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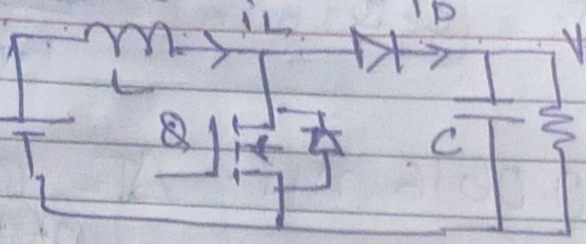
19EE10039

Q1.



$V_g = 24V$
$V_0 = 56V$
$T_s = 10\mu s.$

(i) $i_{d|avg} = I_D = 6A.$ $\quad i_{L\,peak} = 20A \quad \Delta V_0\ 2.8V.$

$L, R, C = ?$

$56/24$

$\frac{24}{56} = \frac{1}{1-D}$ (sic) $\quad 1-D.$

$$\frac{V_0}{V_g} = \frac{1}{1-D}.$$

$$I_0 = \frac{V_0}{R} = I_{d|avg}.$$

$$\frac{56}{R} = 6 \qquad \boxed{R = 9.\bar{3}\ \Omega}$$

$$\frac{\Delta V_0}{V_0} = \frac{D T_s}{RC}.$$

$$1-D = \frac{24}{56}.$$

$$\frac{2.8}{56} = \frac{32 \times 6 \times 10\mu}{56 \times 56 \times C}$$

$$D = \frac{56-24}{56} = \frac{32}{56}$$

$$C = \frac{32 \times 6 \times 10}{56 \times 2.8}\ \mu F$$

$$\boxed{C = 12.245\ \mu F}$$

$$I_0 T_s + \tfrac{1}{2}\Delta I_L T_s = I_L$$

$$I_0(1-D)T_s + \tfrac{1}{2}\Delta I_L(1-D)T_s = I_D = I_0$$

$$\Delta I_L = \left\{\frac{I_D}{T_s} - I_0(1-D)\right\}\frac{\times 2}{(1-D)}$$

$$\Delta I_L = 2I_D\left\{\frac{1}{(1-D)T_s} - 1\right\}.$$

$$\Delta I_L = 2 \times 6 \times \left(\frac{6}{56 \times 10\mu} - 1\right)$$

$$\Delta I_L \approx 12 \times \frac{6 \times 10^5}{56}.$$

$$\frac{\Delta I_L}{I_L} = \frac{(1-D)^2 \cdot D \cdot R T_s}{L}.$$

$$L = \left(\frac{24}{56}\right)^2 \times \frac{32}{56} \times \frac{56}{6} \times 10\mu \times \frac{20}{\Delta I_L}.$$

$$L = \frac{24^2 \times 320 \times 20}{56^2 \times 6 \times \Delta I_L}\ \mu$$

$$L = \frac{195.92}{\Delta I_L}\ \mu H.$$

2

$$I_{L_{peak}} = I_L + \frac{1}{2}\Delta I_L.$$

$$20 = 14 + \frac{1}{2}\Delta I_L.$$

$$12 = \Delta I_L.$$

$$L = \frac{195.92}{12}\ \mu H.$$

$$\boxed{L = 16.32\ \mu H}$$

$$I_L = \frac{V_o}{V_g} \times I_o$$

$$= \frac{1}{1-D} \times 6$$

$$= \frac{56}{24} \times 6$$

$$I_L = 14.$$

(ii) $R = R_{critical}$. boundary betn CCM & DCM.

$$\frac{2L}{RT_s} = K_{critical} = D(1-D)^2 = 0.10496$$

$$\frac{2 \times 16.32 \times 10^{-6}}{R_{critical} \times 10 \times 10^{-6}} = \frac{32}{56}\left(\frac{24}{56}\right)^2$$

$$R_{critical} = \frac{32.64 \times (56)^3}{10 \times 32 \times 24^2}$$

$$\boxed{R_{critical} = 31.099\ \Omega}$$

(iii) $R = 40\Omega$. Duty ratio = ? if $V_o = 56V$.

$$I_D = I_o = \frac{V_o}{R} = \frac{56}{40} = 1.4.$$

$$K = \frac{2L}{RT_s} = \frac{2 \times 16.32 \times 10^{-6}}{40 \times 10 \times 10^{-6}}$$

