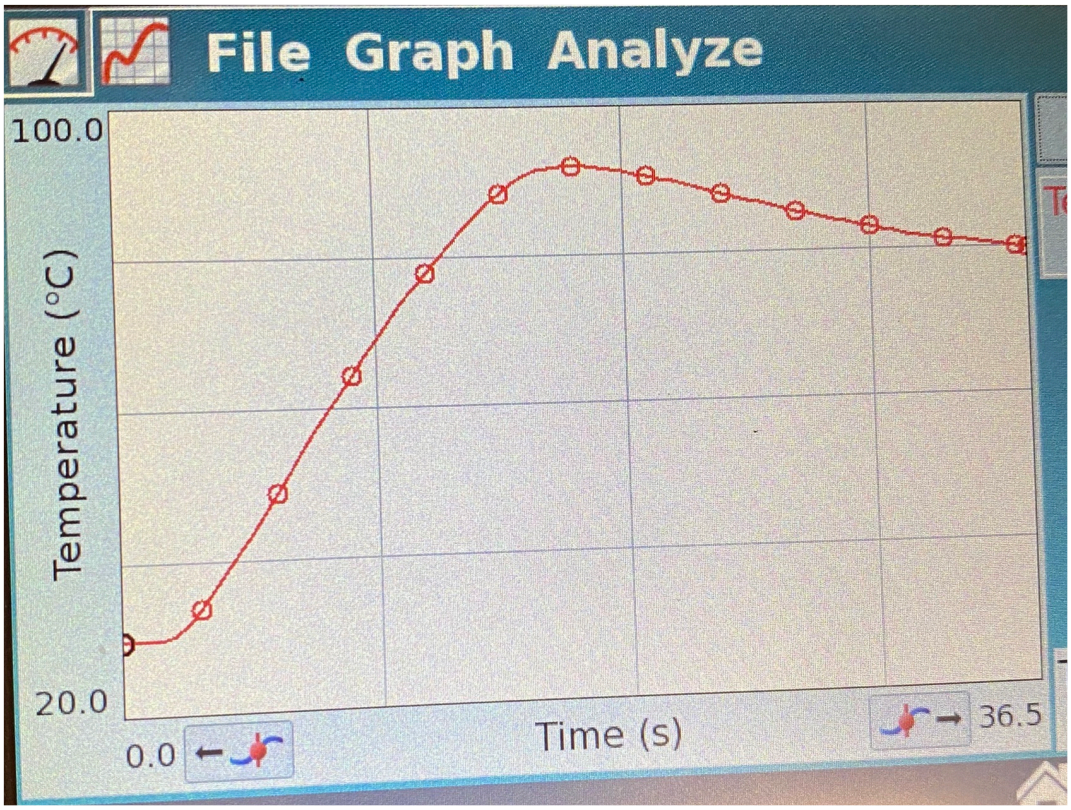
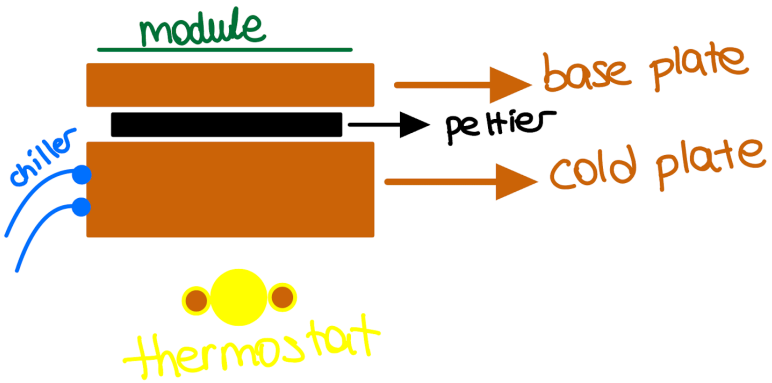
Thermal Performance of a Peltier

The Peltier's warm side can become extremely hot, especially when the chiller is turned OFF. This excessive heat can damage the Peltier. The plot below shows the temperature behavior of the Peltier over time. It reached to 100°C in just 15 seconds. At that turning point, the Peltier got broken, which is why its temperature didn't continue to rise .

