University of Illinois at Urbana Champaign
Department of Electrical and Computer Engineering

ECE 464 - Power Electronics, Fall 2012 Practice Exam 1 Issued: September 28

This is a closed-book exam, you are allowed one sheet of notes. No calculators are allowed.

Unless otherwise specified, you may assume that all switches, diodes, capacitors and inductors are ideal.

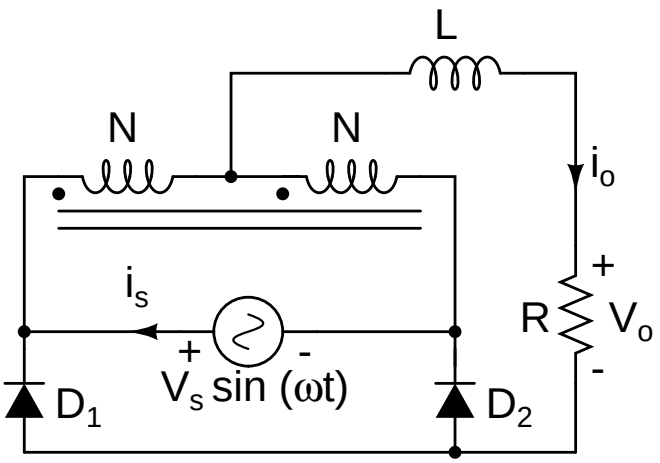

Figure 1: Rectifier circuit

Problem 1 (30 points).

Consider the rectifier circuit of Fig.1. You may assume that the filter inductor L is sufficiently large such that R/L $<< \omega$, and that the transformer and diodes are ideal.

a) Sketch and dimension the input current i_s and the currents through diodes D_1 and D_2 under periodic steady-state conditions. Please label the magnitudes on the plot expressed in terms of parameters given in the problem.

b) What is the power factor (seen by the ac voltage source) in this case?

c) What is the distortion factor k_D and the displacement factor k_θ for this rectifier?

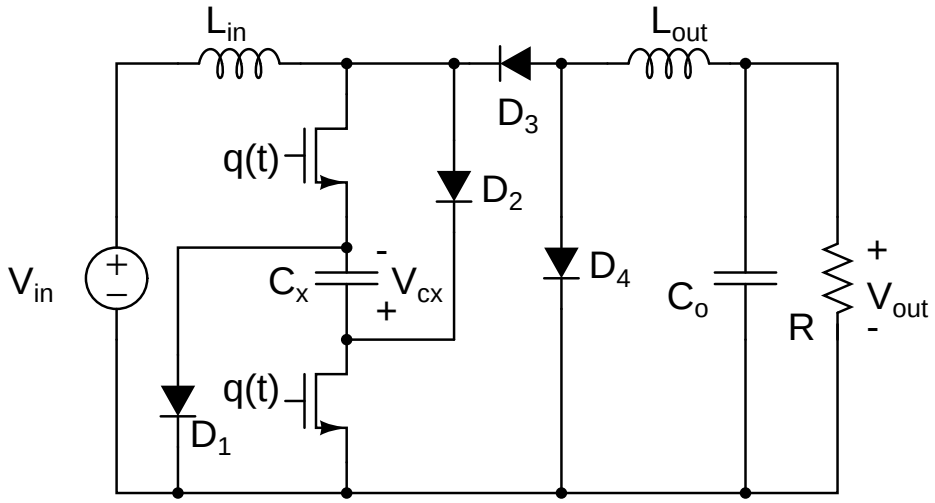

Figure 2: A version of the Sheppard-Taylor converter.

Problem 2 (30 points).
Figure 2 shows a version of power converter known as the Sheppard-Taylor topology. You may assume that V_{in} is positive, $D < 0.5$, and that all inductors and capacitors are large (i.e. they have small ripple). You may also assume that the converter operates in continuous conduction mode.
a) Is the voltage V_{out} positive or negative in periodic steady state? Why? (Note: You should be able to determine this from simple observation rather than a detailed circuit analysis.)

b) Find the voltage conversion ratio V_{in}/V_{out} in periodic steady state.

c) In continous conduction mode, sketch the current through L_{in} and label the slopes.

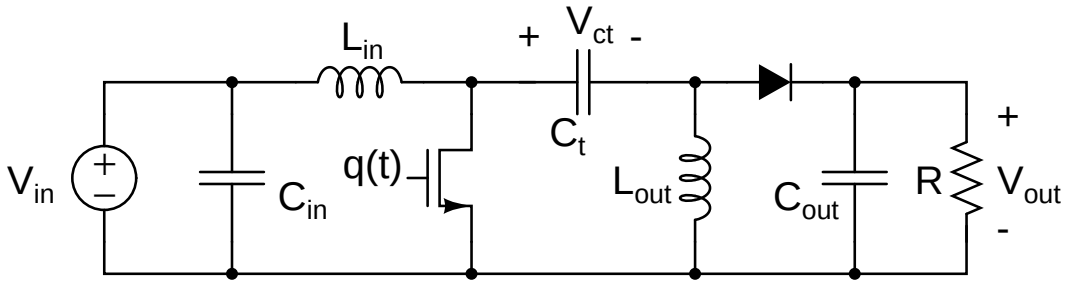

Figure 3: SEPIC converter.

Problem 3 (40 points).
Shown in Fig. 3 is a power converter called a SEPIC converter. You may assume that the inductors and capacitors are large, such that the ripple current and voltages are small.

a) What is the average voltage on the capacitor C_t?

b) What is the polarity of V_o? (Note: you should be able to answer this question without detailed circuit calculations.)

c) Find and expression for the V_{out} in terms of V_{in} and D.
d) Now consider the following operating parameters: $V_{in} = 10$ V, $D = 0.5$, $P_{out} = 20$ W, $f_{sw} = 100$ kHz, $L_{in} = 100\ \mu H$. Carefully sketch the current through the inductor L_{in} and label the maximum and minimum values. You may ignore the voltage ripple on C_t and the current ripple in L_{out} in this analysis.
e) Find the load resistance for which the converter is at the boundary between CCM and DCM operation in terms of D, L, and f_{sw}. Also, please numerically calculate the resistance value assuming the same converter parameters as given in d).