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## Laboratory guide: How to perform temperature measurements using Type K thermocouples and Fluke Helios Plus 2287A datalogger

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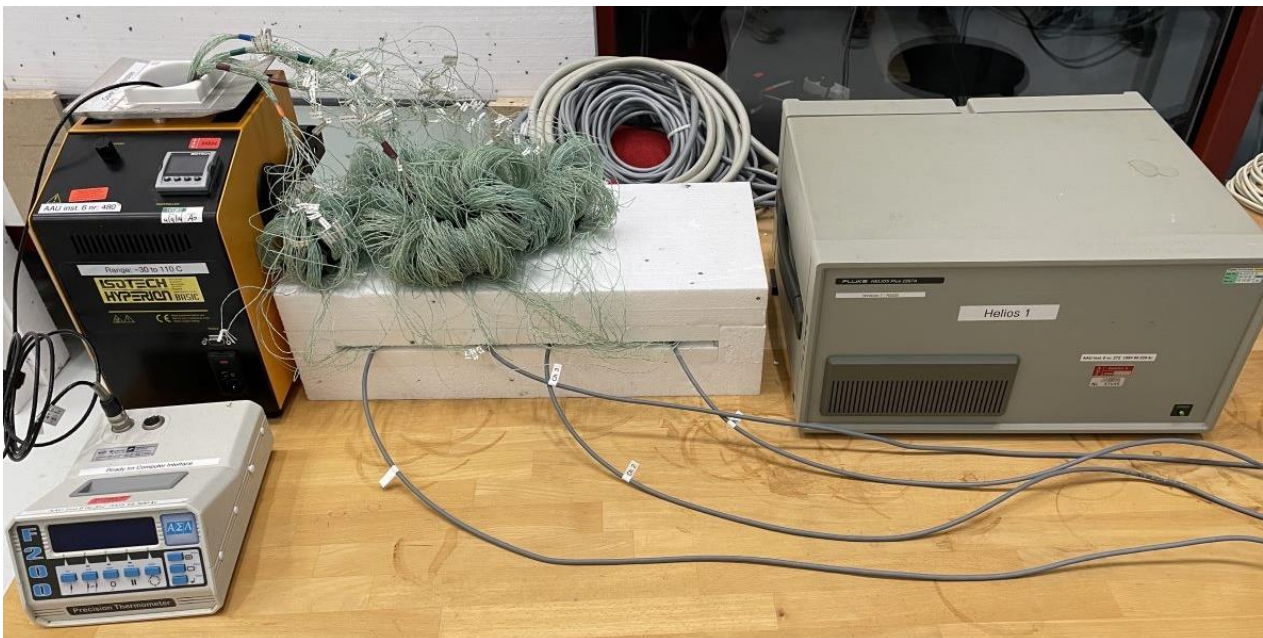
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DEPARTMENT OF THE BUILT ENVIRONMENT  
AALBORG UNIVERSITY

# Laboratory guide: How to perform temperature measurements using Type K thermocouples and Fluke Helios Plus 2287A datalogger

Martin Veit  
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Martin Frandsen  
Rasmus Lund Jensen





Aalborg University  
Department of the Built Environment  
Division of Sustainability, Energy & Indoor Environment

DCE Lecture Notes No. 83

**Laboratory guide:**  
**How to perform temperature measurements using Type K  
thermocouples and Fluke Helios Plus 2287A datalogger**

by

Martin Veit  
Thomas Juul  
Martin Frandsen  
Rasmus Lund Jensen

October 2023

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## 1. Foreword

Temperature measurements with thermocouples are often used in the field of building physics to measure the temperature distribution in building materials, measure air temperature in ducts or window cavities, etc., and it is, therefore, important to have a good understanding of how to conduct measurements properly to get precise results.

The aim of this Lecture Note is to detail the practical procedure of using type K thermocouples with a Helios Fluke 2287A datalogger, and a compensation box system at Aalborg University, Department of the Built Environment (<https://www.en.build.aau.dk/>). Furthermore, it will also serve as a guide for preparing and executing calibration for thermocouples.

This Lecture Note will explain how to set up the entire measurement procedure, background information for the different components, and how to prepare it for calibration. The calibration procedure and the equipment involved are also explained.

The progression of this Lecture Note is the practical approach from start to finish of what to do, and it is advised to start from the top and go through each section until the finish.

Besides the main content of the lecture note, there are four appendices for useful information. A list of the appendices can be found in the table of contents and is repeated below.

1. Calibration of Pt 100's
2. Mounting of thermocouples on different surfaces
3. Naming of individual thermocouples
4. How to extend thin type K thermocouples

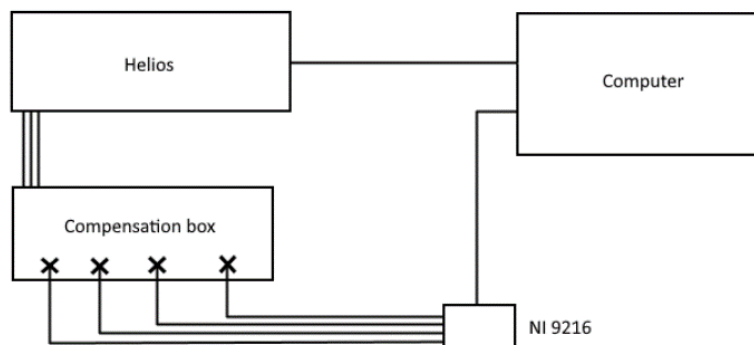
This guideline is meant for people with little to no experience using thermocouples and datalogger system.

## 2. Introduction and motivations

The Fluke Helios Plus 2287A datalogger is a precision datalogger which can be used (among others) to measure small voltages. It is, ideal to use for type K thermocouples, as these are subject to small voltages when experiencing a temperature difference between the two ends of the thermocouple. For an in depth description of how the type K thermocouples and the Helios Fluke 2287A datalogger works, refer to [1].

The entire setup is comprised of the Helios Fluke 2287A datalogger, a compensation box, and thermocouples. The temperature inside the compensation box is measured to know the temperature difference between the junction in the compensation box and the measurement point.

A principle sketch of the setup is shown in Figure 1.



**Figure 1.** Principle sketch of the datalogger setup.

## 3. Explanation of the setup

The entire procedure of setting up the datalogger and calibrating the sensors, can be summarized in the steps below:

1. Connect copper wires and thermocouples to a junction in a compensation box
2. Connect the copper wires from the compensation box to isothermal input connector in the Fluke Helios Plus 2287A
3. Prepare the thermocouples for calibration
4. Setup the software “LabVIEW VI” for the Fluke Helios Plus 2287A and prepare for calibration
5. Calibrate the thermocouples
6. Setup an OPS file for the sensor setup

These steps assume that the Pt 100’s have been calibrated and are ready to measure the temperature in the calibration box. For information on how to calibrate Pt100’s, see Appendix A: Calibration of Pt 100’s.

### 3.1. Connect junction in compensation box

The first step is to connect the copper wires and thermocouples to the junctions in the compensation box.

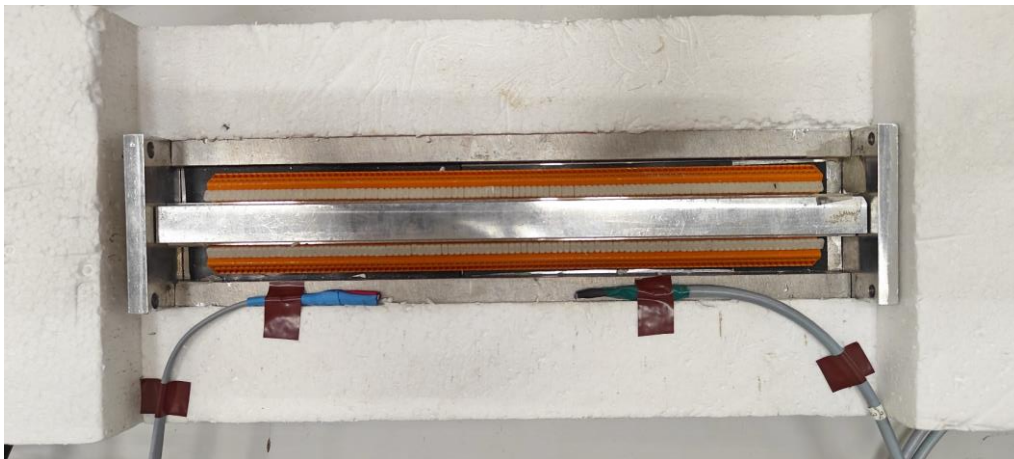
The role of the compensation box is to have an isolated environment for one end of the thermocouples, as the voltage from the thermocouples is based on the temperature difference between each end of the



thermocouples. Therefore, by having a compensation box where the temperature is measured, the temperature at one end is known.

The temperature is measured using a Pt 100, which is a resistance temperature detector (RTD), and uses a known resistance that changes linearly as a function of temperature to determine the temperature of the measured medium. In this case, it is used to measure the temperature inside the compensation box. The amount of Pt 100's needed for the compensation box can be chosen arbitrarily. The authors recommend using one Pt 100 for every 20 thermocouples in a compensation box.

The placement of the Pt 100 varies from compensation box to compensation box, but it should be equally distributed in the compensation box. An example of where to place Pt 100's is shown in Figure 2.



