Tampere University of Technology **Switched-Mode Converters DEE-33106** 10.3. 2015
Electrical Engineering
Teuvo Suntio Programmable calculator allowed

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

Question 1. Define shortly the following terms or concepts relevant to switched-mode converters **a)** Vs balance, **b)** As balance, **c)** M(D,K), **d)** K_{crit} **e)** BCM and **f)** PCM control (**Note**: Direct English language translation is not enough but the meanings are required to be explained!) Each subquestion gives 1 pt.

Question 2. Fig. 1 shows a sample of the inductor current of an ideal buck converter. In addition with the inductor-current waveform (Fig. 1), we know that its output voltage is 30 V. **a)** What is its operation mode (CCM, BCM, DCM)?, **b)** What is its average output current?, **c)** What is its input voltage?, **d)** What is its duty ratio?, **e)** What is the value of its inductor L, and **f)** What is its average output capacitor current? Each subquestion gives 1 p.

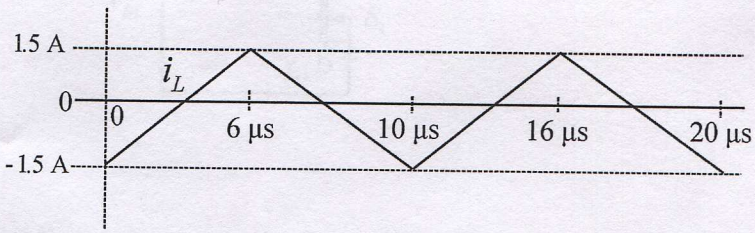

Fig. 1

Question 3. Fig. 2 shows the power stage of a boost converter having switching frequency f_s of 150 kHz. Its critical K_{crit} value equals DD'^2. Assume the diode D_1 to be ideal. a) Choose the value of the inductor L_{in} such that the converter operates in DCM when the output voltage and output power are 50 V and 50 W and the input voltage varies in the range of 12-40 V (3 pts). b) Define of the value of pulse ratio when the output voltage and output power are as defined above and the input voltage equals 30 V (2 pts). c) Define average current of diode D_1 at the operating point of b) (1pts). $D=\sqrt{KM(M-1)}$, $K=\frac{2L}{R_{eq}T_s}$, $M(D)=1/D'$.

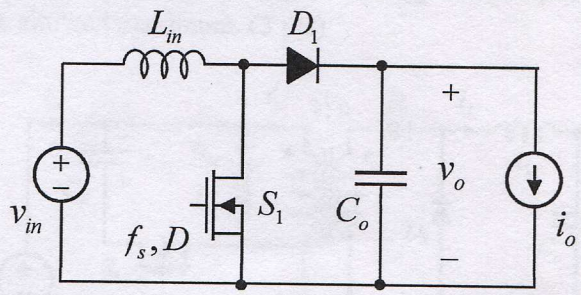

Fig. 2

Question 4. The switching frequency of the Flybcak converter in Fig. 3 is 150 kHz, and it is operating 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 = 40 W. The duty ratio is defined by $D = \sqrt{K} \cdot M$ 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.

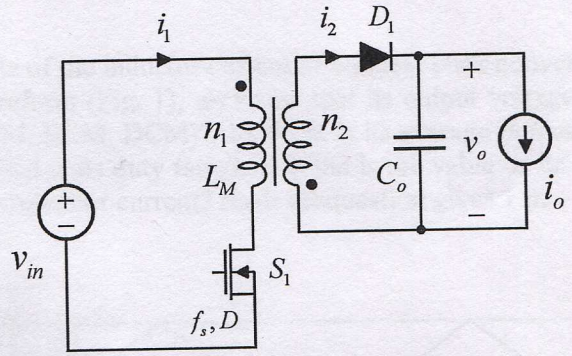

Fig. 3

Question 5. An active reset Forward converter is shown in Fig. 4. 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 % in voltage is required for reliability reasons. *This question gives maximally* 8 pts.

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. (3 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. (3 pts)

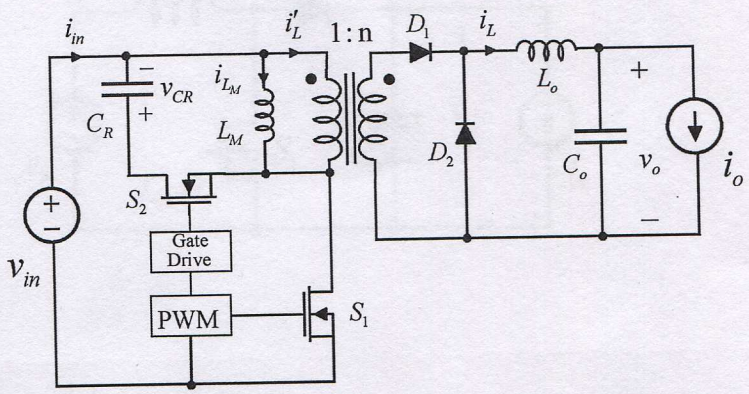

Fig. 4