TEC Controller Temperature Ramp Optimization

Application Note

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1 Introduction

This Application Note describes how the rate of temperature change can be improved by increasing the parameter “Coarse Temp Ramp” when using the Meerstetter Engineering TEC Controllers and the effect this has.

The Parameter “Coarse Temp Ramp” defines the maximal rate of temperature change allowed by the TEC Controller.

2 Autotuning

The PID and Ramp Values generated by the autotuning[1] function of the TEC-Controller are calculated so that they value stability and no overshooting over a maximal rate of temperature change. This is visualized in the graphs below. The actual temperature is always able to follow the calculated nominal temperature.

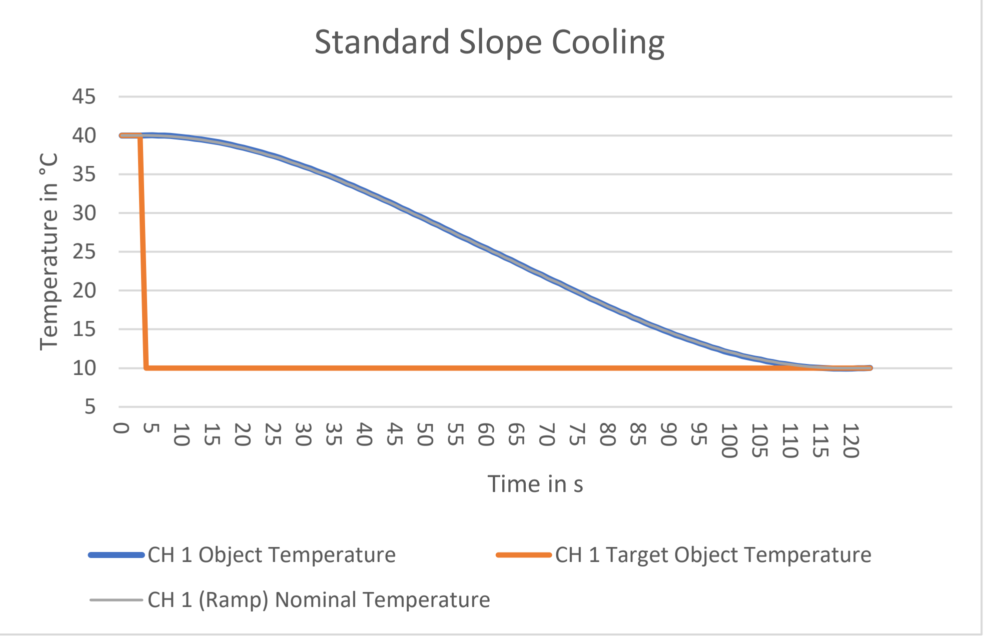

Figure 1. Default falling slope generated by the Autotuning

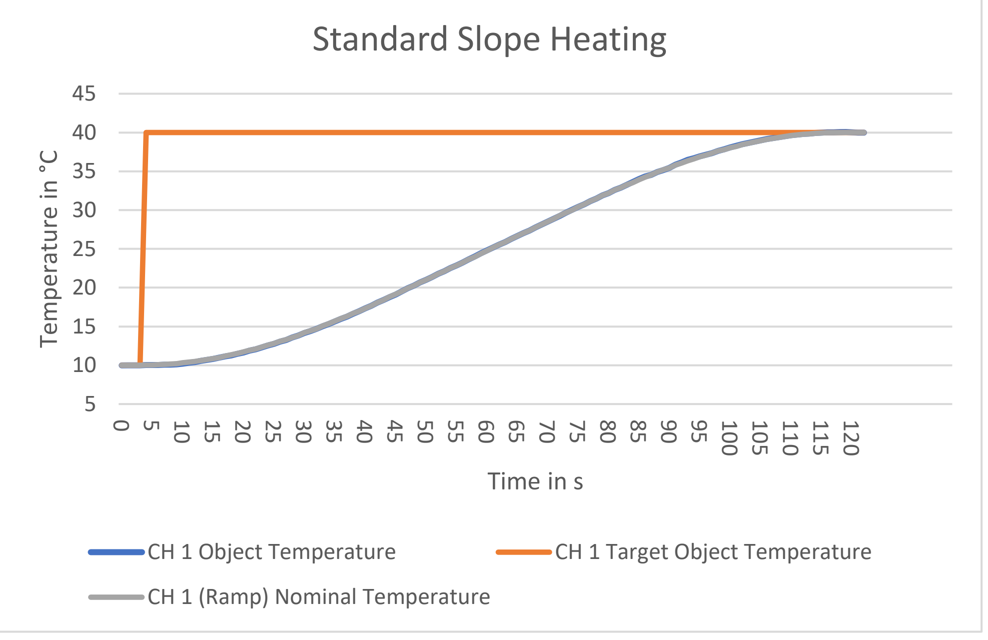

Figure 2. Default rising slope generated by the Autotuning

[1] Please refer to the TEC-Family User Manual for more information about the autotuning function

3 Slope Optimization

The Parameter “Coarse Temp Ramp” is used to set the maximum rate of temperature change. When an auto tuning is performed it is set to a relatively low value which improves stability and prevents overshoot. Once the "Coarse Temp Ramp" value is changed it is no longer certain that the TEC controller can follow the calculated value.

The “Coarse Temp Ramp” value can be increased to improve temperature change rate. The following images highlight the effect of the Temp Ramp value on the temperature change behavior.

First example (Figure 3 and Figure 4)

- **Change:** “Coarse Temp Ramp” value multiplied by 2
- **Result Cooling:** the actual temperature was no longer able to follow the calculated Nominal Temperature all the time.
- **Reason:** This is because when cooling the heat generated on the Object cold side of the Peltier Module (Joule Heating) must be dissipated as well. When the temperature on the cold side is higher than ambient (About 23°C in this case) the heat flow through the thermal resistance of the TEC helped with cooling. This is no longer the case when the temperature is below ambient. The heat flows now in the opposite direction and must be transported away by the Peltier effect.
- **Result Heating:** TEC Controller can follow much steeper temperature ramps while raising the temperature.
- **Reason:** While heating the heat generated that hinders the cooling process is beneficial.

The fast temperature change also generates a small overshoot.