Converter in DCM.

$$K = \frac{16.32}{200} = 0.0816 < K_{critical}$$

$$\frac{V_0}{V_g} = \frac{D + D_2}{D_2} \qquad \therefore \frac{D}{D_2} = \frac{32}{24} = \frac{4}{3}.$$

$$D_2 = \frac{3D}{4} = \frac{K + \sqrt{K^2 + 4KD^2}}{2D}.$$

$$\frac{3D^2}{2} = K + \sqrt{K^2 + 4KD^2}$$

$$(1.5D^2 - K)^2 = K^2 + 4KD^2.$$

$$2.25D^4 + K^2 - 3KD^2 = K^2 + 4KD^2$$

$$2.25D^4 = 7KD^2.$$

$$D^2 = \frac{7 \times 4}{9} \times \frac{16.32}{200}$$

$$D = \frac{2}{30}\sqrt{\frac{7 \times 16.32}{2}}$$

$$\boxed{D = 0.50385}$$

$$D_2 = 0.37788$$

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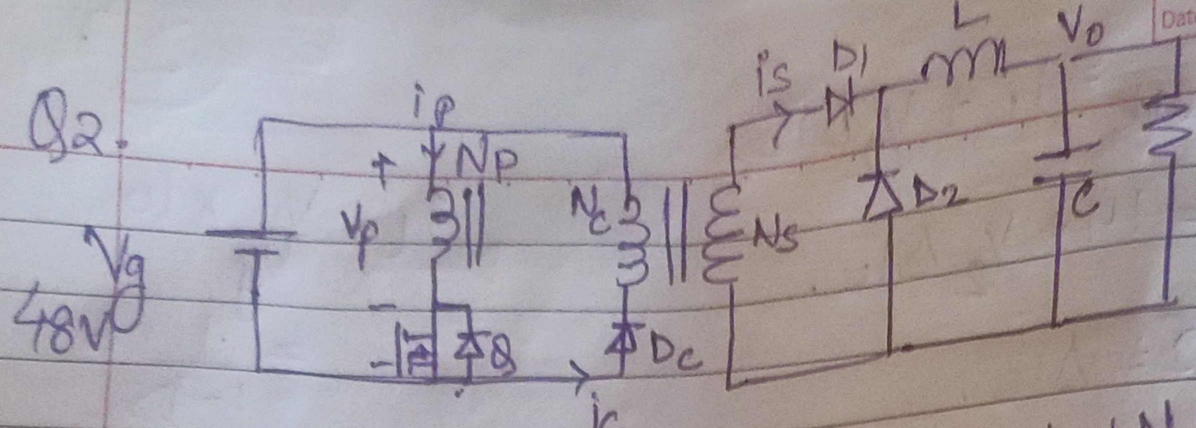
Q2.



$N_p : N_c : N_s = 2:3:1$

$L = 60\,\mu H$

$R = 4\,\Omega$ neglect voltage ripple.

$T_s = 10\,\mu s$ neglect leakage inductance

$V_g = 48V$.

$L_p = 400\,\mu H$.

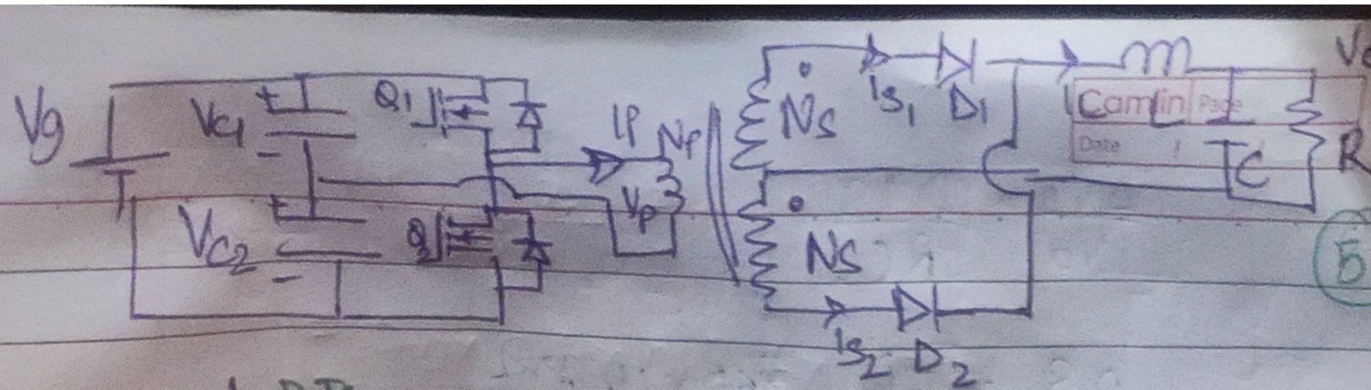
(i) max. Duty ratio = ?

