

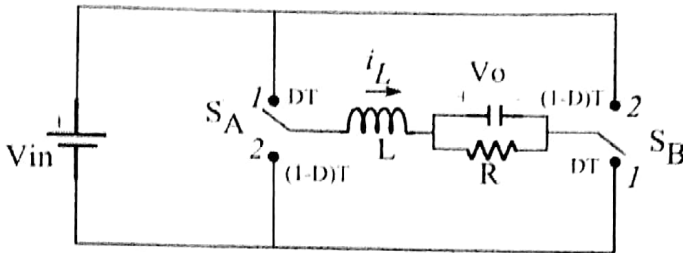
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Minor 1 (Date: 30.08.2017), 9:30-10:30 AM, 3-LH 108

Marks: 20, Time: 60 minutes, Make suitable assumptions if necessary.

ENTRY

Problem 1: (5 marks)



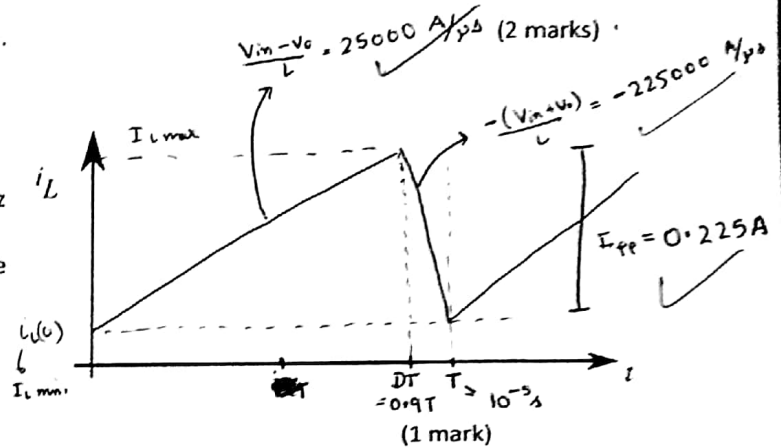
Carefully study the DC-DC converter shown in the diagram. Switches SA and SB are connected to positions '1' for DT duration of time, where T is the switching time period. Switches SA and SB are connected to positions '2' for (1-D)T duration of time.

(a) Calculate the voltage gain of the converter in terms of D.

Ans: $\frac{V_o}{V_{in}} = 2D - 1$

(b) Assume $V_{in}=25V$, $V_o=20V$, $R=10\Omega$, $L=200\mu H$, $f=100\text{ kHz}$ and CCM operation in the converter. Draw the inductor current waveform indicating the slopes of the current in the waveform during DT and (1-D)T time periods. Indicate the peak to peak ripple current magnitude.

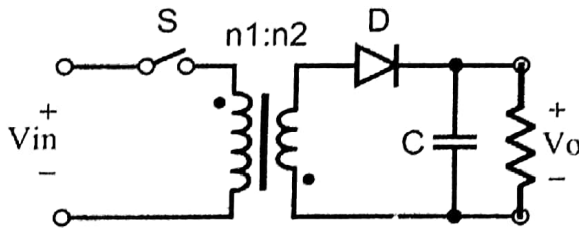
(2 marks)



(c) What is the average value of the inductor current?

Ans: 2 A

Problem 2 (5 marks)



The figure shows a flyback converter operating in CCM mode. The output voltage is 10V delivering a power of 20W. The input voltage is 150V. The turns ratio of the transformer is 1:0.25. The switching frequency is 10 kHz and $C=500\mu F$.

(a) Find out the operating duty ratio.

(1 mark)

Ans: $\frac{V_o}{V_{in}} = 0.2105$

(b) Find out the charge lost by the capacitor C during the time switch S is turned on.

(1 mark)

Ans: $\frac{8}{14} \times 10^{-4} = 0.421 \times 10^{-4} \text{ Coul (lost)}$

(c) If a safety factor of 2 is taken, then what is the voltage rating of the switch S?

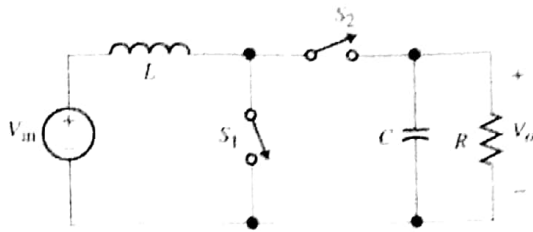
(1 mark)

Ans: $2(150 + 4 \times 10) = 380V$

(d) What is the output voltage ripple of the converter expressed as a percentage of the output voltage? (2 marks)

Ans: $\frac{0.421}{5} = 0.0842$

Problem 3 (5 marks)



A boost converter is designed to give 6V output to supply a load current of 1A. The input voltage can vary between 2.7V to 3.6V. A closed loop control circuit ensures that the output voltage is constant in presence of changing input voltage. The switching frequency is 200 kHz.

(a) Determine the minimum value of the inductor such that under the worst case input, the converter operates in CCM mode of operation. (2 marks)

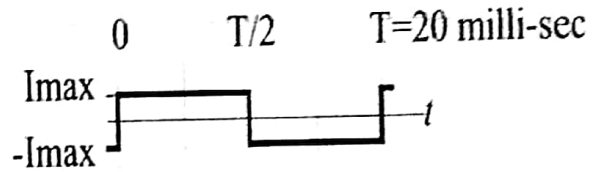
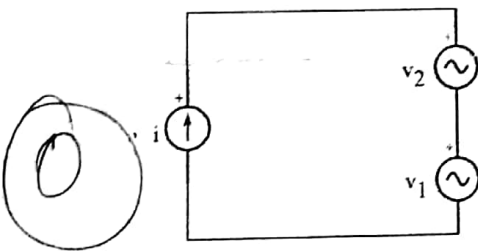
2) Ans: $2.16 \times 10^{-6} \text{ Henry} = 2.16 \mu\text{H}$ ✓

(b) Determine the minimum value of inductor such that under all operating conditions, the peak to peak ripple in inductor current is not more than 50% of the average inductor current. (3 marks)

0) Ans: $15 \times 10^{-6} \text{ Henry} = 15 \mu\text{H}$ ✗

Problem 4 (5 marks)

Consider the current source $i(t)$ feeding into two voltage sources $v_1(t)$ and $v_2(t)$. The waveform for $i(t)$ is shown, where $I_{max}=20\text{A}$. Assume $v_1(t)=50 \sin(\omega t)$ and $v_2(t)=5 \sin(3\omega t)$ where $\omega=2\pi \cdot 50 \text{ rad/s}$.



(a) Determine the magnitude of the fundamental component of current. (1 mark)

Ans: 20 A ✗

(b) Determine the magnitude of the 2nd harmonic component of current. (1 mark)

Ans: 10 A ✗

(c) Determine the magnitude of the 3rd harmonic component of current. (1 mark)

Ans: 3.333 A ✗

(d) What is the power absorbed by the voltage source v_1 ? (1 mark)

Ans: 500 W ✗

(e) What is the power absorbed by the voltage source v_2 ? (1 mark)

Ans: $100/3 = 33.33 \text{ W}$ ✗