in the database of resistors with index *<resistor>*.

Example: send RES:MAN4? to request the 'Manufacturer' of the fourth resistor in the database.

9.7.99 Command RESistor:MODel#<resistor>

Format: RESistor: MODel# *<resistor>* *<model>*

Sets the 'Model' field in the database of resistors with index *<resistor>* to *<model>.*

Example: send RES:MOD3 Model 456 to set the 'Model' field of the third resistor in the database to "Model 456".

9.7.100 Command RESistor:MODel#<resistor>?

Format: RESistor:MODel# *<resistor>*?

Returns the 'Model' field in the database of resistors with index *<resistor>.*

Example: send RES:MOD4? to request the 'Model' of the fourth resistor in the database.

9.7.101 Command RESistor:SERial#<resistor>

Format: RESistor:SERial# *<resistor> <serial number>*

Sets the 'Serial Number' field in the database of resistors with index *<resistor>* to *<serial number>.*

Example: send RES:SER3 ITL1234/5 to set the 'Serial Number' field of the third resistor in the database to "ITL1234/5".

9.7.102 Command RESistor:SERial#<resistor>?

Format: RESistor:SERial# *<resistor>*?

Returns the 'Serial Number' field in the database of resistors with index *<resistor>*.

Example: send RES:SER4? to request the 'Serial Number' of the fourth resistor in the database.

9.7.103 Command RESistor:DATe<resistor#>

Format: RESistor:DATe<resistor#> *<date>*

Sets the 'Recalibration Date' field in the database of resistors with index <resistor#> to <date >. The format of the date must be "dd/mm/yyyy" (leading zeros in the day or month may be omitted).

Example: send RES:DAT3 21/4/2026 to set the 'Recalibration Date' field of the third resistor in the database to "25/04/2026" (25th April 2026).

9.7.104 Command RESistor:DATe#<resistor>?

Format: RESistor:DATe# *<resistor>*?

Returns the 'Recalibration Date' field in the database of resistors with index *<resistor>.* The format is always "dd/mm/yyyy".

Example: send RES:DAT4? to request the 'Recalibration Date' of the fourth resistor in the database.

9.7.105 Command RESistor:VALue<resistor#>

Format: RESistor:VALue# *<resistor> <value>*

Sets the 'Value' field in the database of resistor with index *<resistor>* to *<value>*, where the value units are Ω.

Example: send RES:VAL 100.1234 to set the 'Value' field of the third resistor in the database to 100.1234Ω.

9.7.106 Command RESistor:VALue#<resistor>?

Format: RESistor:VALue# *<resistor>*?

Returns the 'Value' field in the database of resistors with index *<resistor>*. The temperature units are Ω.

Example: send RES:VAL4? to request the 'Value' field of the fourth resistor in the database.

9.7.107 Command RESistor:CREate

Format: RESistor:CREate *<name>*

Creates a new entry in the resistor database with name <name>. N.B. This command causes the resistor database to be re-indexed and the order of the resistors is indeterminate. The order of the resistors can, of course, be re-determined using the RESistor:NAMe# *<resistor>*? command (see section 9.7.96). Alternatively, resistor index numbers for resistor names can be re-determined using the RESistor:FIND? *<name>* command (see section 9.7.109).

Example: send RES:CRE my new resistor to create a new resistor in the database called "my new resistor".

9.7.108 Command RESistor:DELete#<resistor>

Format: RESistor:DELete# *<resistor>*

Deletes the resistor in the database with index *<resistor>*. N.B. after a resistor is deleted from the database, the database is re-indexed and the order of the resistors is indeterminate. The order of the resistors can, of course, be re-determined using the RESistor:NAMe# *<resistor>*? command (see section 9.7.96). Alternatively, resistor index numbers for resistor names can be re-determined using the RESistor:FIND? *<name>* command (see section 9.7.109).

Example: send RES:DEL5 to delete the fifth resistor in the database.

9.7.109 Command RESistor:FIND?

Format: RESistor:FIND? *<name>*

Finds the database index number for a resistor with the field 'Name' set to *<name>.*

Example: send RES:FIND? 100R to find the index number of the resistor named "100R".

9.7.110 Command MICRoskanner:FIND

Format: MICRoskanner:FIND

Used to reinvokes the discovery of microsKanners on either RS232 port (this occurs automatically at startup).

Example: send MICR:FIND to discover microsKanners attached to either RS232 port.

9.7.111 Command MICRoskanner:COUNt?

Format: MICRoskanner:COUNt?

