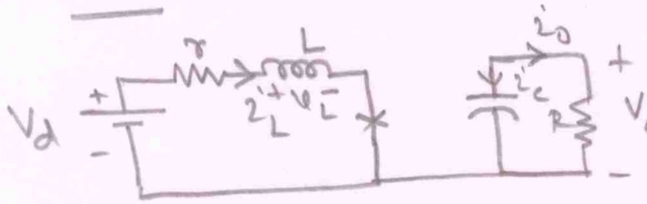
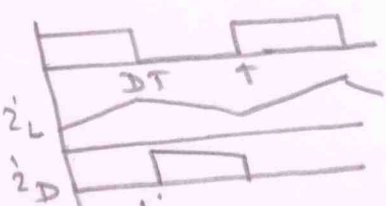
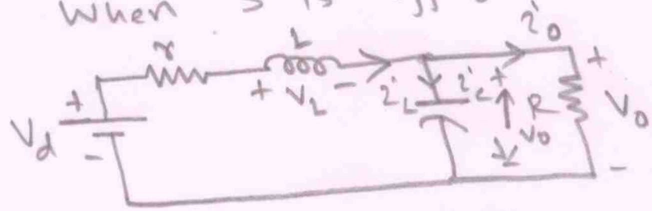
Q1 When S is on:



$$V_L = L\frac{di_L}{dt} = V_d - r\,i_L$$



When S is off:



$$v_L = L\frac{di_L}{dt} = V_d - V_o - r\,i_L$$

At steady state average voltage drop across the inductor is zero

$$\therefore \left(V_d - r\,i_L\right)DT + \left(V_d - V_o - r\,i_L\right)(1-D)T = 0$$

$$\because I_o = (1-D)\bar{i}_L \qquad \therefore \bar{i}_L = \frac{I_o}{1-D}$$

or, $V_o(D-1) = r\,i_L - V_d$

$$\simeq r\,\bar{i}_L - V_d.$$

$$\simeq r\frac{I_o}{(1-D)} - V_d. = \frac{r}{R}\frac{V_o}{1-D} - V_d.$$

or, $V_o(1-D) = V_d - \dfrac{r}{R}\dfrac{V_o}{1-D}$ or $V_o = \dfrac{V_d(1-D)}{\frac{r}{R}+(1-D)^2}$

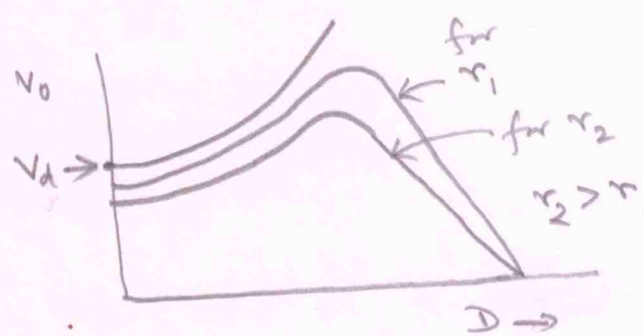
$\therefore$ At $D=0$, $V_o = \dfrac{V_d}{R+r}\times R. \simeq V_d$. (if r is small)

At $D=1$, $V_o = 0$, Hence $V_o(max)$ occurs in the range of $0 \leq D \leq 1$

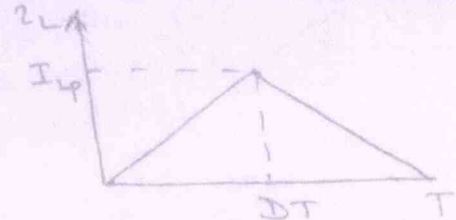
$$\frac{dV_o}{dD} = 0 \Rightarrow -\left\{\frac{r}{R} + (1-D)^2\right\}V_d - V_d(1-D)(2D-2) = 0$$