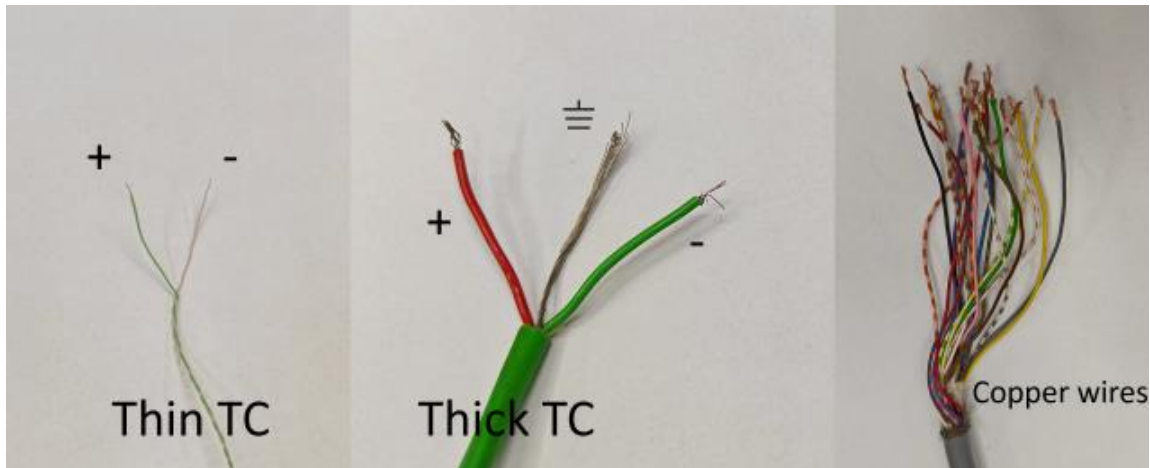
**Figure 2.** Example of where to place Pt 100's in a compensation box.

At each junction, a copper wire-thermocouple pair is connected. The copper wire is inserted at one side of the terminal, with the thermocouple wire at the opposite side and corresponding place of the junction. A close up of the junction is shown in Figure 3.



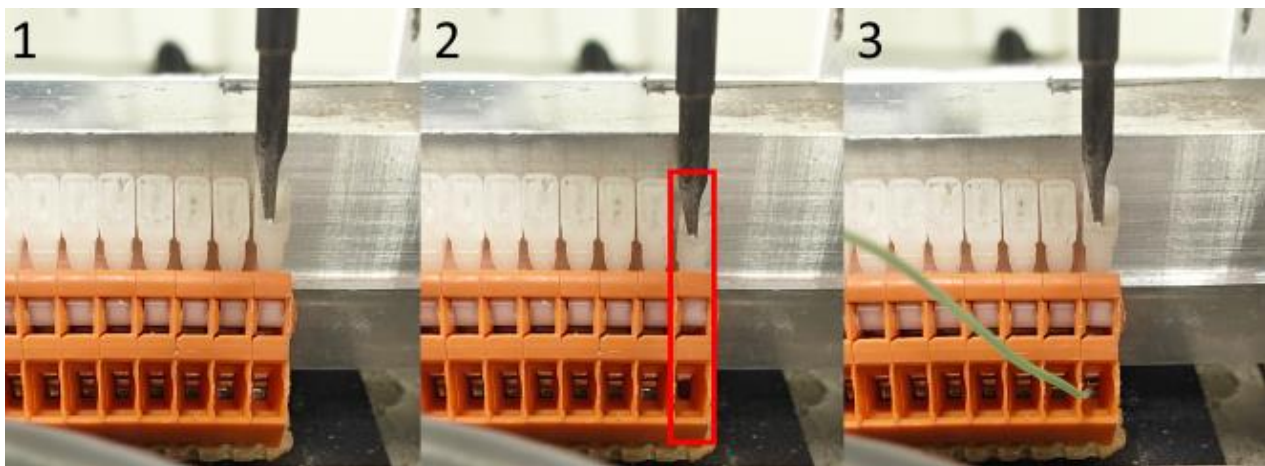
**Figure 3.** Close-up of the junctions in the compensation box.

When connecting the thermocouples to the compensation box, they are connected through an electrical junction. There is a slight difference between how the thin and the thick thermocouple are connected. The thin has a positive and negative wire, while the thick thermocouple has a positive, negative, and a ground. The compensation box is connected to a Fluke Helios Plus 2287A datalogger with copper wire. The different wires can be seen in Figure 4.



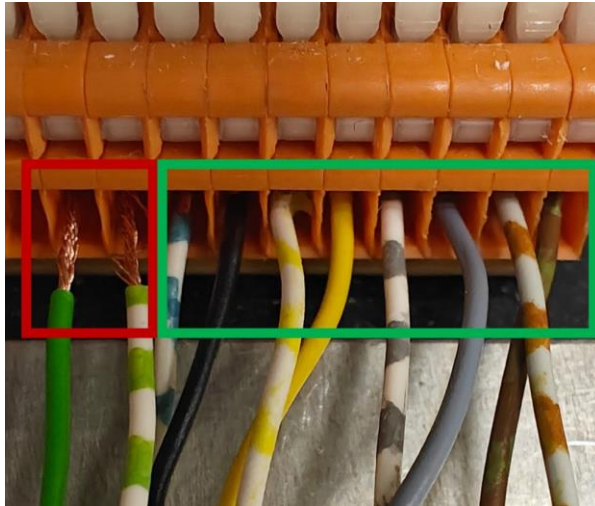
**Figure 4.** Different wires to connect to the compensation box.

To connect thermocouples to the compensation box, use a small flat screwdriver. Use the screwdriver to press down on the plastic ‘button’. When the button is pressed down, the junction opens, and the wire can be inserted. When the wire is connected, release the button, and the junction will lock the wire. Make sure the wire is attached by pulling the wire softly. The process is shown in Figure 5.



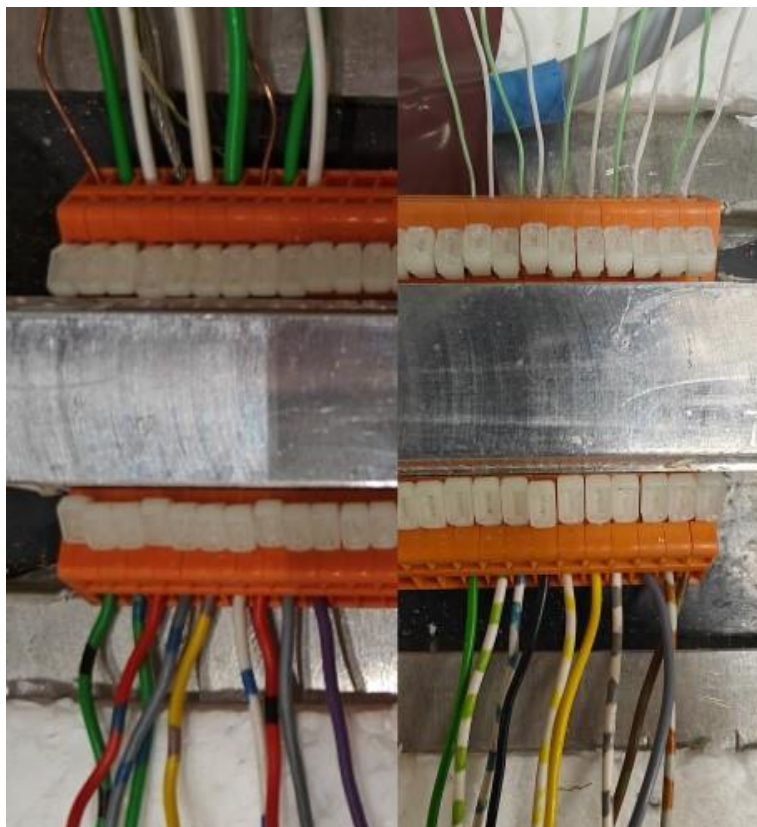
**Figure 5.** Process of connecting thermocouples to a compensation box.

On the opposite side of the terminal with the thermocouples, copper wires are placed. These are connected using the same procedures as thermocouples. When connecting, make sure there is no exposed copper outside the junction. The correct connection is shown with a green outline in Figure 6, while the exposed copper is marked with red.



**Figure 6.** Bad connection of copper wires (red) and good connection of copper wires (green).

The color of the copper wire doesn't matter when connecting it to the compensation box. A completed segment of a compensation box is seen in Figure 7.



**Figure 7.** A completed segment of a compensation box.

Fill the remaining junctions with however many thermocouples are needed and connect copper cables on the other side. When this is finished, the copper cables should be connected to the “isothermal input connector”, which is an input module for the Fluke Helios Plus 2287A datalogger.

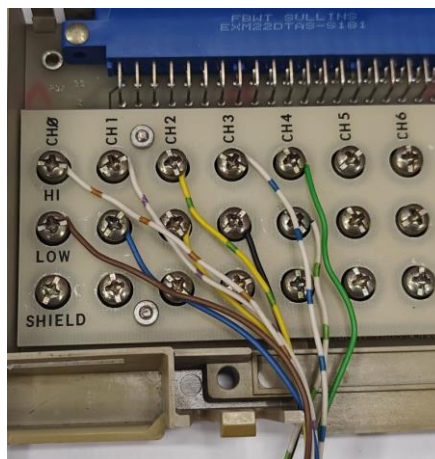
### 3.2. Connect the copper cables to the isothermal input connector

The copper wires connects the compensation box and “isothermal input connector”. The connector is shown in Figure 8.