Returns the number of microsKanner discovered on the RS232 ports.

Example: a microK^2 connected (daisy chained) to two microsKanners will respond to MICR:COUN? with: "2".

9.7.112 Command MICRoskanner:ORIGinal:COUNt?

Format: MICRoskanner:ORIGinal:COUNt?

Returns the number of original microsKanners discovered on the RS232 ports. Original microsKanner will work with the microK^2. However, they have a maximum keep-warm current of 10 mA

Example: a microK^2 connected (daisy chained) to two microsKanners will respond to MICR:ORIG:COUN? with: "2".

9.7.113 Command MICRoskanner:LIST?

Format: MICRoskanner:LIST?

This command is used by the microK^2 to collect information on microsKanners attached to its RS232 ports. It lists details (model, serial number, software version) on all microsKanners and the microK^2 connected in the RS232 "daisy-chain". The list stops at the first microK^2 in the daisy-chain. So, if sent to the microK^2 it will only return information on it. If sent to a microsKanner, the information will start with the first microsKanner and stop with the microK^2.

Example: if a microK^2 is connected (in an RS232 daisy-chain) to one microsKanner HC and MICR:LIST? is sent to the microsKanner HC, it will respond with:

microsKanner HC,ITL12345-6,1.00
Isothermal Technology,microK2 Elite,ITL12345-6 ,1.23

9.7.114 Command MICRoskanner:SERialnumber#<microsKanner>?

Format: MICRoskanner:SERialnumber# *<microsKanner#>*?

Reports the serial number of the microsKanner at position *<microsKanner>* in the daisy-chain.

Example: a microK^2 connected (daisy-chained) to one microsKanner HC will respond to MICR:SER1? with the serial number of the microsKanner e.g."ITL65432-1"

9.7.115 Command MICRoskanner:VERSion#<microsKanner>?

Format: MICRoskanner:VERSion#*<microsKanner>?*

Reports the firmware version of the microsKanner at position *<microsKanner>* in the daisy-chain.

Example: a microK^2 connected (daisy-chained) to one microsKanner HC will respond to MICR:VERS1? with the firmware version of the microsKanner e.g."1.00"

9.7.116 Command MICRoskanner:PORT?

Format: MICRoskanner:PORT?

Reports the COM port on the microK^2 to which microsKanners are attached.

Example: a microK^2 will respond to MICR:PORT? with the port to which any microsKanner are attached (1, 2) or 0 if there are no microsKanner detected).

9.7.117 Command PASSword:RECovery:KEY?

Format: PASSword:RECovery:KEY?

The password recovery process is most easily implemented using the password recovery facility (see section 3.7.11.1). This command provides an alternative method for revealing the password recovery key. You can then send this key to Isotech in order to get a one-time password that you can use to set a new password using the CAL:PASS command (see section 9.7.63) or the change password facility (see section 3.7.11).

Example: send PASS:REC:KEY? to reveal the password recovery key. This will by an 8 digit string such as "b197aa4c".

10 Specification

Ranges	Resistance Thermometers:	0 Ω to 500 kΩ
	Thermocouples:	± 125 mV
Accuracy – PRTs	µK² Elite:	< 3×10^{-8} for resistance ratios between 0 and 1 for SPRTs with $R_0 \geq 2.5\ \Omega$ (equivalent to 0.03 mK)
	µK² 60:	< 6×10^{-8} for resistance ratios between 0 and 1 for SPRTs with $R_0 \geq 2.5\ \Omega$ (equivalent to 0.06 mK)
	µK² 150:	< 1.5×10^{-7} for resistance ratios between 0 and 1 for SPRTs with $R_0 \geq 2.5\ \Omega$ (equivalent to 0.15 mK)
	µK² 300:	< 3×10^{-7} for resistance ratios between 0 and 1 for SPRTs with $R_0 \geq 2.5\ \Omega$ (equivalent to 0.3 mK)
Accuracy – Thermocouples	Voltage uncertainty:	<150 nV (between 0 and 20 mV)
	equivalent to <6 mK for Au-Pt thermocouple at 1000 °C	
Resolution	Ratio:	1×10^{-8} (≡ 0.01 mK) (microK² Elite/60)
		1×10^{-7} (≡ 0.1 mK) (microK² 150/300)
	Resistance:	< 0.01 ppm of range (microK² Elite/60)
		< 0.1 ppm of range (microK² 150/300)
	Voltage:	1 nV (microK² Elite/60)
		10 nV (microK² 150/300)
Stability	Resistance (excluding resistance standard):	0 (note1)
	Voltage:	< 3 ppm of value/year
Measurement Time	< 2 s (resistance)	
Temperature Conversions	PRTs:	ITS-90, Callendar-van Dusen
	Thermocouples:	IEC60584-1 Ed. 3.0 2013 (B,E,J,K,N,R,S,T), L, Au/Pt, Pt/Pd
	Thermistors:	Steinhart-Hart, polynomial
Sensor Current	0-14.2 mA in 3 ranges:	
	0.1 mA	± 0.4% of value, ± 0.1 µA, resolution 40 nA
	1.42 mA	± 0.4% of value, ± 1 µA, resolution 400 nA