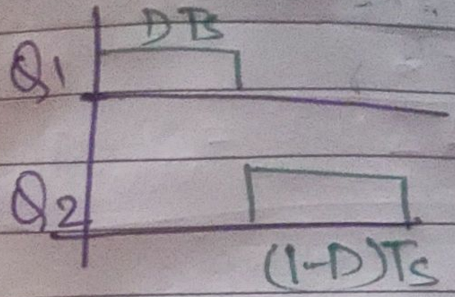
for forward converter $D \leq \dfrac{1}{1 + \frac{n_c}{n_s}}$.

$$D_{max} = \frac{1}{1 + \frac{3}{1}} = \frac{1}{4}$$

$$\therefore \boxed{D_{max} = 1/4 = 0.25}$$

Q3





$V_g = 120V$ $\quad R = 6\Omega$

$V_0 = 24V$ $\quad L = 30\mu H$

$T_s = 10\mu s$ $\quad$ C is very large

$D = 0.4$ $\quad$ ignore voltage ripple.

(i) avg V_{C1}, avg V_{C2}.

half bridge converter

$$V_{C1} + V_{C2} = V_g.$$

$\langle V_{Lp} \rangle = 0$ from voltage second balance eqn!

$$\left(V_g \frac{DT_s}{2} + V_{C2}(1-D)\frac{T_s}{2} + V_{C2}(1-D)\frac{T_s}{2}\right)\frac{1}{T_s} = V_{C2}.$$

$$\frac{V_g}{2}D + V_{C2}(1-D) = V_{C2}.$$

$$\therefore V_{C2} = \frac{V_g}{2} = V_{C1}. = \frac{120}{2}$$

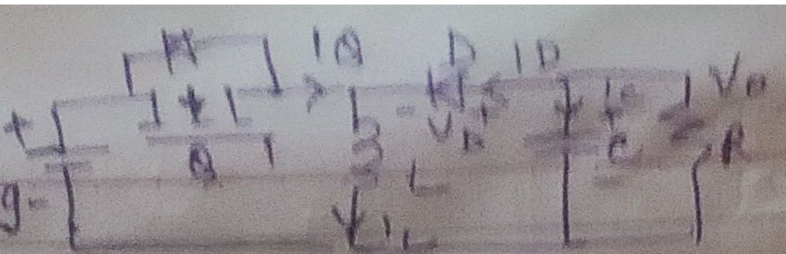
$$\boxed{\therefore \underset{\text{avg}}{V_{C1}} = \underset{\text{avg}}{V_{C2}} = 60V}$$

(ii) $\frac{N_P}{N_S} = ?$

$$V_0 = 0.5 \frac{N_S}{N_P} D V_g.$$

$$24 = 0.5 \times \left(\frac{N_S}{N_P}\right) \times 0.4 \times 120. = \frac{20 \times 120}{100} \times \left(\frac{N_S}{N_P}\right).$$

$$\boxed{\frac{N_P}{N_S} = 1}$$

Q4. 

