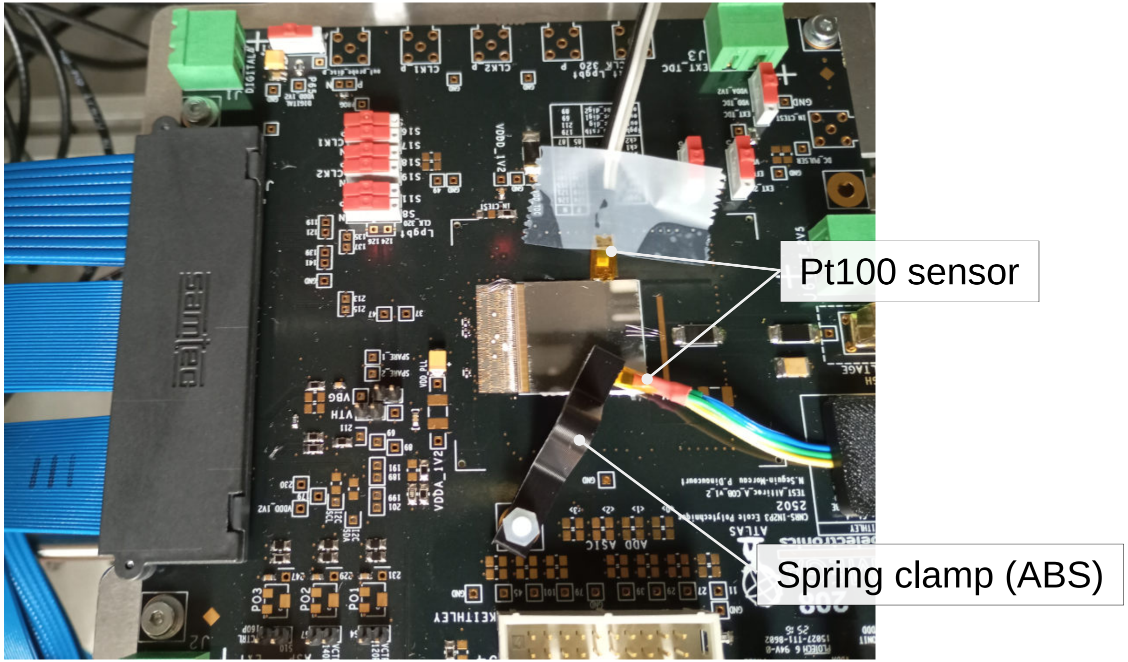
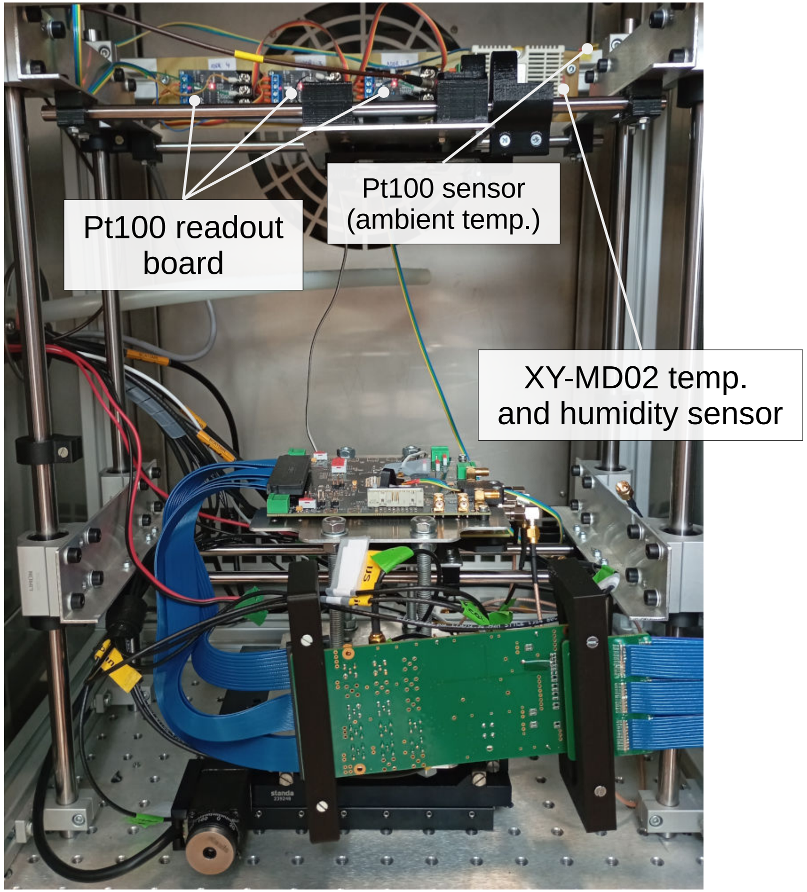
HGTD hybrid temperature calibration