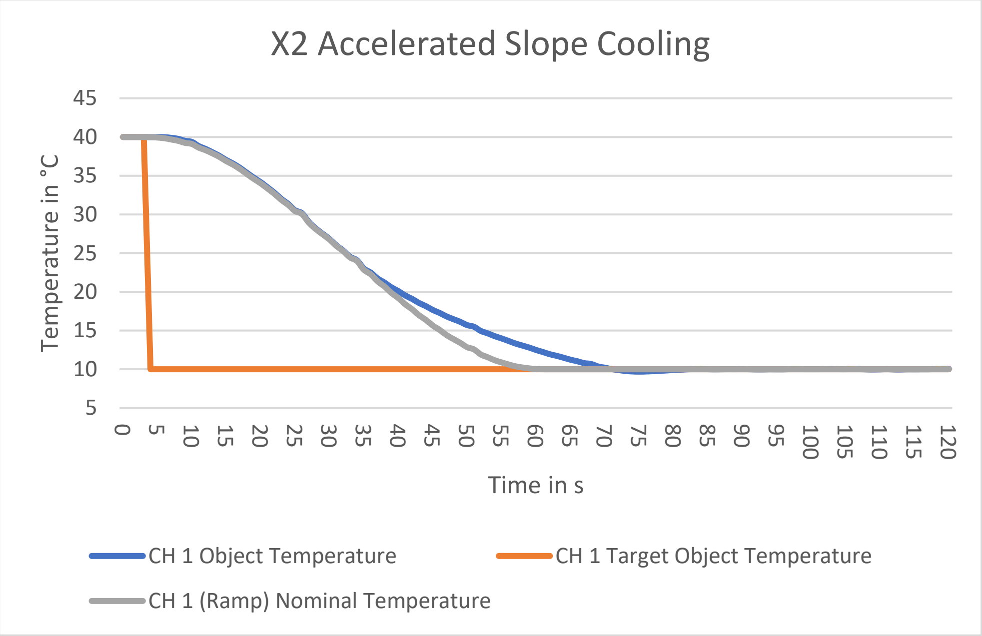

Figure 3. Temperature slope generated by increasing the Coarse Temp Ramp

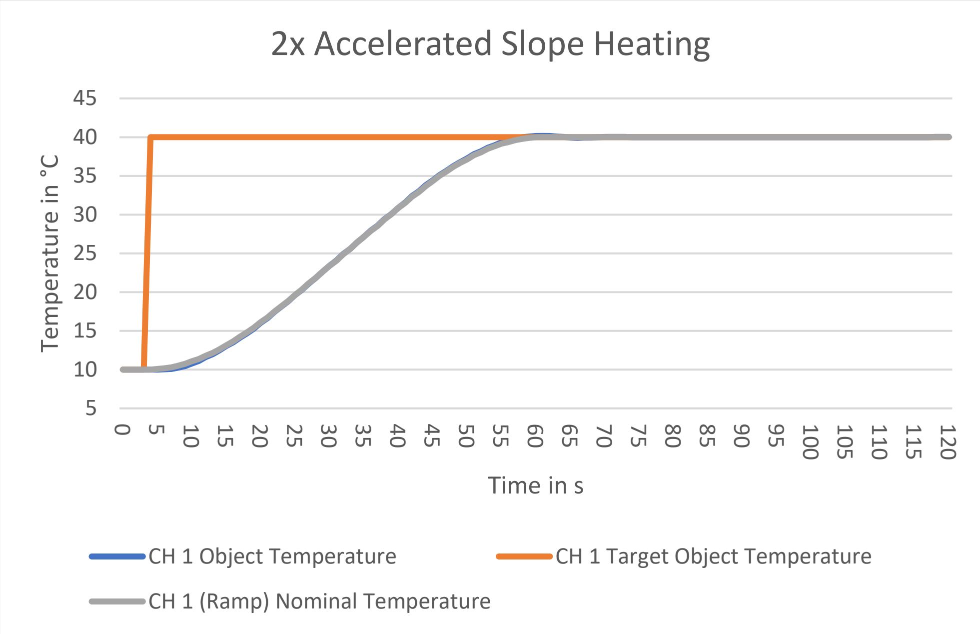

Figure 4. Temperature slope generated by increasing the Coarse Temp Ramp

Second example (Figure 5, Figure 6)

- **Change:** “Coarse Temp Ramp” value multiplied by 5
- **Result Cooling:** , the actual temperature is not able to follow the calculated temperature ramp at all.
- **Result Heating:** The TEC Controller can follow the calculated temperature ramp” but there is an overshoot.

While cooling, the actual temperature is not able to follow the calculated temperature ramp at all. This means that further increasing the Temperature Ramp will have no effect on cooldown time. The TEC Controller already cools as fast as possible while taking the current and voltage limits into account.

Furthermore, the difference between “warmup” and “cooldown” time is now very clearly visible. If an identical slope for heating and cooling is required, the Temperature Ramp values have to be reduced.