or, $D = 1 - \sqrt{\dfrac{r}{R}}$

$$\therefore V_o(max) = \frac{V_{dc}}{2}\sqrt{\frac{R}{r}}$$



Q2. i) $T = 5 \times 10^{-5}$ s



$I_{Lp} = \frac{100}{L} DT$

and

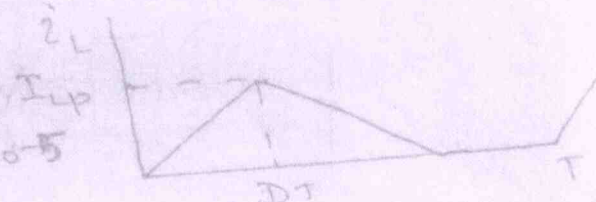
$I_{Lp} - \frac{400}{L}(1-D)T = 0$

or, $\frac{100}{\cancel{L}} D\cancel{T} - \frac{400}{\cancel{L}}(1-D)\cancel{T} = 0 \quad \therefore D = 0.8$

ii) As $D = 0.5$ which is less than 0.8, the system operates in discontinuous mode of operation

$$\text{Power transferred} = \frac{\text{Energy stored in the inductor at DT}}{T}$$

$I_{Lp} = \frac{100}{L} DT$



$= \frac{100}{100 \times 10^{-6}} \times 0.5 \times 5 \times 10^{-5}$

$= 25A$

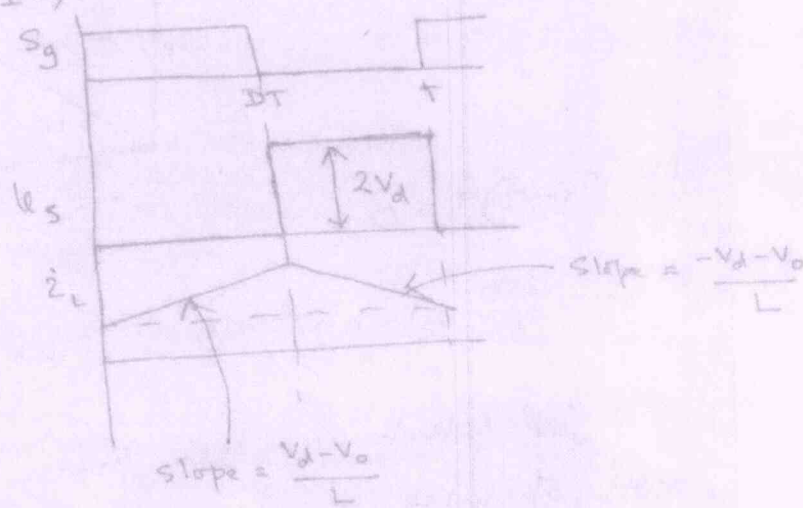
$\therefore$ Energy stored in the inductor at DT $= \frac{1}{2} \times L \times (25)^2$ W-sec

$\therefore$ Power transferred $= \frac{1}{2} \times 100 \times 10^{-6} \times 625 \times \frac{1}{5 \times 10^{-5}}$ W

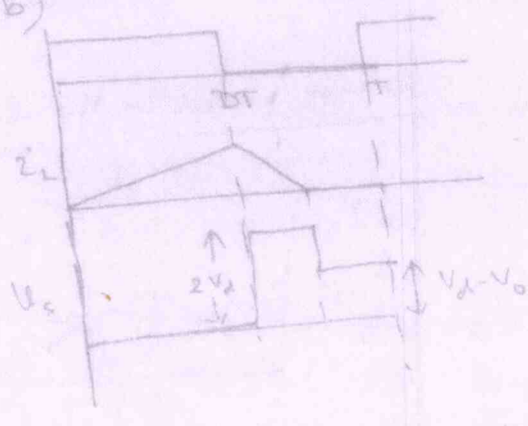
$= 625$ Watt.

iii) Inductor current will continually build up and steady state will never be reached.

