Lab 5: Report

The reports for Lab 4 and Lab 5 will be combined into one major report worth 15% of the total grade for this subject. You may work in a group of up to three members. All group members must attend the same lab sessions. Your group must be the same for Labs 4 and 5. Submit the combined report on Canvas.

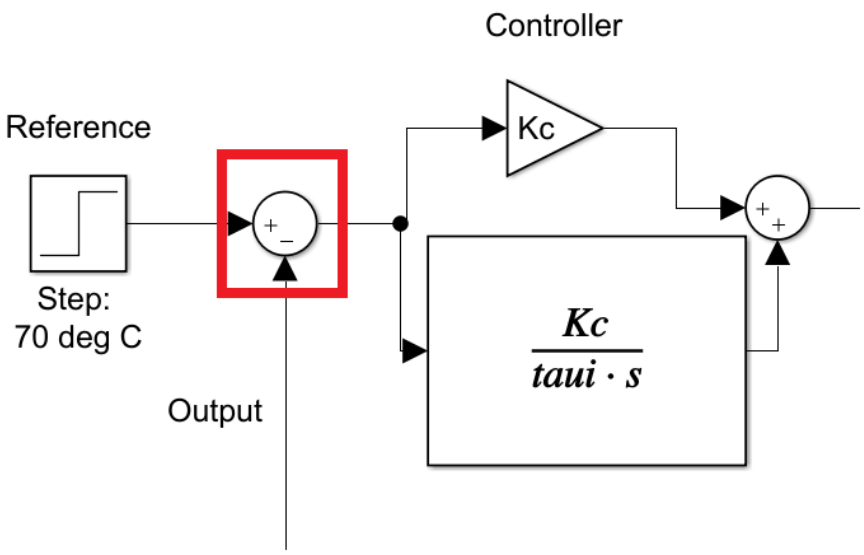
The Lab 5 report has **[120 marks]**.

For the entire report:

1. Present results and diagrams clearly with explanations for complicated features. Include the legend, title, x-axis and y-axis labels.
2. Presentation quality of the Lab 5 report **[10 marks]**.
3. Please answer the questions in the order suggested below.

Task 1A

1. Include your Simulink diagrams, MATLAB scripts and plots **[5 marks]**
2. Why is the saturation block for the control signal unnecessary now? **[1 mark]**
3. For this task, the suggested solution does not have the +/- block to subtract the output from the reference signal as shown below in the red square. Why is this not required for the discrete PI controller? Show evidence. **[1 mark]**



Task 1B

1. Include your Simulink diagrams, MATLAB scripts and plots **[15 marks]**
2. Compare the simulation with the experimental results. Identify key similarities. If there were significant differences with the simulation, identify and explain possible sources for the differences. **[3 marks]**
3. Discuss possible reasons for why the closed-loop performance for Lab 4, Task 2A/2B is different to Lab 5, Task 1A/1B despite using the same controller parameters. Hint: There is a difference between using the saturation block vs. the proper anti-windup implementation. **[3 marks]**

Task 2B

1. Include your Simulink diagrams, MATLAB scripts and plots **[10 marks]**
2. Show the derivation for how your controller parameters c_2, c_1 and c_0 were designed. **[5 marks]**
3. Discuss the effects of changing λ on the reference-tracking ability of the system and also, the control signal. **[3 marks]**
4. What was your choice for λ? What were the calculated controller parameters? **[1 mark]**
5. Show evidence that the design criteria have been achieved in simulation. **[2 mark].**
6. What are some factors that could limit the maximum gradient of the ramp that the closed-loop system could track? **[2 marks]**
7. How is the suggested controller $\left(C(s) = \frac{c_2 s^2 + c_1 s + c_0}{s^2}\right)$ able to track both, a ramp as well as a constant value (essentially, a step signal)? Support your answer using the final value theorem on the:
    a. Feedback error assuming a ramp reference $R(s) = \frac{1}{s^2}$, **[6 marks]** and also:
    b. Feedback error assuming a step reference $R(s) = \frac{1}{s}$ **[5 marks]**.
8. Would a standard PID controller $\left(C(s) = \frac{c_2 s^2 + c_1 s + c_0}{s}\right)$ be able to track a ramp reference signal? Use the final value theorem to support your answer. **[5 marks]**
9. In simulation, verify that the suggested controller $\left(C(s) = \frac{c_2 s^2 + c_1 s + c_0}{s^2}\right)$ is able to track a step reference signal. Use a reference signal of 50°C, overshoot ≤ 20%, settling within 1000 seconds. You may need to adjust λ. Confirm that the controller is able to reject an OUTPUT disturbance of -5°C and is robust under limited amounts of measurement noise (Sources: Random Number: Mean = 0, Variance = 0.2) **[6 marks]**

Task 2C

1. Include your Simulink diagrams, MATLAB scripts and plots **[20 marks]**
2. Identify if/when the control signal was limited by the saturation block in simulation and in the experiment. **[1 mark]**
3. Compare the simulation with the experimental results. Identify key similarities. If there were significant differences with the simulation, identify and explain possible sources for the differences. **[3 marks]**
4. Assume that somebody performed these operations: Run Simulink on the Arduino, the program is running on the Arduino for some time – say 10 seconds, then, the power switch is switched on. Normally, this would result in higher overshoot and oscillations which were not consistent with the simulations. Why might this happen? **[4 marks]**
5. What should have been observed, was that after a peak overshoot, the control input should suddenly drop to near-zero. Qualitatively, explain why this is the expected outcome referring to your understanding of the plant, environment, and control theory. **[4 marks]**
6. Assuming that the board temperature is hot (e.g. 70°C), would it be possible to design a control system that tracks a negative ramp reference signal i.e. controlled cooling? What factors would limit the negative gradient of the reference signal that could be tracked? **[5 marks]**