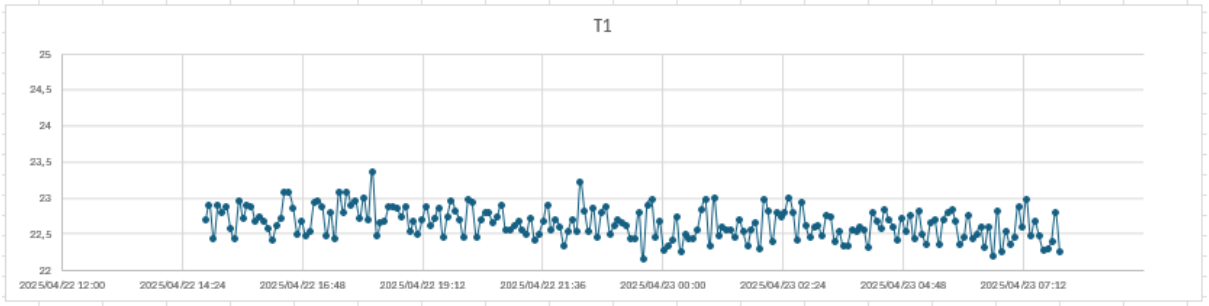
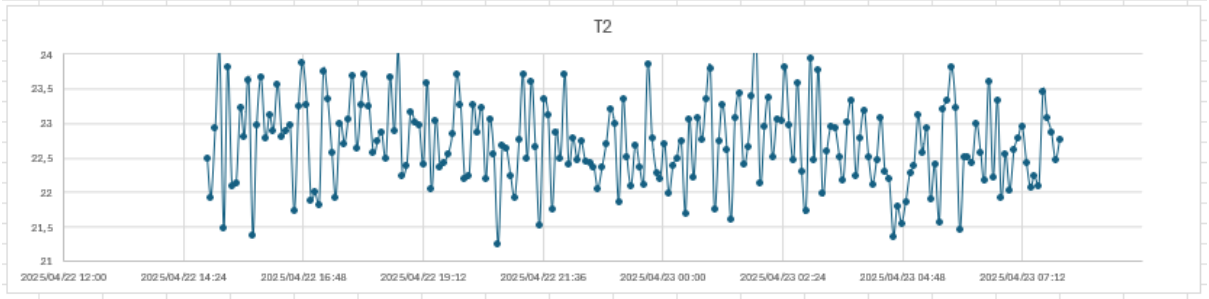
This document sets out to validate the Large Soil Moisture Probe Temperature readings and counter readings (Counter readings have already been confirmed to meet requirements).

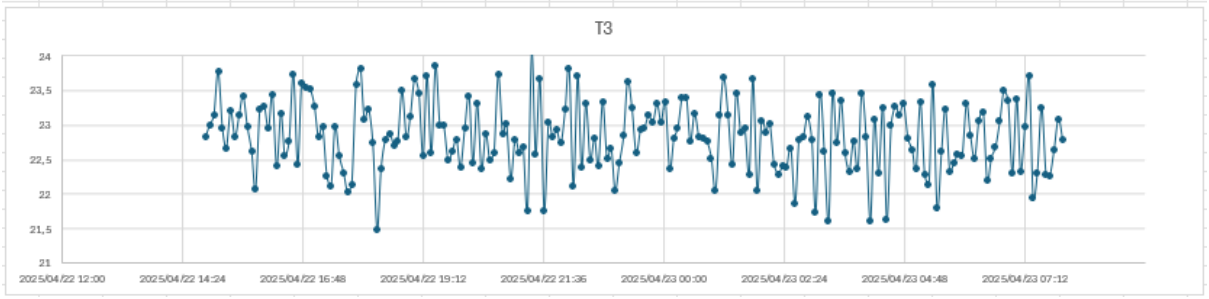
XP1=1st Cast Probe, XP2=2nd Open Probe

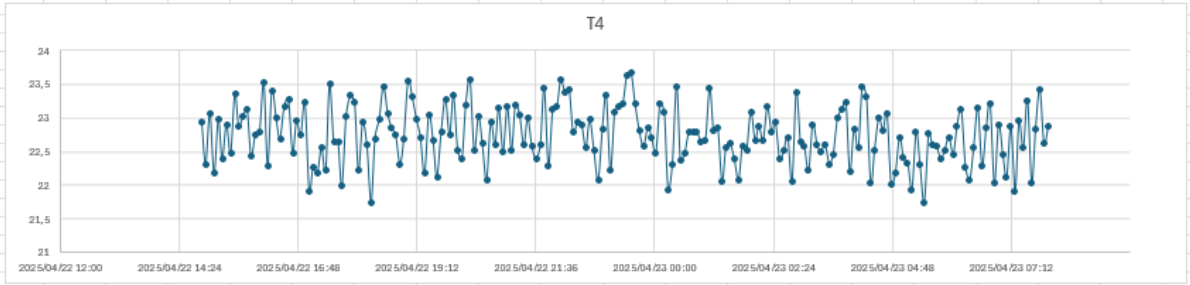
Wednesday the 23rd of April 2025

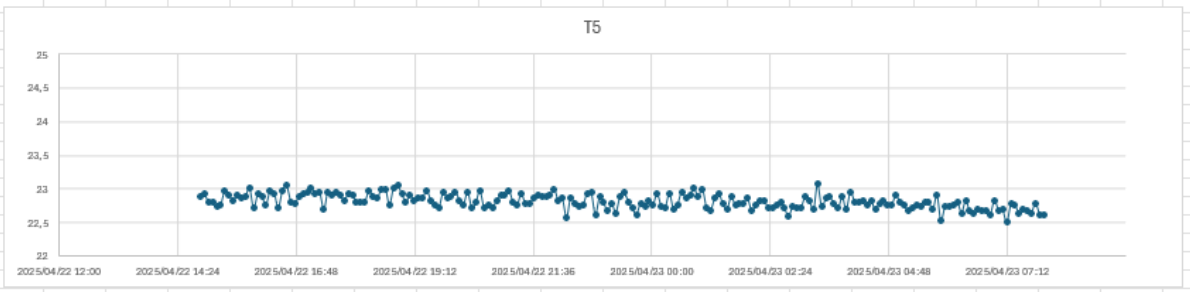
Open probe is now using 10k NTC along with 10k voltage divider circuit. Overnight Temperature readings using the open test probe are shown below:

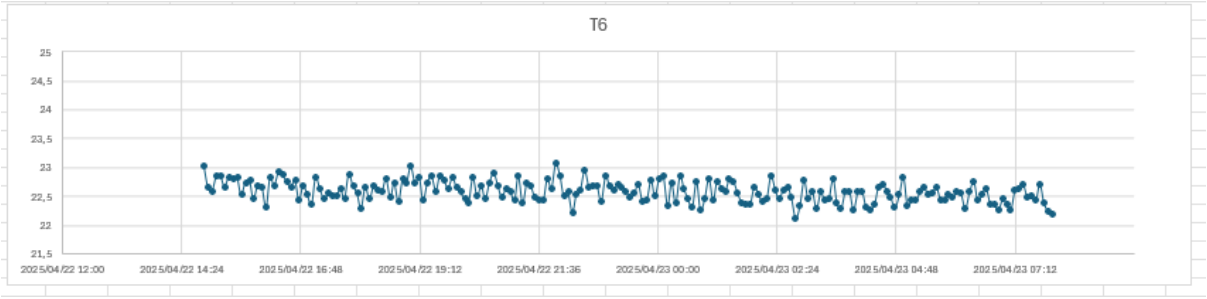


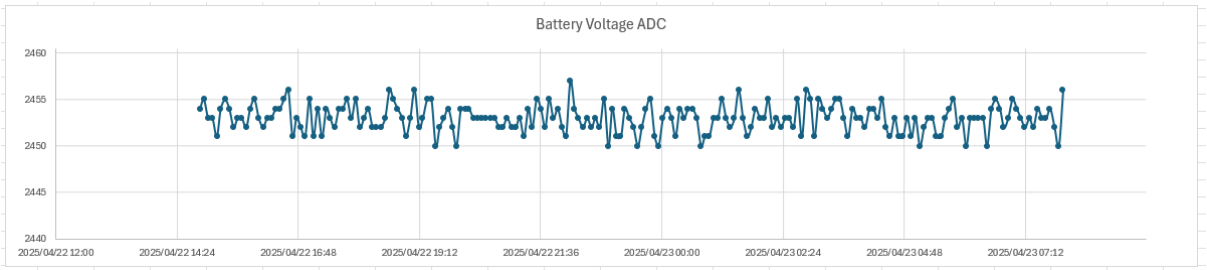



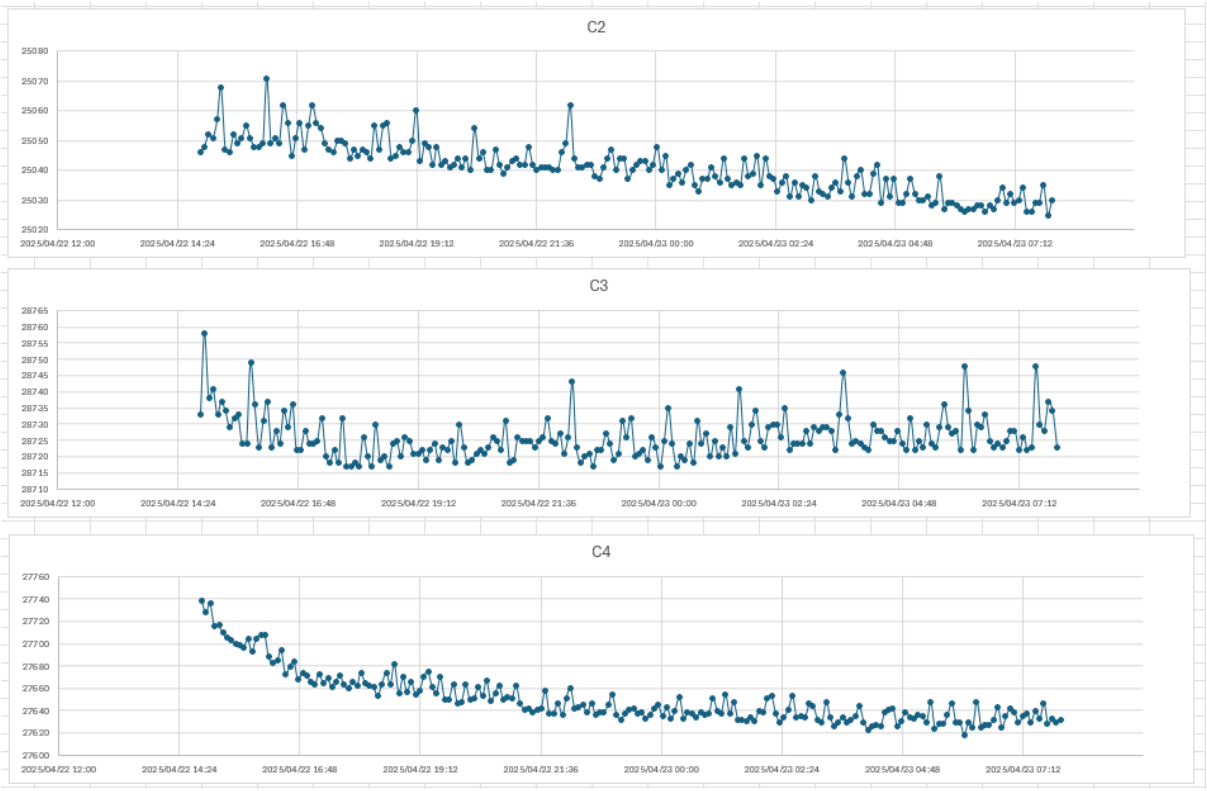



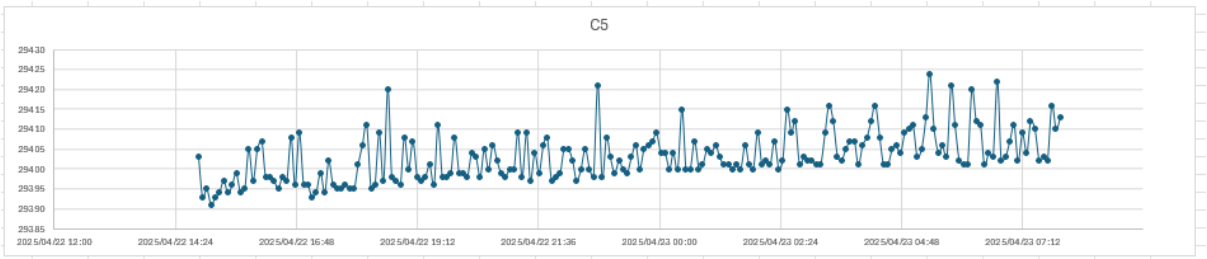


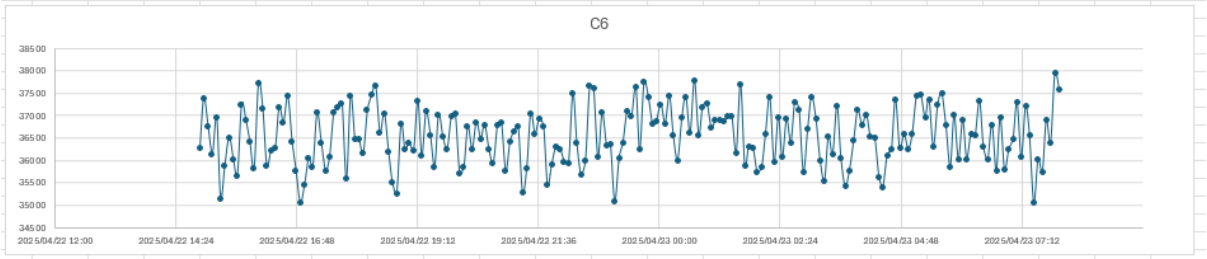




The above graphs do not meet the requirements for the temperature validation due to high noise on temperatures 2,3 and
4. Potential reasons for the noise include RS485 communication cable running through sense boards 1-4, or discrepancies in build quality of the sense rings. The RS485 cable was removed along with swapping sense ring #1 and #2 to see if a noticeable occurs. Also shown above is the battery voltage control test which shows an extremely high level of accuracy of the ADC.

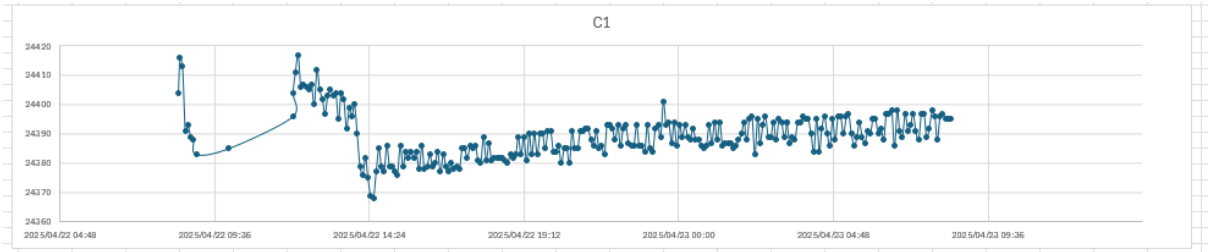
The graphs below are taken from XP2(the open test probe). They show that the counter value is still within the required specs except for Counter 6. Counter 1 is excluded in this test due to space requirements on Irricheck and the inclusion of the battery voltage adc.

