

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 V_s balance, **b)** Explain the meaning of A_s 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 Boost converter, what is its average output current? and **f)** what is its average input current? Each subquestion will give one point.

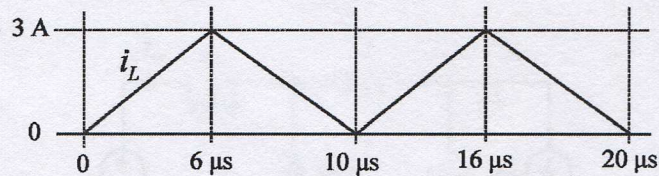


Fig. 1

Question 2. Fig. 2 shows the power stage of a certain current-fed converter. The MOSFET gate control scheme is defined in the figure. The converter operates in CCM. **a)** Define $M(D)$ of the converter in terms of I_o / I_{in} (3 pts) **b)** Define V_{in} / V_o (1 pt), **c)** What is the type of the converter (buck, boost or buck-boost) (1 pt), and **d)** Define the average inductor current in terms of input current (1 pt).

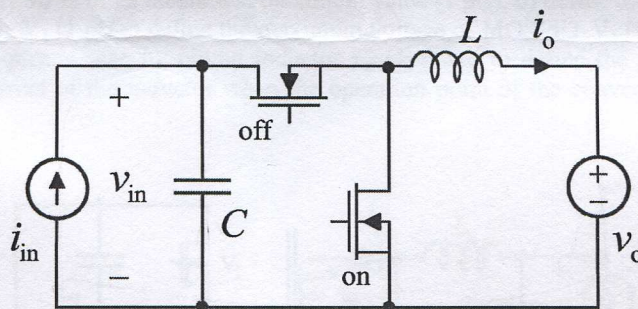


Fig. 2

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).

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

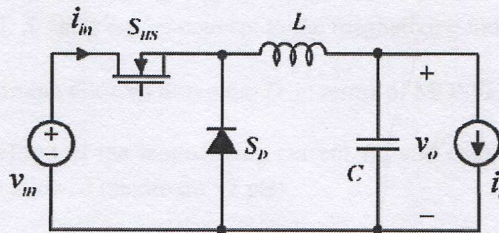


Fig. 3

Question 4. Fig. 4 shows a certain buck-derived converter, where the switching frequency of V_1 and V_2 equals 100 kHz, and the converter operates in CCM. Its input voltage V_{in} varies from 200 V to 400 V, output voltage $V_o = 48$ V, $C_o = 330 \mu\text{F}$, $L_o = 100 \mu\text{H}$ and output power $P_o = 48$ W. The primary-side capacitors can be assumed to be high enough so that the midpoint voltage stays constant. Assume the output diodes V_3 and V_4 to be ideal: a) define the required transformer turns ratio (N_2/N_1) for obtaining the stated output voltage when the maximum duty ratio can be only 90 % of its theoretical maximum value (1 pts), b) define the maximum reverse voltage of diode V_3 (1 pt) c) define the maximum voltage of MOSFET V_1 (1 pt), d) what is the operational frequency seen by output inductor L_o (1pt), and e) define the maximum peak-to-peak ripple current of the inductor when the operation point of the converter varies as stated above (2 pts).

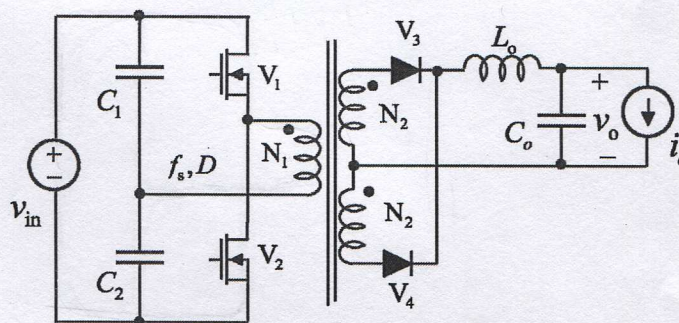


Fig. 4

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.

- 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)
- What is the maximum allowed duty ratio D in terms of MOSFET specification? (2 pts)
- Sketch the waveform of the magnetizing current i_{LM} and compute its peak value when the duty ratio is the allowed maximum. (2 pts)

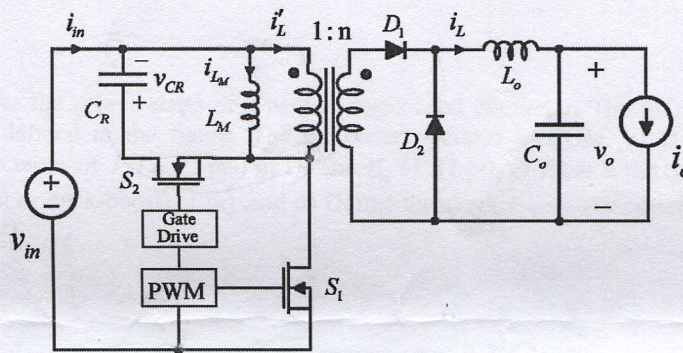


Fig. 5