EE152 F13 Midterm 1

Name: (please print)________________________________

In recognition of and in the spirit of the Stanford University Honor Code, I certify that I will neither give nor receive unpermitted aid on this exam.

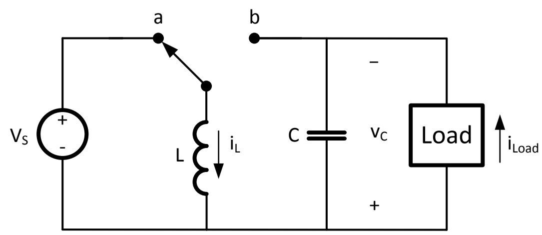
Signature:____

You may not, collaborate in any manner on this exam. This exam is open notes, open book. You have 90 minutes to complete the exam. Please do all of your work on the exam itself. Attach any additional pages as necessary.

Before starting, please check to make sure that you have all 6 pages.

1		**20**
2		**20**
3		**20**
4		**20**
5		**20**
Total		**100**

Problem 1 [20 Points]

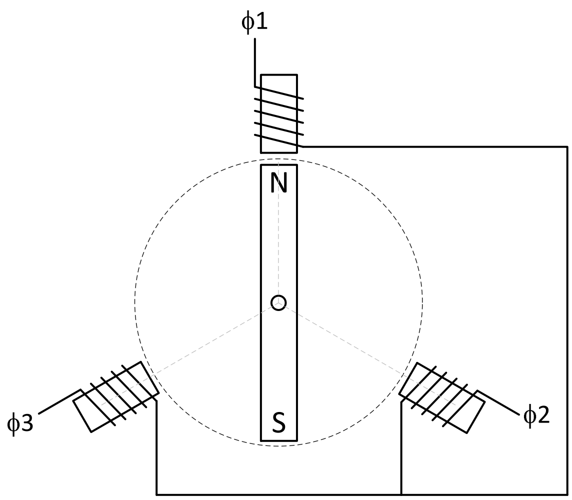


Consider the switching converter shown in the Figure above operating with a switching cycle time of t_{cy}.

(a) [10 Points] What is the relationship between output voltage V_C and input voltage V_S as a function of the duty factor of the switch in position **a** D_a in the periodic steady state.

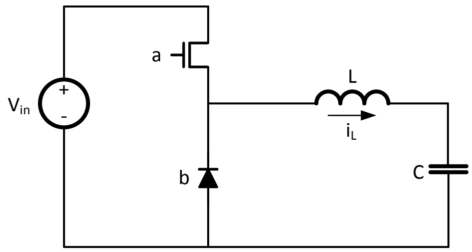
(b) [10 Points, 5 Points Each] Write expressions for the change in inductor current ΔI and the change in capacitor voltage ΔV over one cycle when not in the periodic steady state.

Problem 2 [20 Points]



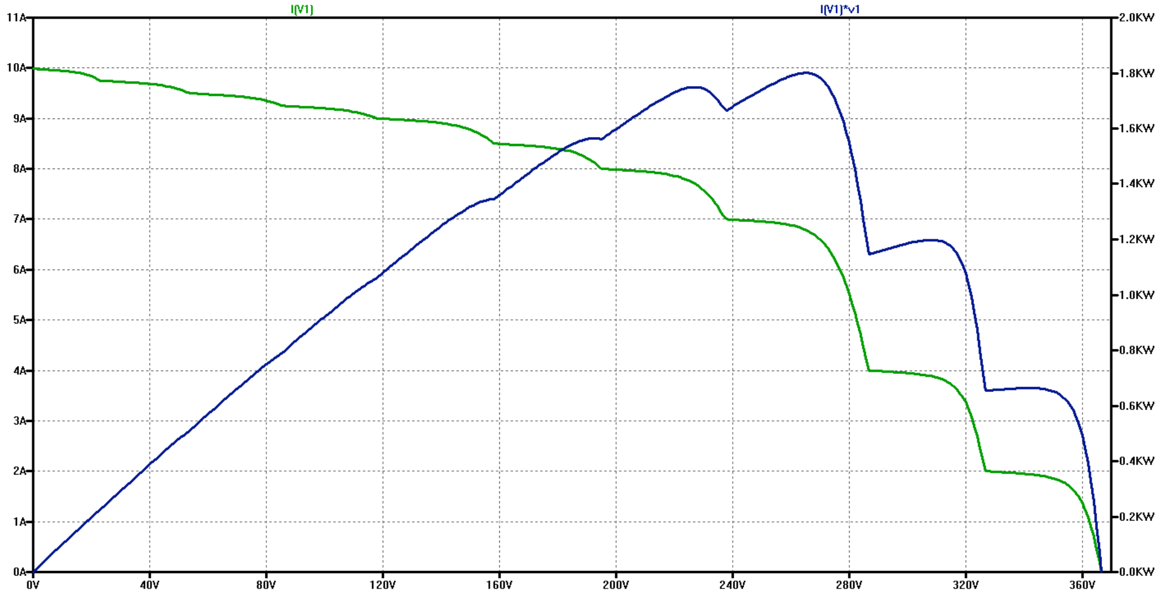
Suppose you have a 3-phase brushless permanent magnet motor (as shown above) with motor constant K_M = 1 Vs/rad for which the drive to ϕ3 has become disconnected. Assuming that you drive ϕ1 and ϕ2 with appropriate sine waves of current with peak amplitude of 1A, write an expression for the torque of this motor as a function of θ. Assume that you have an explicit return from the common point of the windings so that the current to ϕ1 and ϕ2 can be controlled independently.