**Figure 8.** Example of an open isothermal input connector.

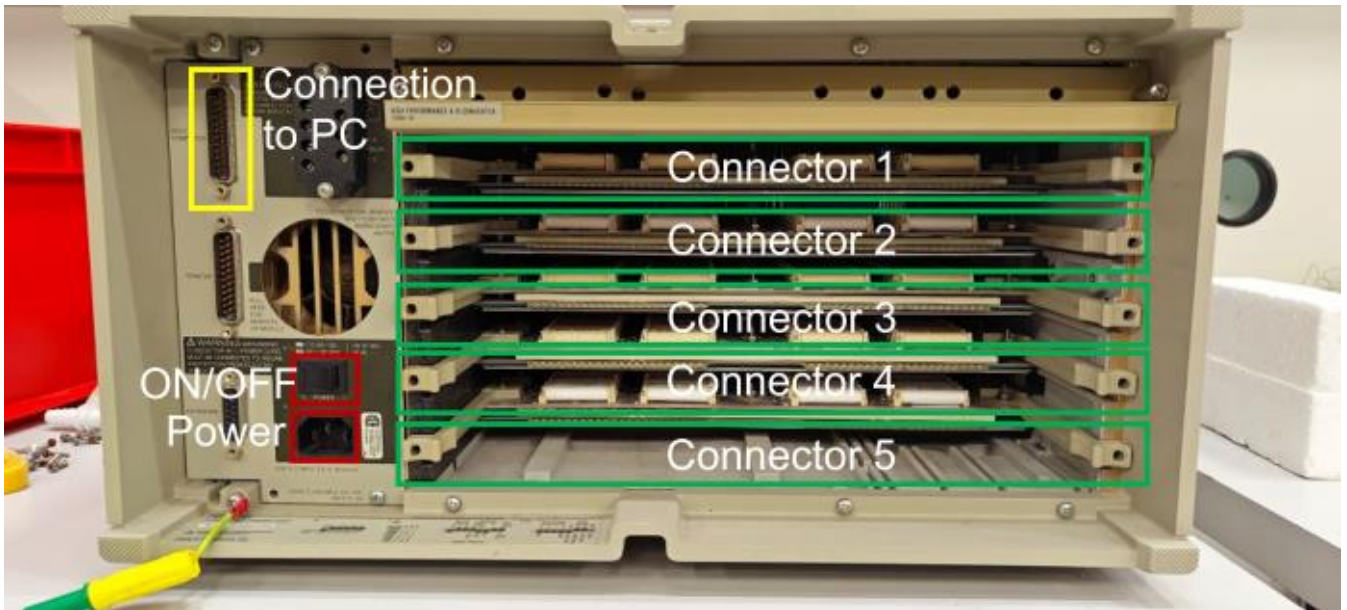
Inside the connector, there are 20 channels with three screws each: High, Low, and Shield. High is connected to the positive wire, Low is connected to the negative, and Shield is only used with the thick thermocouples to connect the ground wire. To connect the wire, make a half-circle with the uninsulated copper wire end, put it under the screw, and screw it in. A finished segment of the connector is seen in Figure 9.



**Figure 9.** Isothermal input connector with copper wires connected.

The isothermal input connectors are then inserted into the Fluke Helios Plus 2287A datalogger. The Helios datalogger has room for 5 connectors. The back of a Helios is seen in Figure 10, where necessary information is marked.





**Figure 10.** Backside of Fluke Helios Plus 2287A datalogger.

**IMPORTANT:** When connecting the Fluke Helios Plus 2287A datalogger to power, make sure to use a power cable with ground to reduce electrical noise on the thermocouples.

### 3.3. Preparation of thermocouples for calibration

Type K thermocouple (used in this Lecture Note) consists of two different alloys called Chromel (green wire, positive) and Alumel (white wire, negative). Two different thermocouples are used in this Lecture Note, which are shown in Figure 11.

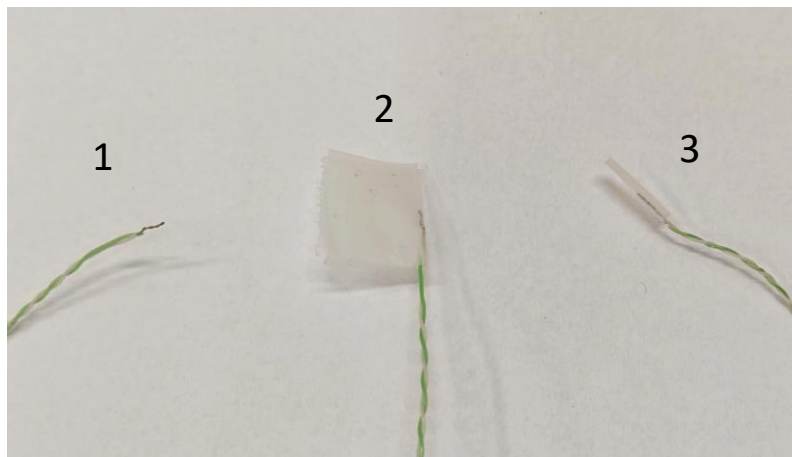
Thin thermocouples are the most commonly used thermocouples, and can be used for most temperature measurements, such as measurements in insulation layers, window cavities, surface temperature, etc. The thicker thermocouples can be used for cases involving radiation from an artificial sun. Furthermore, if the temperature fluctuates fast, thin thermocouples are recommended as they have a lower time constant.

After determining which type of thermocouple is needed, make sure they are of sufficient length to reach the intended spot in the setup. Afterward, the thermocouples need to be prepared for calibration.



**Figure 11.** *Two different thermocouples of type K.*

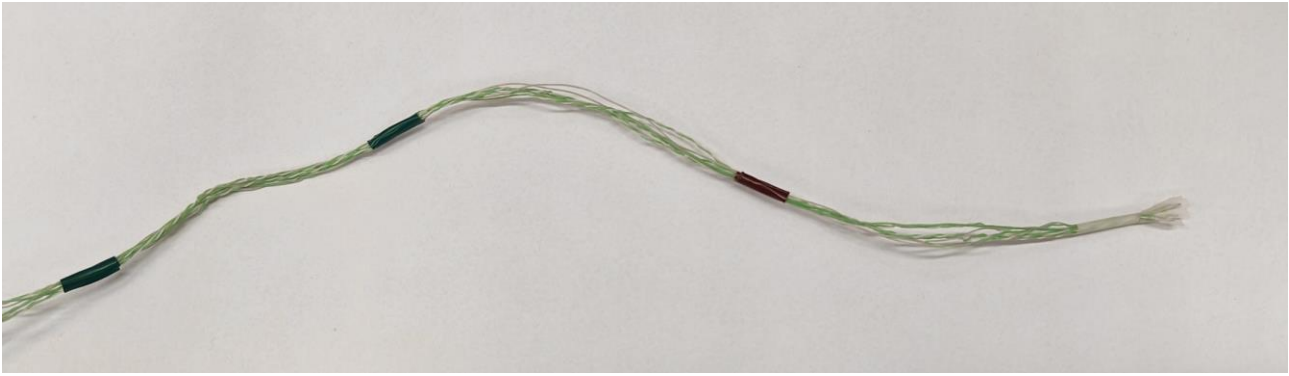
The thin thermocouples must be taped at the measurement point to reduce noise during calibration. The end should be covered with a piece of thin tape. Only a small amount of tape is needed, and the remaining can be removed using scissors. The procedure is shown in Figure 12.



**Figure 12.** *Preparation of thin thermocouples.*

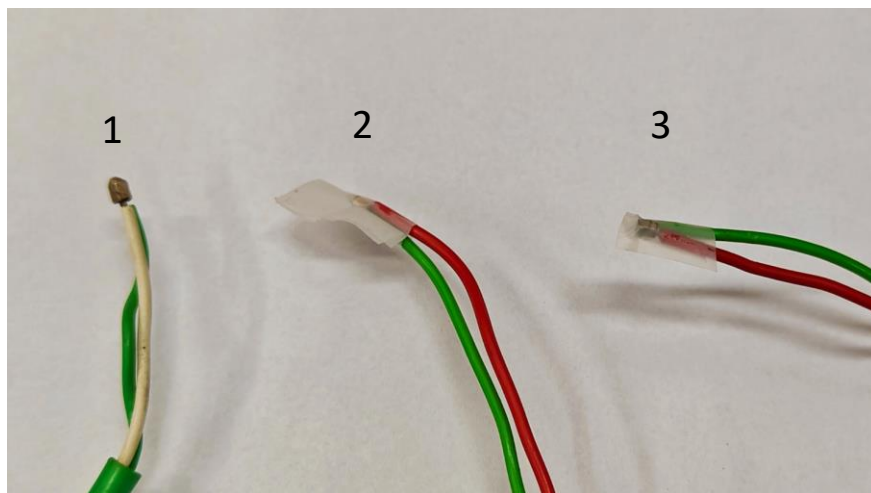
During calibration, it is advantageous to make bundles of 5-10 thermocouples taped together. This increases robustness and ensures each of the thermocouples are the same depth in the calibration well.