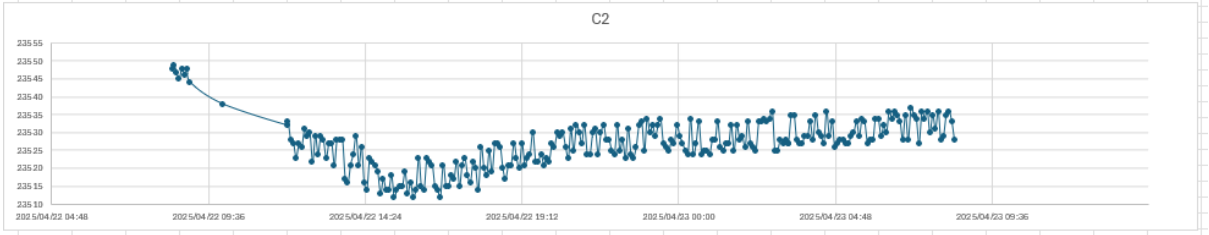


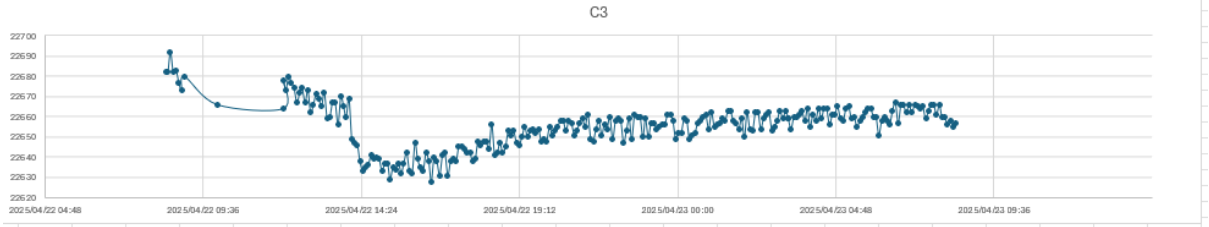


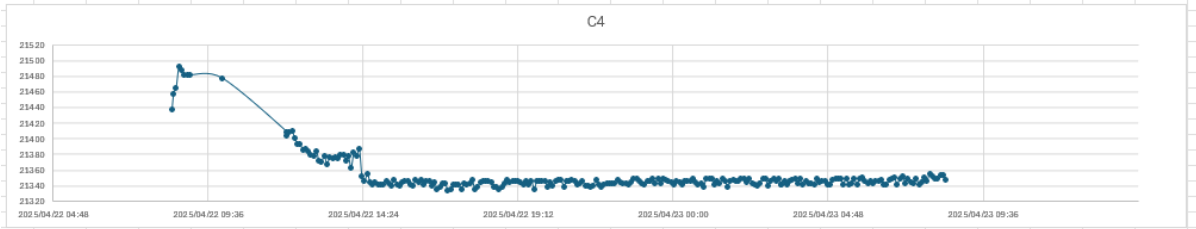



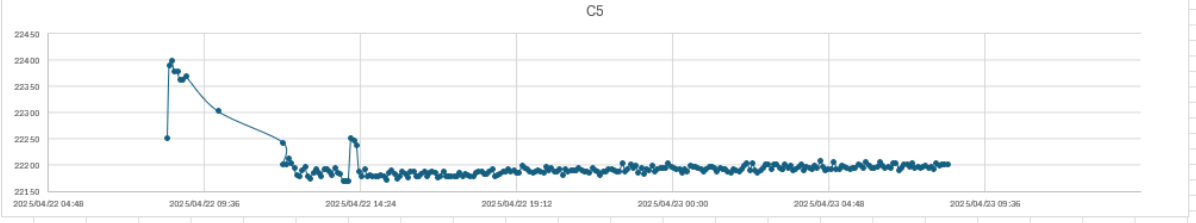

Counter validation can be confirmed using the cast test probe, with the data collected from the 22nd of April 2025 08:30 until now(23rd April 2025 08:30):

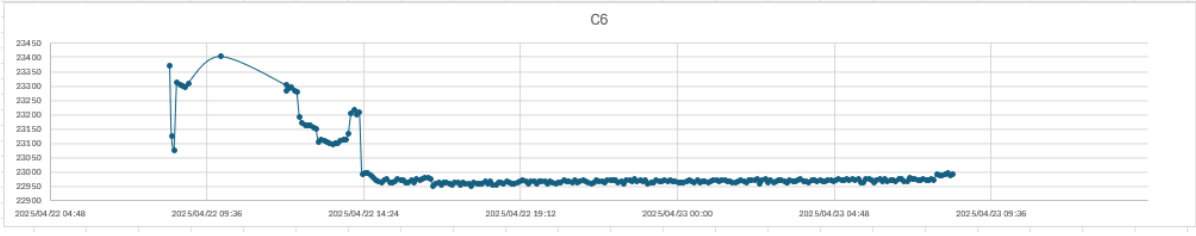


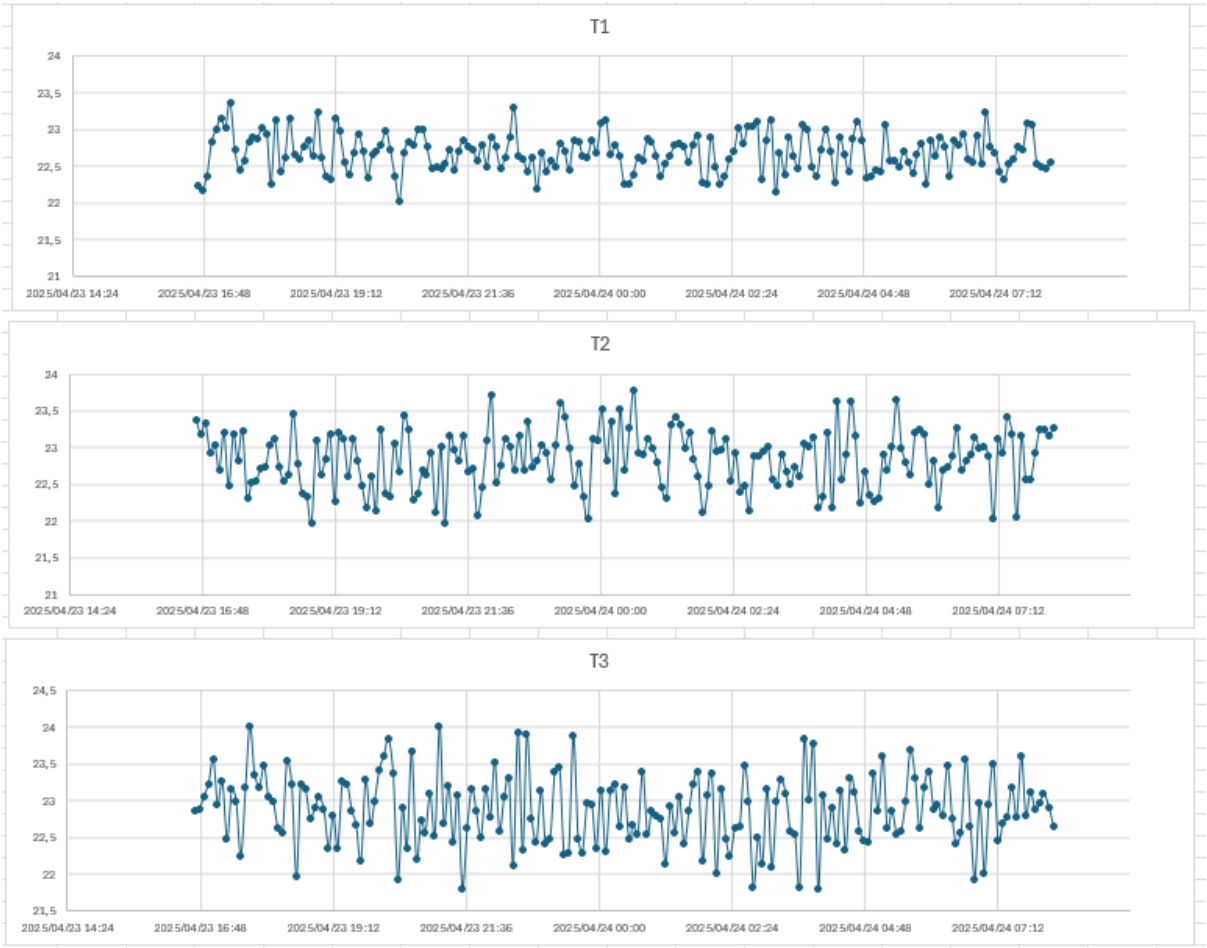



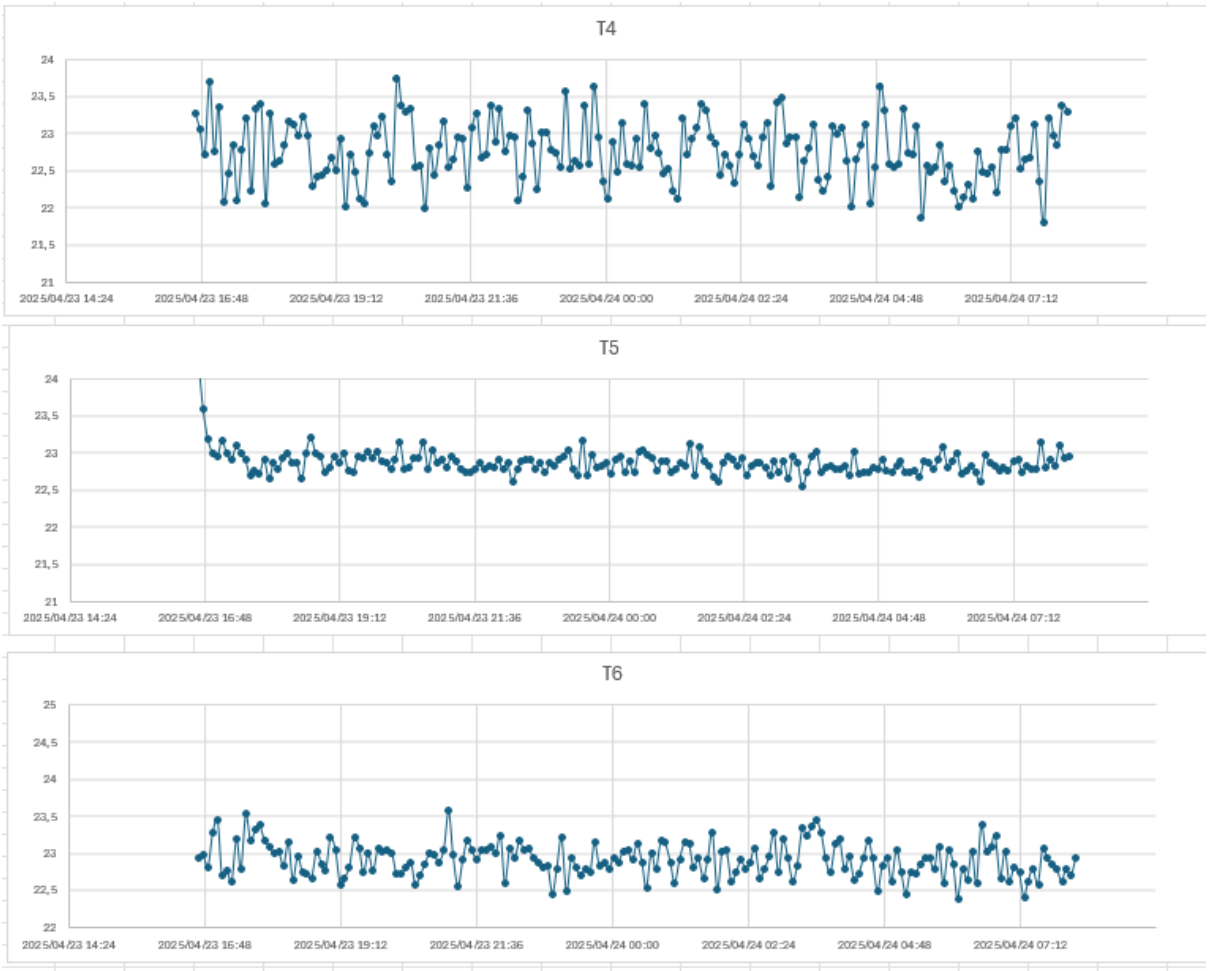
XP2(Open Probe 2) Swapped ring 5&6 at 16:22 23/04/2025.

XP2(Open Probe 2) Swapped in a rebuilt ring at position 6 at 16:33 23/04/2025

24th April 2025 XP2 (Open Probe Test)

Below are the readings taken from 23/04/2025 16:51 to 24/04/2025 08:15 of the open test probe, showing the temperature readings.






Ring 4 is swapped with the spare ring (Ring 6 from the morning readings on the 23/04/2025) to confirm if the software or hardware is causing the inaccuracy.

29/04/2025

Plot the data for the last 5 days and analyse the results.

Below are the results of the Open probe XP2, the counter values C2-C6.

Confirmation of the battery voltage divider was tested with the results in the table below, measuring was done on the voltage divider and on the appropriate pin on the MCU.

| Supply voltage | Voltage on the voltage divider | Voltage on the MCU PIN |
|---|---|---|
| 4.18V | 1.903V | 1.903V |
| 4.06V | 1.852V | 1.852V |
| 3.99V | 1.818V | 1.818V |
| 3.89V | 1.767V | 1.766V |
| 3.78V | 1.716V | 1.717V |
| 3.67V | 1.665V | 1.664V |
| 3.57V | 1.620V | 1.620V |
| 3.49V | 1.578V | 1.578V |

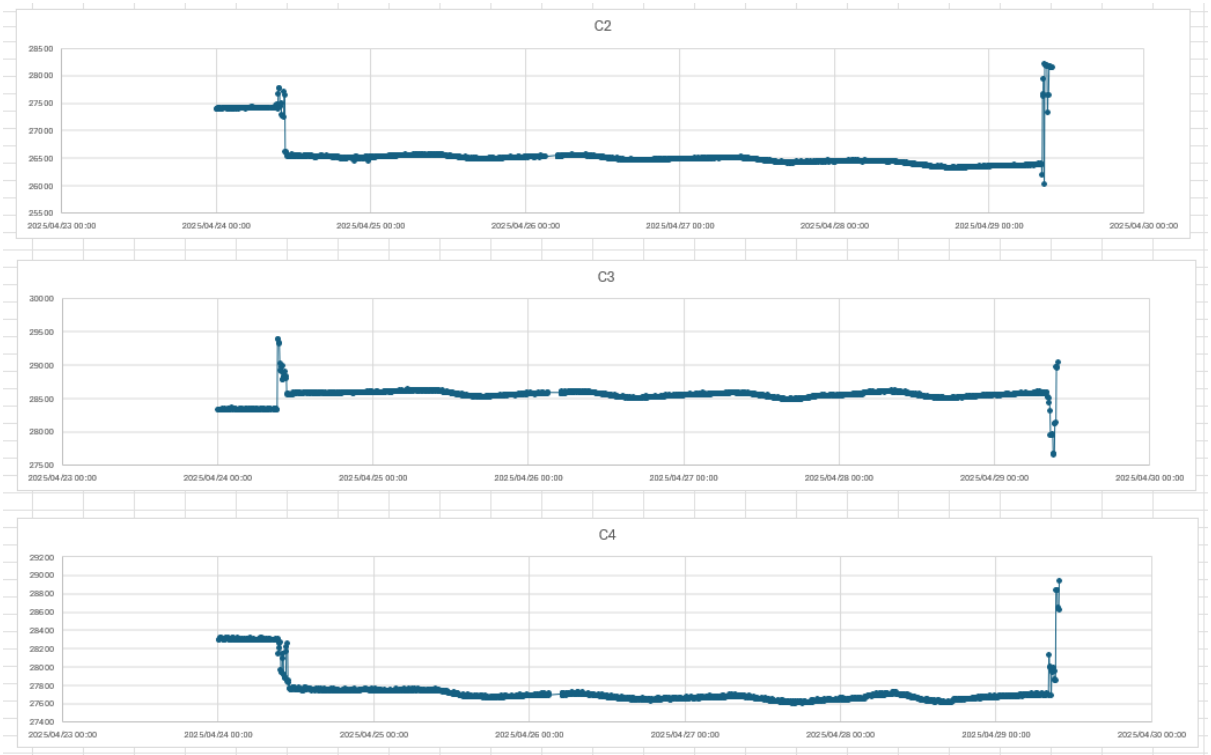
| | | |
|---|---|---|
| 3.39V | 1.528V | 1.528V |
| 3.18V | 1.426V | 1.426V |
| 3.07V | 1.376V | 1.376V |
| 3.00V | 1.342V | 1.342V |
| 2.89V | 1.292V | 1.292V |

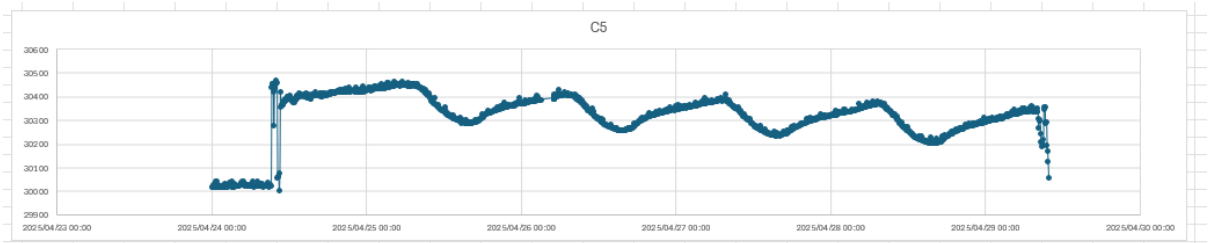
RS485 Serial Output voltage testing of different supply voltages

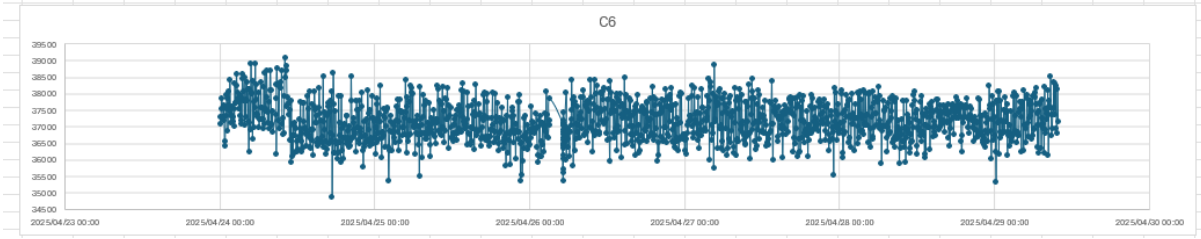
| Supply Voltage | Raw ADC value | MCU calculated Voltage |
|---|---|---|
| 4.21V | 2266 | 1.990V |
| 4.10V | 2204 | 1.931V |
| 3.99V | 2142 | 1.881V |
| 3.88V | 2081 | 1.828V |
| 3.78V | 2025 | 1.778V |
| 3.70V | 1987 | 1.745V |
| 3.59V | 1925 | 1.691V |
| 3.49V | 1852 | 1.627V |
| 3.28V | 1733 | 1.523V |
| 3.17V | 1674 | 1.471V |
| 3.10V | 1630 | 1.432V |
| 2.99V | 1571 | 1.380V |
| 2.89V | 1512 | 1.328V |

The output string was checked using the COM port on a laptop and the correct voltage for the battery was printed out.