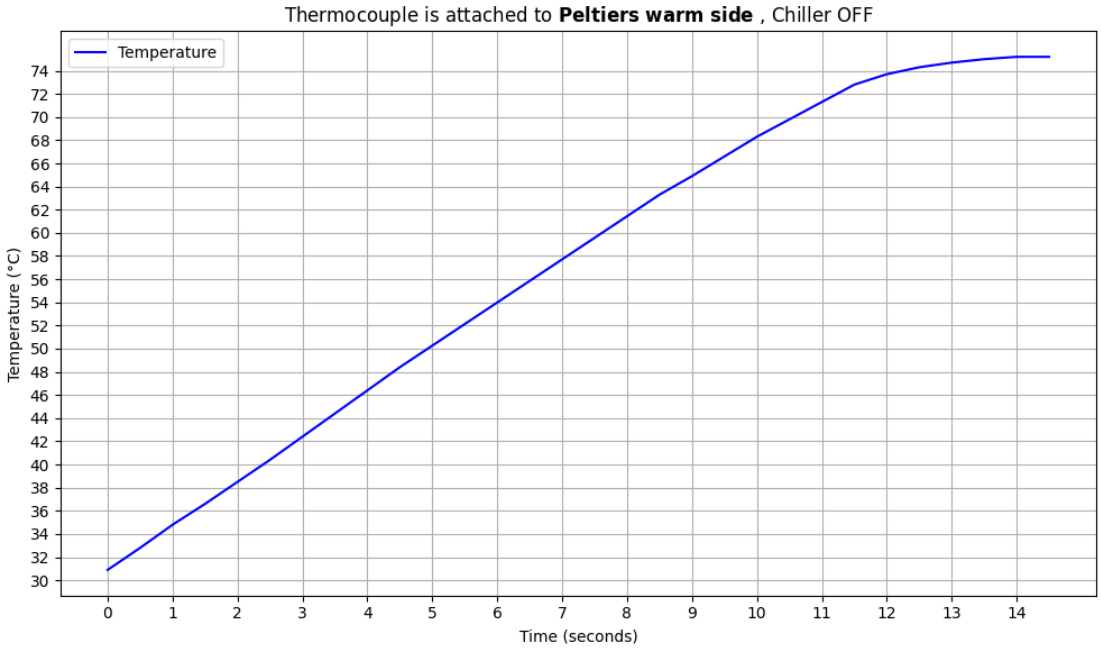
Conclusion: Without the chiller, the Peltier breaks down in approximately 20 seconds. The max temperature reaches around 100C.





1. **Thermocouple is measuring Peltier's warm side while chiller is OFF**

Aim: The aim is to observe how hot the Peltier gets when there's no external cooling. It will give an idea of the maximum temperature it might reach in the absence of chiller.

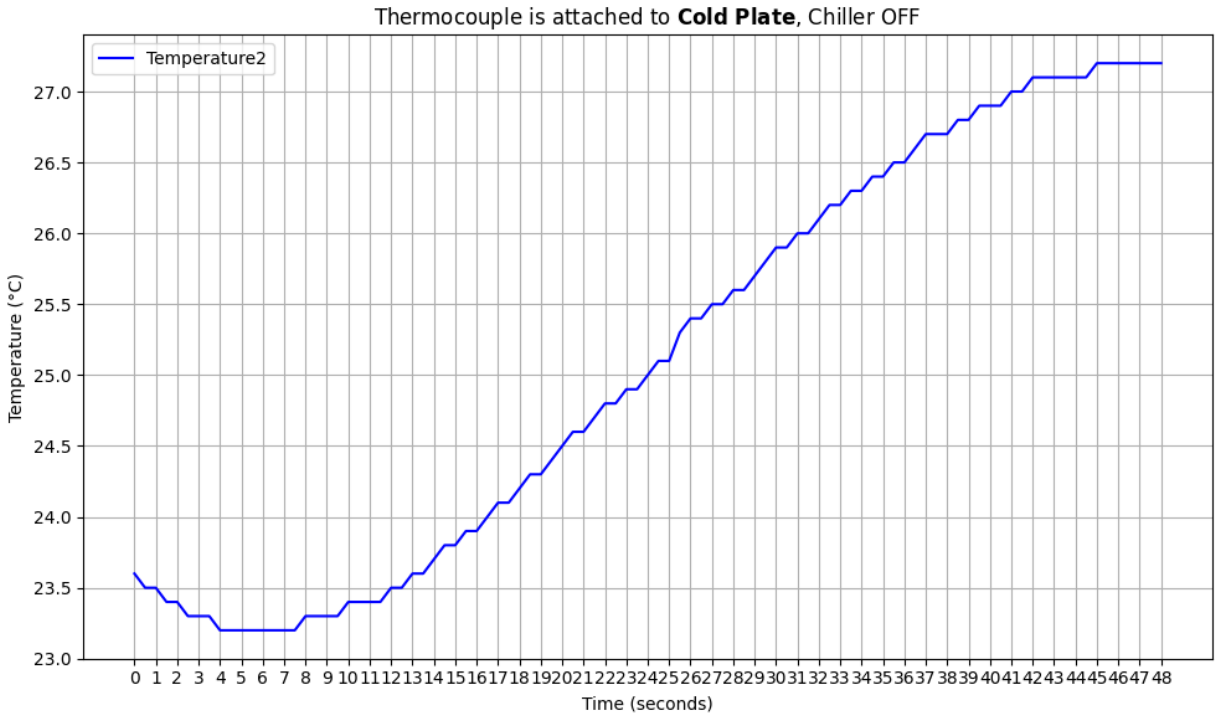


2. **Thermocouple is measuring cold plate while Peltier is ON, chiller is OFF**

Aim: The aim is to observe the temperature behavior of the cold plate, which is in contact with the Peltier's warm side, without the chiller. In the absence of chiller, the cold plate can become excessively hot over a long period, potentially damaging other components in the setup.

