Midterm Exam **Name (Print):** _____
Fall 2023, EE270
11/16/2023
Time Limit: 100 Minutes

This exam contains 2 pages (including this cover page) and 4 problems. Check to see if any pages are missing. Enter all requested information on the top of this page.

You are required to show your work on each problem in this exam. The following rules apply:

1. Print and sign your name on this page before you start.
2. Closed book closed note. Calculator is allowed. One page A4 cheat sheet is allowed.
3. Do everything on this exam, and make your methods as clear as possible.
4. Mobile devices must be turned off.

1. (32 points) The Buck-Boost converter below has an input voltage $V_g = 12V$. The duty cycle $D = 0.6$, and the switching frequency is $25kHz$. For the inductance $L = 250\mu H$ and for filter capacitance $C = 220\mu F$. The average load current is $I_a = 1.2A$.

   (a) (6 points) Determine the average output voltage V.
   (b) (6 points) Determine the peak-to-peak output ripple voltage ΔV_c.
   (c) (6 points) Determine the peak-to-peak ripple current of inductor ΔI.
   (d) (6 points) Determine the peak current of the transistor I_p.
   (e) (8 points) Determine the critical values of L (the condition for continuous inductor current and capacitor voltage).

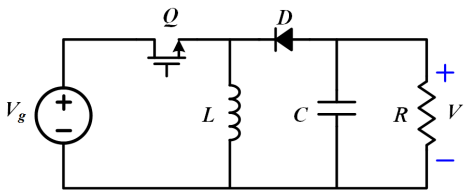

Figure 1: buck-boost converter

2. (24 points) In a Flyback converter operating at steady state, the input voltage, $V_{in} = 48V$, duty-ratio, $D = 0.385$, turns ratio, $n_p/n_s = 6$, the magnetizing inductance, $L_m = 150\mu H$, and the switching frequency, $f = 200kHz$. Neglect the leakage inductances and assume the converter to be lossless. Assume the output voltage to be ripple-free. The magnetizing inductor is operating at Boundary Conduction Mode.

   (a) (8 points) Compute the output voltage, V_o.
   (b) (8 points) Calculate and draw the waveforms of the input current, and the current supplied to the output stage consisting of the parallel combination of the output capacitor and the load-resistance.

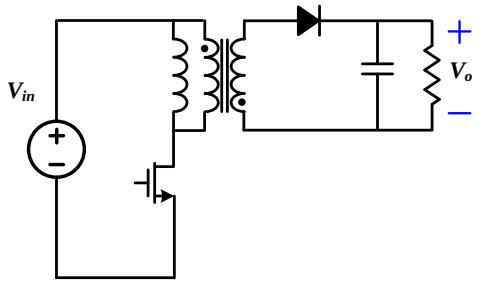

Figure 2: flyback converter

(c) (8 points) Calculate the output power, P_o.

3. (32 points) In the Cuk Converter below, the MOSFET has on-resistance R_{on}, diode forward voltage drop V_D. All other losses can be ignored.

   (a) (12 points) Use the state-space averaginig method, derive the steady-state averaged equation in matrix form.

   (b) (10 points) Perturb and linearlize, to determine the small-signal ac equations in matrix form.

   (c) (10 points) construct the small-signal ac equivalent circuit model for this circuit.

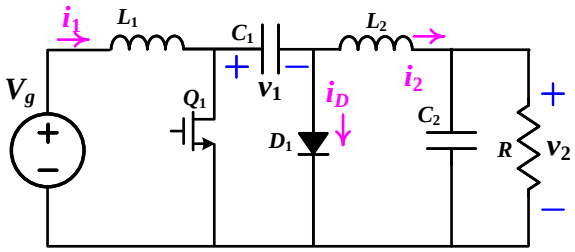

Figure 3: Cuk converter

4. (12 points) Bode plot. Given an RC circuit. $R = 10\Omega$, $L = 160\mu H$.

   (a) (6 points) Derive its transfer function $v_2(s)/v_1(s)$.

   (b) (6 points) Sketch its Bode plot. Mark the corner frequency and gradient.

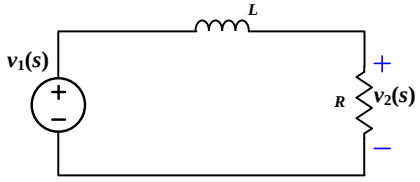

Figure 4: LC circuit