MASSACHUSETTS INSTITUTE OF TECHNOLOGY

DEPARTMENT OF ELECTRICAL ENGINEERING AND COMPUTER SCIENCE

6.622 Power Electronics Assessment #8

Due: Thursday April 27, 2023 at 11:00 pm (Cambridge time)

YOUR NAME Solutions

YOUR KERBEROS ID

General Instructions:

1. You must complete this assessment on your own with no consultation or discussion with any other person, excepting 6.622 staff, of whom you may ask clarifying questions. Do not discuss your solutions with anyone until the solutions have been released.
2. You may use a calculator and review the course lectures, handouts, notes, textbook (Principles of Power Electronics) and other materials provided for the course on Canvas when completing this assessment. Please do not use other computational tools or reference materials.
3. Please do all of your work in the space provided. In particular, try to do your work for each question within the boundaries of the question, or on the additional pages at the end of the uploaded document, clearly marking those pages to indicate what problem they relate to. Place the answer to each question within the appropriate answer box.
4. The assessment must be completed and uploaded by the indicated date/time to receive credit.
5. Please make sure to show all of your work. This is important both for you to receive credit for a correct answer and to receive partial credit when an answer is wrong or incomplete.

Name:________________________________

Problem 1

Figure 2 is an annotated portion of a figure from US patent 6,551,233. At t=0, capacitor C is charged to an initial voltage V_0, and inductor L has zero current. Starting at $t = 0$, switches S_1 and S_2 are switched on and off together, with constant on-state duty ratio D ($0.5 < D < 1$) and switching period T ($T \ll 2\pi\cdot(LC)^{1/2}$). This continues until $v_C = 0$, at which point switches S_1 and S_2 are turned off and remain off. For purposes of this problem, you may assume that all of the switches, diodes, inductor and capacitor are ideal (lossless) elements.

Find a pair of *state space equations* that describe the behavior of the *local averages* of $i_L(t)$ and $v_C(t)$ during the time the switches are modulating.

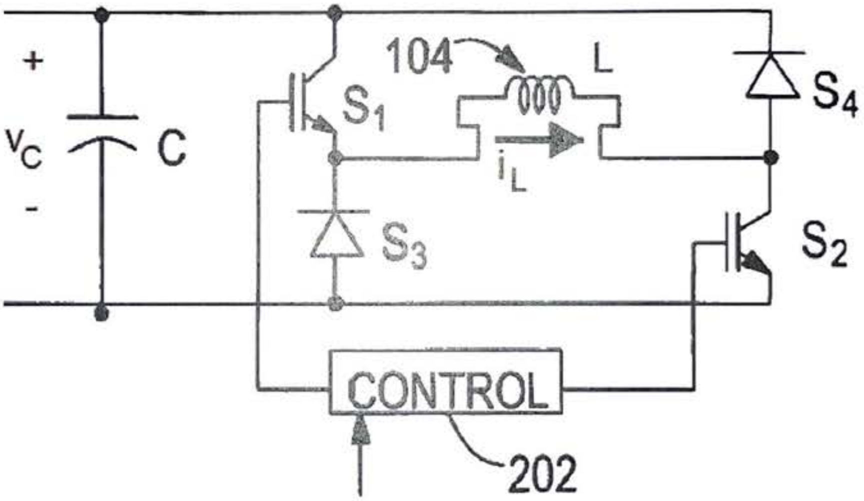

Figure 2 A portion of Fig. 4 from US Patent 6,551,233, "Magnetic Stimulator Power and Control Circuit" (annotated).

$$\left\{\begin{aligned} L\frac{di_L}{dt} &= v_c \cdot q(t) - v_c\left(1 - q(t)\right) \\ C\frac{dv_c}{dt} &= -i_L\, q(t) + i_L\left(1 - q(t)\right) \end{aligned}\right.$$

$$\left\{\begin{aligned} \overline{\frac{di_L}{dt}} &= \frac{1}{L}\,\overline{v_c\,\left(2q(t) - 1\right)} \\ \overline{\frac{dv_c}{dt}} &= \frac{1}{C}\,\overline{i_L\left(1 - 2q(t)\right)} \end{aligned}\right.$$

If i_L, v_c have small ripple, slow variation, and $\overline{q(t)} = D$

$$\left\{\begin{aligned} \frac{d\bar{i}_L}{dt} &= \frac{1}{L}(2D - 1)\cdot\bar{v}_c \\ \frac{d\bar{v}_c}{dt} &= \frac{1}{C}(1 - 2D)\cdot\bar{i}_L \end{aligned}\right.$$

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