This plot shows how effective the cold plate is at dissipating heat on its own without additional cooling source.

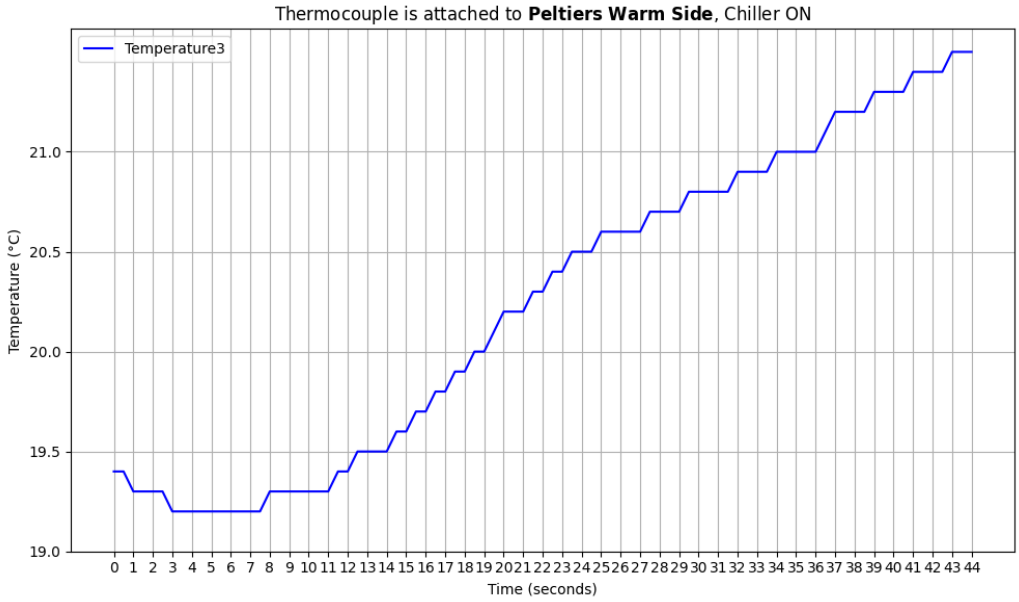
Conclusion: From the previous plot, we know that the Peltier can reach temperatures of around 60°C within ~10 seconds. Within a span of 10-15 seconds, the cold plate's temperature rises to approximately 24°C without chiller. Thus, if an interlock switch is placed on the cold plate, a threshold would be around 25-30°C.



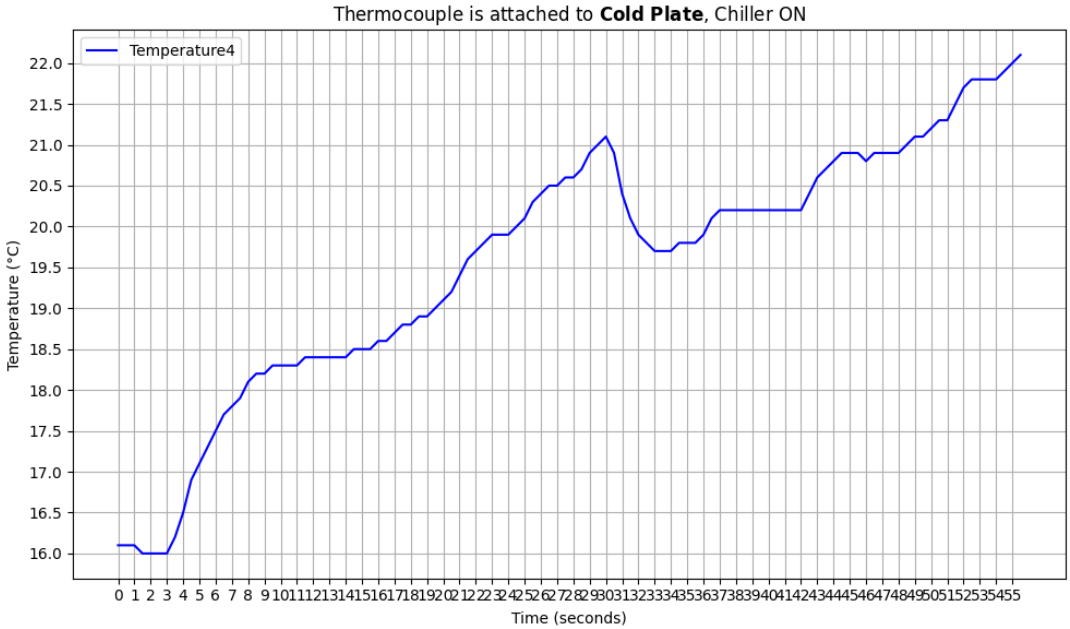
3. **Thermocouple Measures the Peltier's Warm Side, chiller is ON**

Aim: To observe how effective the chiller can reduce the temperature of the Peltier's warm side. A comparison with the first plot shows the difference the chiller makes.

