This document guides you through the preliminary design of your buck converter. For all questions, you should cite all sources used, if applicable. See rubric on Brightspace for more information on how your submission will be marked.

Question 1. In this question, you design the active power LPF filter.

a) Briefly discuss the theoretical tools developed in other courses you are leveraging to guide the LPF design.

b) Enumerate all missing information that must be gathered to produce an implementable design.

   Hint: E.g., specific aspects of op amp and microcontroller specifications.

c) Complete your design and provide a schematic snapshot and a brief description of the suitability of each passive and active component used.

Question 2. In this question, you design the LC voltage LPF.

a) Briefly discuss the theoretical tools developed in this course you are leveraging to guide the power filter design.

b) Enumerate all missing information that must be gathered to produce an implementable design. Enumerate all intermediate steps to get to the solution.

c) Analytically derive an expression for the buck current and voltage ripple as a function of all appropriate parameters. Determine the minimum value of L and C

d) Describe the relevant constrains for the selection of an inductor and capacitor. Discuss how selecting an inductor is different from determining a value of L. Provide component part numbers for the inductor and capacitor along with a brief description of their suitability.

   Hint: Show how they meet all constraints listed in 2b.

e) Produce a steady-state simulation in simulink showing how the system, with the selected parameters meets the specifications laid out on the project instructions.

Question 3. In this question, you design the feedback control system.

a) Find the averaged model of the converter and, if applicable, linearize it.

b) Design a PI controller with crossover frequency $\omega_c \geq 10$ rad/s and $PM \geq 60°$. Document your control design and show the compensated loop bode-plot, highlighting the phase-margin and crossover frequency.

c) Simulate your system under load transients from $R_o = 57\ \Omega$ to $R_o = 100\ \Omega$. In the simulation, include non-idealities such as inductor and capacitor ESR, diode forward voltage drop, and transistor R_{on}. Present your results and discuss the observed performance. You must also model the LPF from **Question 1** in the feedback signal.

Question 4. Produce a PCB schematic, layout, and bill-of-materials (BOM).

a) Show a high-level schematic detailing the connections. In particular, show what MCU pin is used for PWM and ADC. Show the PCB layout.

b) Show the LPF schematic (it should be it's own hierarchical sheet) and a zoomed in images of the PCB layout. Discuss your implementation including calculations such as cutoff frequencies, voltage limits, etc..

c) Show the GD schematic (it should be it's own hierarchical sheet) and a zoomed in images of the PCB layout. Discuss your implementation including calculations such as power drawn, power supply voltages, etc..

For each subsystem, such as gate driver and sensor Op Amp filter, present a separate schematic representation and include links to sources you used to make your designs, such as reference design and datasheets.

Upload your KiCAD project, including library files, to github. Include a link to your project in the deliverable PDF.

Question 5. Discuss the risks to persons and equipment incurred during testing this project, especially before the design has been experimentally validated.

Provide an itemized bring-up plan for your board and, for each item, discuss what the objective and theoretical motivation for the test or inspection.