The bundle needs to be approximately 25 cm long. A bundle is shown in Figure 13.



**Figure 13.** A bundle made from thin thermocouples.

The thick thermocouples also need to be taped. It is done the same way as with the thin. The procedure is shown in Figure 14.



**Figure 14.** Preparation of thick thermocouples.

The thermocouples are now ready to be calibrated. For this, a specific LabVIEW VI is used, see the following.

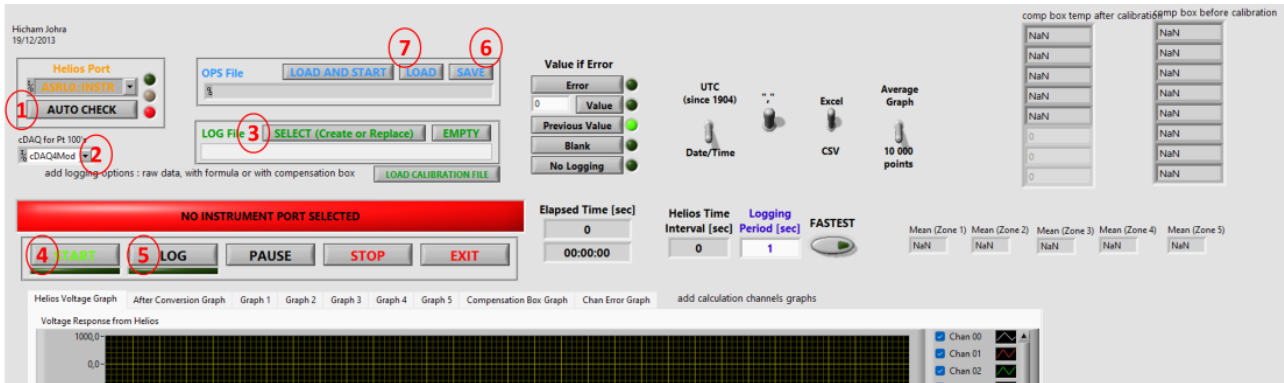
### 3.4. How to setup Helios

The Helios is connected to a computer with a Helios data-cable. The data-cable needs to be connected to an USB-to-serial converter, like shown on Figure 15.



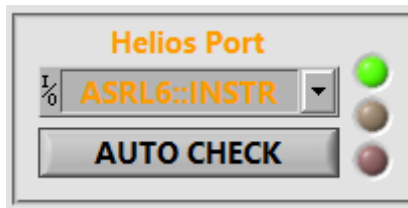
**Figure 15.** Helios data-cable connected to an USB-to-serial converter.

The LabVIEW script for the Helios Datalogger can be found on [Moodle](#) (LabVIEW programs -> Helios). Download the folder and open the Virtual instrument (VI) called 'Helios\_Main'. It should look like Figure 16.



**Figure 16.** Custom-made LabVIEW VI for the Fluke Helios Plus 2287A datalogger.

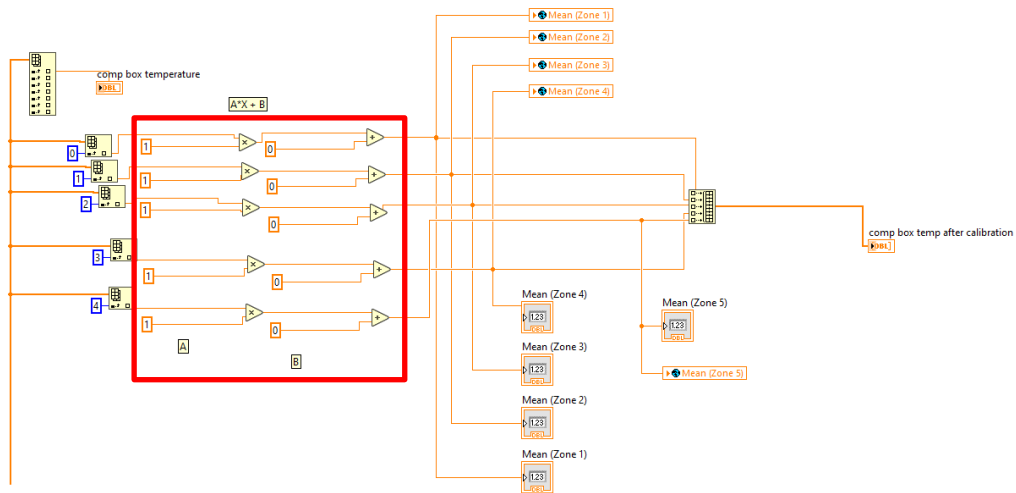
(1) Run the script and press 'Auto check' for the script to recognize the Helios. **OBS:** The button may need to be pressed more than once. When the light is green the Helios is connected. The green light is shown in Figure 17.



**Figure 17.** Indication of a successful connection between the computer and Fluke Helios Plus 2287A datalogger.

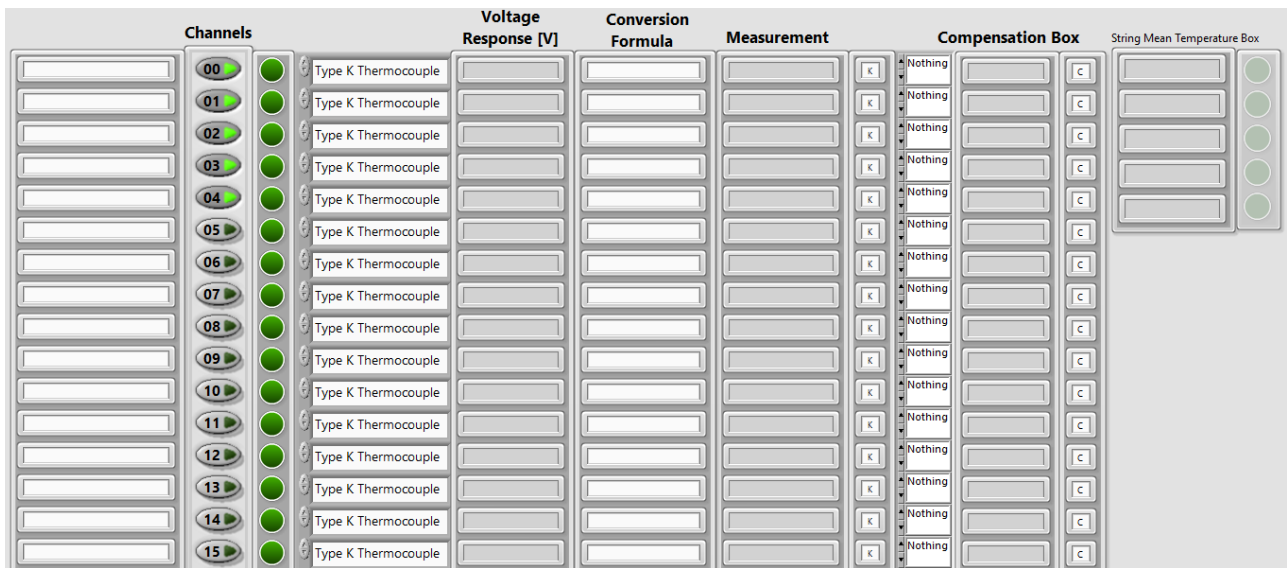
(2) Choose the cDAQ for Pt 100's. (3) Create a log file by clicking the 'SELECT (Create or Replace)' button. Afterward, the calibration of the Pt 100's (linear function on the form  $y = A \cdot X + B$ ) needs to be input. This is done in the block diagram (click 'CTRL + E' to access the code). The relevant code is located at the top of the code. The block diagram is shown in Figure 18.





**Figure 18.** The block diagram for the Pt 100 calibration formulas.

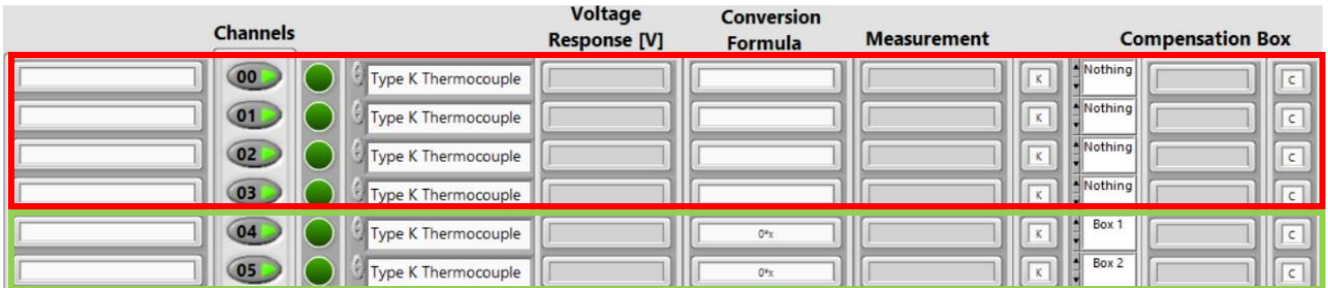
The Pt 100 with index 0, is shown as Zone 1 or box 1 in the script. When the calibration for the Pt 100 is inserted, close the block diagram. Scroll down to see the channel selection area. The area is shown in Figure 19.