Conclusion: I didn't observe temperatures exceeding ~23C on the Peltier's warm side when chiller is on.



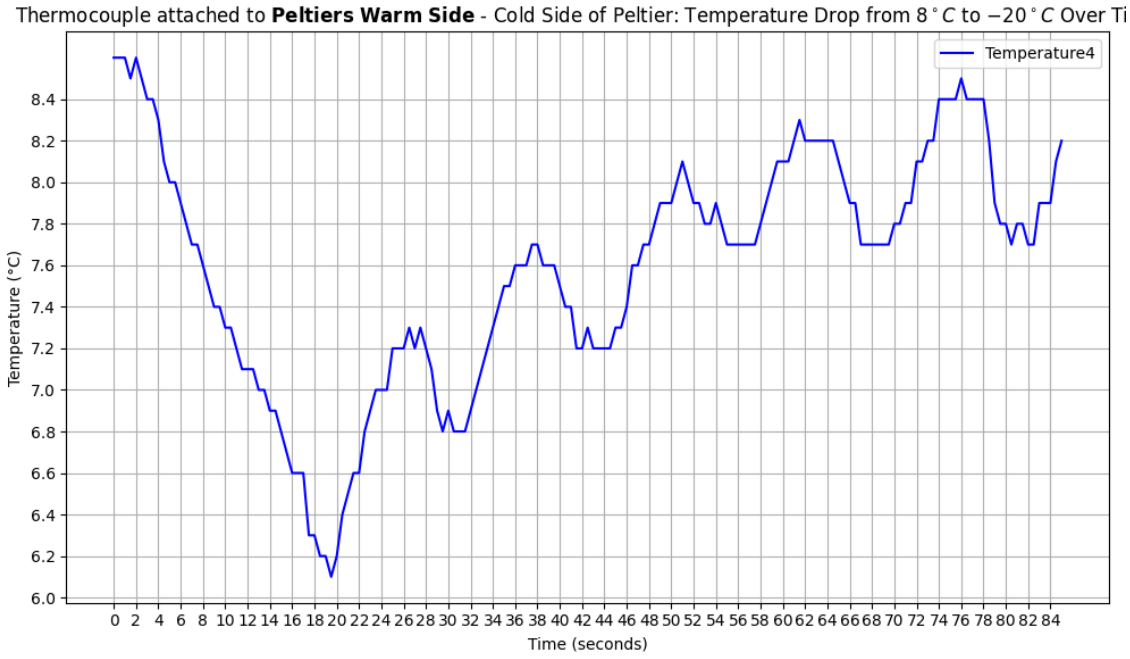
4. **Thermocouple is measuring the temperature of the cold plate while Peltier is ON, chiller is ON**



Temperature of Peltier's Warm Side while Cold Side drops from 8C to -20C

Chiller is ON and set to -3C.

Max Temperature observed is 8.5C on the warm side.



Overall Analysis:

- Before the high temperatures begin to damage the components inside the coldbox, the Peltier is typically fails first. Thus, I prioritized its condition, as it is like an early indicator that something may go wrong in the system.
- I based my analysis on the temperatures that could potentially damage the Peltier.
- Comparing the first and third plots shows how effective the chiller is in reducing the Peltier's temperature. It seems it is probably safe to operate the Peltier for extended periods when the CHILLER IS ON.

1. Placing the Thermostat on the Peltier's Warm Side:

- Provides a direct measurement of the Peltier's temperature, which is the primary source of heat.
- Ensures a faster response to turn off the Peltier.
- The threshold should be set below 70°C. Above this temperature, the likelihood of damage to the Peltier increases significantly.
- A threshold value of 50°C is suggested since it rarely approaches this temperature value (see plot 1 and 3).

2. Placing the Thermostat on the Cold Plate:

- Measures the combined heat effect on the cold plate, which can be more representative of the total system's thermal state in case chiller fails to effectively cool the Peltier over time.
- Cons: There will be a slightly delayed response compared to measuring the Peltier directly.
- Threshold value for the switch shouldn't exceed ~25-30°C because the Peltier can reach damaging temperatures even when the copper cold plate remains ~25-30°C. Maybe 27C?