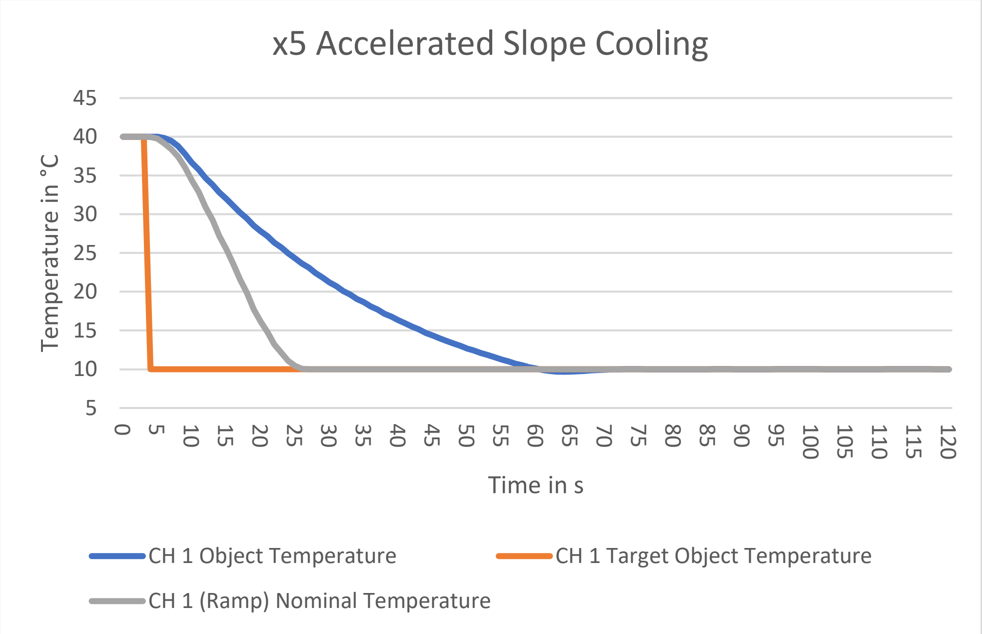

Figure 5. Slope generated by increased Temp Ramp Value

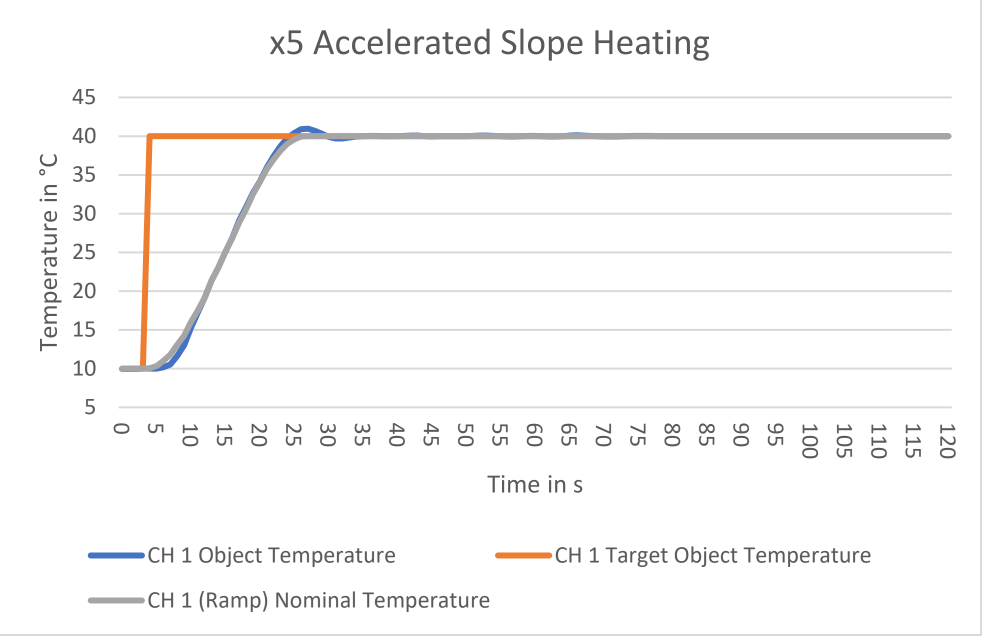

Figure 6. Slope generated by increased Temp Ramp Value

Figure 7 and Figure 8 visualize the contrast between different “Coarse Temp Ramp” Values. The gain of slew rate and the tradeoff of increased overshoot can clearly be observed while the target object is heated up. While cooling both temperature change rates are close to the maximum rate of temperature change and even exceed it at lower temperatures. Because of this, the slew rates are almost identical.