- Use temperature sensors in climate chamber to determine thermal characteristics of the hybrid
  - One XY-MD02 temperature/humidity sensor (min. range: -40 °C, +/- 0.5 °C)
  - Three Pt100 sensors with readout boards (min. range: -20 °C)
    - Readout boards can also measure resistance directly
    - Increase range by adding series resistor (~50 Ω to virtually increase temperature)
    - This introduces some offset between sensors (same added resistance does not produce equal temperature increases)
      - Remove the difference with calibration relative to XY-MD02 - climate chamber at constant temperature remove offsets between devices
      - Need to wait for some time for temperature to stabilize across devices (different thermal capacity of Pt100 vs XY-MD02

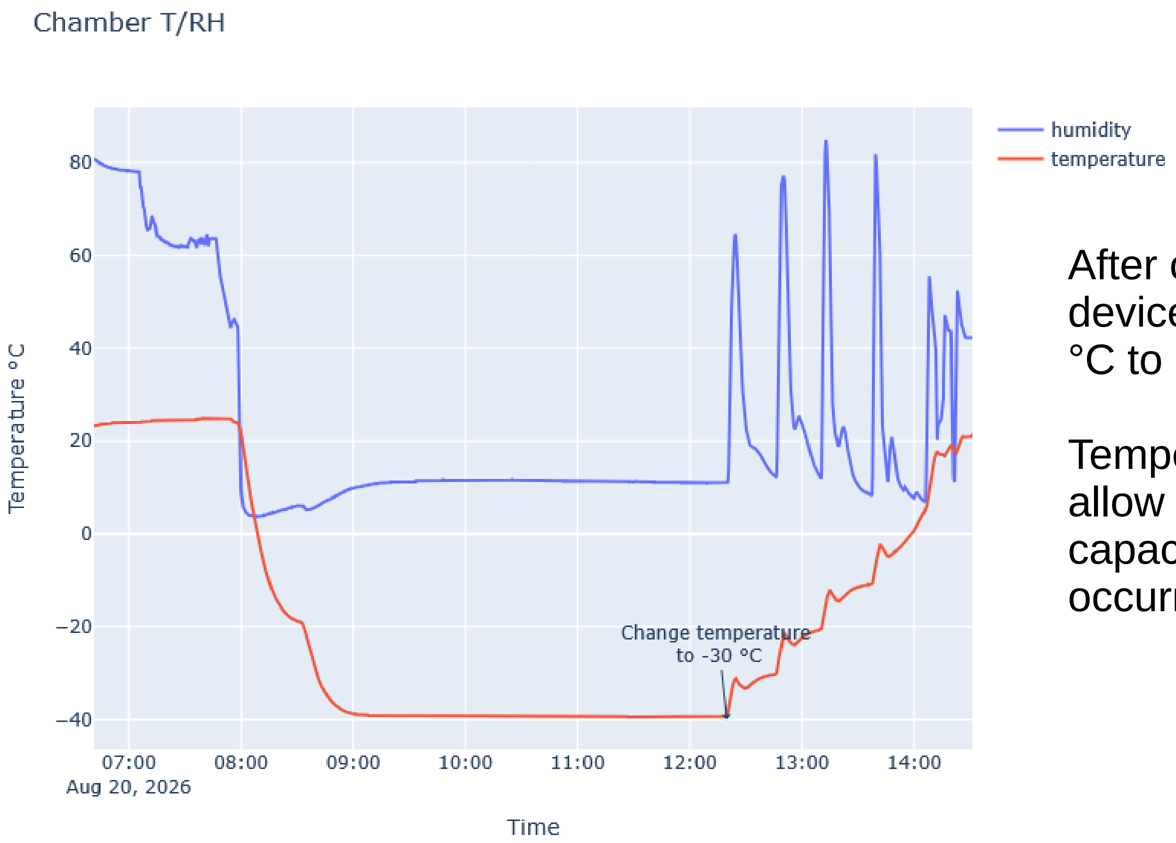
Testing temperature measurement system

- Using climate chamber and irradiated hybrid ($2.5 \cdot 10^{15}\ n_{eq}/cm^2$) with broken column