	14.2 mA ± 0.4% of value, ± 10 µA, resolution 4 µA
Keep-Warm Currents	0-14.2 mA ± 0.4% of value, ± 10 µA, resolution 4 µA
Cable Length	< 30 m (maximum 10 Ω per core and 10 nF shunt capacitance)
Internal Standard Resistors	25, 100 and 400 Ω (custom values available): TCR < 0.2 ppm/°C stability < 2 ppm over 6 years
Input Connectors	Channel 1-3: binding posts for 4 mm plugs, spades or bare wires, contact material = gold plated tellurium copper Channel 4: Lemo connector EZG.1B.306.NLNG, gold plated bronze contacts, 5000 mating cycles
Digital Interfaces	2 x RS232 (9,600 baud) Ethernet (IEEE 802.3/803.3u: 100Base-TX / 10Base-T) IEEE-488 GPIB 3 x USB (2.0) – host
Display	256 mm / 10.1" WXGA (1280 x 800) colour TFT LCD
Operating Conditions	15-30 °C / 50-85 °F 10-80% RH (for full specification) 5-40 °C / 40-105 °F 0-80% RH (operational)
Power	88 – 264 V (RMS), 47-63 Hz (Universal) 20 W maximum
Size	539 mm x 200 mm x 300 mm / 21.33" x 7.9" x 11.9"(W x H x D) 19" Rack Mountable
Weight	13.5 kg / 29.7 lb

Please note: The microK^2 uses a 'substitution technique' in which the Device-Under-Test and the Reference are successively switched into the same position in the measuring circuit. This means that the stability of resistance ratio measurements is immeasurably small.

11 Approvals

The microK^2 has been independently verified as complying with the regulatory requirements of the EU and FCC for electromagnetic compatibility and safety (EU only).

11.1 UKCA Declaration

The microK^2 Precision Thermometry Bridge manufactured by Isothermal Technology Limited of Pine Grove, Southport, Merseyside, PR9 9AG, United Kingdom conforms to the requirements of the UK Statutory Instruments and their amendments:

1091	The Electromagnetic Compatibility Regulations 2016
3032	The Restriction of the Use of Hazardous Substances in Electrical and Electronic Equipment Regulations 2012
1101	The Electrical Equipment Safety Regulations 2016

11.2 CE Declaration

The microK^2 Precision Thermometry Bridge manufactured by Isothermal Technology Limited of Pine Grove, Southport, Merseyside, PR9 9AG, United Kingdom conforms to the requirements of the European Community directives:

2014/30/EU	The Electromagnetic Compatibility Regulations
2011/65/EU	The Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment Regulations
2014/35/EU	The Electrical Equipment Safety Regulations

11.3 FCC Statement

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area may cause harmful interference, in which case the user will be required to correct the interference at their own expense. Changes or modifications to this equipment not expressly approved by Isothermal Technology could degrade EMC performance and void the user's authority to operate the equipment.

11.4 Standards Applied

The following standards have been applied in assessing compatibility with the requirements for CE marking and for FCC compliance:

Conducted Emissions (class B)	EN61326-1:2021 (class B) EN55011:2016(+A1/A11/A2) EN55032:2015(+A11)
Radiated Emissions (class B)	EN61326-1:2021 EN55011:2016(+A1/A11/A2) EN55032:2015(+A11)
Harmonic Currents	EN61000-3-2:2019(+A1)
Flicker	EN61000-3-3:2013(+A1)

Conducted Immunity	EN61326-1:2021
Radiated Immunity	EN61326-1:2021
Electrical Fast Transients	EN61326-1:2021
Electrostatic Discharge	EN61326-1:2021
Surge	EN61326-1:2021
Voltage Dips & Interruptions	EN61326-1:2021
Electrical Safety	EN61010-1 Edition 3.0:2010

12 Revision History

Change Note	Date	Manual Issue
Initial release	29/08/2025	1.00