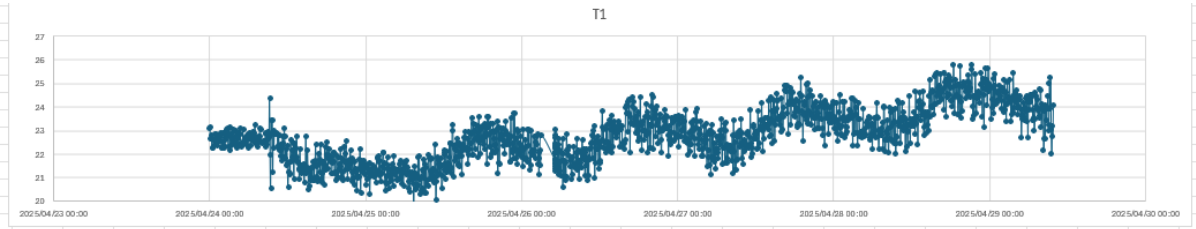
The battery voltage recorded is constant due to the Roman outputting 5V to the Probe.

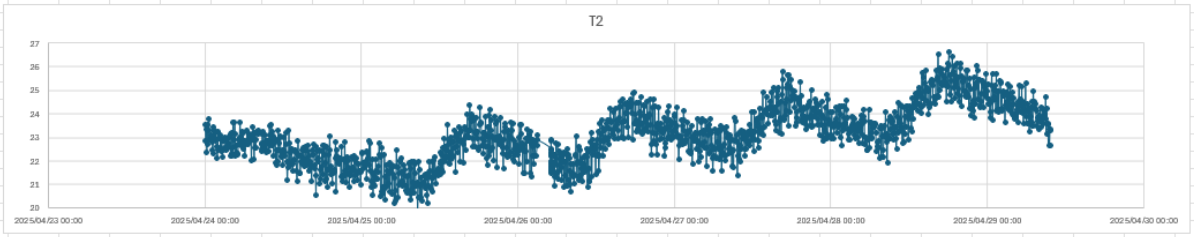


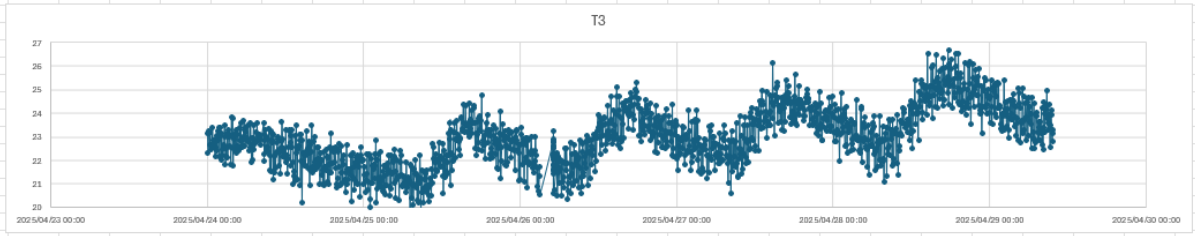


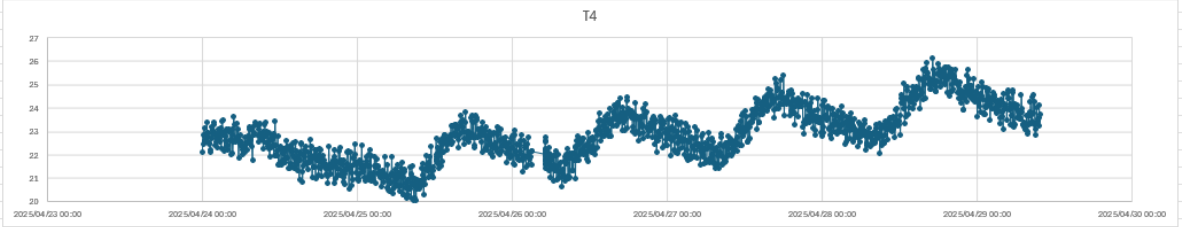



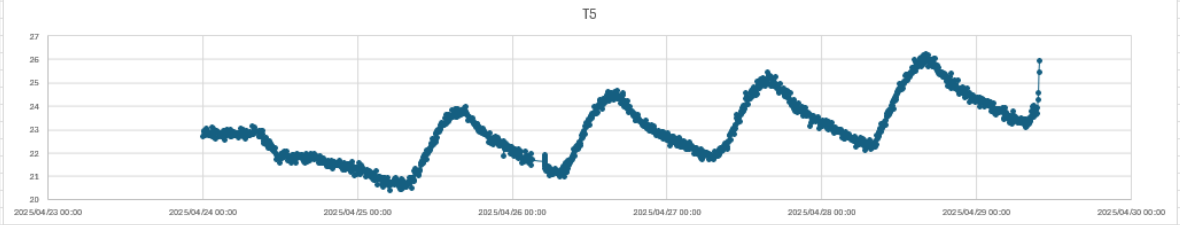

Below are the results of the temperature readings for the past 5 days.

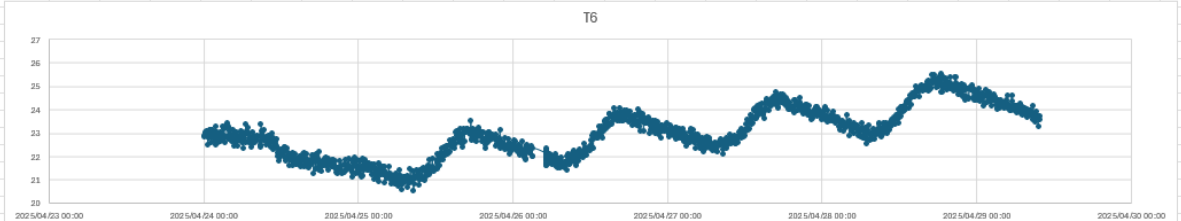


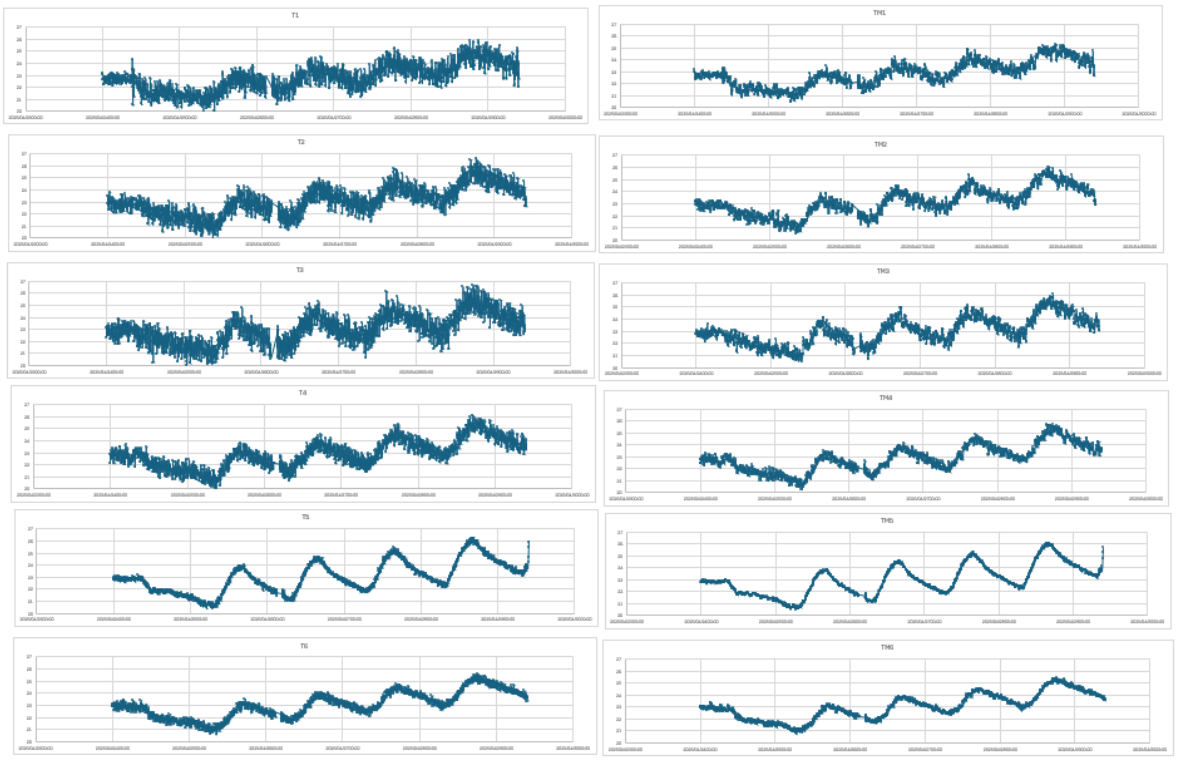



Temperature graphs with a moving average applied:

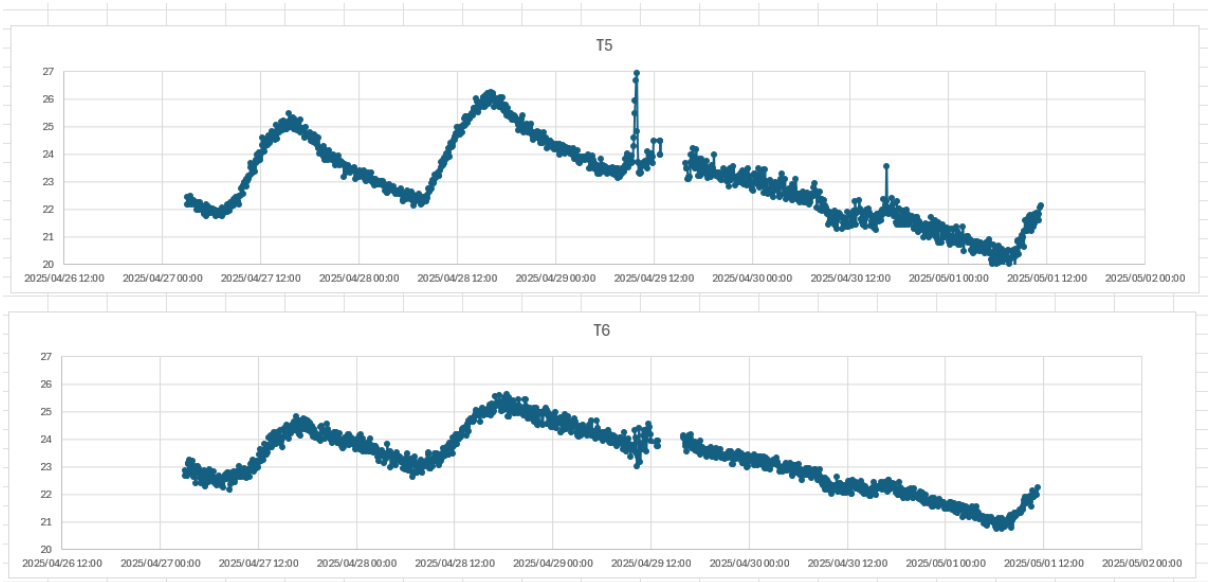


Changes to be made and tested.

Open Probe: Cables on sense rings 5 and 6 have been swapped.

01/05/2025

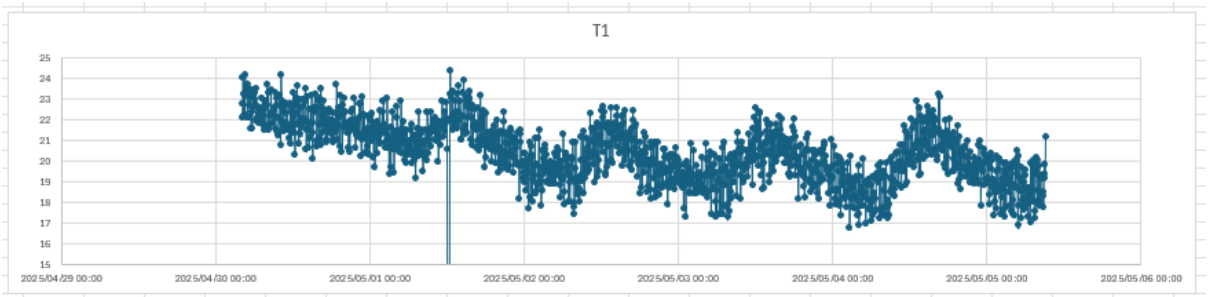
Below are the temperature readings from sense rings 5&6 after simply swapping the cables used between them it can be observed that the accuracy of sensor 6 improved and the accuracy of sensor 5 decreased.

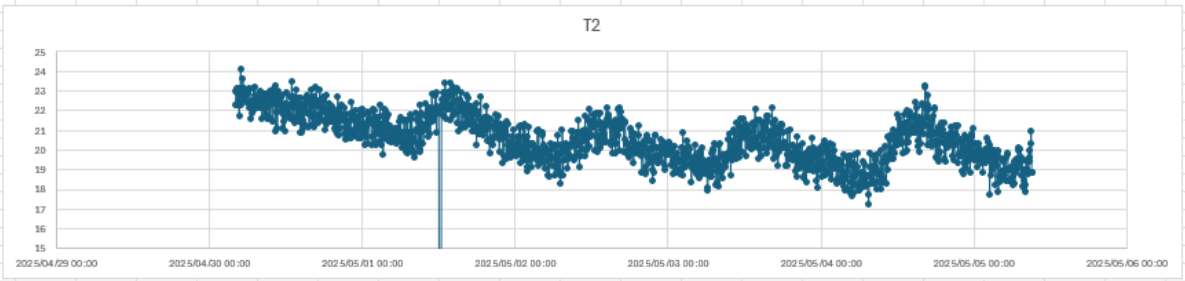


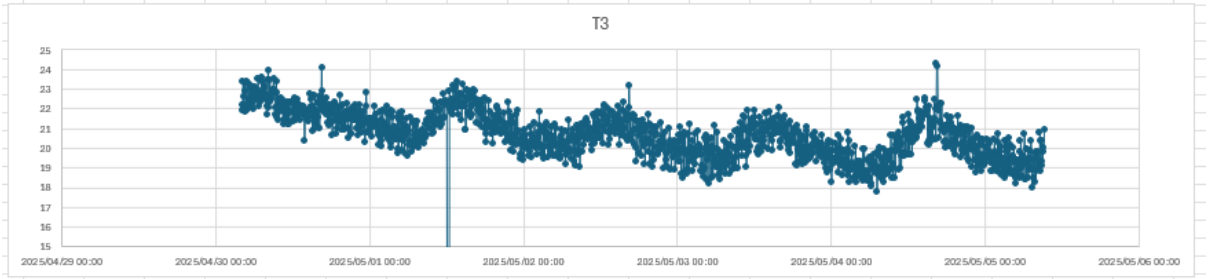
Changing all cable lengths to be the same length as the cable used for sense ring 6 that was plotted above. 01/05/2025 12:00.

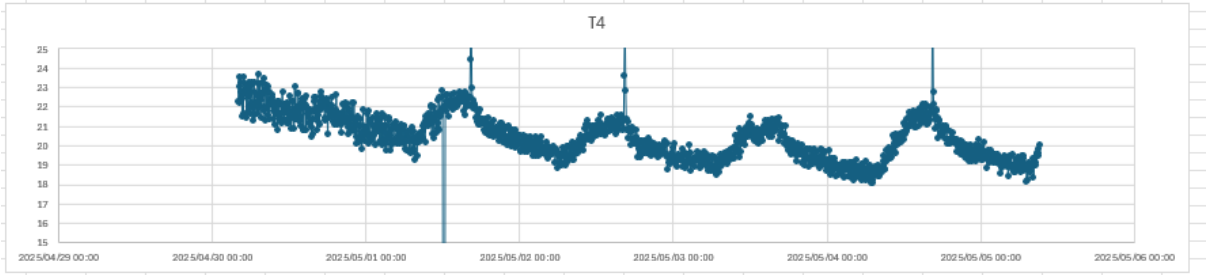
05/05/2025

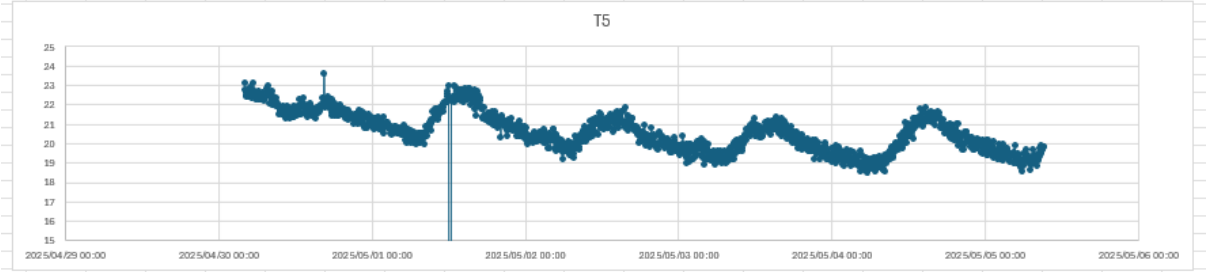
Plotting the data from the 01/05/2025 to 05/05/2025 in the below graphs. This shows that the wire length has a slight improvement influence on Temperature sense board 4, but on the other sense boards it has a negligible effect.