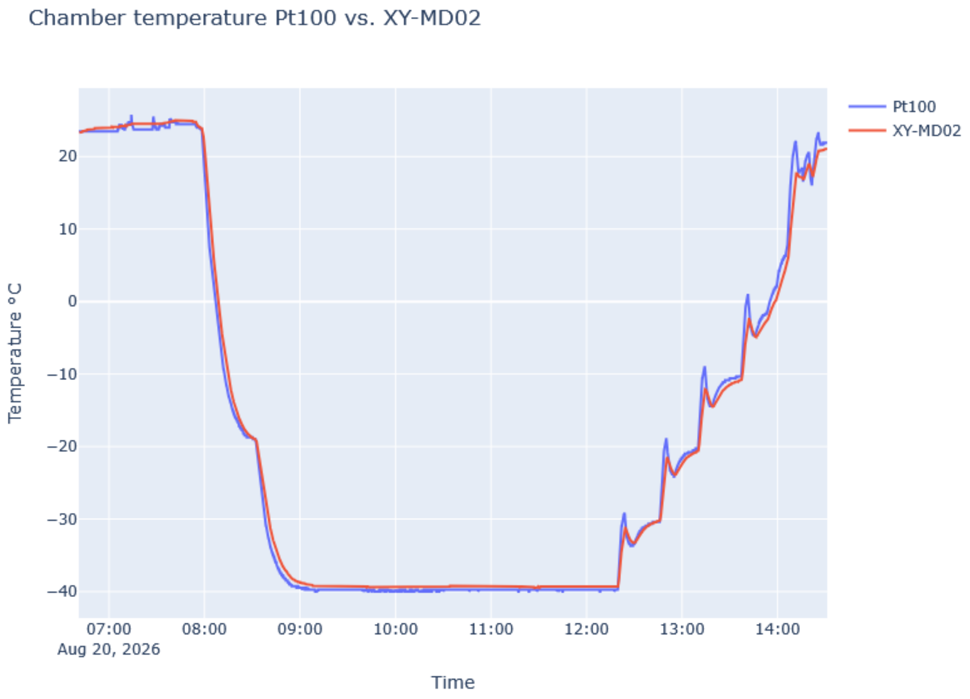
Chamber temperature

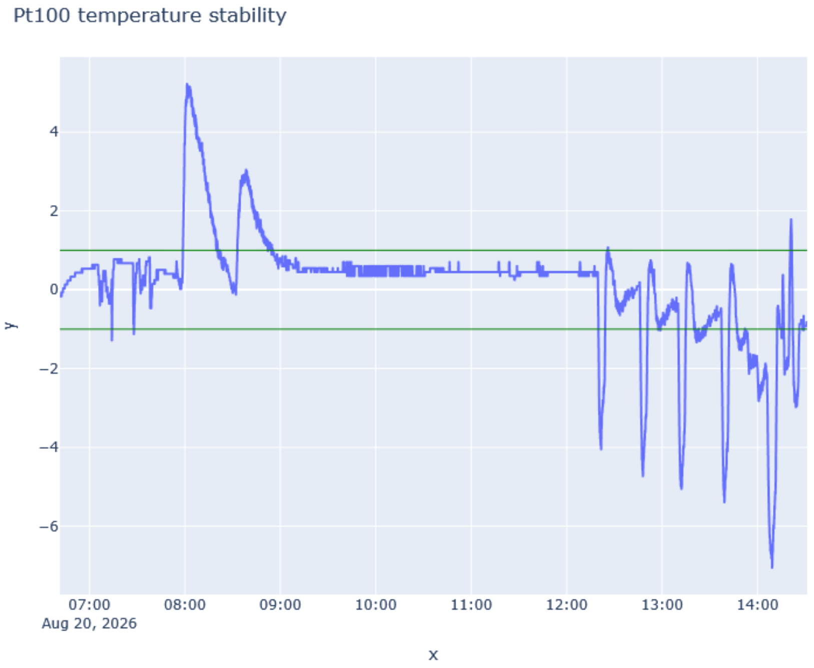


After calibration of Pt100 sensors test all devices by performing a temperature cycle (20 °C to -40 °C and back to room temperature)