$V_g = 70V$
$L = 15\,\mu H$
$T_s = 10\,\mu s$
$D = 0.6$
$C = 22\,\mu F$
$R = 30\,\Omega$

(i) $I_{Q\,rms}$? $I_{D\,avg}$, $I_{L\,avg}$, $V_{o\,peak}$.

$$\frac{2L}{RT_s} = \frac{2\times15}{30\times10} = 0.1$$

∴ circuit in DCM.

$$\therefore \; V_L = V_g D T_s + V_o D_2 T_s = 0.$$
$$V_g D + V_o D_2 = 0.$$

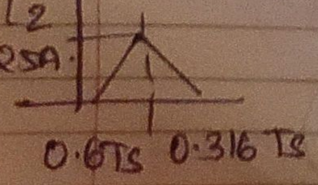
$$\Delta I_L = V_g \frac{DT_s}{L} = \frac{70\times10}{15} D = \frac{140}{3} D.$$

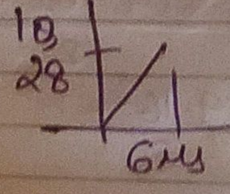
$$I_D = I_o = \frac{\frac{1}{2} D_2 T_s V_g \frac{DT_s}{L}}{T_s} = \frac{-V_o}{R}.$$

$$\frac{V_g D D_2 T_s}{2L} = \frac{-V_o}{R}.$$

$$\frac{V_o D_2^2 D T_s}{2L} = \frac{V_o}{R}$$

$$D_2^2 = \frac{2L}{RT_s} = \frac{2\times15}{30\times10} = 0.1 \qquad D_2 = 0.316.$$





$$I_Q = \frac{28A \cdot t}{6\,\mu s}.$$

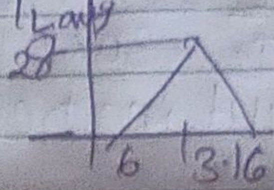
$$I_{Q\,rms}^2 = \frac{1}{10\mu}\int\left(\frac{28\,t}{6\times10^{-6}}\right)^2 dt.$$

$$\boxed{I_{Q\,rms} = 12.52\ A}$$

$$I_{D\,avg} = \frac{V_g\, D\, D_2}{2L} T_s$$

$$= \frac{70 \times 0.6 \times 0.316 \times 10}{2 \times 15}$$

$$\boxed{I_{D\,avg} = 4.42\text{ A}}$$

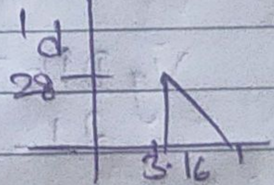


$$I_{L\,avg} = \frac{\frac{1}{2} \times 9.16 \times 28}{10} = 12.824\text{A}.$$

$$\therefore \boxed{I_{L\,avg} = 12.82\text{A}}$$

$$V_o = -\frac{V_g D}{D_2} = \frac{70 \cdot 0.6}{0.316} = \cancel{13.2}\ 132.91\text{ V}$$

$$\boxed{V_{Q\,peak} = V_g - V_o = 202.91\text{ V}}$$

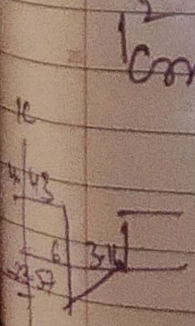


(ii) $$I_o = \frac{V_o}{R} = \frac{132.91}{30} = 4.43\text{A}.$$

$$I_C = I_o - I_D.$$

$$(i_{C\,rms})^2 = \frac{1}{10}\left(\int_0^6 4.43^2\, dt + \int_{9.16}^{10} 4.43\, dt + \int_6^{9.16} 23.57^2\left(-1 + \frac{1t}{3.16}\right)^2 dt\right)$$

$$I_{C\,rms}^2 = \frac{1}{10}\left(4.43^2 \times 6.84 + (-23.57)^2 \times 3.16 + \left(-2 \times \frac{23.57^2}{3.16} \times \frac{(9.16)^2 - 6^2}{2}\right) + \frac{23.57^2}{3.16^2} \times \frac{9.16^3 - 6^3}{3}\right).$$



$$\boxed{I_{C\,rms} = 19.27\text{ A}}$$

$$\Delta V_o = \frac{Q}{C} = \frac{23.57 \times 3.16/2}{22} = \boxed{1.693\text{V} = \Delta V_o}$$

$\therefore \boxed{D_{max} = 1/4 = 0.25}$

Q2: (iii) $V_o = ?$

$$V_o = D V_g \frac{N_s}{N_c} = \frac{1}{4} \times 48 \times \frac{2}{3} = 8$$

$$V_o = 8\,V$$