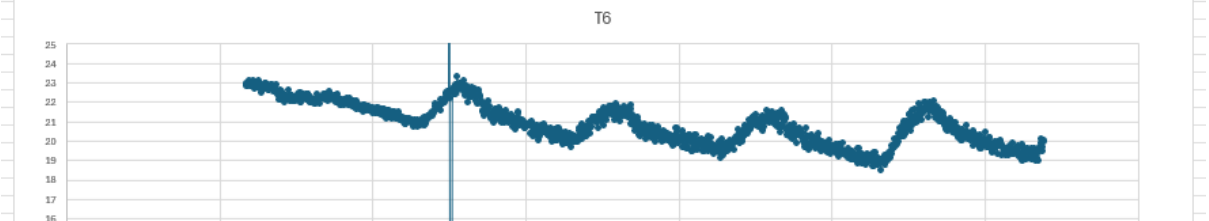


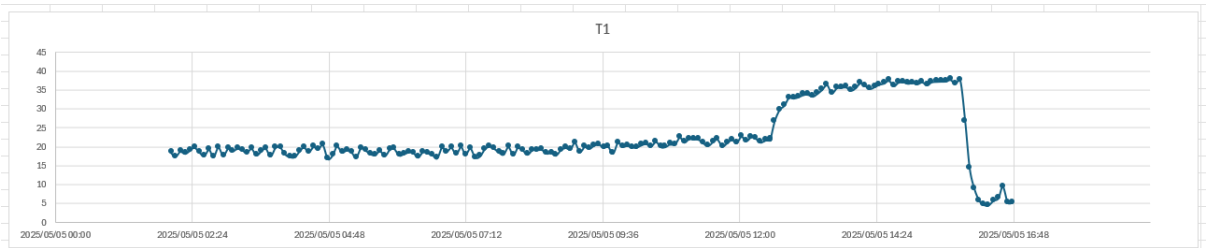
05/05/2025 10:00 Swapping of the sensors was done in accordance with the integration and test plan. Below is a table showing the newly moved positions of the different sense boards.

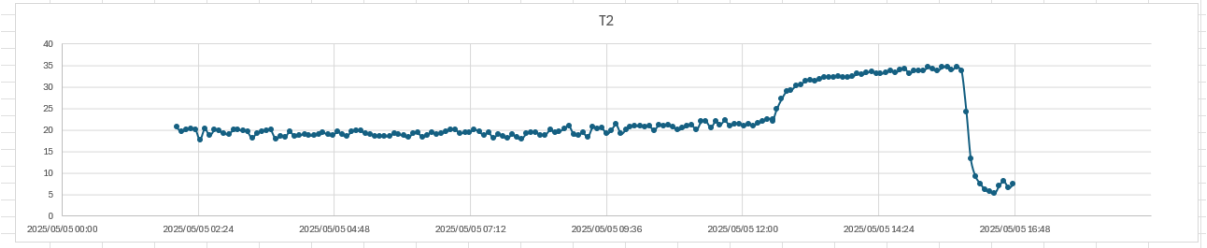
| Original Position | Moved Position |
|---|---|
| 6 | 1 |
| 5 | 3 |
| 4 | 2 |
| 3 | 5 |
| 2 | 4 |
| 1 | 6 |

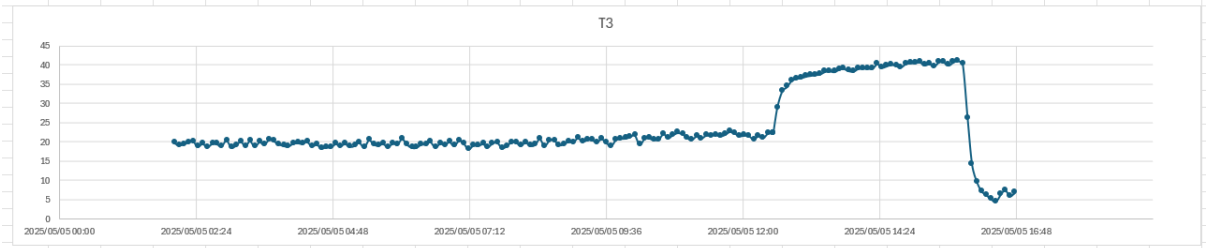
05/05/2025 12:22 added a canopy sensor to the test roman RL02291.

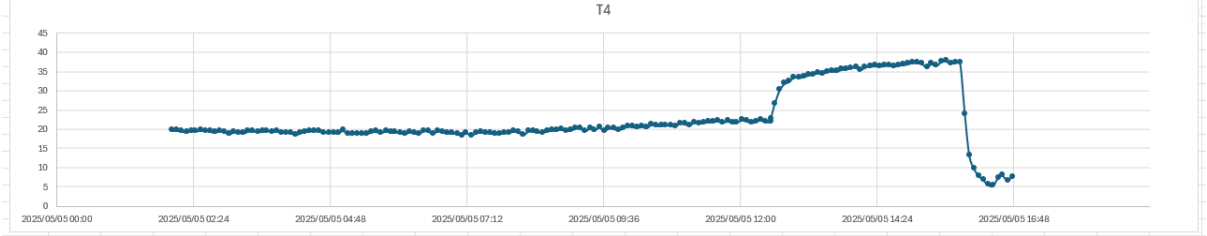
05/05/2025 12:33 Both the XP2 and the canopy sensor where placed into the hot box and it was switched on.

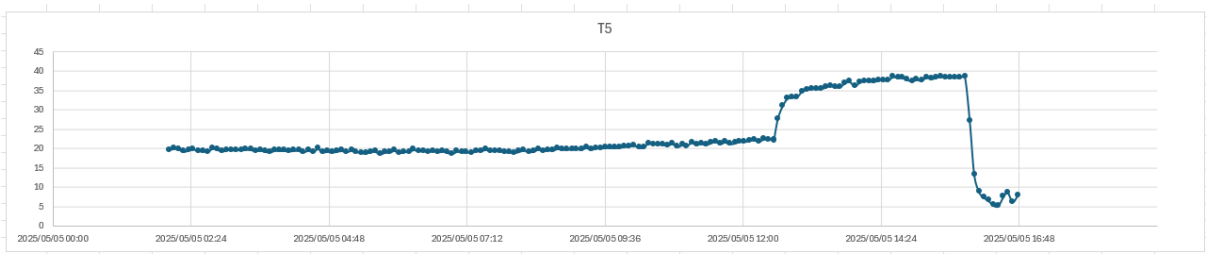
The graphs below were plotted after hours on the 05/05/2025