Q3 1 a)



1 b)



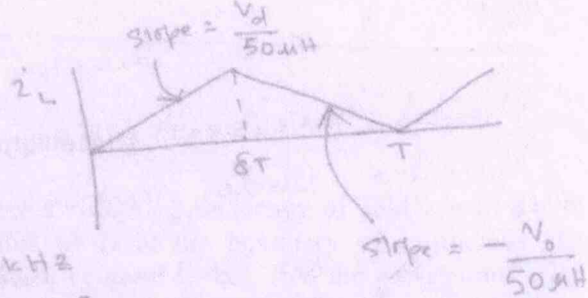
2) Average voltage across the inductor is zero.

$$\therefore (V_d - V_o)DT - (V_o + V_D)(1-D)T = 0$$

$$\therefore V_o = (2D-1)V_d.$$

$$I_{rp} = \frac{V_d - V_o}{L} DT = 2V_d(1-D)\frac{DT}{L}$$

Q4 As the system is on the boundary of cont and discont. mode



$$\frac{V_0}{V_d} = \frac{\delta}{1-\delta} \qquad f = 50\,kHz \quad \therefore T = 2\times10^{-5}\,s$$

Average load current at this condition:

$$\frac{1}{2}\,\frac{V_d\,\delta T}{50\times10^{-6}} \times T \times \frac{1}{T} = \frac{10}{R_L}$$

or, $$\frac{1}{2}\cdot\frac{(1-\delta)}{\cancel{\delta}}\,10 \times \frac{1}{50\times10^{-6}} \times \cancel{\delta} \times 2\times10^{-5} = \frac{10}{R_L}$$

or, $$(1-\delta)\,\frac{5}{5\times\cancel{10^{-5}}} \times 2\times\cancel{10^{-5}} = \frac{10}{R_L}$$

or, $$2(1-\delta) = \frac{10}{R_L}$$

or, $$1-\delta = \frac{5}{R_L} \quad \text{or,} \quad \delta = 1-\frac{5}{R_L}$$

$$V_d = \frac{10(1-\delta)}{\delta} = \frac{10 \cdot 5/\cancel{R_L}}{\frac{R_L-5}{\cancel{R_L}}} = \frac{50}{R_L-5}$$

$$I_{D(peak)} = \frac{V_d}{50\times10^{-6}}\,\delta T$$

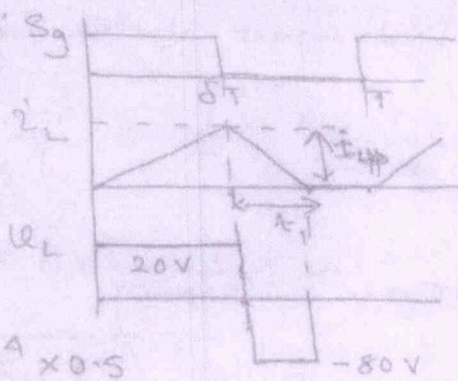
$$= \frac{50}{(50\times10^{-6})(R_L-5)} \times 0.5 \times 2\times10^{-5}\ A$$

$$= \frac{10}{R_L-5}\ A$$

Q5 $\delta = 0.5$, therefore the o/p voltage should have been $50V$, if the converter operates under continuous mode of conduction.

As $V_0 = 80 > 50V$, the converter is operating under discontinuous mode of conduction.

$$I_{Lp} = \frac{20}{2.5\times10^{-3}} T \times 0.5$$



$$T = \frac{1}{5\times10^{+3}}$$

$$= 2\times10^{-4}.$$

$$\therefore I_{Lp} = \frac{20}{2.5\times10^{-3}} \times 2\times10^{-4} \times 0.5$$

$$= 0.8A$$

Average voltage drop across the inductor is zero

$$\therefore 20\times1\times10^{-4} - 80 t_1 = 0$$

$$\therefore t_1 = \frac{20\times10^{-4}}{80} = 0.25\times10^{-4}$$

$$\therefore \bar{i}_L = I_0 = \frac{1}{2}\times\left(1.25\times10^{-4}\right)\times0.8\times\frac{1}{2\times10^{-4}}$$

$$= 0.25A$$

$$\therefore R_L = \frac{80}{0.25}A = 320\Omega.$$