Solution : Assignment 1

(Q- 1) :- ⇒ old configuration :-

Train has 8 coaches + 1 locomotive.

8 coaches → 30 wheels. (All Dummy)

1 locomotive → 30 wheels out of which 20 Driving wheels. 10 Dummy wheels.

Tractive Force developed by the locomotive is

$$F_{T\,loco} = C_\mu \left(\frac{\omega}{30}\right) * 20 = \frac{2}{3}\omega C_\mu \quad — (2)$$

where 'ω' is the weight of locomotive = weight of coach = weight of motorised coach.

⇒ New configuration :- Suburban Train (EMU) of 8 coaches.

Given $F_{T_{EMU}} = 4 * F_{T\,loco.} = 4 * \frac{2}{3}\omega C_\mu = \frac{8}{3}\omega C_\mu$ — (1)

The no of Driving wheels required to generate this force are $= \frac{\left(\frac{8}{3}\omega\right)\cancel{C_\mu}}{\left(\frac{\omega}{30}\right)\cancel{C_\mu}} = 80$ — (2)

Total no of wheels in all the 8 coaches (EMU)

$= 30 \times 8 = \boxed{240.}$ — (1)

out of which $\boxed{\text{80 are Driving wheels}}$ $\boxed{\text{160 Dummy wheels}}$

Configuration - 1 :-

Assuming all 8 coaches are motorized coaches.

each coach having 10 Driving wheels $\rightarrow$ $8 \times 10 = 80$

20 Dummy wheels $\rightarrow$ $8 \times 20 = 160$

$240.$

$$F_{TEMU(1)} = 8 * \frac{\omega}{30} * 10 \times C_M = \frac{8}{3}\omega \times C_M$$

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Configuration - 2 :-

Assuming 4 motorized coaches and 4 trailer coaches.

4 motorized coaches

each having

20 Driving wheels $\rightarrow$ $4 \times 20 = 80$

10 Dummy wheels $\rightarrow$ $4 \times 10 = 40$

120

4 trailer coaches.

No Driving wheels

30 Dummy wheels $\rightarrow$ $4 \times 30 = 120$

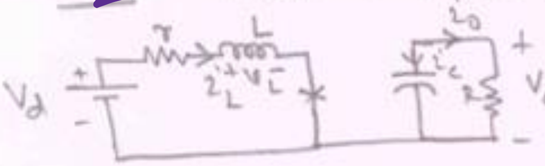
$$F_{TEMU(2)} = 4 * \frac{\omega}{30} * 20 \times C_M$$

240.

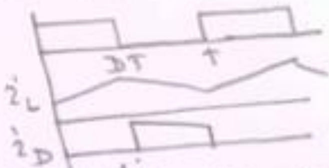
$$= \frac{8}{3}\omega \cdot \times C_M$$

*

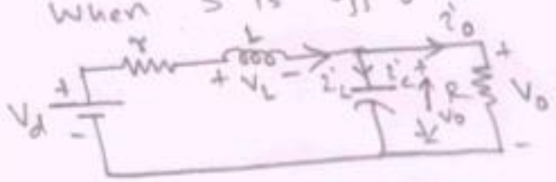
S2. When S is on:



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



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

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

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

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)

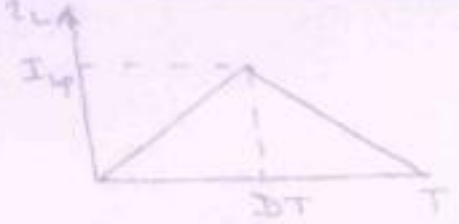
At $D=1$, $V_o = 0$, Hence $V_o(max)$ occurs in the range of $0 \leq D \leq 1$

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

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

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

Q3. i) $T = 5\times10^{-5}$ 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

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

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

$= \frac{100}{100\times10^{-6}} \times 0.5 \times 5\times10^{-5}$

$= 25A$

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

$\therefore$ Power transferred $= \frac{1}{2}\times 100\times10^{-6}\times 625\times\frac{1}{5\times10^{-5}}$ W

$= 625$ Watt.