Temperature is brought back up in steps to allow sensors to stabilize (different heat capacity) and to prevent condensation from occurring

Pt100 vs XY-MD02

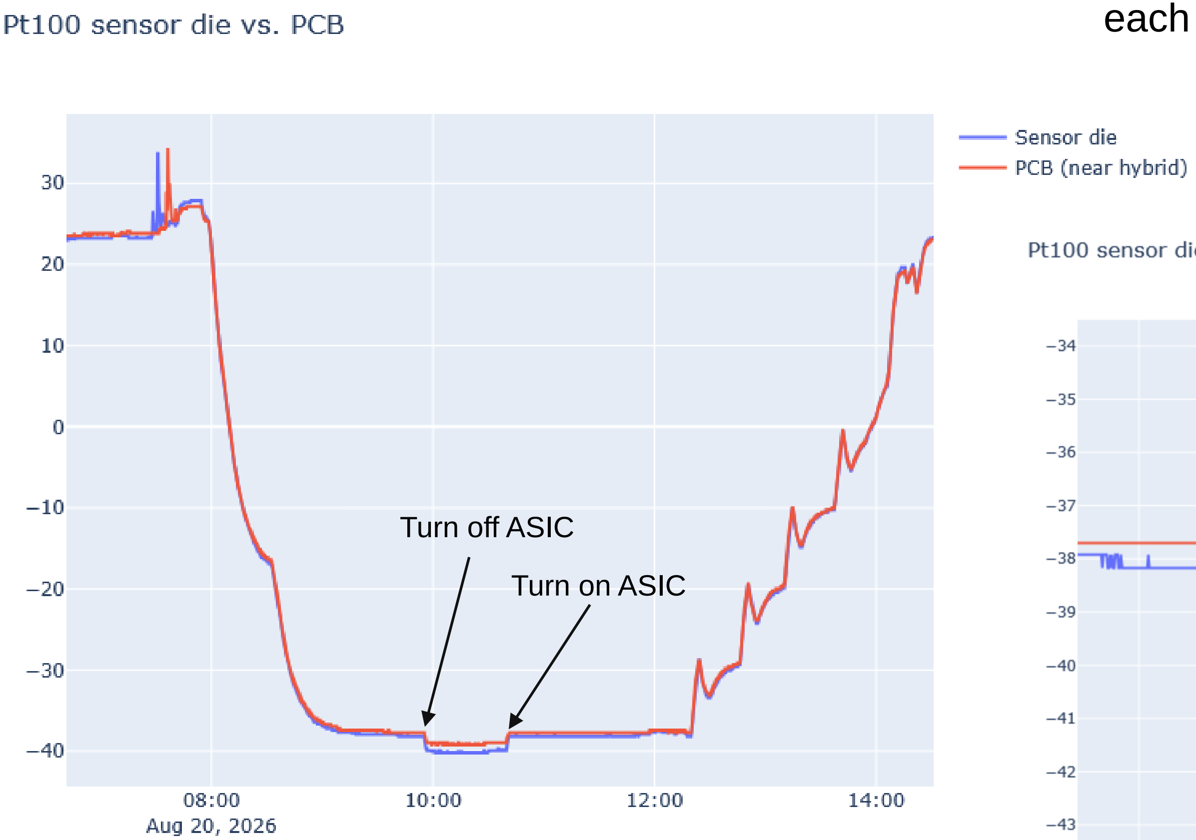




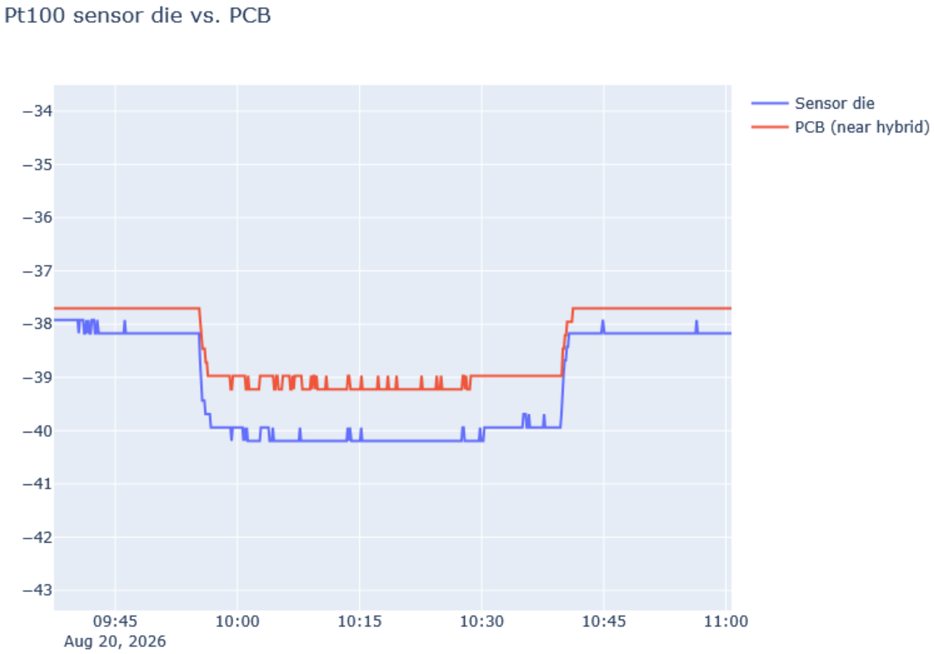
Chamber temperature measured with “calibrated” Pt100 is in good