Tampere University of Technology **Switched-Mode Converters DEE-33106** 1.3. 2016
Electrical Engineering
Teuvo Suntio Programmable calculator allowed

Note: The answers can be given either in English or Finnish.

Question 1. The next six subquestions are related to certain relevant terms in power electronics and the inductor current shown in Fig. 1. **a)** Explain the meaning of Vs balance, **b)** Explain the meaning of As balance, **c)** What is the operating mode of the converter having inductor current as shown in Fig. 1 (CCM, DCM or BCM) ?, **d)** What is the switching frequency of the converter? **e)** If we assume that the converter is a Buck converter, what is its average output current? and **f)** what is its average input current? Each subquestion will give one point.

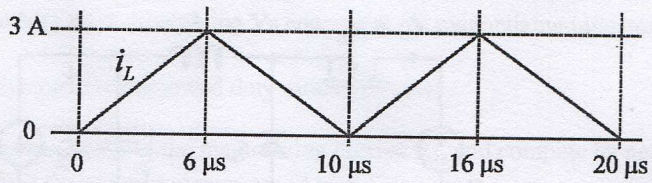

Fig. 1

Question 2. Fig. 2 shows the sample waveforms of the input and output currents as well as the capacitor of voltage of an ideal basic second-order switched-mode converter. The output voltage of the converter is 75 V. **a)** What is the name of the converter (buck, boost or buck-boost)?, **b)** what is its operating mode (CCM, DCM, or BCM)?, **c)** what is its duty ratio?, **d)** what is its input voltage?, **e)** What is the value of its inductor L, and **f)** What is the value of its output capacitor C? Each subquestion gives 1 p.

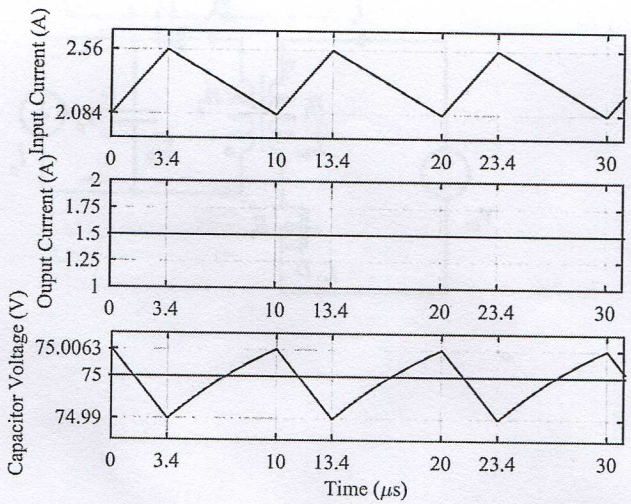

Fig. 2

Question 3. Fig. 3 shows the power stage of an ideal buck converter having switching frequency f_s of 150 kHz. Its K_{crit} value equals D'. a) Choose the value of the inductor L such that the converter operates in DCM when the output voltage and current are 50 V and 1 A as well as the input voltage varies in the range of 60-150 V (3 pts). b) Define of the value of duty cycle (D) when the output voltage and current are as defined above and the input voltage equals 80 V (2 pts), and c) Define the peak-to-peak inductor current at the same operating point as in (b) (1 pt).

$$D = M\sqrt{\frac{K}{1-M}} \qquad K = \frac{2L}{T_s R_{eq}}$$

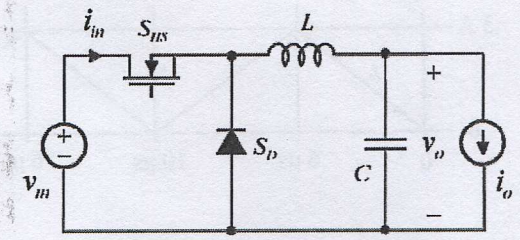

Fig. 3

Question 4. The switching frequency of the Flyback converter in Fig. 4 equals 150 kHz, and the converter operates in DCM. Its input voltage V_{in} = 350 V, output voltage V_o = 48 V, transformer turns ratio n_2/n_1 = 0.21, L_M = 2 mH, C_o = 330 µF, and output power P_o = 48 W. The duty ratio is defined by $D = M\sqrt{K}$ and the critical K by D'^2. Assume the output diode D_1 to be ideal. Define **a)** the maximum voltage of the switch S_1, **b)** the maximum voltage of the diode D_1, **c)** the K value of the converter, **d)** the duty ratio, **e)** the peak current of S_1, and **f)** the average current of the diode D_1. Each subquestion gives 1 pt.

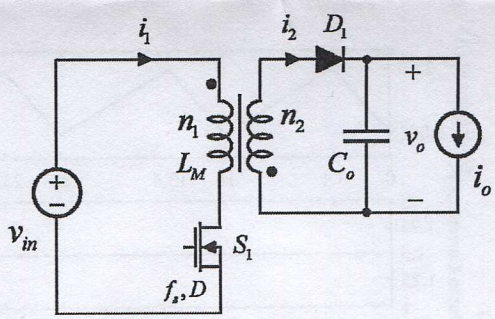

Fig. 4

Question 5. An active reset Forward converter is shown in Fig. 5. The converter works in such a way that the main switch S_1 conducts during the on time, and the auxiliary switch S_2 during the off time, respectively. The input voltage is 200 V, the switching frequency is 100 kHz, and the magnetizing inductance is 4 mH, respectively. The active reset capacitor is large enough so that its voltage can be assumed constant. The absolute maximum voltage of the MOSFET S_1 is 600 V. Derating of 15 % is required for reliability reasons.

a) Compute the steady-state voltage v_{CR} as a function of the input voltage and the duty ratio D of the MOSFET S_1 applying Vs concept to the magnetizing inductor. (2 pts)

b) What is the maximum allowed duty ratio D ? (2 pts)

c) Sketch the waveform of the magnetizing current i_{LM} and compute its peak value when the duty ratio is the allowed maximum. (2 pts)

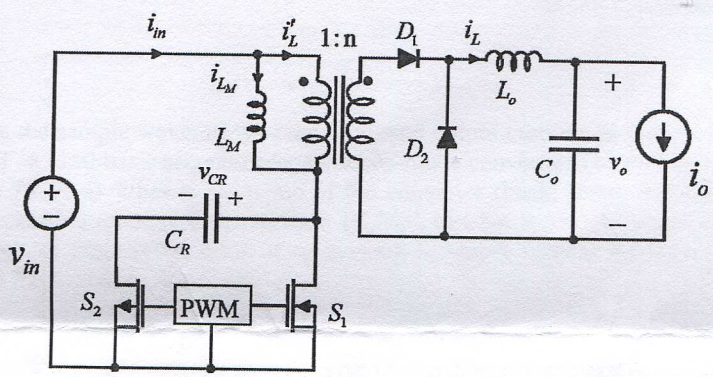

Fig. 5