

**MASSACHUSETTS INSTITUTE OF TECHNOLOGY**  
**Department of Electrical Engineering and Computer Science**

6.334 Power Electronics  
Problem Set 5

Issued: March 9, 2007  
Due: March 16, 2007

Reading: KSV Chapter 8

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**Problem 5.1**

Consider the isolated SEPIC converter of Fig. 1. (As with the flyback converter, the transformer is used as an energy-storage element. Figure 1 shows the transformer magnetizing inductance as an explicit circuit element.) You may assume the converter operates in heavy continuous conduction mode.

- a. What is the input to output conversion ratio with a transformer turns ratio of 1:n?
- b. If the nominal input voltage is 5 V, and the desired output voltage is 60 V, what is the optimum transformer turns ratio to minimize the device stresses? At what nominal duty ratio would the converter operate in this case?
- c. How do the device stresses of this case compare to that for a non-isolated indirect converter with the same input and output voltage magnitudes (*cf* KSV Sect. 6.6).

**Problem 5.2** KSV Problem 7.3

**Problem 5.3**

Figure 1 shows the schematic of an example 50 W *off-line* converter (powered from the ac line voltage). The ac line voltage is rectified to provide a (nominal) voltage  $V^+ = 170$  V dc (across capacitor  $C_{25}$ ), which the dc/dc converter section uses to generate multiple low-voltage dc outputs.

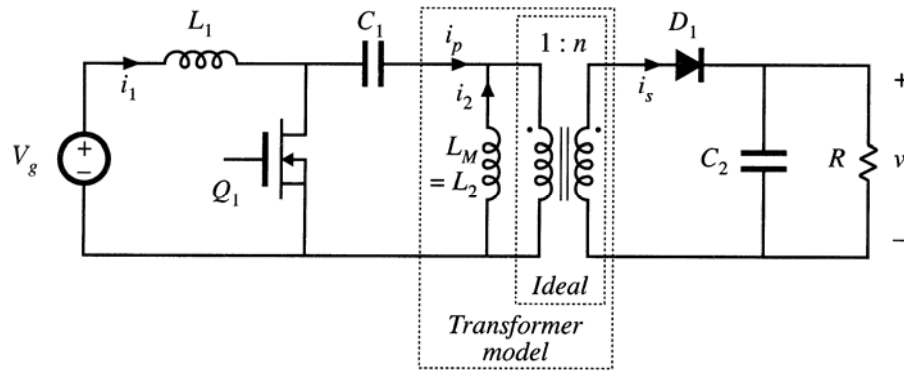
- a. What type of dc/dc topology is at the core of this converter?
- b. Would the multiple windings on transformer T1 be wound on a parallel or series magnetic core structure (*e.g.*, KSV Fig. 20.21 or Fig. 20.22)?
- c. Would it be better to use a gapped or an ungapped core structure in this converter? Why?
- d. Consider the case where the 3.3 V output is heavily loaded and the other outputs are lightly loaded. Considering the effects of transformer leakage inductance and diode drops, will the 5 V output tend to sit above, at, or below its nominal value of 5 V? (*Note: it is the 3.3 V output that is regulated in this converter.*)