**Figure 19.** The menu to activate specific channels, with conversion formula and options for compensation box.

To activate a channel, press the button with the channel number (the light should turn green). The channels correspond to the channels from the connectors in the Helios, where connector 1 is channel 0-19 and connector 2 is 20-39, etc. In the boxes for 'Conversion Formula', the calibration formula for the thermocouples can be entered after the calibration. The last thing that should be done is to select the relevant Pt 100 for the specific thermocouple. This is done in the 'Compensation Box' drop-down menu (that says 'nothing' in Figure 19). In the drop-down, select the 'Box'-number corresponding to the Pt 100, placed near the selected thermocouple.

**IMPORTANT:** If the custom LabVIEW VI is used for calibration, the option 'Nothing' should be chosen for the 'Compensation Box' option. For each of the Pt 100's used for the specific calibration, an empty channel should be activated with '0\*x' written in the 'Conversion Formula' box. Then, for the 'Compensation Box' option, each Pt 100 should have a channel. These settings will ensure that the voltage is measured for the thermocouples and temperature from the Pt100's. An example of this is shown in Figure 20.



**Figure 20.** Example of the Helios VI being used for calibration of channel 00-03 (Red). 04 and 05 are used for Pt 100 temperatures (Green).

The custom LabVIEW is now ready to be used for calibration, and the measurement can begin. For this, click on 'START' (4) in Figure 16, followed by 'LOG' (5). The measurement will be displayed on the chart, and the data will be saved to a log file on the specified file location with the specified file name.

### 3.5. Calibration of thermocouples

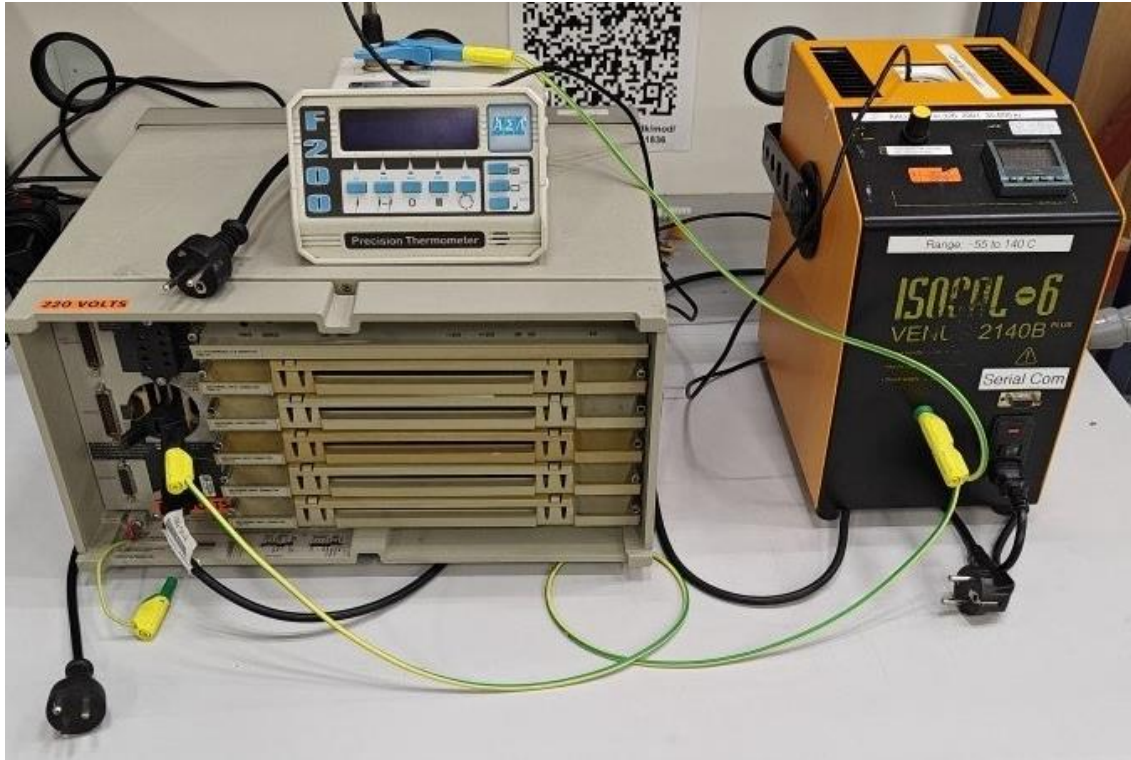
Calibration of any sensor requires a 'true value' and a 'measured value'. The calibration ensures that the measured value is close to the true value by using a reference equipment that has been calibrated by the proper authorities. For temperature measurements at BUILD, the F200 Precision Thermometer is used.

The goal of the calibration is to obtain a calibration curve that has a formula for converting the measured value to a value close to the true value. For thermocouples of type K, it is advised to use a 3<sup>rd</sup> order polynomial for the calibration curve when the temperature range is both negative and positive. If the temperature range is strictly positive or negative, a 1<sup>st</sup> order polynomial can fit a line to the data points.

An overview of the calibration of type K thermocouples can be found in [2]. The remainder of this section will be focused on the practicalities of using the equipment to perform the calibration.

#### Mitigation of electrical noise

To minimize the amount of electrical noise experienced on the thermocouples, it is advised to ground the setup during calibration. This is done using a power cable with ground to one (*and only one*) of the equipment. From the grounded equipment, use jumper wires to ground the remaining equipment. This is shown for this specific calibration in Figure 21.



**Figure 21.** Jumper wires and power cables used in the calibration. Only the power cable to the Helios datalogger is grounded.

### F200 Precision Thermometer

To calibrate the thermocouples the F200 Precision Thermometer is needed. A guide on how to use it, and the LabVIEW script can be found on [Moodle](#) - (LabVIEW programs -> F200 Precision Thermometer).

Alternatively, a manual read of the display can be performed. It is advised that the temperature from the F200 Precision Thermometer is stable for at least 2 minutes, with a maximum deviation of  $\pm 0.005$  °C.

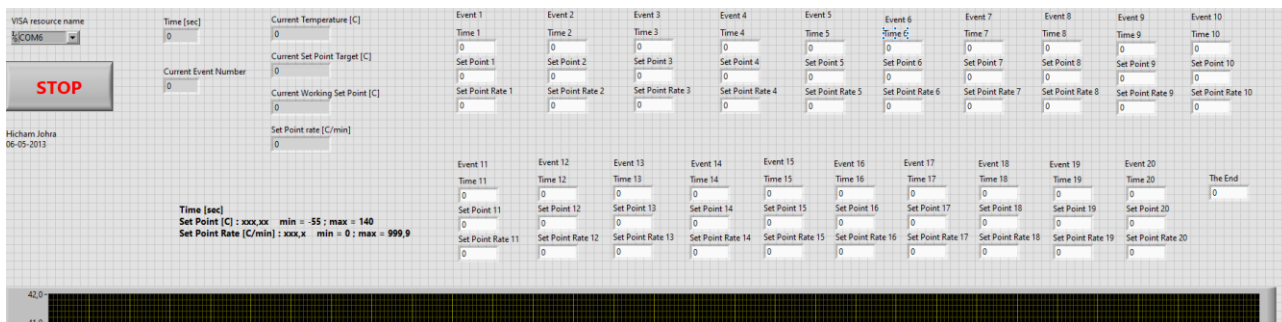
### ISOCAL Calibration well

The calibration well can be used manually, or with a LabVIEW script. To manually set the temperature, use the buttons below the display. The display and the buttons to adjust the temperature are shown in Figure 22.



**Figure 22.** The display on the calibration well.

The LabVIEW script can be found on [Moodle](#) (LabVIEW programs -> ISOCAL 6 Venus 2140B). Open the VI called 'Ramp and Step controller'. The VI should look like Figure 23.



**Figure 23.** Interface of the 'Ramp and Step controller VI'.

Connect the calibration well to a RS232 cable, and to the computer with a USB-to-serial converter. The cable is seen in Figure 24.



**Figure 24.** RS232 with USB-to-serial converter.

Once connected, select the correct port from the drop-down menu below 'VISA resource name' in the upper left corner. On the right side of the script, it is divided into 20 events. Each event describes a different setpoint, and for how long the calibration well is at this temperature. The time is in seconds and the set points are in °C. Always set the Set Point Rate (rate of change of temperature) to 999, which is the max. Event 1 describes the starting point. Therefore, 'Time 1' is set to 0.

When calibrating, the setpoints should cover the whole expected measurement range. For the outermost setpoints the temperature interval can be 10 °C. In the temperature range where the majority of the measurements are expected, the interval should be 5 °C.

For setpoints below 0 °C it is recommended to run each event for 2 hours. For positive setpoints, 1 hour for each event is recommended.



**IMPORTANT:** The time for each event should be written as the accumulated time, not the runtime for the specific event.

An example of a calibration event is the setpoints -20, -10, -5, 0, 5, 15, 20, 30, 40 and 60 °C. This is shown in Figure 25.