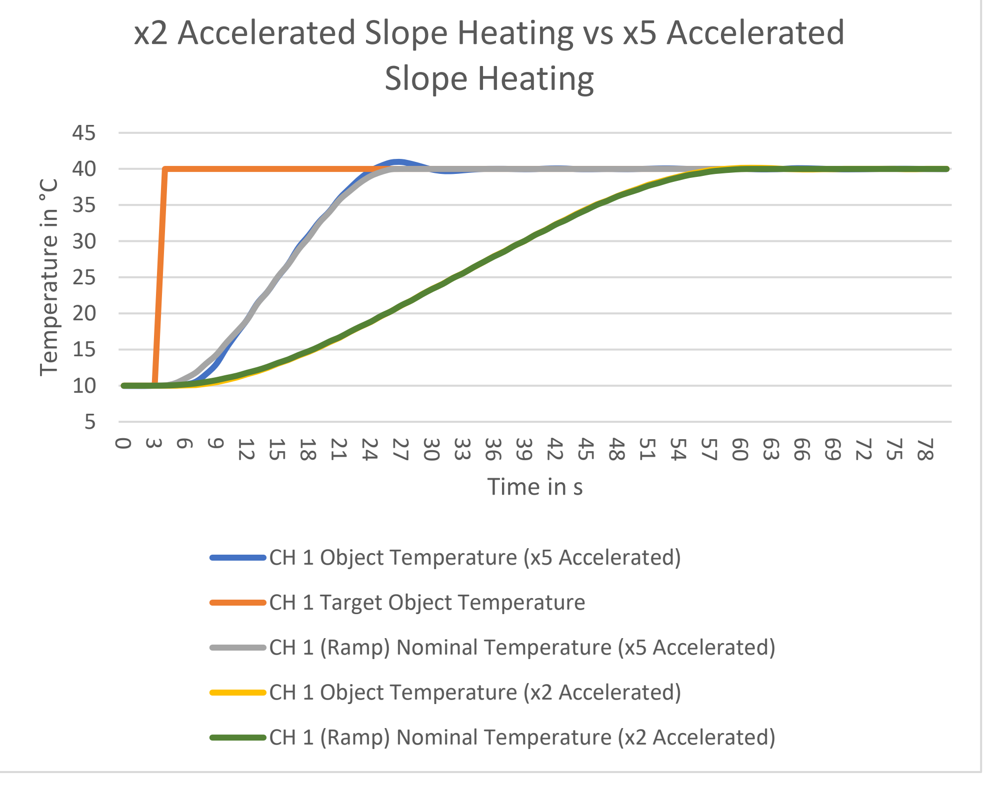

Figure 7. Comparison between different Coarse Temperature Ramp values

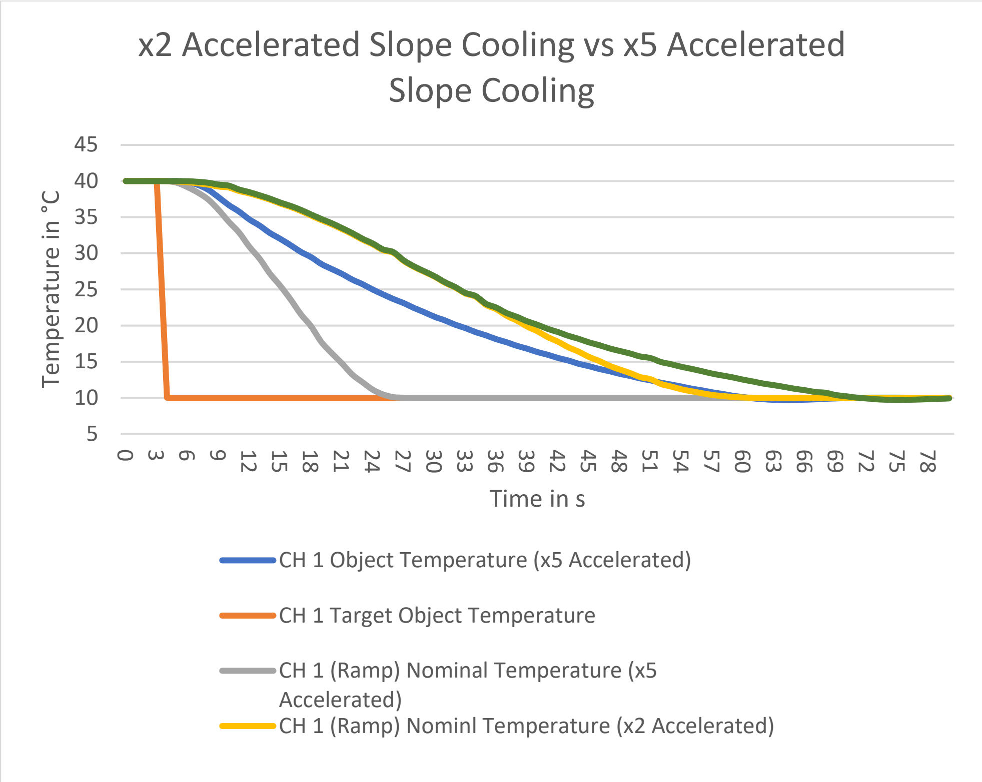

Figure 8. Comparison between different Coarse Temperature Ramp values