agreement with XY-MD02 device. Difference between two devices is < 1 °C after transient is complete (Pt100 responds to changes much faster).

Influence of sensor location

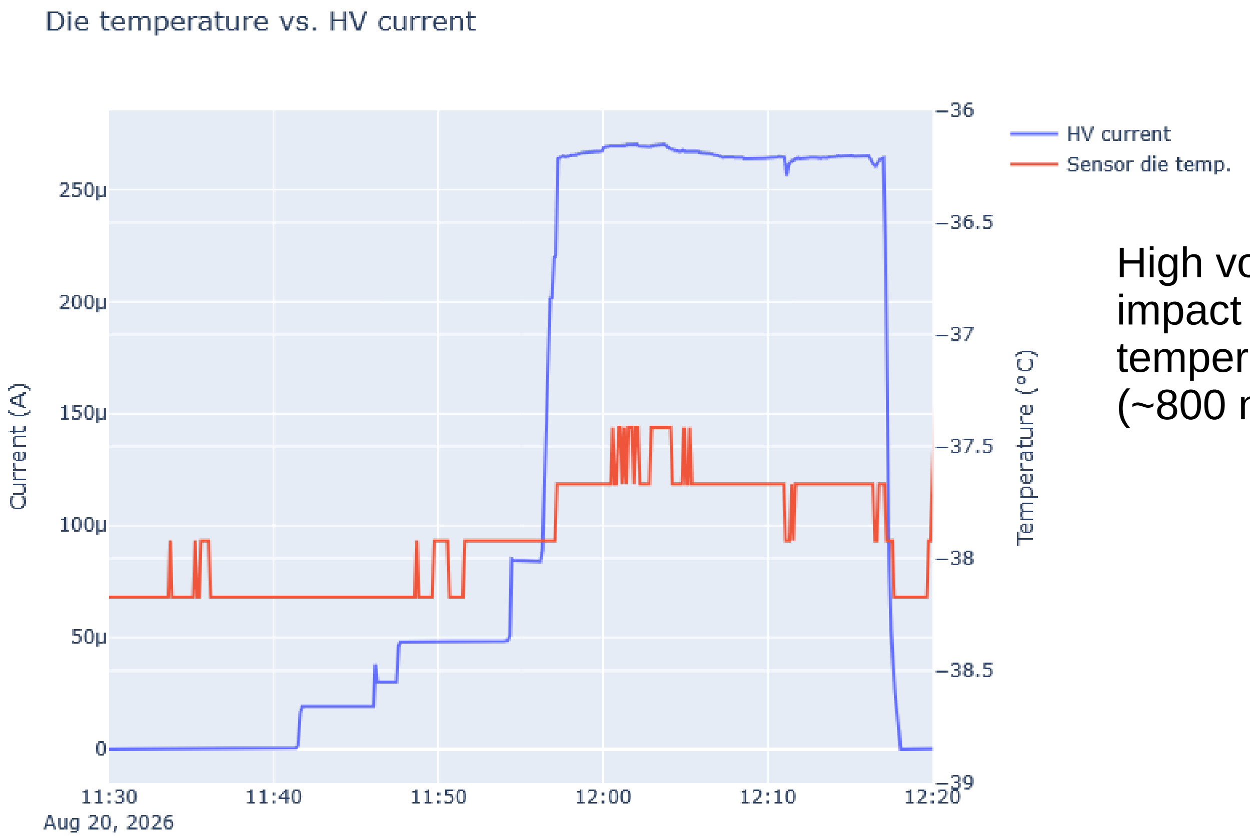
Sensor die temperature and PCB temperature near sensor are very close to each other (ΔT < 1°C)