**Problem 5.4** KSV Problem 8.1

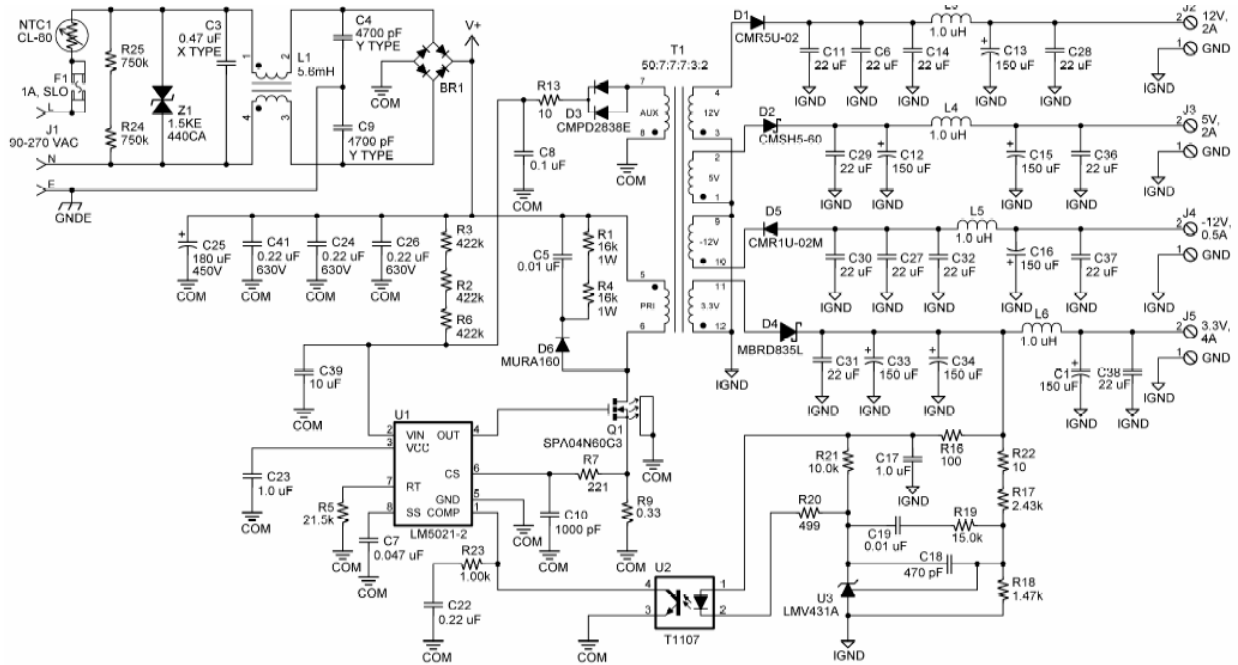
**Problem 5.5**

Figure 2 shows the structure of a forward converter having an active clamp. The main switch Q1 is modulated with duty cycle  $D$ , and the auxiliary switch  $Q_{AUX}$  is turned on and off exactly oppositely to the main switch. The function of the clamp circuit (comprising  $C_{AUX}$  and  $Q_{AUX}$ ) is to reset the transformer core.

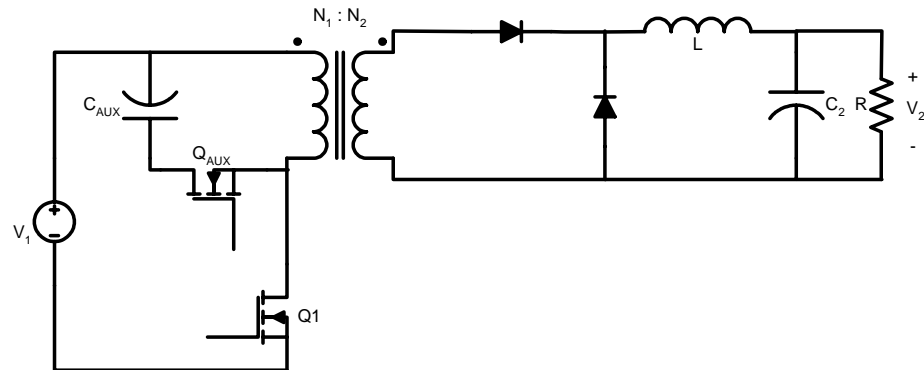
- a. In periodic steady state operation, what is the voltage on  $C_{AUX}$  as a function of  $V_1$  and  $D$ ?
- b. Sketch the shape of the magnetizing inductance current in periodic steady-state operation for  $V_1 = 48$  V,  $D = 0.4$ ,  $T = 5$   $\mu$ s, and  $L_{\mu 1} = 50$   $\mu$ H (magnetizing inductance referred to the primary side). Does this transformer have a unipolar or bipolar flux swing?
- c. If one wanted to minimize the energy stored in the transformer magnetizing inductance, should the transformer be wound on a gapped core or an ungapped core? (Recall that the peak stored energy is  $0.5 L_{\mu 1} i_{\mu 1, \text{peak}}^2$ .)



**Figure 1** An isolated SEPIC converter. The magnetizing inductance of the transformer is shown as an explicit circuit element.



**Figure 2A** 50 W off-line converter (NSC datasheet example).



**Figure 3** A forward converter with an active clamp.