Event 1	Event 2	Event 3	Event 4	Event 5	Event 6	Event 7
Time 1	Time 2	Time 3	Time 4	Time 5	Time 6	Time 7
0	7200	14400	21600	28800	32400	36000
Set Point 1	Set Point 2	Set Point 3	Set Point 4	Set Point 5	Set Point 6	Set Point 7
-20	-20	-10	-5	0	5	15
Set Point Rate 1	Set Point Rate 2	Set Point Rate 3	Set Point Rate 4	Set Point Rate 5	Set Point Rate 6	Set Point Rate 7
999	999	999	999	999	999	999

**Figure 25.** Example of how to prepare the events.

The last thing is to put in the total runtime for the calibration. This is done in the ‘The End’ next to Event 20. The time should be higher than the time for the last event. When the VI is completed, it is ready to run.

**OBS:** An additional event should be added after the final measurement event, to return the temperature well to ambient temperature, in order to not stress the equipment for extended periods of time. The additional event should have a time that is before the end time of the VI, so the VI ends at the ambient temperature.

Event 1	Event 2	Event 3	Event 4	Event 5	Event 6	Event 7	Event 8	Event 9	Event 10
Time 1	Time 2	Time 3	Time 4	Time 5	Time 6	Time 7	Time 8	Time 9	Time 10
0	7200	14400	21600	28800	32400	36000	39600	43200	46800
Set Point 1	Set Point 2	Set Point 3	Set Point 4	Set Point 5	Set Point 6	Set Point 7	Set Point 8	Set Point 9	Set Point 10
-20	-20	-10	-5	0	5	15	20	30	40
Set Point Rate 1	Set Point Rate 2	Set Point Rate 3	Set Point Rate 4	Set Point Rate 5	Set Point Rate 6	Set Point Rate 7	Set Point Rate 8	Set Point Rate 9	Set Point Rate 10
999	999	999	999	999	999	999	999	999	999
Event 11	Event 12	Event 13	Event 14	Event 15	Event 16	Event 17	Event 18	Event 19	Event 20
Time 11	Time 12	Time 13	Time 14	Time 15	Time 16	Time 17	Time 18	Time 19	Time 20
50400	50500	0	0	0	0	0	0	0	0
Set Point 11	Set Point 12	Set Point 13	Set Point 14	Set Point 15	Set Point 16	Set Point 17	Set Point 18	Set Point 19	Set Point 20
60	20	0	0	0	0	0	0	0	0
Set Point Rate 11	Set Point Rate 12	Set Point Rate 13	Set Point Rate 14	Set Point Rate 15	Set Point Rate 16	Set Point Rate 17	Set Point Rate 18	Set Point Rate 19	Set Point Rate 20
999	999	0	0	0	0	0	0	0	0

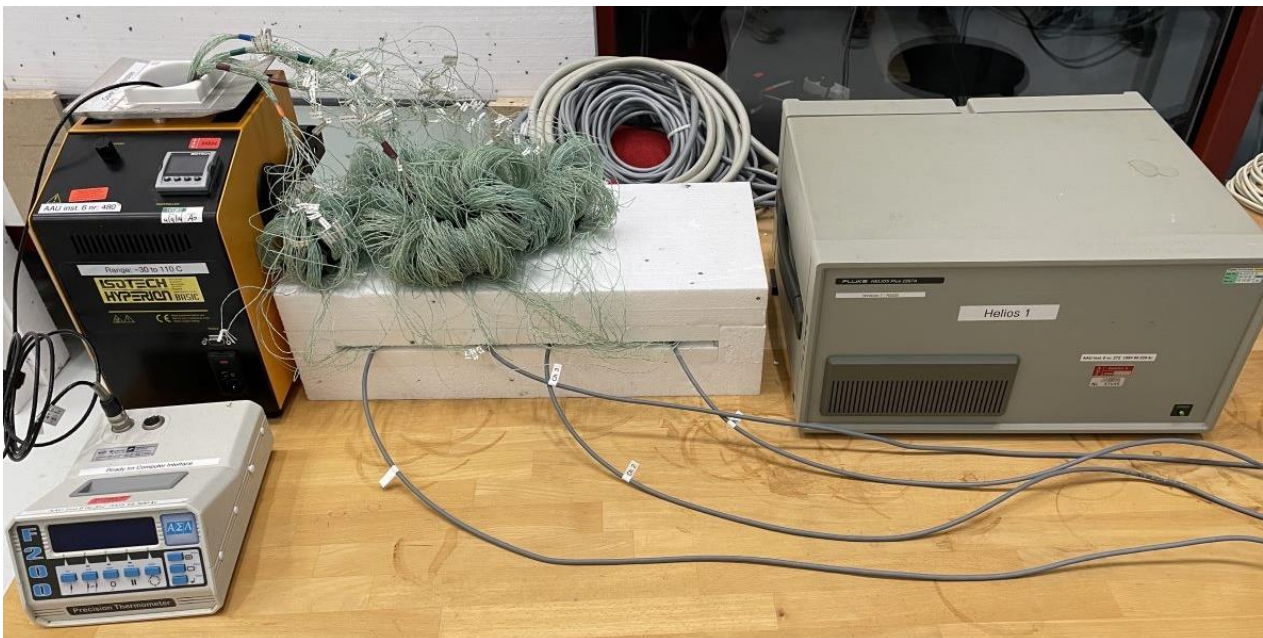
**Figure 26.** The VI using the information from the example.

When the relevant boxes for the events required are filled out, and the correct port is chosen, put the precision thermometer probe and the bundles of thermocouples in the metal insert at the top of the temperature well. Furthermore, seal the top with a paper towel to insulate the metal insert. The calibration well with and without paper can be seen on Figure 27.



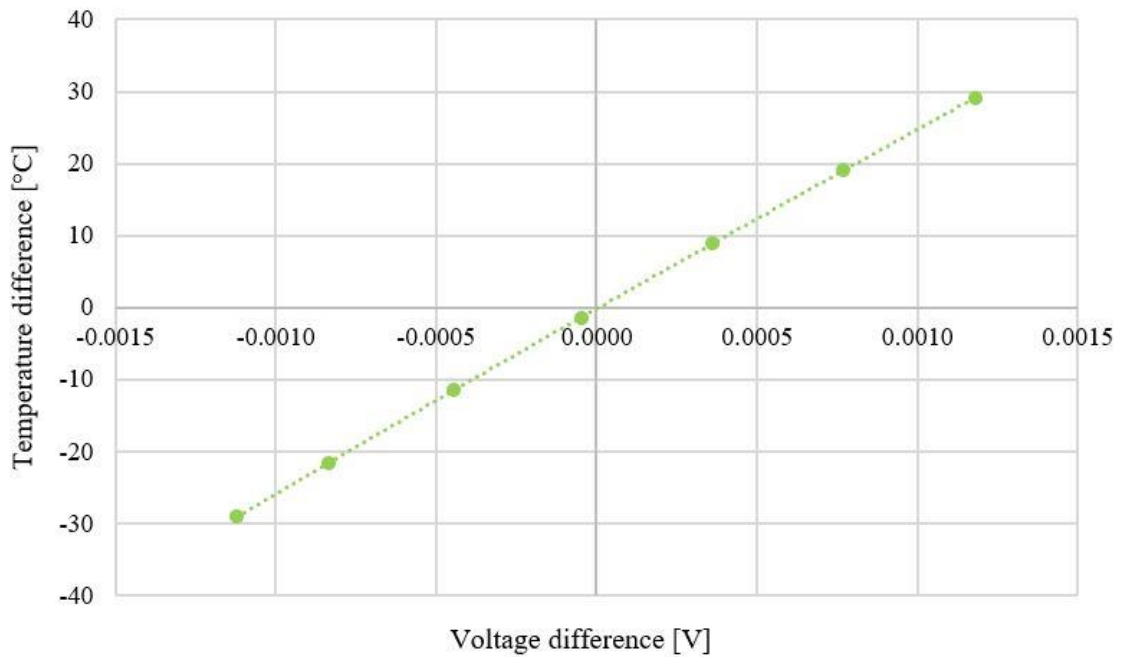
**Figure 27.** Calibration well with thermometer probe and thermocouples.

When the Fluke Helios Plus 2287A datalogger, F200 Precision Thermometer, and calibration well is ready, the finished setup should look like Figure 28.



**Figure 28.** Finished setup to calibrate thermocouples.

The calibration is now ready to be performed. The result of the calibration is a calibration curve on the form  $y = C_0 + C_1 x + C_2 x^2 + C_3 x^3$  for a 3<sup>rd</sup> order polynomial. An example of this is shown in Figure 29.



**Figure 29.** Example of calibration curve for type K thermocouples.

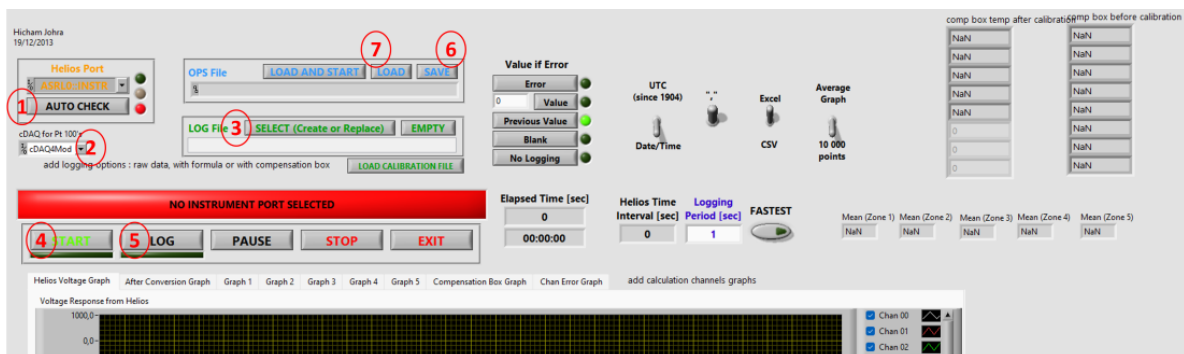
The function of the calibration curve for the thermocouple shown in Figure 29 is  $y = -10.01 \cdot 10^7 x^3 - 4.22 \cdot 10^5 x^2 + 2.52 \cdot 10^4 x - 0.15$  with an  $R^2$ -value of 1.00.