Problem 3 [20 points]



Consider the buck converter shown above operating in the periodic steady state with V_{in} = 12V, V_C = 1V, I_L = 30A, and a 200kHz switching frequency f_{cy}. Suppose the MOSFET has an Ron of 5mΩ and switches with a linear current ramp of 1A/ns for both turn-on and turn-off. Assume that the capacitance on the source of the MOSFET is negligible. Also assume that the diode, inductor, and capacitor are ideal and that ripple current is negligible. Compute the switching loss and conduction loss of this converter.

Problem 4 [20 Points, 5 Points Each]



A string of 10 PV modules has the I-V (left axis) and P-V (right axis) curves shown above. Which of the following statements above this string of modules are true? (Mark each as T or F)

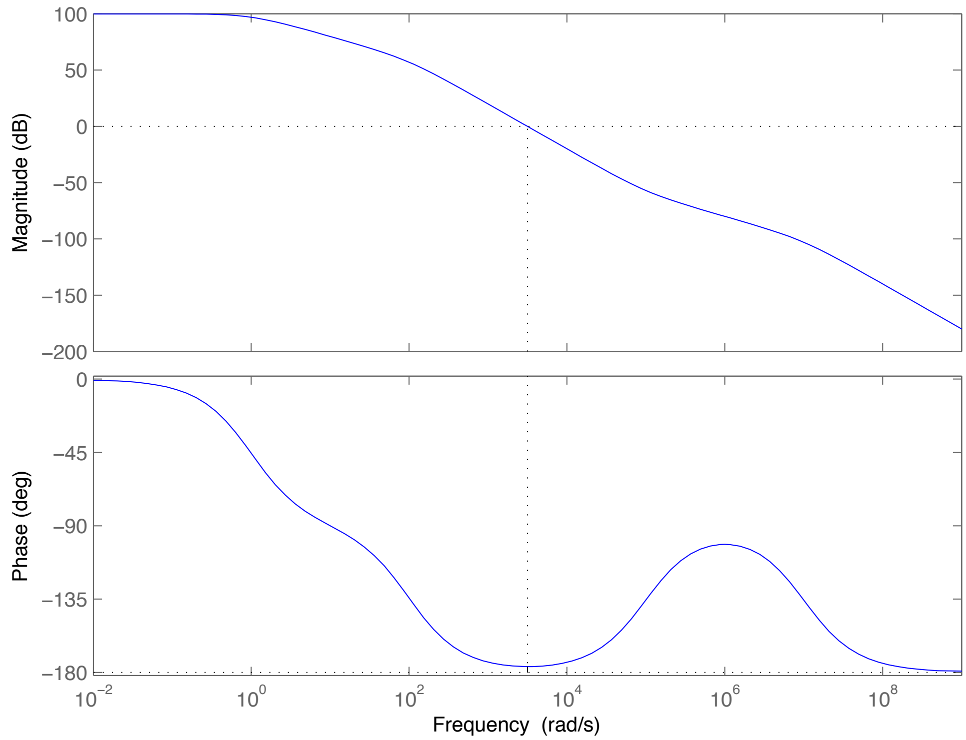
(a) The maximum power point (MPP) occurs at the open-circuit string voltage.

(b) The maximum power point (MPP) occurs at the short-circuit string current.

(c) The maximum power point occurs at about 265V.

(d) The maximum power point can be found via a hill-climbing algorithm starting from the open-circuit voltage.

Problem 5



You have a plant plus controller with the open-loop frequency response as shown in the Bode plot above. Suppose you close a feedback loop around this system. Answer the following questions about the resulting system:

(a) Is the system adequately damped, i.e., will any ringing after an abrupt transition die out in at most a cycle or two? (yes/no)

(b) At what frequency in (rad/s) will any ringing occur?

(c) At what frequency in (rad/s) are the poles and zeros of this system?

(d) Which of the following will increase the phase margin, and hence the damping of the sytem (circle all that will):

i) Increase the DC gain by 100 (40dB).
ii) Decrease the DC gain by 100 (40dB).
iii) Move the first zero up by three decades.
iv) Move the first zero down by three decades.