6.334 Power Electronics
Spring 2007

6.334 Power Electronics   Issued: February 16, 2007

Problem Set 2   Due: February 23, 2007

Reading: KSV Chapter 4 through 4.1, Chapter 6

Problem 2.1
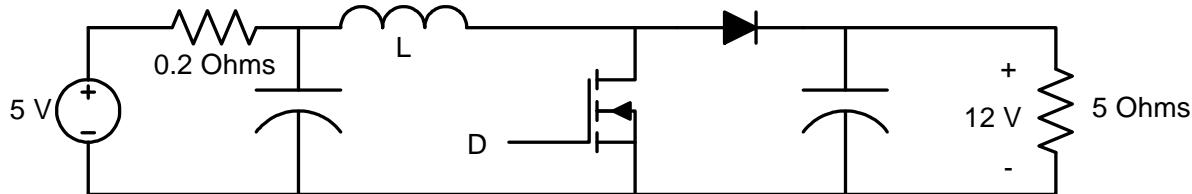
Figure 1 A boost converter operating from a source with output resistance.

Figure 1 shows a boost (up) converter supplying 12 V to a load of 5 Ω from a 5 V source having an internal resistance of 0.2 Ω. Determine the duty ratio D at which the converter operates. (You may neglect semiconductor device drops in your calculations.)

Problem 2.2   KSV Problem 6.5

Problem 2.3

Derive the *current* conversion ratio I_2/I_1 of the converter in KSV Fig. 6.15. Which direction(s) can power flow in this converter?

Problem 2.4

There are many factors that influence sizing of the passive components in practical power converters. Among these are:

1. Ripple (e.g., how much voltage and current ripple are permissible in the component, input and output voltages and currents in periodic steady state operation.)
2. Transient performance (e.g., how much peak deviation away from steady state will occur during a transient condition, such as when the load resistance changes.)
3. A desire to limit the size and cost of the passive components (inductors and capacitors).

This problem concerns the selection of passive component values for the buck converter of Fig. 2. This converter operates with a switching frequency of $f_s = 250$ kHz from an input voltage of $V_{IN} = 48$ V at a constant duty ratio of D = 0.5. The load resistance R_L can vary over the range $0.5\ \Omega < R_L < 1\ \Omega$.

A.   A decision has been made to design the system such that the capacitor receives less than

4 A (RMS) of ripple current in periodic steady-state operation. It is also desirable to keep the inductor value reasonably small to save cost and space. Select an appropriate inductor value and calculate the RMS current that the capacitor will receive in periodic steady-state operation.

B.   A decision has been made that the output ripple voltage must be less than 1.2 Volts peak-to-peak in periodic steady state operation, but that the capacitor should be kept reasonably small to save cost and space. Select an appropriate capacitor value to meet this requirement. Calculate an approximation for the expected peak-to-peak ripple voltage on the capacitor.

C.   Simulate your design and verify that the requirements in parts (A) and (B) are met.

D.   A transient specification is now added. The output voltage should remain between 16 and 32 V during a transient when the load steps between 0.5 and 1 Ω (either direction). Simulate this transient. Does your design comply with this new requirement? If not, propose a second set of L and C values that meet all of the above requirements.
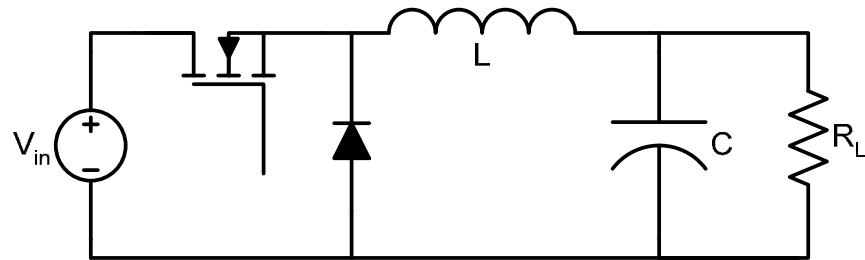
Figure 2 A buck converter supplying a resistive load.