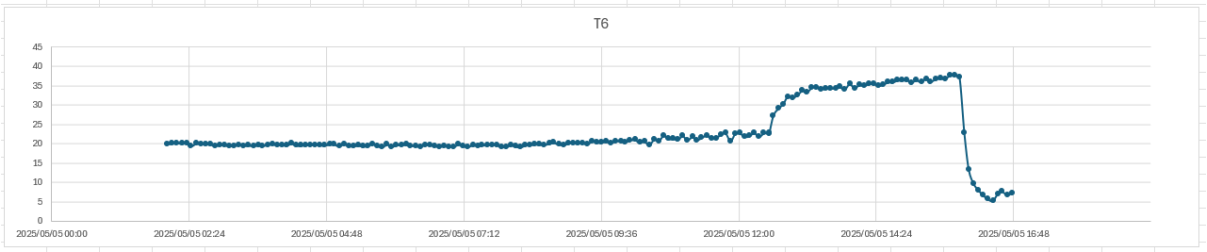


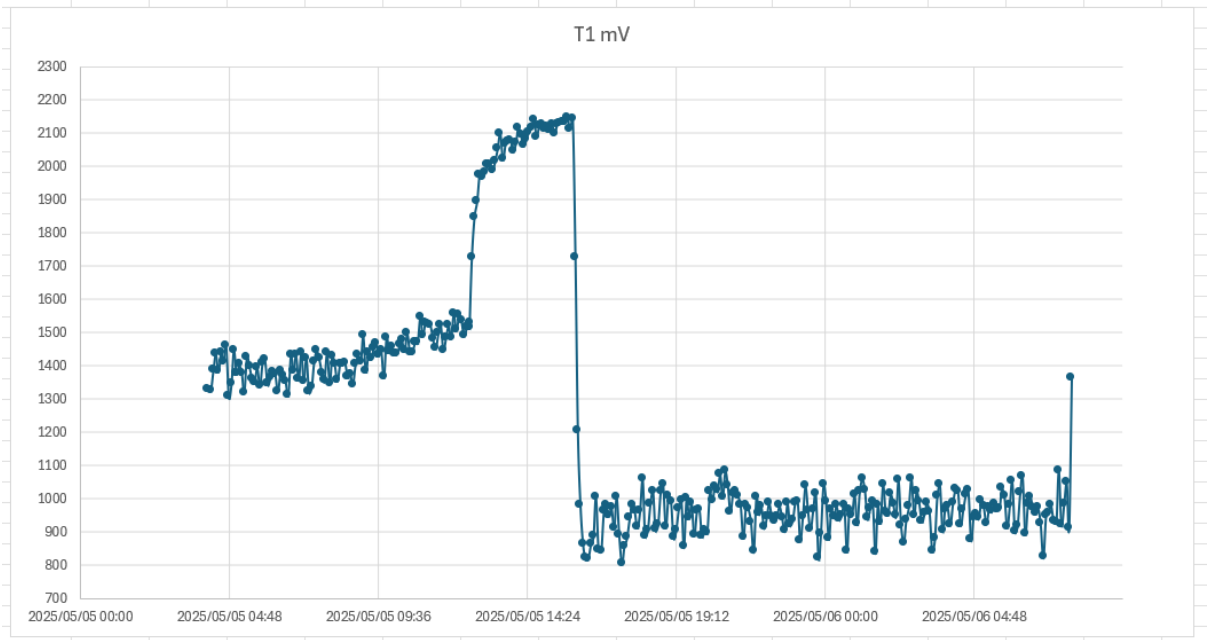



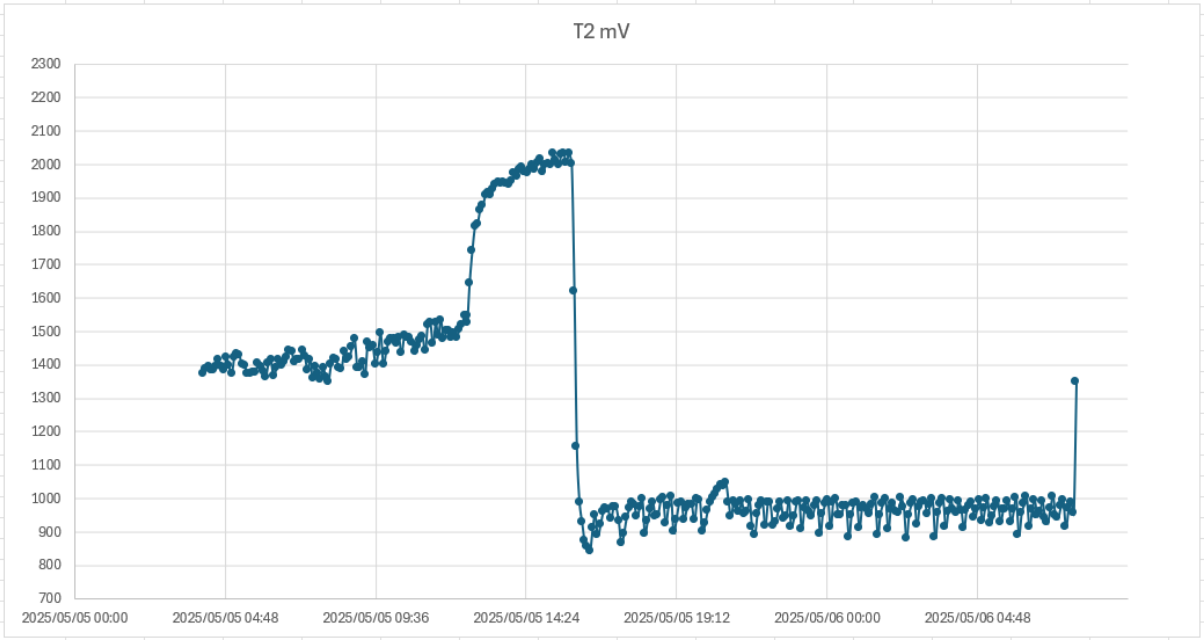


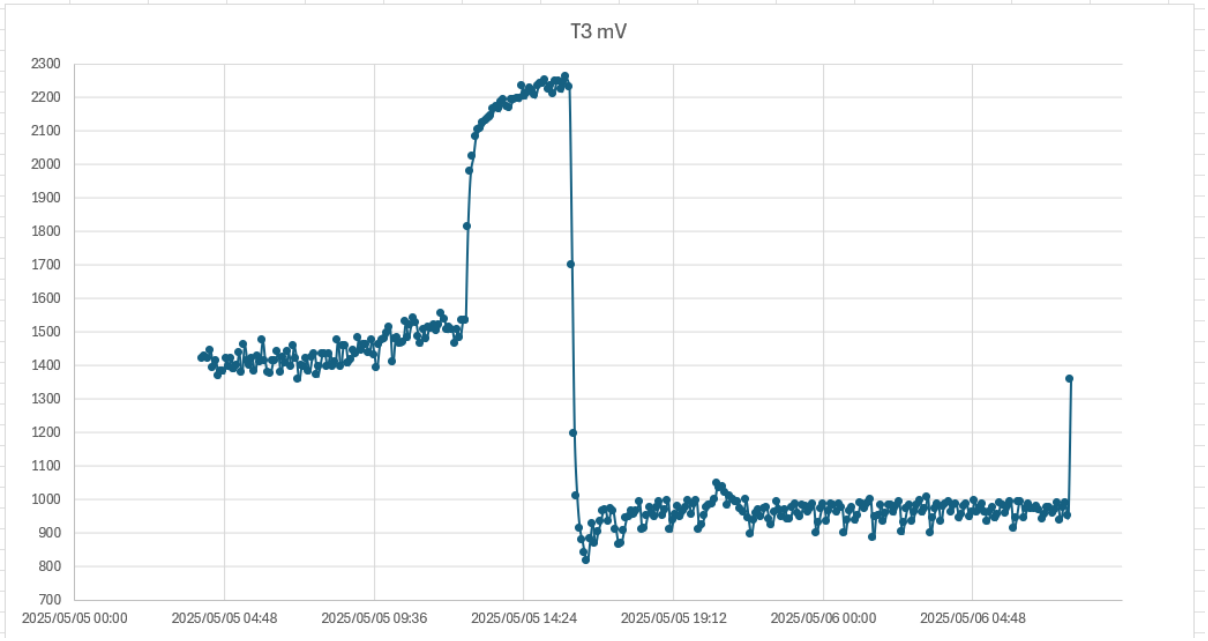



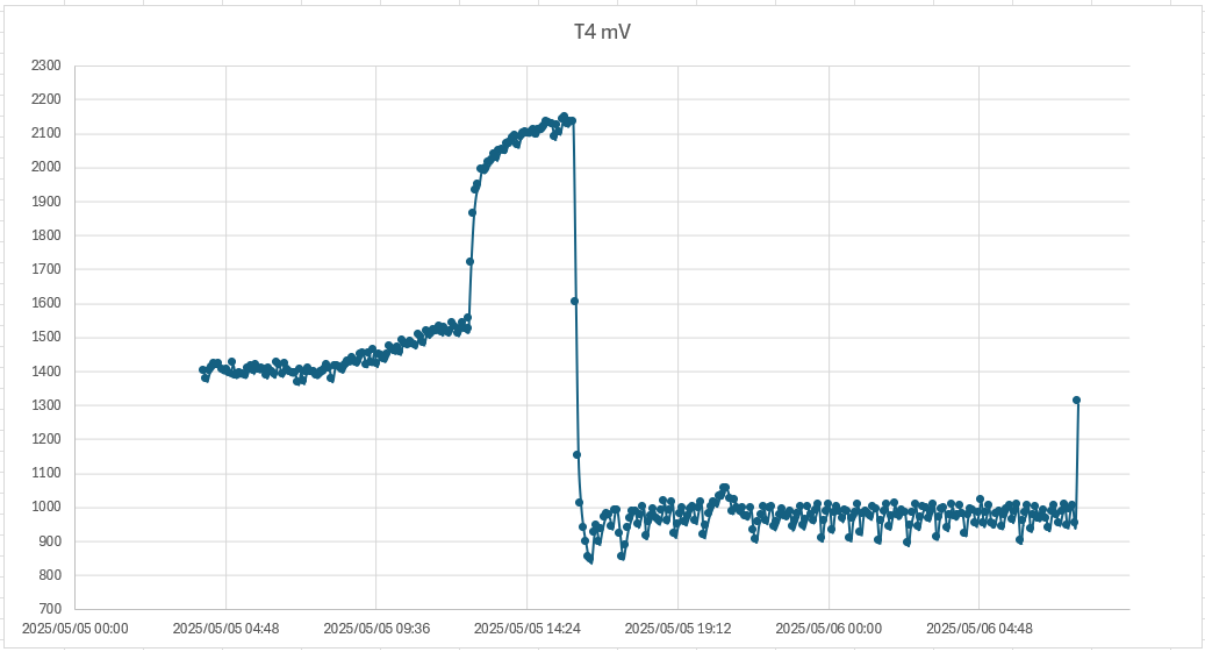

06/05/2025

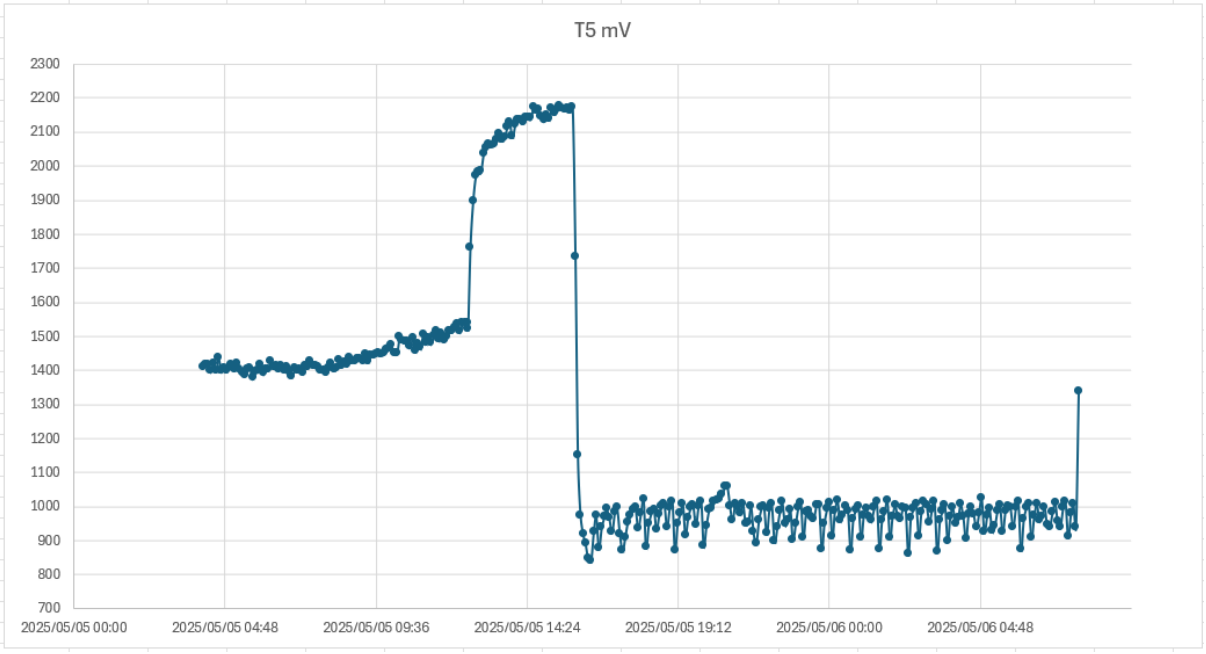
Plotted the graphs after swapping the sensors as described in the table above.

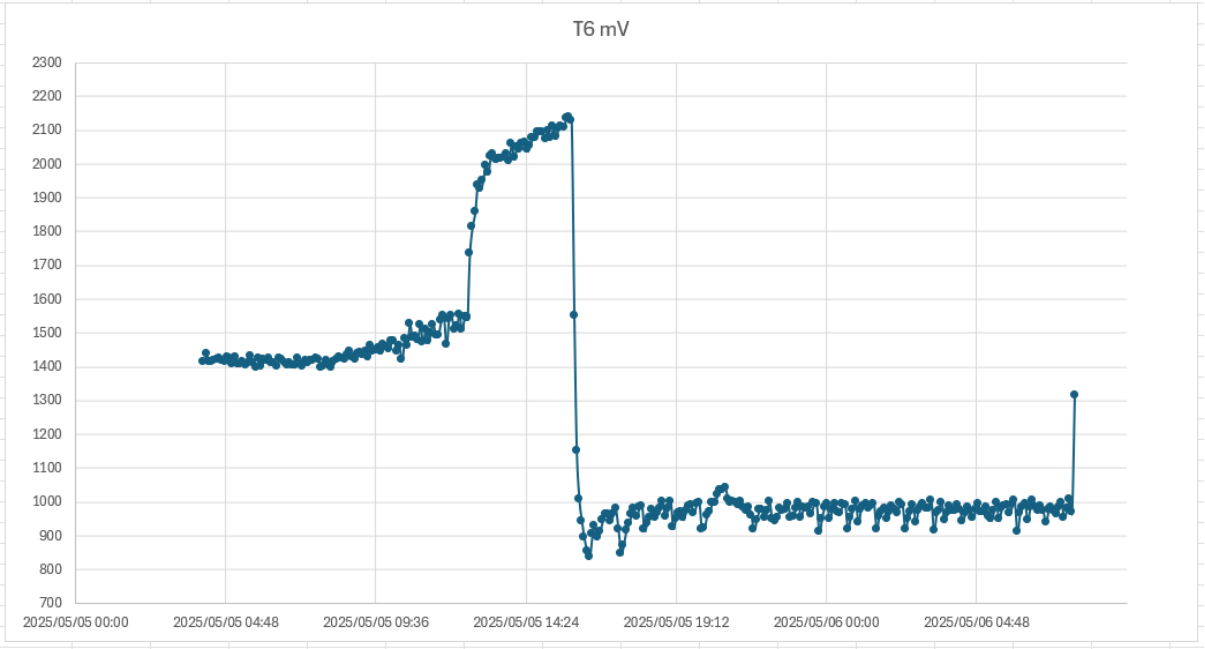



T2 mV
2300
2200
2100
2000
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
2025/05/05 00:00
2025/05/05 04:48
2025/05/05 09:36
2025/05/05 14:24
2025/05/05 19:12
2025/05/06 00:00
2025/05/06 04:48


T3 mV
2300
2200
2100
2000
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
2025/05/05 00:00
2025/05/05 04:48
2025/05/05 09:36
2025/05/05 14:24
2025/05/05 19:12
2025/05/06 00:00
2025/05/06 04:48

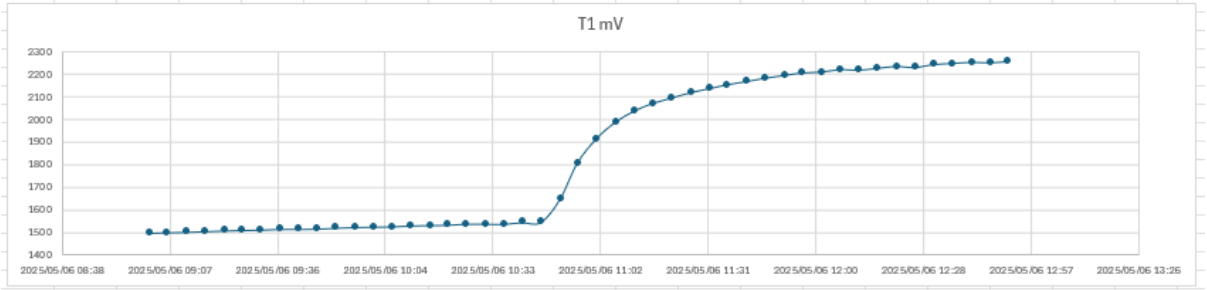

T4 mV
2300
2200
2100
2000
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
2025/05/05 00:00
2025/05/05 04:48
2025/05/05 09:36
2025/05/05 14:24
2025/05/05 19:12
2025/05/06 00:00
2025/05/06 04:48

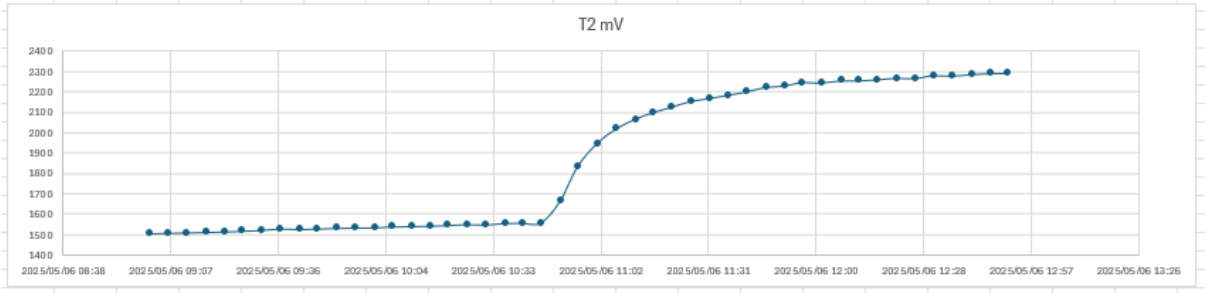


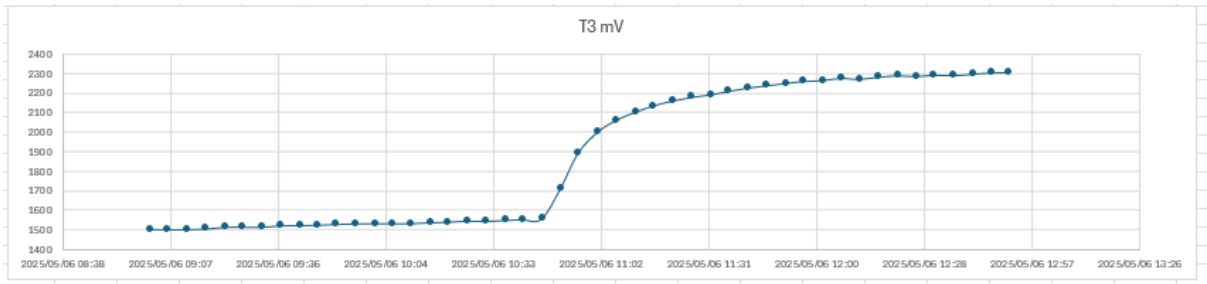



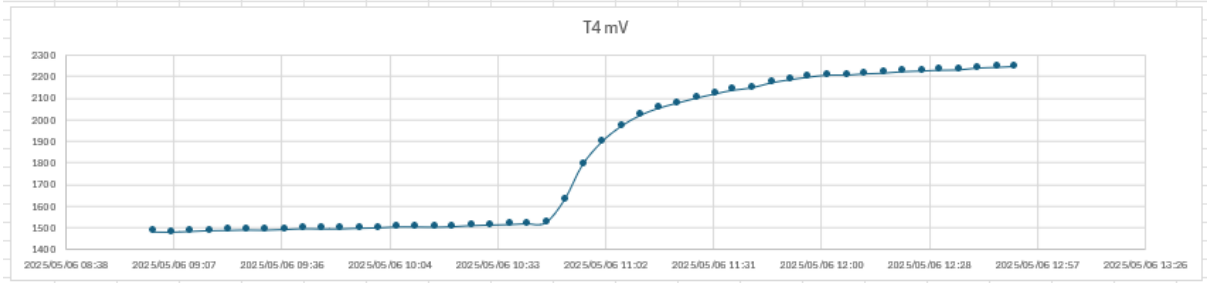

06/05/2025 09:00 All 6 sensors used in all the tests above are removed and replaced with 5 carefully built and tested sensors that do not have the RF(moisture detection circuitry built in).

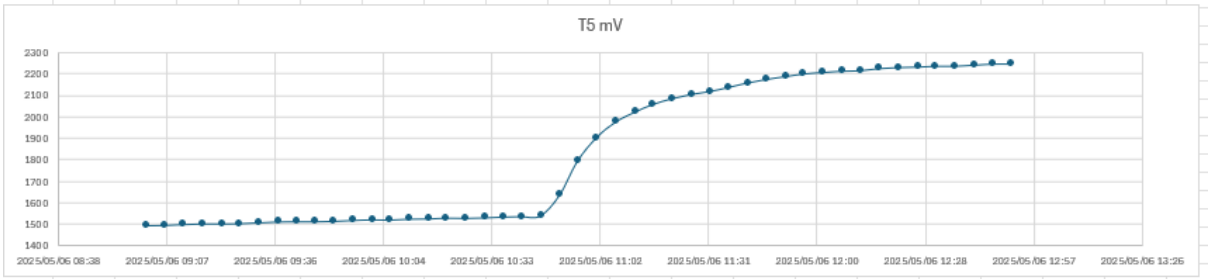
06/05/2025 Below shows the plotted graphs using the new sense boards that do not include RF:


T1 mV
2300
2200
2100
2000
1900
1800
1700
1600
1500
1400
2025/05/06 08:38
2025/05/06 09:07
2025/05/06 09:36
2025/05/06 10:04
2025/05/06 10:33
2025/05/06 11:02
2025/05/06 11:31
2025/05/06 12:00
2025/05/06 12:28
2025/05/06 12:57
2025/05/06 13:26


T2 mV
2400
2300
2200
2100
2000
1900
1800
1700
1600
1500
1400
2025/05/06 08:38
2025/05/06 09:07
2025/05/06 09:36
2025/05/06 10:04
2025/05/06 10:33
2025/05/06 11:02
2025/05/06 11:31
2025/05/06 12:00
2025/05/06 12:28
2025/05/06 12:57
2025/05/06 13:26


T3 mV
2400
2300
2200
2100
2000
1900
1800
1700
1600
1500
1400
2025/05/06 08:38
2025/05/06 09:07
2025/05/06 09:36
2025/05/06 10:04
2025/05/06 10:33
2025/05/06 11:02
2025/05/06 11:31
2025/05/06 12:00
2025/05/06 12:28
2025/05/06 12:57
2025/05/06 13:26


T4 mV
2300
2200
2100
2000
1900
1800
1700
1600
1500
1400
2025/05/06 08:38
2025/05/06 09:07
2025/05/06 09:36
2025/05/06 10:04
2025/05/06 10:33
2025/05/06 11:02
2025/05/06 11:31
2025/05/06 12:00
2025/05/06 12:28
2025/05/06 12:57
2025/05/06 13:26


T5 mV
2300
2200
2100
2000
1900
1800
1700
1600
1500
1400
2025/05/06 08:38
2025/05/06 09:07
2025/05/06 09:36
2025/05/06 10:04
2025/05/06 10:33
2025/05/06 11:02
2025/05/06 11:31
2025/05/06 12:00
2025/05/06 12:28
2025/05/06 12:57
2025/05/06 13:26

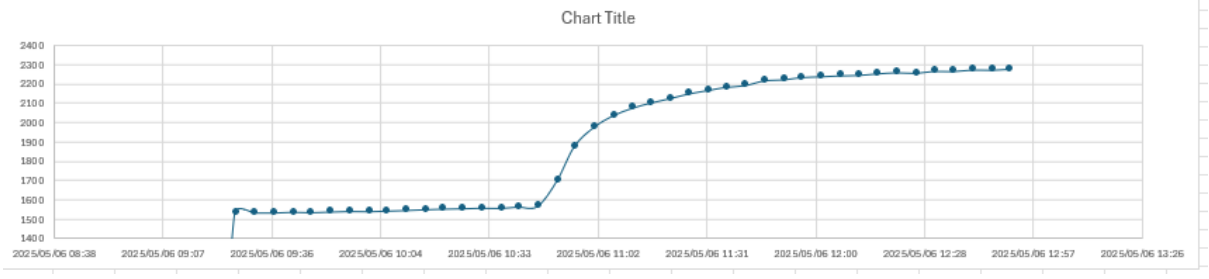


Chart Title
2400
2300
2200
2100
2000
1900
1800
1700
1600
1500
1400
2025/05/06 08:38
2025/05/06 09:07
2025/05/06 09:36
2025/05/06 10:04
2025/05/06 10:33
2025/05/06 11:02
2025/05/06 11:31
2025/05/06 12:00
2025/05/06 12:28
2025/05/06 12:57
2025/05/06 13:26

06/05/2025

Picoscope readings of sense boards temperatures:

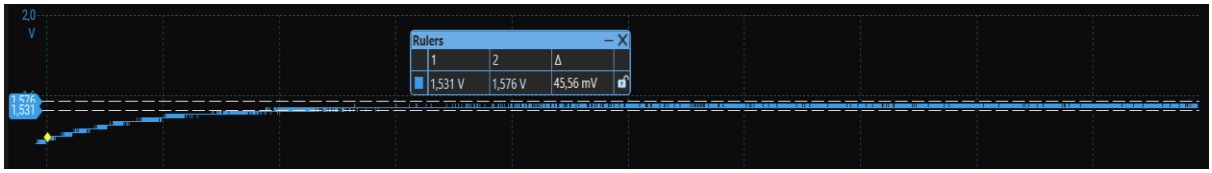



*Figure 1 No RF board*

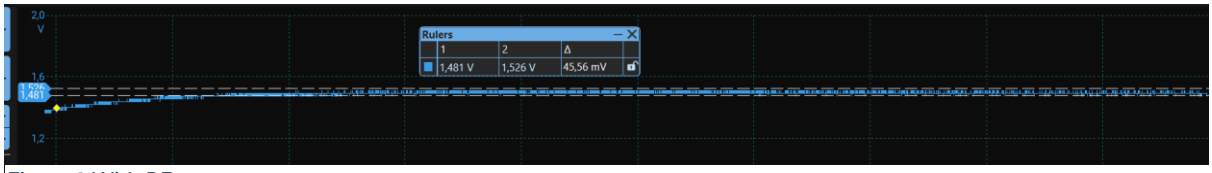



*Figure 2 With RF*

06/05/2025

Swapping Sensor 3 with a sensor that has an oscillator (15:55)

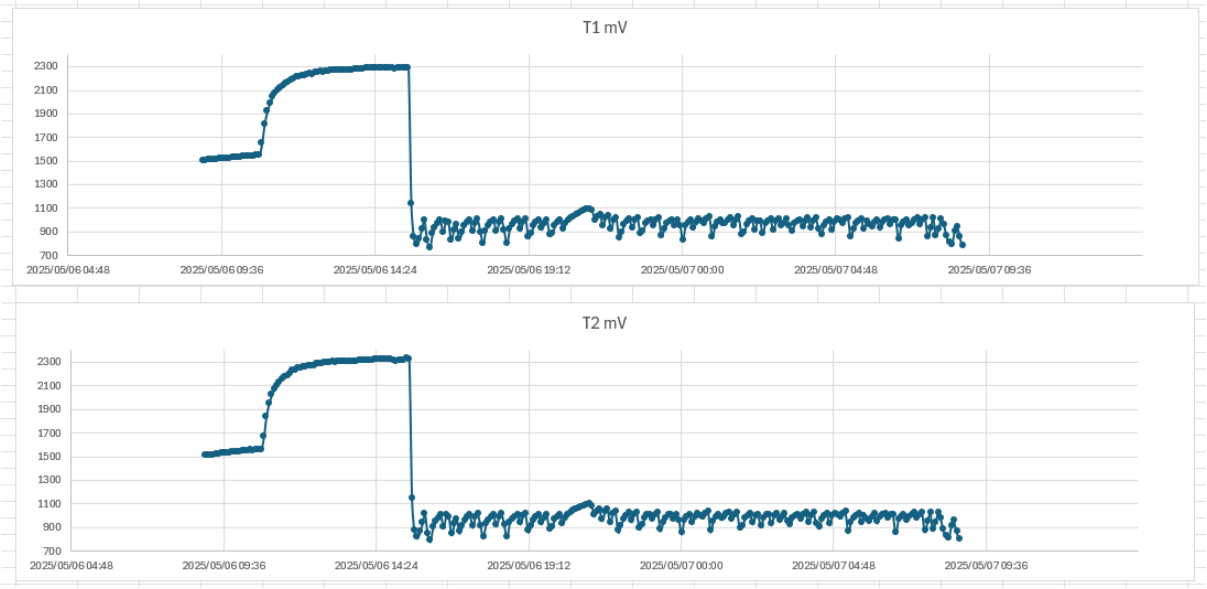
Observation: Looking at the graphs plotted on the 06/05/2025, it shows that the temperature sensing and ADC of the microcontroller has the potential to be extremely accurate and within the required specification for the product. Furthermore it proves that the NTC thermistor and associated circuitry is functional.

Suggested measures to mitigate the in accurate temperature readings:

- Use a 5-pin connector and a control wire to a switch or demultiplexer on the sense board (in effect switching the temperature measuring circuit on while the moisture sensing circuit remains off) to ensure an accurate temperature reading can be taken.
- Use a RC circuit that delays the switching on of the high frequency moisture sensing circuit so that an accurate temperature reading can be taken.
- RF shielding used to mitigate the high frequency RF from causing inaccurate readings of the temperature.

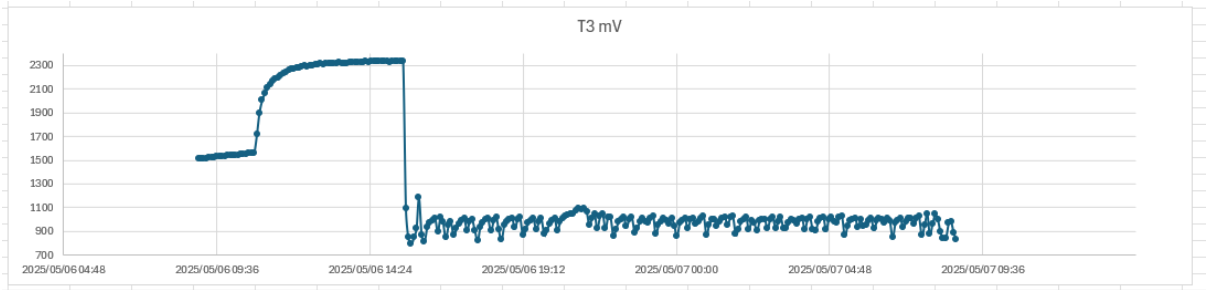
07/05/2025

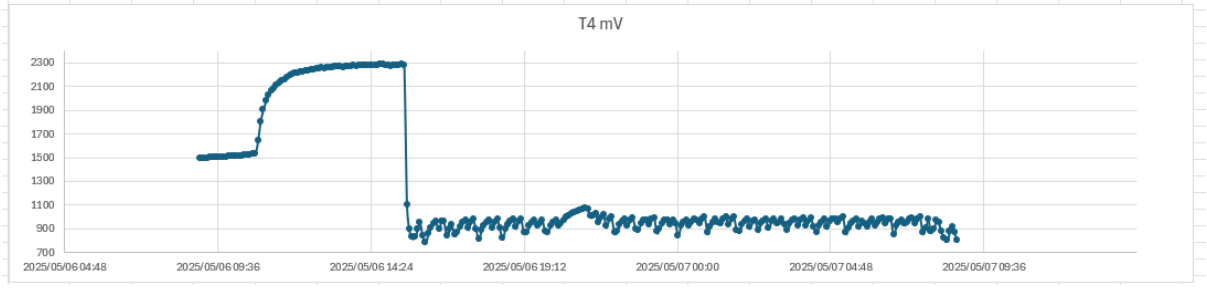
Plotting the data for the last day which includes the swapping of sensor 3 with a unit that oscillates;

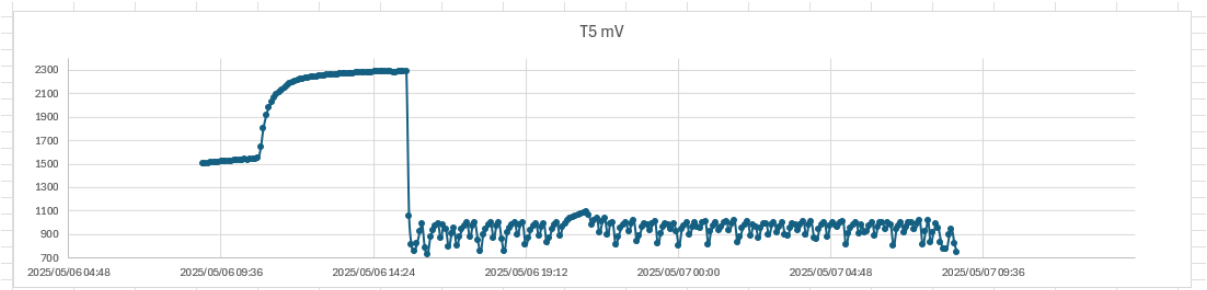


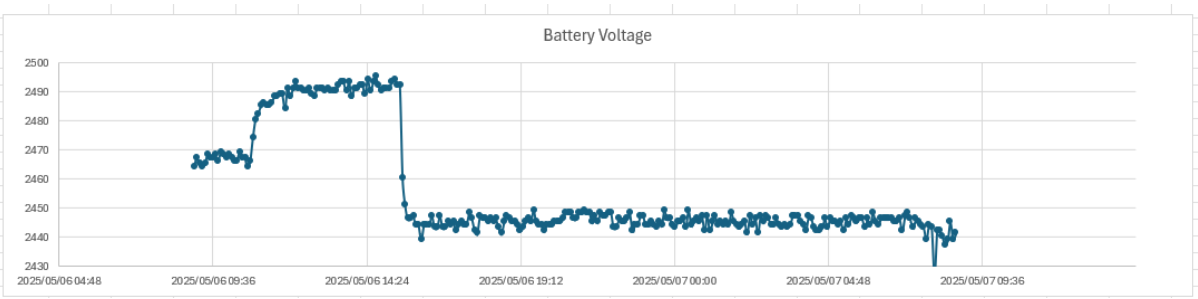




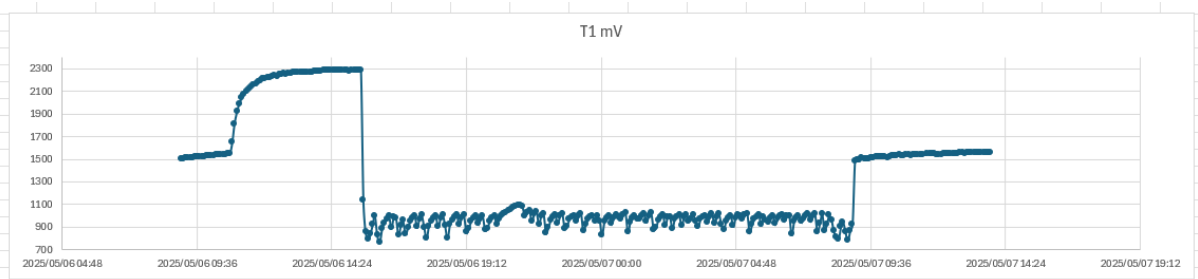


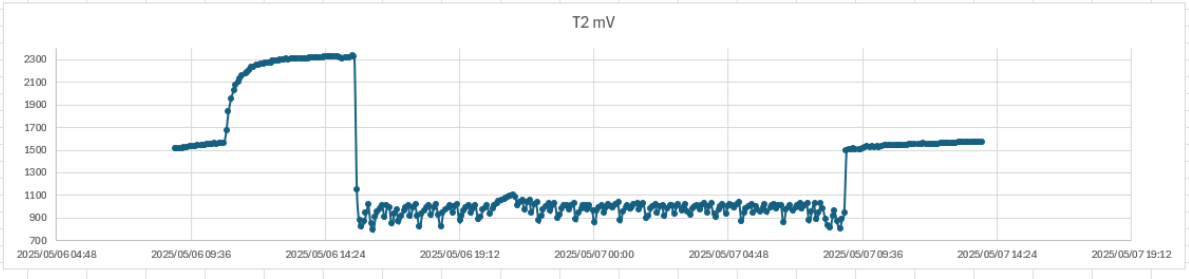



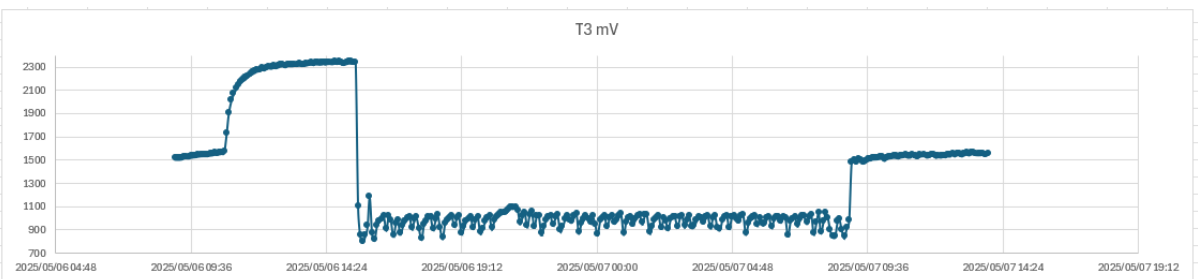



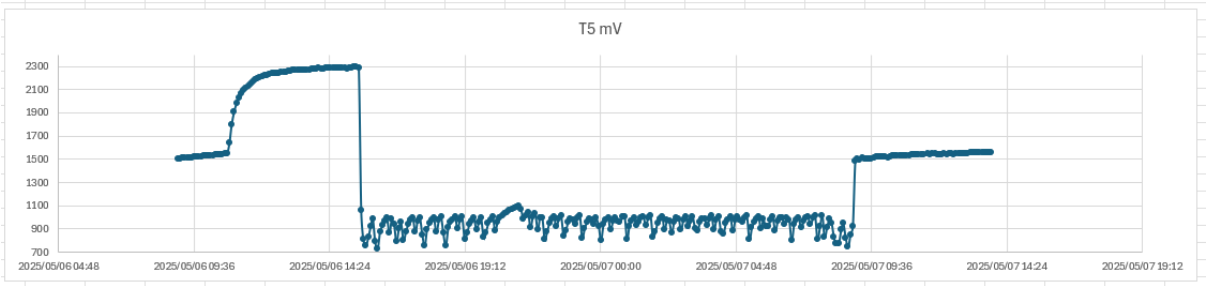



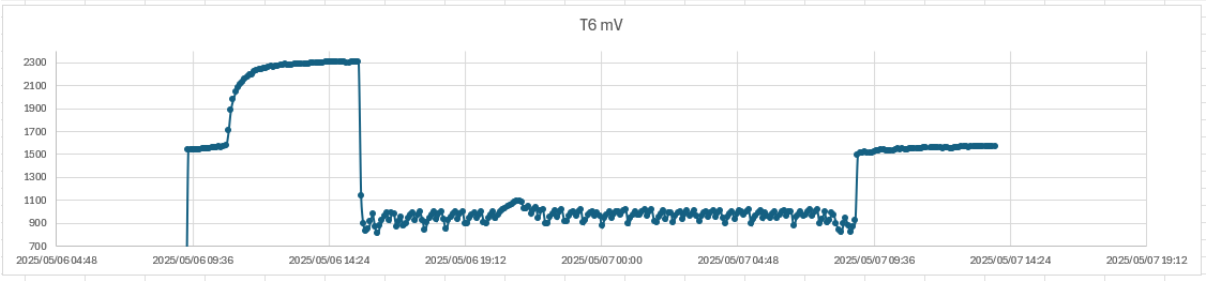

The readings below were taken on the 07/05/2025 and are of 5 non RF sense boards and 1 RF sense board at position 3.