Turning off ASIC at -40 °C reveals that temperature on sensor die drops more compared to PCB (die seems to cool faster)

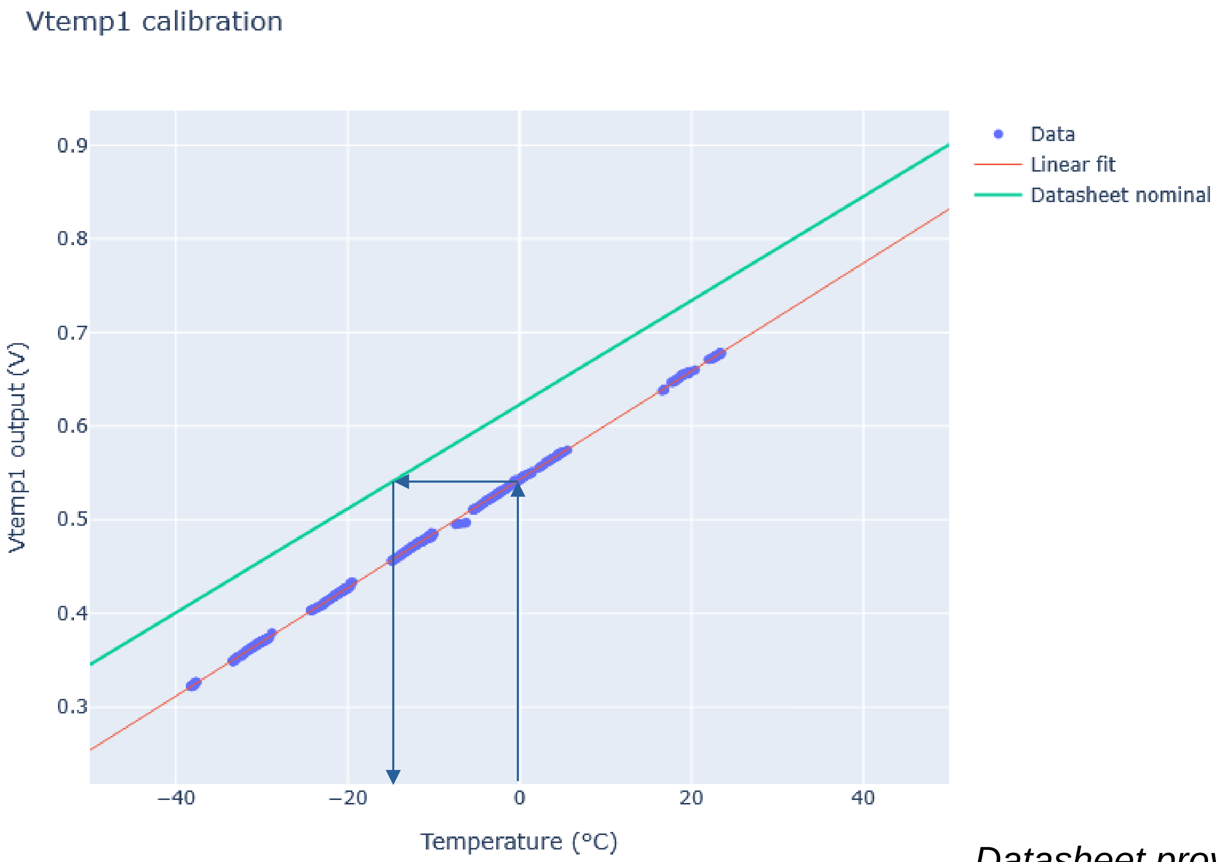


Effect of HV current on temperature



High voltage bias current has minimal impact on die temperature. Most of the temperature rise comes from ASIC itself (~800 mW).

