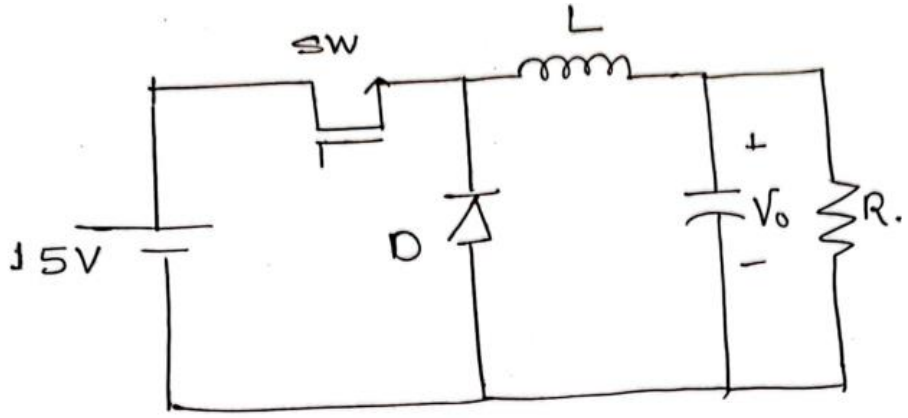
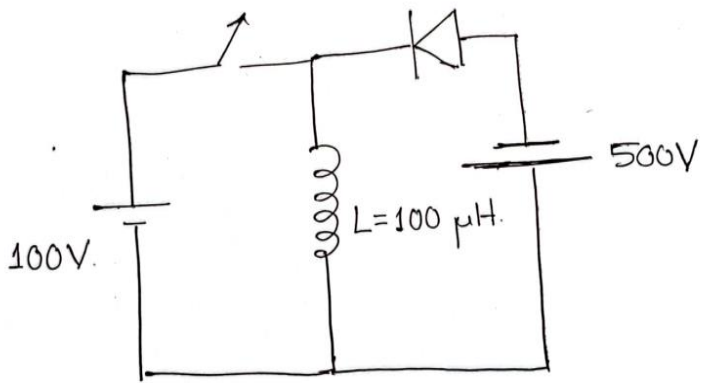
Assignment 2 (EE 238)

1. Design a buck converter with a source voltage of 50 V and duty ratio of 0.6. The load resistance is 20 Ω. The maximum voltage ripple in the capacitor is 1% of the average capacitor voltage and the maximum ripple current is 5% of the average output current. Assume the converter is operating in CCM (Continuous Conduction Mode). The switching frequency is 2 kHz. **(Ans: L=80 mH; C=15.625 μF)**

2. Find the output voltage of the following circuit considering the forward voltage drop of the MOSFET as 1 V and the forward voltage drop of the diode as 0.7 V. The switch is ON for 40% of the time in a switching cycle. The switching frequency is 5 kHz and assume CCM. **(Ans: V_0=5.18 V)**



3. Consider the following circuit. The f_s=10 kHz of the switch.

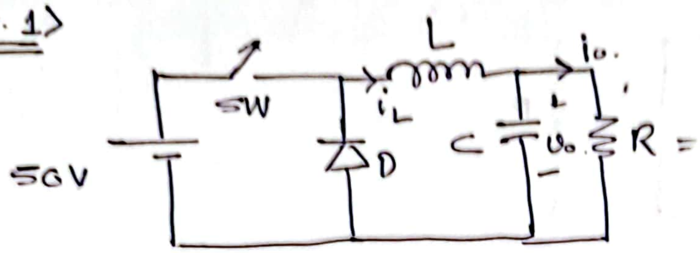


The minimum current of the inductor is zero but never for a finite duration at the steady state. Find the peak value of the inductor current and also the duty ratio. **(Ans: $I_{L,pk}$=83.33 A; D=5/6)**

4. For a buck converter, the source voltage is 100 V, the duty ratio is 0.4 and the output voltage is 50 V. Given L=200 µH and f_s=20 kHz, find
   a) the peak value of the current.
   b) The average output current. **(Ans: $I_{L,pk}$=5 A, I_0=2 A)**

5. Assuming CCM, draw the waveforms of the switch current, diode current, inductor current and the capacitor current for both Boost and Buck-Boost converters.