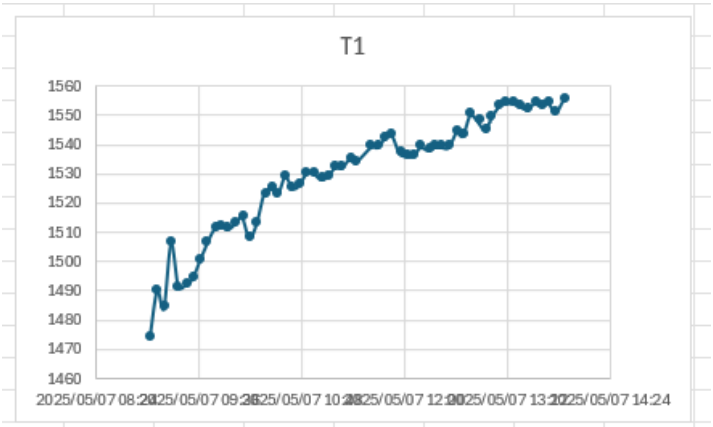



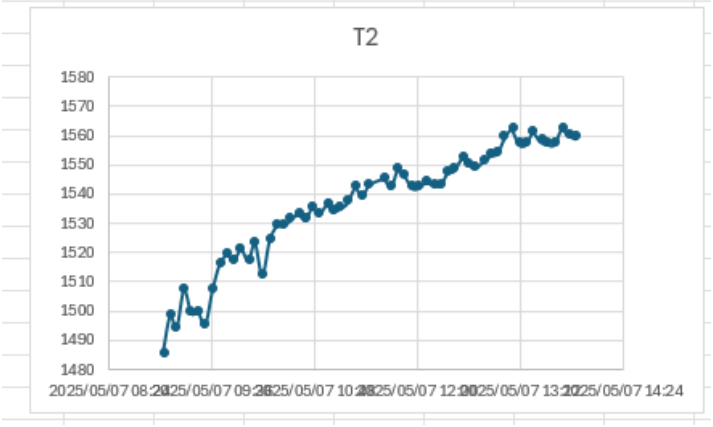



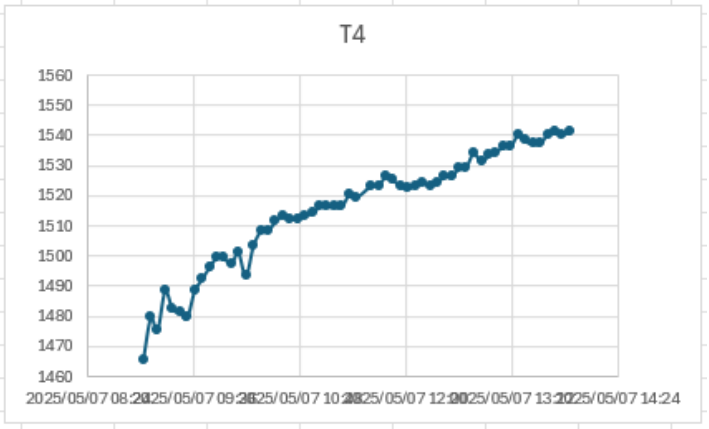



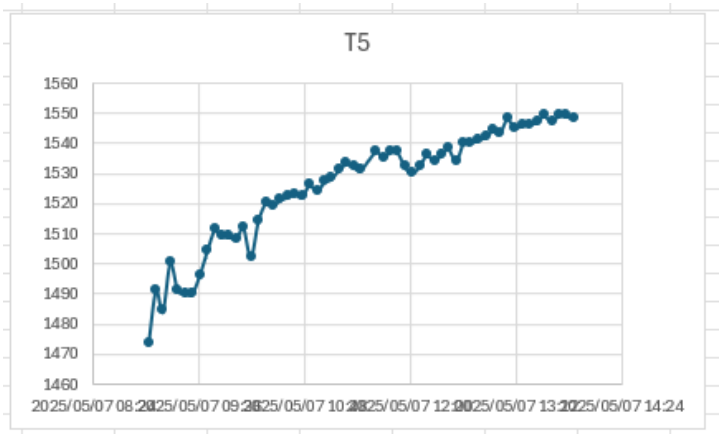

Below is a close-up of the above readings after being taken out of the fridge

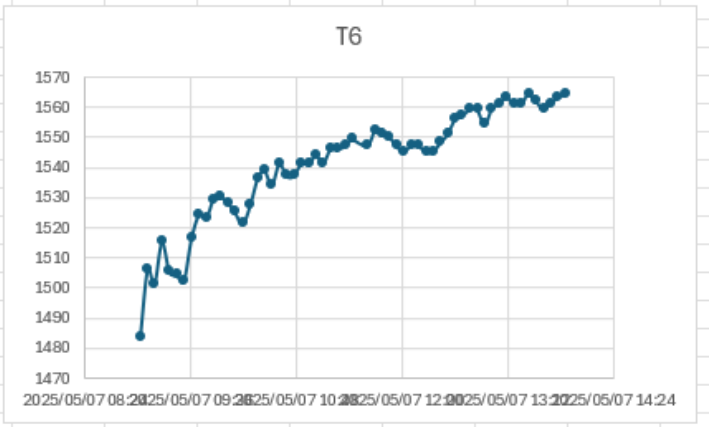








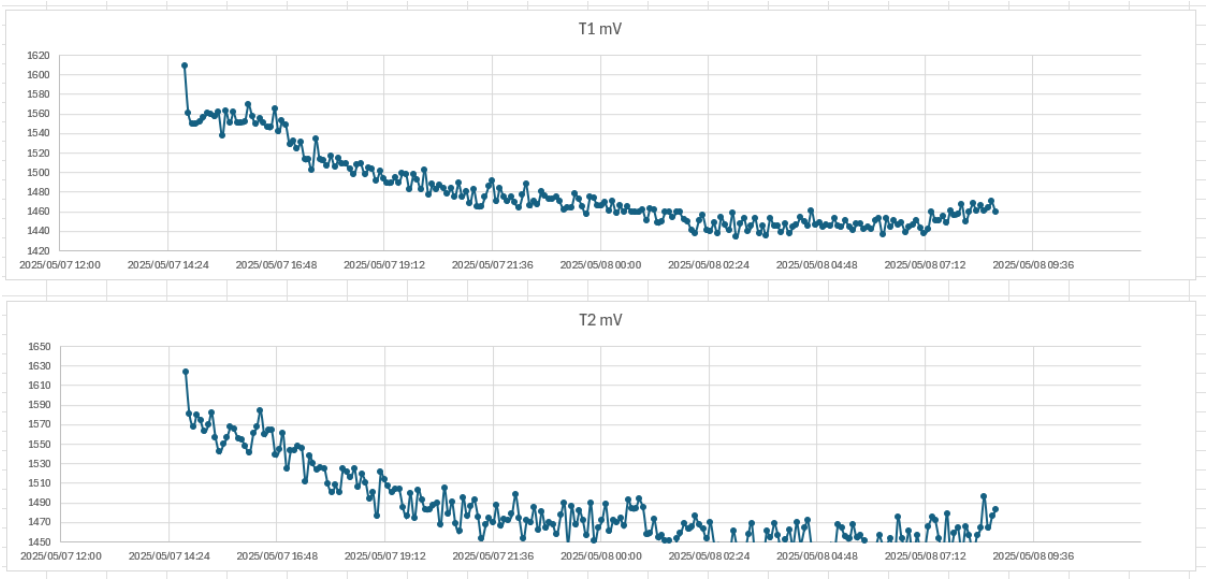



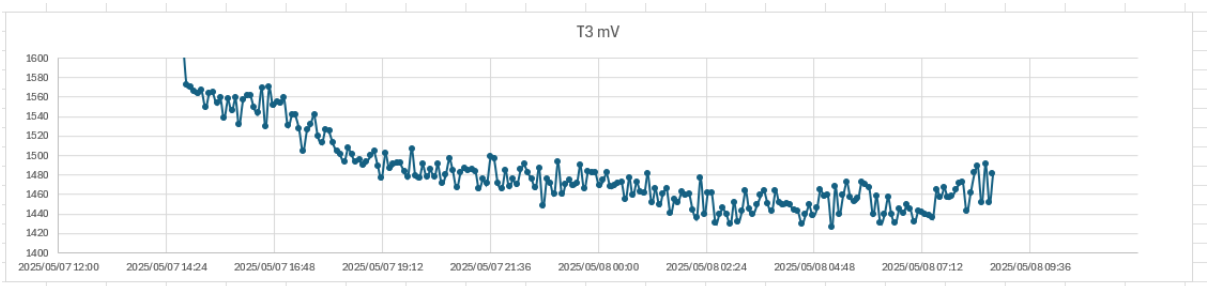

07/05/2025 14:30 the old sense boards with RF and rings was put back onto XP2 (the open probe) with the firmware reversing the order that the measurements are taken.

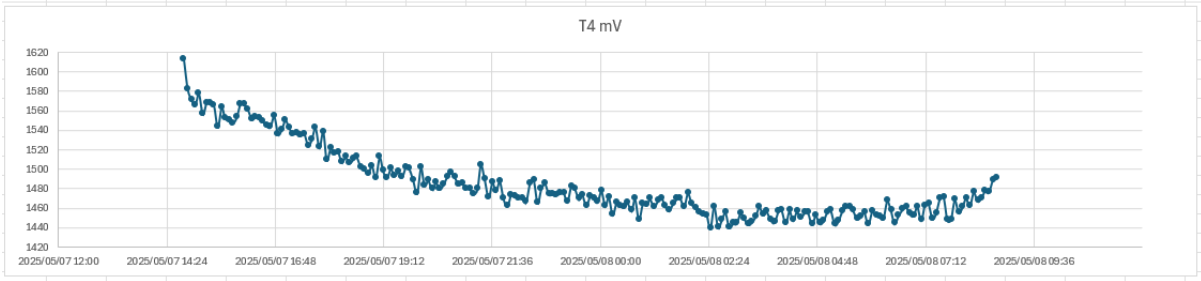
08/05/2025

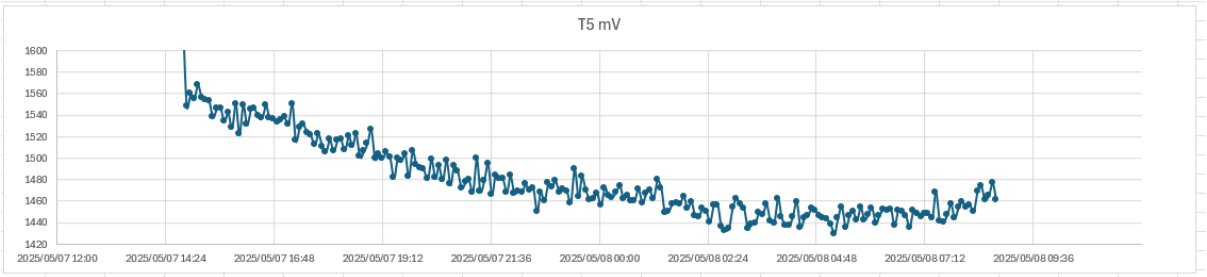
Plotting the results for the above mentioned change.

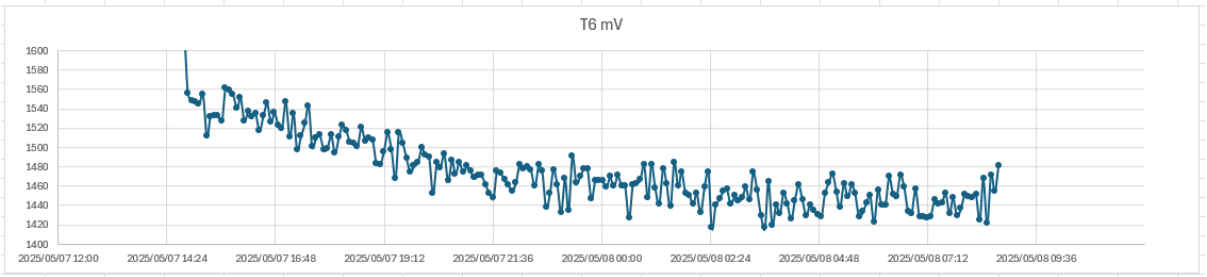
Observations, no tangible result can be concluded from the reversal of the order of measurements taken. I am unsure if this is related to poor manufacturing of the sense boards or RF noise being picked up by the temperature sensing circuit.






08/05/2025

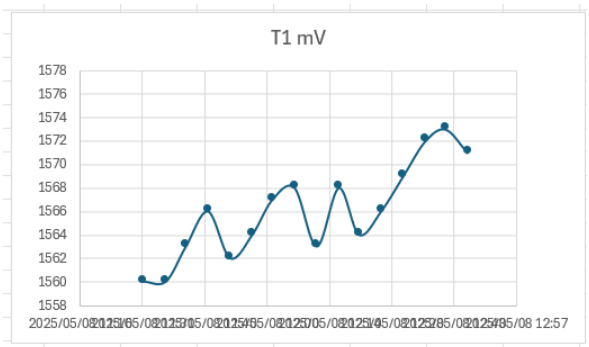
Solder on noise cancelling 100nF capacitors onto the ADC data line for each sense board connection.

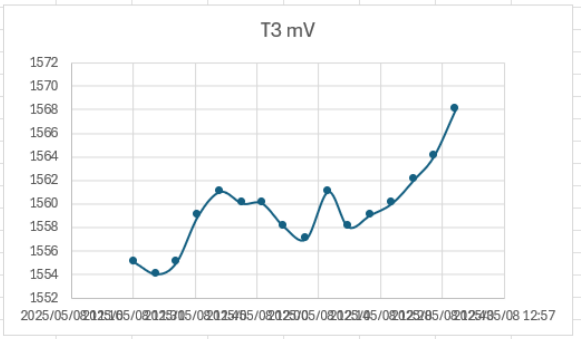
Replace and check temperature sensing circuits on the currently running sense boards (Replace all the ntcs)

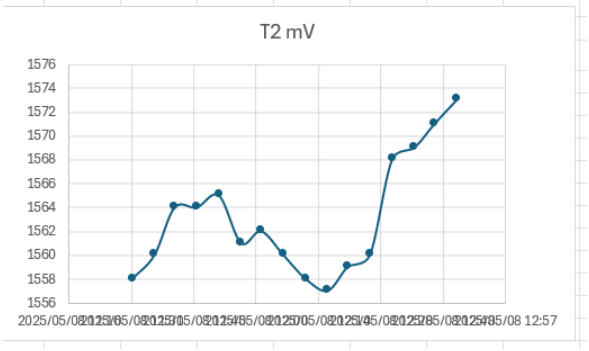
08/05/2025

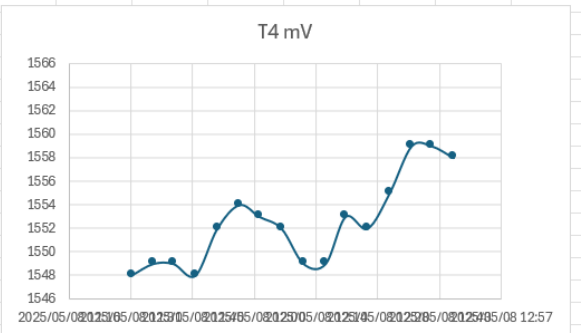
Preliminary results from the noise filtering capacitors and new Thermistors soldered on are shown below:

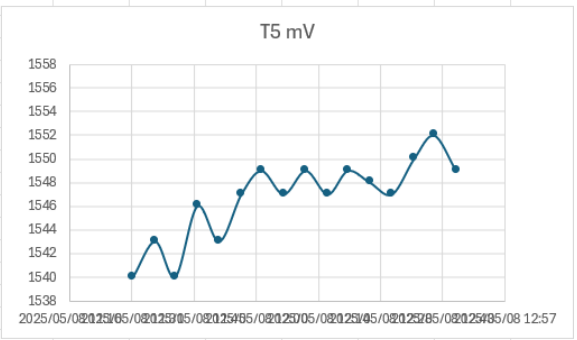
Observation: The results are very stable, with the largest jump being 8mV across all the sensors.