For each thermocouple, a conversion formula is written in plain text in the 'Conversion Formula' textbox (see Figure 19). An example of a conversion formula is "-100100000\*x^3-422000\*x^2+25200\*x+0.15".

To validate the precision of the thermocouples after calibration, the procedure should be performed again with the calibrated sensors. It is possible to obtain an error of less than  $\pm 0.15$  °C.

### 3.6. Make an OPS file for the setup in the custom-made LabVIEW VI

After all the relevant sensors has been activated, been given a conversion formula and assigned a specific Pt 100 (under 'Compensation box' in Figure 19), the options can be saved as an OPS file. By doing this, the options can be loaded next time the setup is used, to avoid the tedious work of choosing the sensors and inserting conversion formulas. To save the current options, click 'SAVE' at the OPS File box (6). To load an OPS file, click 'LOAD' at the OPS File box (7).



**Figure 30.** Custom-made LabVIEW VI for the Fluke Helios Plus 2287A datalogger. (repeated)

Everything is now in order to perform the measurements with the thermocouples using the Fluke Helios Plus 2287A datalogger.



## References

- [1] Artmann, N, Vonbank, R & Jensen, RL 2008, *Temperature Measurements Using Type K Thermocouples and the Fluke Helios Plus 2287A Datalogger*. DCE Technical reports, no. 52, Department of Civil Engineering, Aalborg University, Aalborg.
- [2] Veit, M & Johra, H 2022, *Experimental Investigations of a Full-Scale Wall Element in a Large Guarded Hot Box Setup: Methodology Description*. DCE Technical Reports, no. 304, Department of the Built Environment, Aalborg University, Aalborg.
- [3] Johra, H 2020, *Assembling temperature sensors: thermocouples and resistance temperature detectors RTD (Pt100)*. DCE Lecture notes, no. 78, Department of Civil Engineering, Aalborg University, Aalborg.

## Appendix A: Calibration of Pt 100's

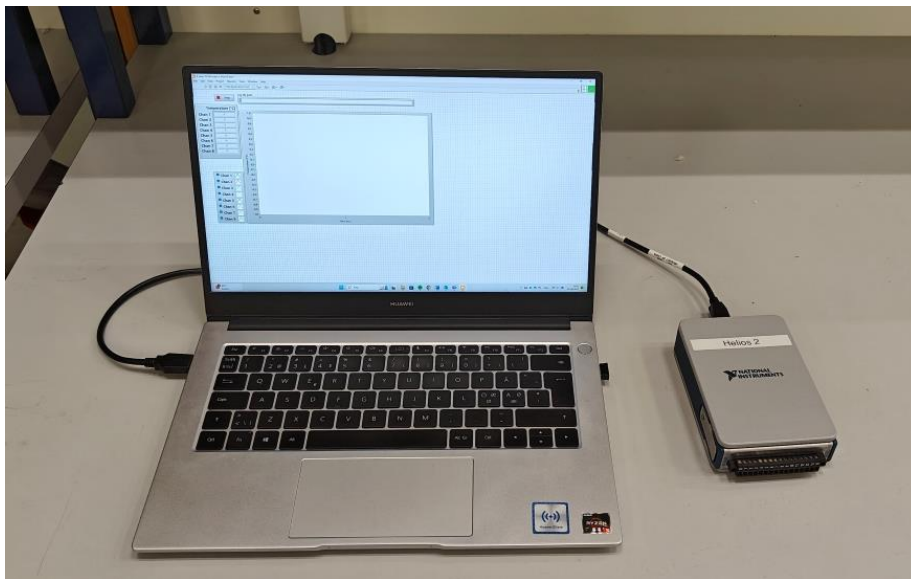
This appendix will focus on the software needed to calibrate Pt 100's. For the practical setup, refer to [2]. For assembling Pt 100's, refer to [3].

To calibrate Pt 100's, they should first be connected to a National Instrument (NI) module specifically used for RTD measurements. In this Lecture Note, the NI 9216 (8 channels) and NI 9217 (4 channels) are used. The modules are shown in Figure 31.



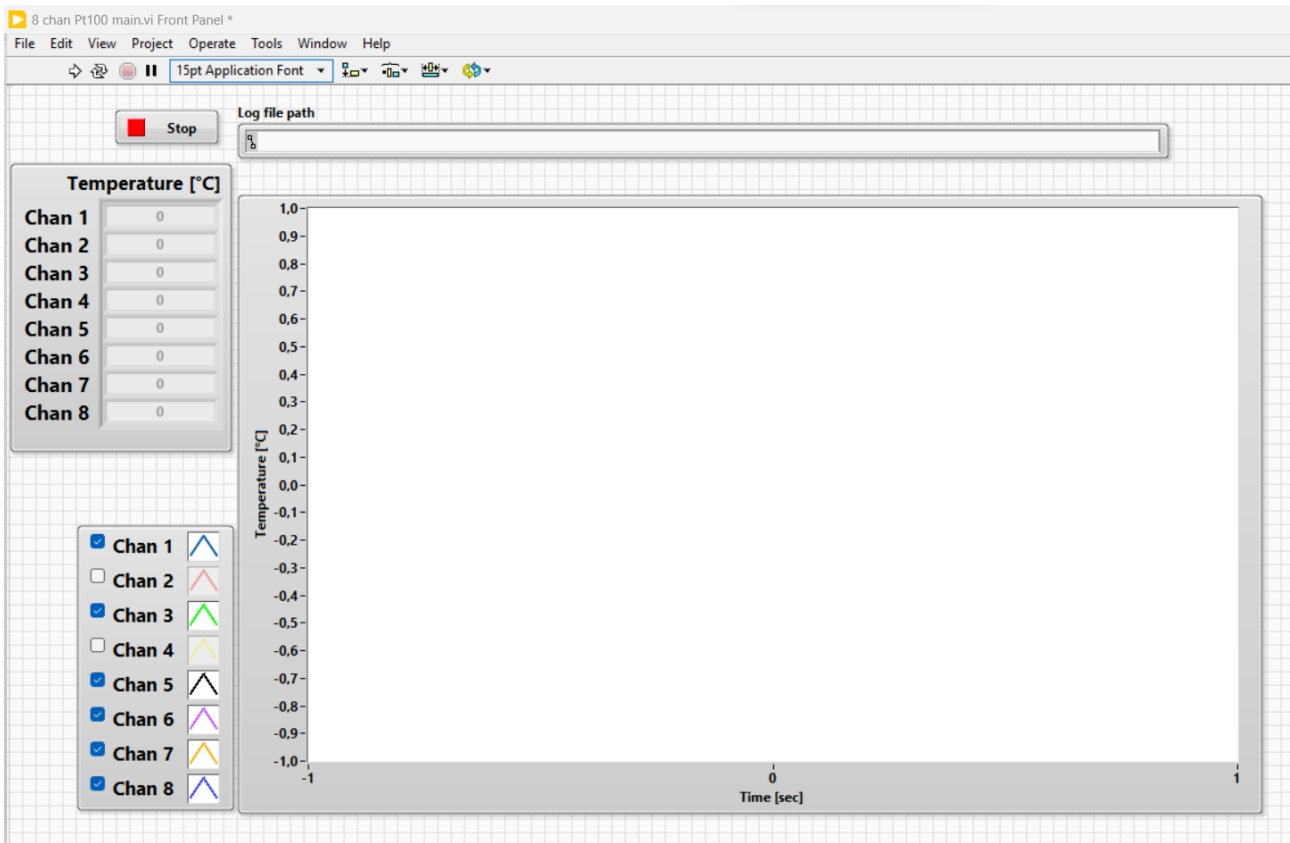
**Figure 31.** Different NI modules used for RTD measurements.

The chosen RTD module is connected to a NI cDAQ-9171 module, to connect the module with the computer. One RTD module connected to a computer is shown in Figure 32.