Vtemp1 calibration



Calibrate internal Vtemp1 sensor by using die temperature Pt100 measurements as reference.

To avoid errors caused by transient effects only points where rate of change of temperature is below certain threshold.

Resulting fit parameters:

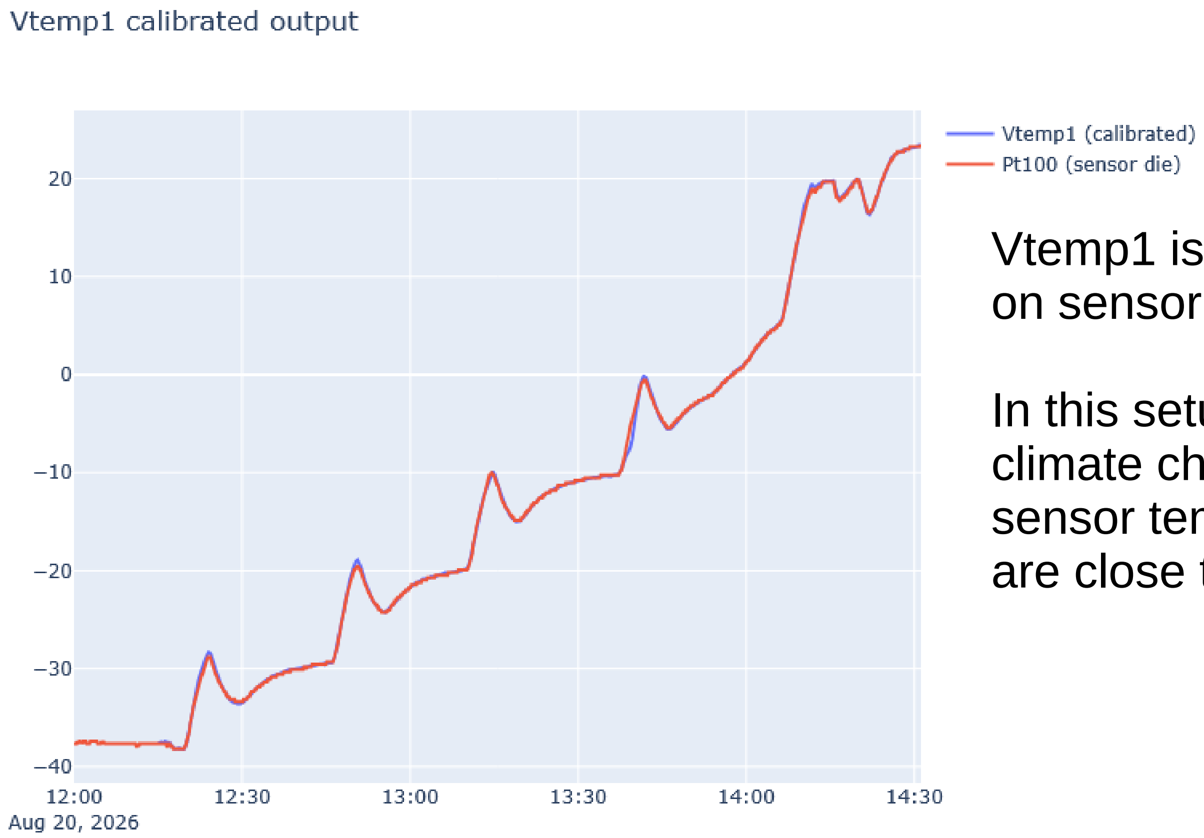
- Vtemp1 (0 °C) = 543 mV
- Sensitivity: 0.173 °C/mV

Datasheet values:

- Vtemp1 (0 °C) = 623 ± 24 mV
- Sensitivity: 0.18 ± 0.010 °C/mV
- Vtemp1 is sensitive to TID

Datasheet provided values read 16 °C lower temperature.