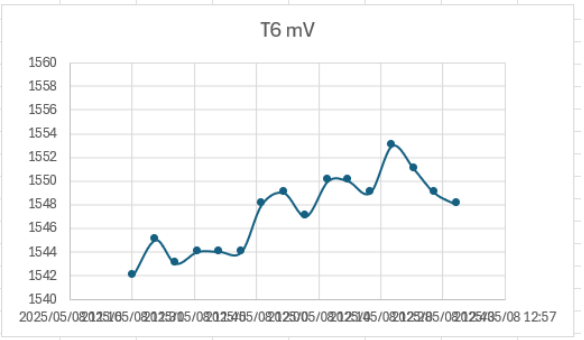

T1 mV
1578
1576
1574
1572
1570
1568
1566
1564
1562
1560
1558
2025/05/08 12:57


T3 mV
1572
1570
1568
1566
1564
1562
1560
1558
1556
1554
1552
2025/05/08 12:57

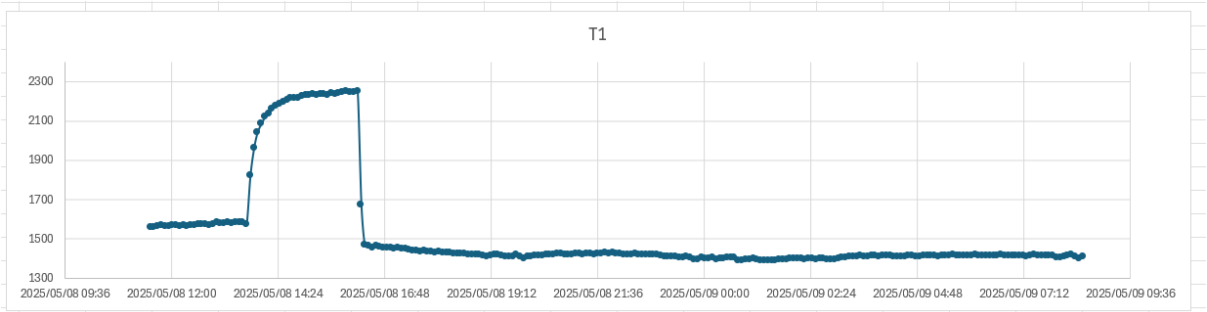

T2 mV
1576
1574
1572
1570
1568
1566
1564
1562
1560
1558
1556
2025/05/08 12:57

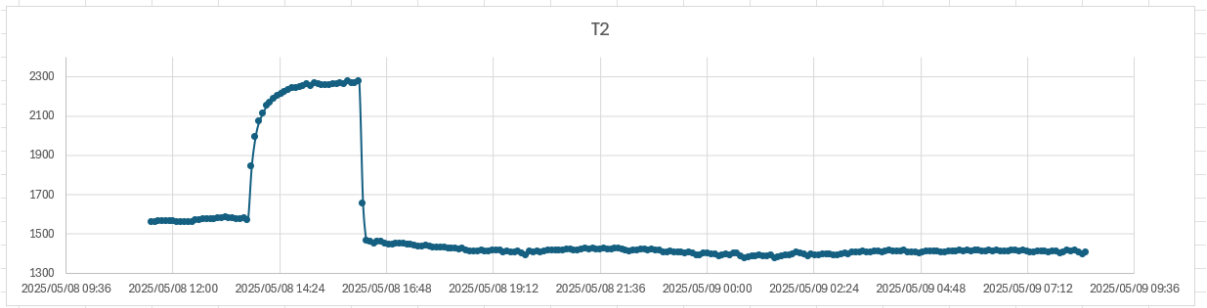

T4 mV
1566
1564
1562
1560
1558
1556
1554
1552
1550
1548
1546
2025/05/08 12:57

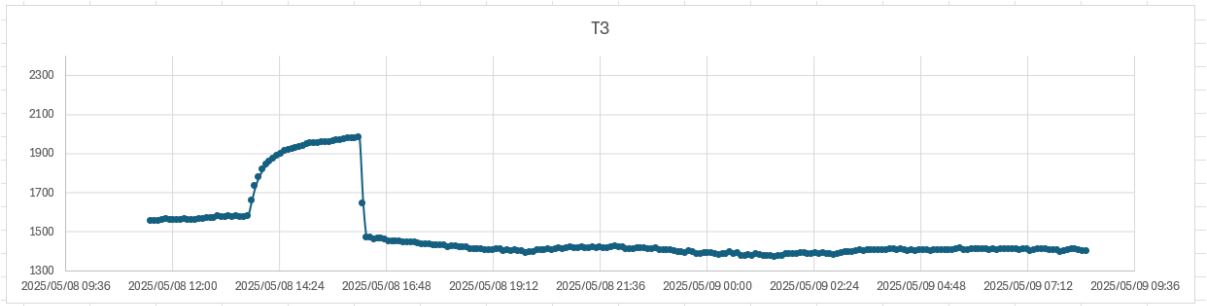

T5 mV
1558
1556
1554
1552
1550
1548
1546
1544
1542
1540
1538
2025/05/08 12:57

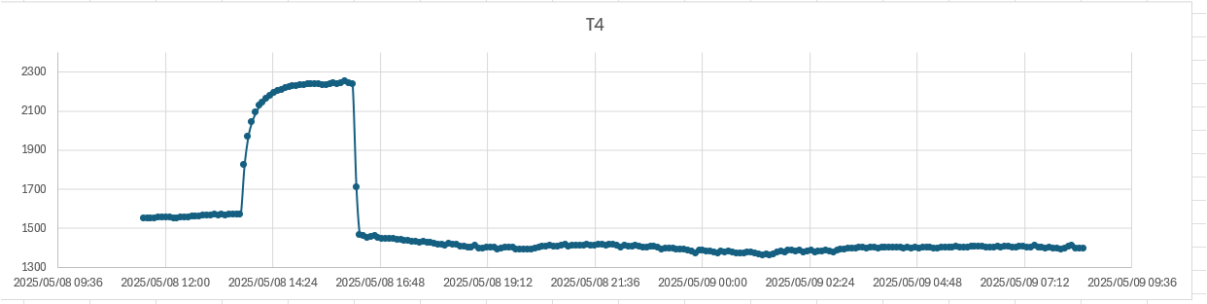

T6 mV
1560
1558
1556
1554
1552
1550
1548
1546
1544
1542
1540
2025/05/08 12:57

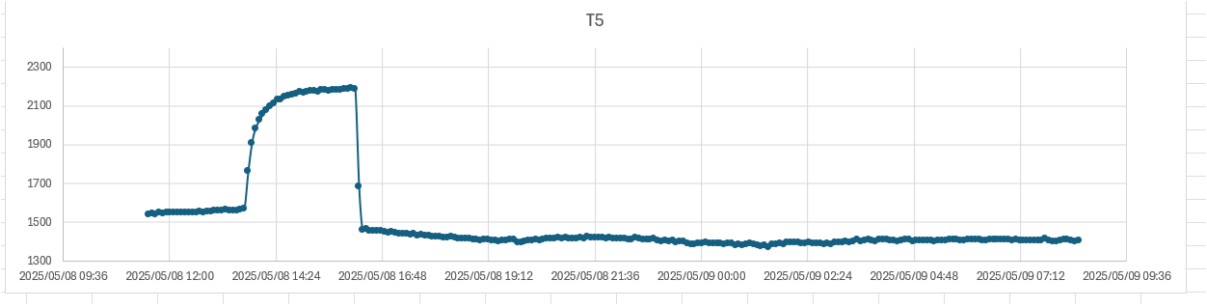
09/05/2025 data plotted for the previous half day and night.

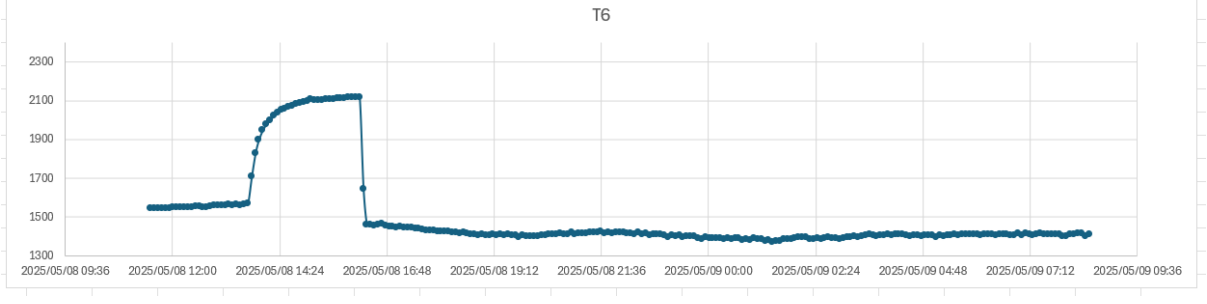


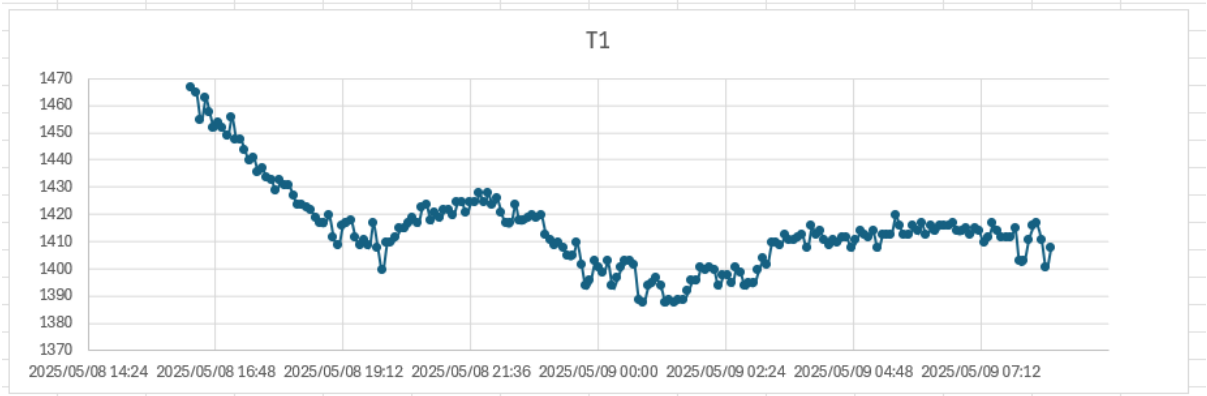



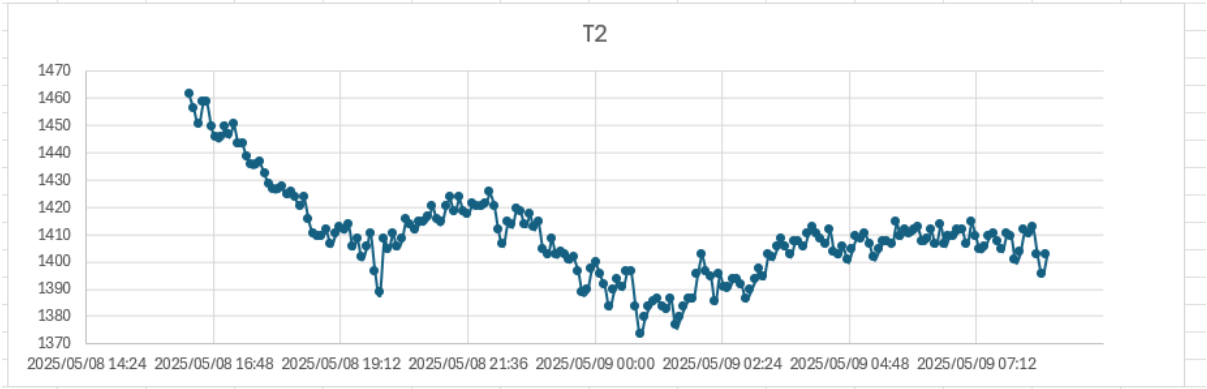



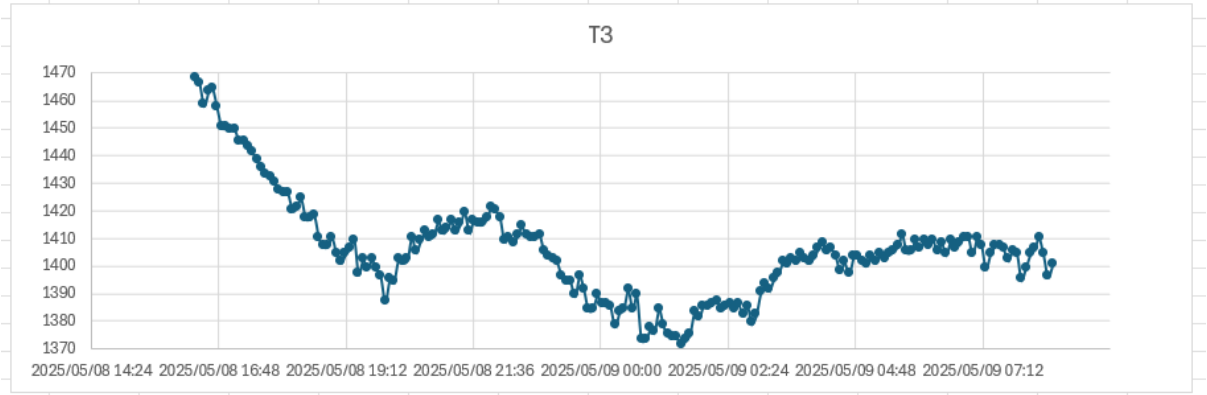



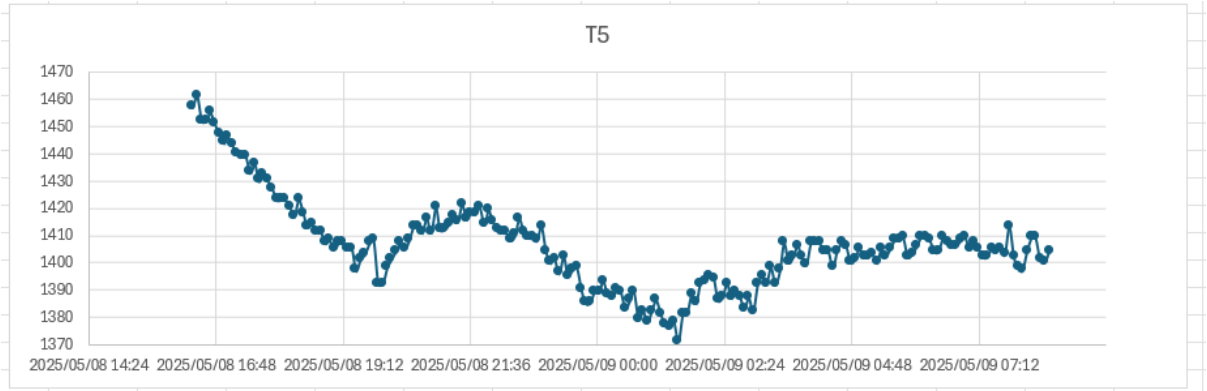
Data plotted for just the night portion below:

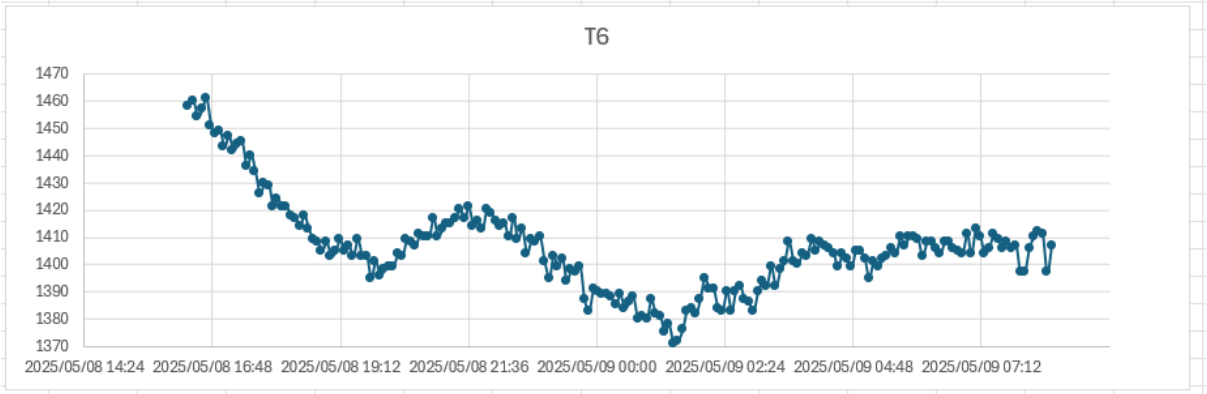
Observations: Temperature data oscillations have been removed. The data is now within the necessary specification for compliance with the requirements for the soil moisture probe.



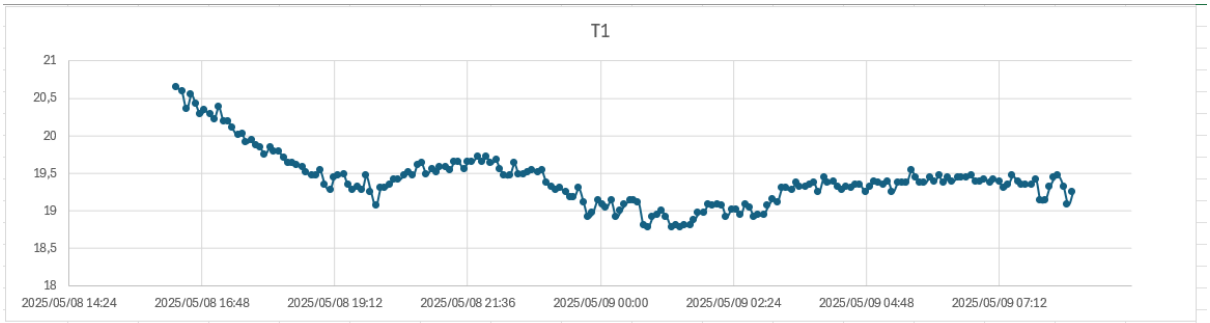



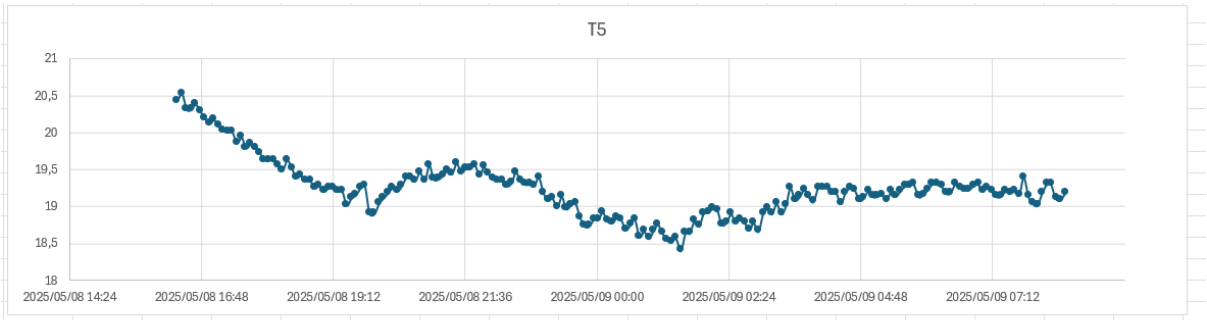



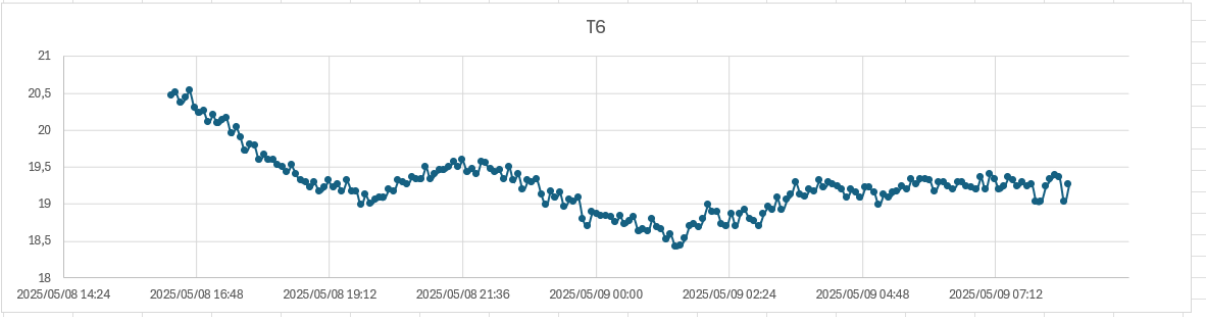




Values converted to temperatures:







T5
21
20,5
20
19,5
19
18,5
18
2025/05/08 14:24
2025/05/08 16:48
2025/05/08 19:12
2025/05/08 21:36
2025/05/09 00:00
2025/05/09 02:24
2025/05/09 04:48
2025/05/09 07:12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