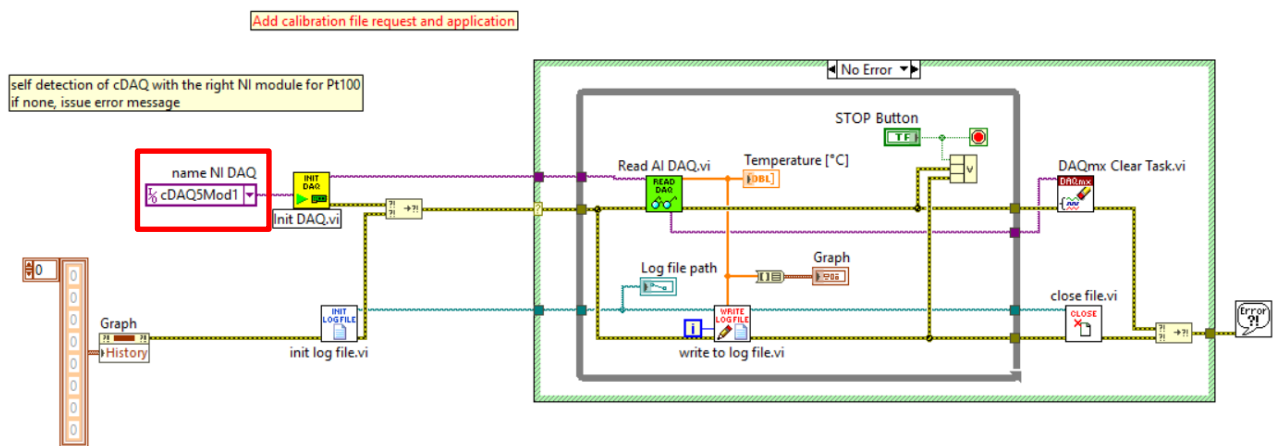
**Figure 32.** One RTD module connected to a computer.

To access a custom made LabVIEW VI for using the RTD modules can be found on [Moodle](#) (LabVIEW programs -> Pt 100 logger). This LabVIEW VI is shown in Figure 33.



**Figure 33.** Custom LabVIEW VI to measure data using the NI 9216 module.

Before starting the VI, access the block diagram (press CTRL + E), and choose the relevant DAQ by clicking the dropdown menu highlighted in Figure 34.



**Figure 34.** Block diagram of the custom LabVIEW VI for the NI 9216 module.

After the DAQ is chosen, start the VI (see Figure 33), choose a file location for the measured data, and begin the calibration as described in [3].

## Appendix B: Mounting of thermocouples on different surfaces

When mounting the thermocouples, it can be done differently depending on which surfaces are nearby. To mount the thick thermocouples on a flat surface, the special stapler in Figure 35 should be used.

**IMPORTANT:** *The stapler leaves a mark on the surface. Make sure it is okay to damage the surfaces before using it.*



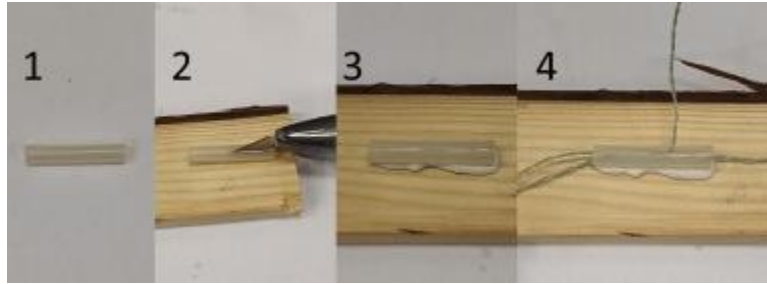
**Figure 35.** Special stapler for mounting thermocouples.

When using the stapler, find the spot where the thermocouples should be mounted. Grab the stapler, line up the thermocouple with the half circle at the bottom, and press down on the handle. The process is shown in Figure 36.



**Figure 36.** How to mount thick thermocouples on flat surfaces.

To mount the thin thermocouples, find a small piece of plastic tubing. Cut it lengthwise and attach it to a surface with blue tack or glue (Use something that is easily removed without damaging the surface). The thermocouples can now be added to and removed from the plastic tube. The process is shown on Figure 37.



**Figure 37.** How to mount thin thermocouples on flat surfaces.

If there are no surfaces near the thermocouples, they can be bundled up with Velcro or zip ties. These solutions are shown on Figure 38 and Figure 39.

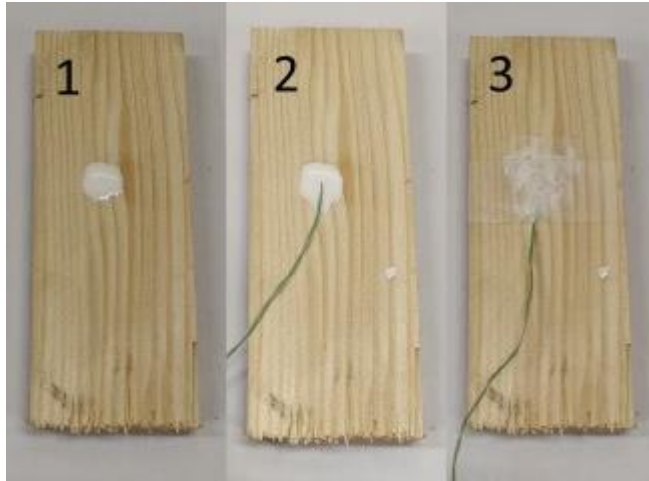


**Figure 38.** Gathering of free hanging thermocouples with Velcro.



**Figure 39.** Gathering of free hanging thermocouples with zip tie.

Finally, the sensor needs to be attached to the measuring point. This is done by adding a small amount of thermal paste on top of the sensor and adding thin tape to keep it in place. The step-by-step is shown in Figure 40.



**Figure 40.** *Mounting the sensor on a surface.*



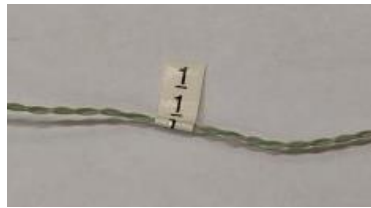
## Appendix C: Naming of individual thermocouples

When working with multiple thermocouples, it is recommended to name each cable for practical purposes and identification. There is no correct way to do it but use a system that is easy to remember. It could be naming channel 1 for 001, channel 002 for 2, and so forth. To mark the cables, there are two different methods. For the thin thermocouples, the stickers shown in Figure 41 should be used.



**Figure 41.** Cable markers for thin thermocouples.

Grab a piece of the numbered tape and wrap it around the thermocouple, shown in Figure 42.



**Figure 42.** Example of a named thin thermocouple.

For the thick thermocouples, use the plastic rings in Figure 43. These rings should be attached before the thermocouple is mounted on the wall.



**Figure 43.** Cable marking for thick thermocouples.

Slide the ring onto the end of the thermocouples and use the heat gun to shrink them until they are attached. The finished naming should look like Figure 44.



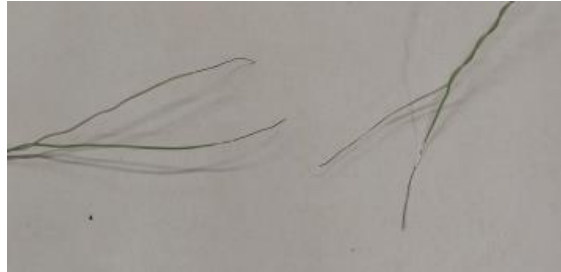
**Figure 44.** Example of a named thick thermocouple.



## Appendix D: How to extend thin type K thermocouples

**IMPORTANT:** Extending thin thermocouples should only be done if necessary. Make sure there are no other thermocouples of sufficient length before proceeding.

Start with stripping approximately 2 cm of insulation from every wire in the thermocouple, like in Figure 45.



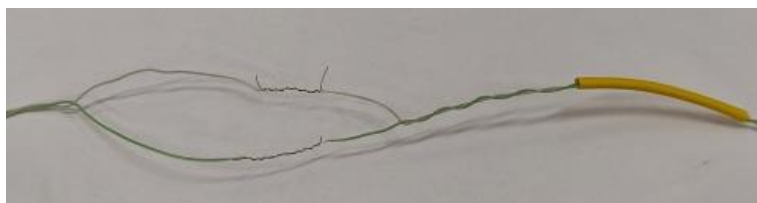
**Figure 45.** Stripped ends of a thermocouple.

Afterward, cut a piece of shrinkable tubing (5 cm should be enough) and slide it on one of the thermocouples. It is recommended to use 1,6 mm shrinkable tubing.



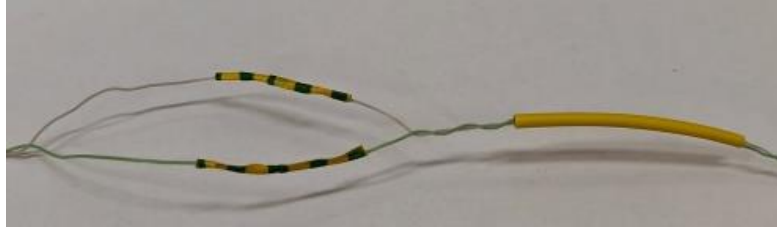
**Figure 46.** Shrinkable tubing on one of the thermocouples.

Twist the wires together like shown in Figure 47. The green wire should be attached to the green and white to white. When they are twisted slightly tug on the wires to make sure they are fully attached to each other. Cut off the unnecessary wire.



**Figure 47.** Thermocouples twisted together.

Wrap the exposed wires in electrical tape. The wires should be wrapped individually and as thin as possible. Afterwards it should look like Figure 48. Electrical tape wrapped around the exposed wires.



**Figure 48.** *Electrical tape wrapped around the exposed wires.*

Slide the shrinkable tubing on top of the taped wires. It might need a bit of work. When the tubing is fully covering the tape, use the heat gun to shrink it. The finished extension should look like Figure 49.



**Figure 49.** *The finished connection between two thermocouples.*

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