Ans. 1)



$D = 0.6$

$R = 20\,\Omega$.

$f_s = 2\,kHz$.

$\Delta v_o = 0.01\,V_o$. —(1)

$V_o = D\,V_{dc} = 0.6 \times 50 = 30V$. —(2)

$\Delta v_c = 0.01 \times 30 = 0.3V$ —(3)

$\Delta v_c = \frac{\Delta I_L}{8C}$ —(4)

$I_o = I_L = \frac{30}{20} = 1.5A$ —(5)

$\Delta I_L = \frac{V_o(1-D)T_s}{L}$ —(6)

$0.05 \times 1.5 = \frac{30 \times 0.4}{2k \times L}$

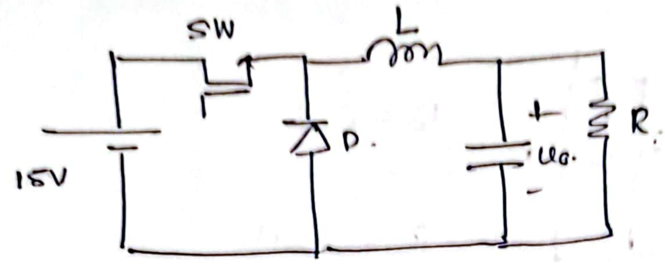
$\Rightarrow \boxed{L = \frac{12}{1.5 \times 0.05 \times 2k} = 80mH.}$ —(1)

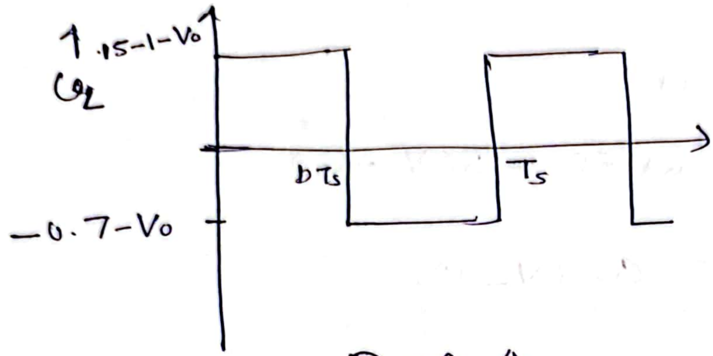
$C = \frac{\Delta I_L T_s}{\Delta v_c \times 8} = \frac{0.05 \times 1.5}{8 \times 0.01 \times 30\, f_s}$

$= \frac{5 \times 1.5}{240} \times \frac{1}{2K}$.

$\Rightarrow \boxed{C = 15.625\mu F}$ —(2)

2)





$$D = 0.4$$

$$\langle v_L \rangle = 0 \Rightarrow (15-1-V_o)\,D\cancel{T_s} = (+0.7+V_o)(1-D)\cancel{T_s}.$$

$$\Rightarrow (14-V_o)\times 0.4 = (+0.7+V_o)\times 0.6.$$

$$\Rightarrow 5.6 - 0.4V_o = +0.42 + 0.6V_o.$$

$$\Rightarrow \cancel{-0.2V_o = -55.58}$$

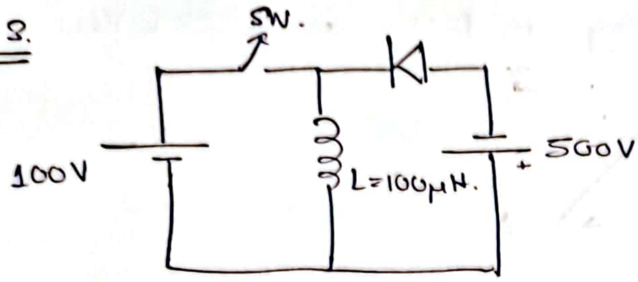
$$\Rightarrow \cancel{V_o =}$$

$$\Rightarrow \cancel{\boxed{55.58 = V_o.}}$$

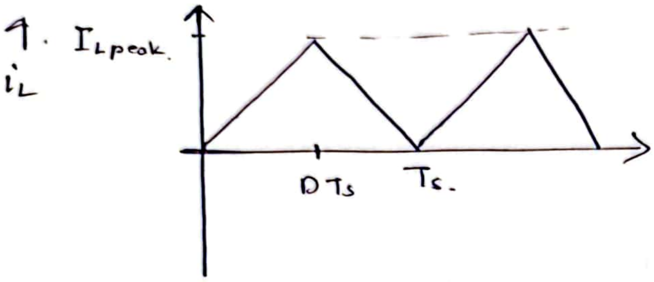
$$\therefore \cancel{V_o = 55.58\ V.}$$

$$\Rightarrow \boxed{V_o = 5.18V}$$

Ans 3.