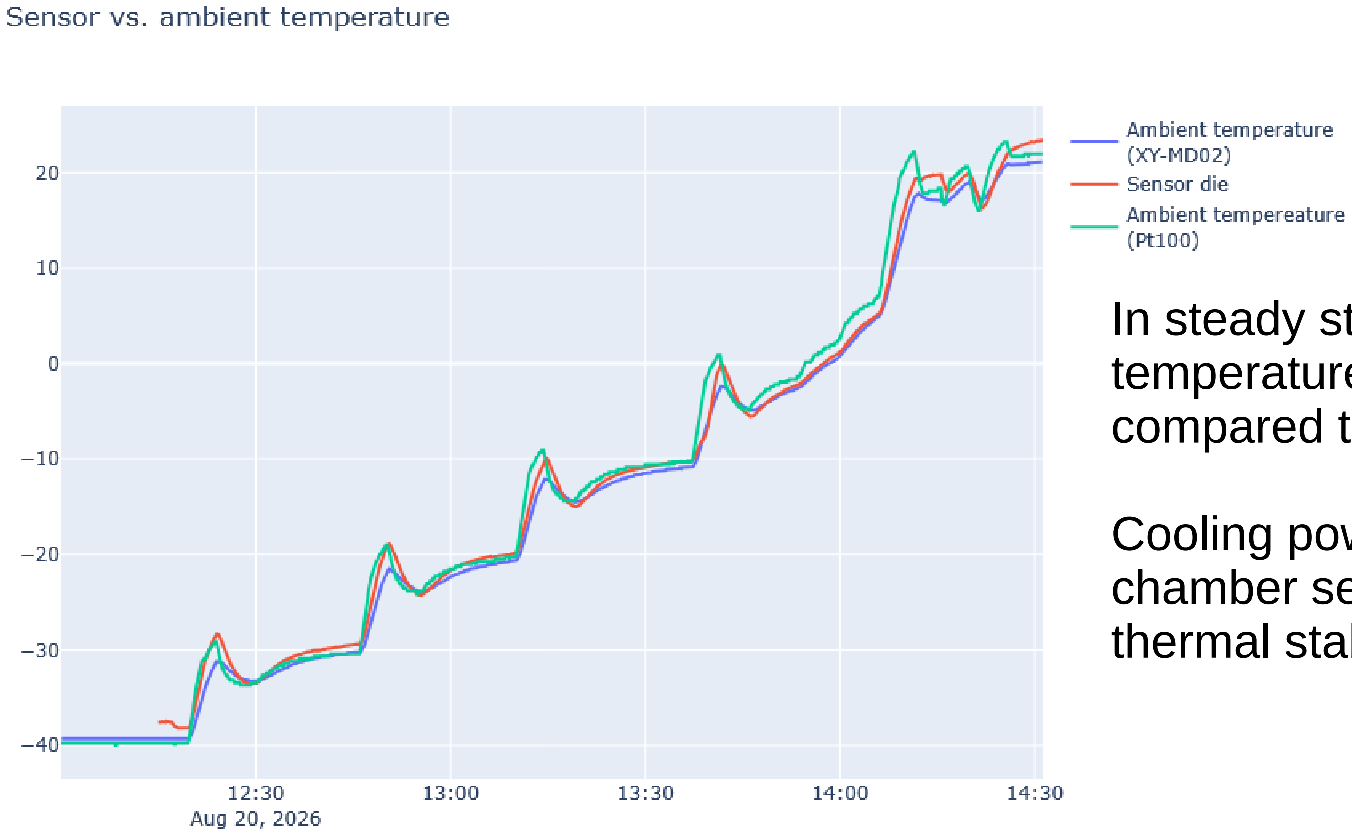
Calibration results



Vtemp1 is in good agreement with Pt100 on sensor die.

In this setup due to cooling power of climate chamber it can be assumed that sensor temperature and ASIC temperature are close to each other.

Sensor temperature vs. ambient temperature



In steady state conditions, sensor temperature is ~1 °C higher compared to ambient.

Cooling power and airflow inside chamber seems to provide good thermal stability and cooling power.

Sensor die vs. ambient temperature difference

Pt100 ambient temperature sensor has very low heat capacity - fast reactions to air temperature changes. XY-MD02 inside its housing has slower response time.