$f_s = 10kHz.$



$$\frac{100}{\cancel{L}} \times D\cancel{T_s} = (1-D)\cancel{T_s} \times \frac{500}{\cancel{L}}$$

$$\Rightarrow \quad 5 = \frac{D}{1-D}$$

$$\Rightarrow \quad \boxed{D = \frac{5}{6}} \quad -(1)$$

$$\cancel{\therefore I_{L,peak} = \frac{100}{L} \times DT_s = \frac{100}{100\mu} \times \frac{5}{6} \times \frac{1}{10k}}$$

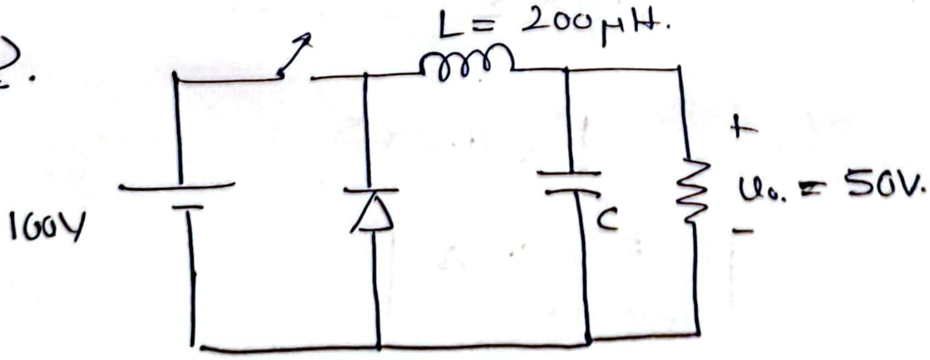
$$\cancel{\boxed{I_{L,peak} = 83.33A}}$$

$$I_{Lpeak} = \frac{100}{L} \times DT_s$$

$$= \frac{100}{100\mu} \times \frac{5}{6} \times \frac{1}{10k}$$

$$\boxed{I_{L,peak} = 83.33A}$$

Ans. 4).



D=0.4.

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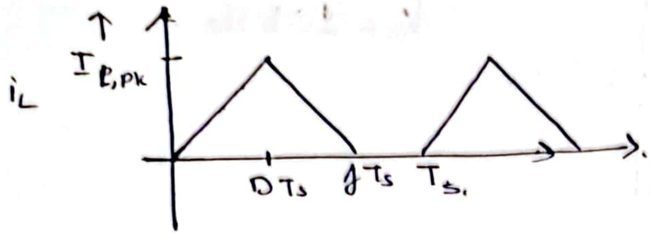
The circuit is operating in DCM as $V_o > DV_{dc}$.



$$\frac{50}{100} = \frac{D}{\delta}$$

$$\Rightarrow \delta = \frac{D \times 100}{50}$$

$$= \frac{0.4 \times \cancel{100}^{2}}{\cancel{50}}$$

$$\boxed{\delta = 0.8} \quad -(1)$$

a) $$I_{L,peak} = \left(\frac{V_{dc} - V_o}{L}\right) DT_s$$

$$= \frac{(100-50)}{200\mu} \times \frac{0.4}{20K}$$

$$\boxed{I_{L,peak} = \frac{50 \times 0.4}{4\cancel{000}\,\cancel{\mu \times K}} = \frac{20}{4} = 5A.}$$

b) $$I_o = \langle i_L \rangle = \frac{1}{2} \times \frac{\delta \cancel{T_s} \times I_{L,pk}}{\cancel{T_s}}$$

$$= \frac{1}{2} \times 0.8 \times 5$$

$$\boxed{I_o = 2A.}$$