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

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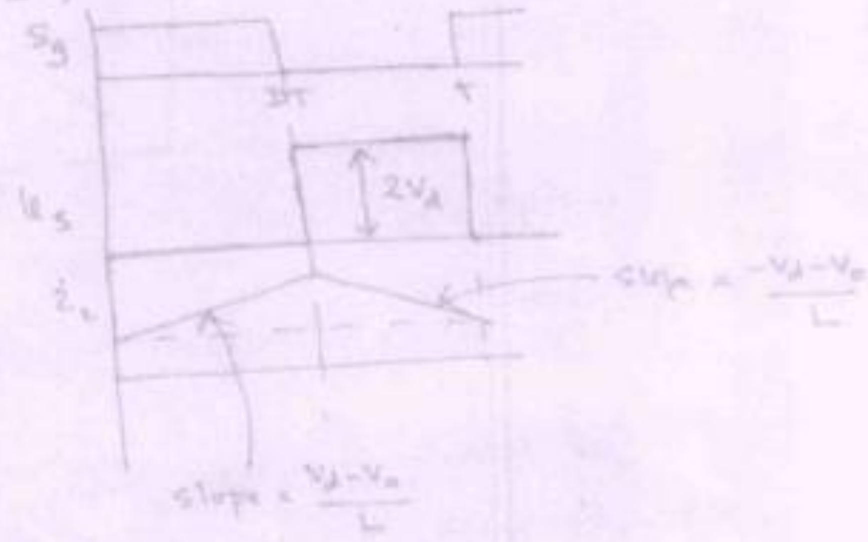
1 a)



1 b)

2) Average voltage across the inductor is zero.

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

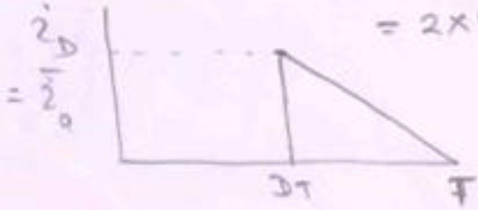
$$\therefore V_o = (2D-1)V_d$$

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

Q5 As the converter is on the boundary of continuous and disc mode of conduction

$L = 50 \times 10^{-6}$ H

$T = \frac{1}{50 \times 10^3}$ s $= 2 \times 10^{-5}$ s



$$\frac{V_o}{V_d} = \frac{D}{1-D}$$

or, $V_d = \frac{1-D}{D} V_o$

$$i_{D\,peak} = \frac{V_d}{L} DT \quad \therefore \bar{i}_D = I_o = \frac{1}{2}(1-D)T \times \frac{V_d}{L} D\cancel{T} \times \frac{1}{\cancel{T}}$$

$$= \frac{10}{R_L}$$

$$\frac{D(1-D)T}{100 \times 10^{-6}} \times V_d = \frac{10}{R}.$$

$$\frac{D(1-D)T}{100 \times 10^{-6}} \times \frac{1-D}{D} V_o = \frac{10}{R}.$$

or $$\frac{\cancel{D}(1-D) \times 2 \times 10^{-5}}{100 \times 10^{-6}} \times \frac{1-D}{\cancel{D}} \cancel{V_o} = \frac{\cancel{10}}{R_L}$$

or $(1-D)^2 = \frac{5}{R}$ or, $1-D = \pm\sqrt{\frac{5}{R_L}}$ or $D = 1 \pm \sqrt{\frac{5}{R_L}}$

D cannot be more than 1.

$\therefore D = 1 - \sqrt{\frac{5}{R_L}}$, $V_d = \frac{1-1+\sqrt{5/R_L}}{1-\sqrt{5/R_L}} \times 10 = \frac{\sqrt{5/R_L}}{1-\sqrt{\frac{5}{R_L}}} \times 10$ V

$$I_{D(peak)} = \frac{V_d}{50 \times 10^{-6}}\left(1-\sqrt{\frac{5}{R_L}}\right) \times 2 \times 10^{-5} \text{ A.}$$

$$= \frac{2V_d}{5}\left(1-\sqrt{\frac{5}{R_L}}\right)$$

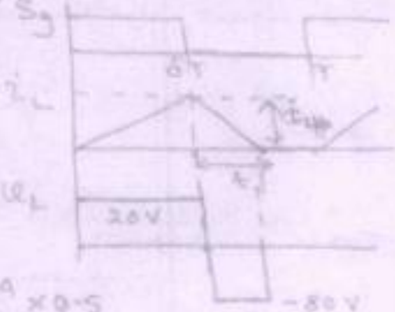
$$= \frac{2}{5} \frac{\sqrt{5/R_L}}{\cancel{1-\sqrt{\frac{5}{R_L}}}} \cancel{\left(1-\sqrt{5/R_L}\right)} \times 10 \text{A}$$

$$= 10 \times \frac{2}{5}\sqrt{\frac{5}{R_L}} \text{ A} = \frac{20}{\sqrt{5R_L}} \text{ A}$$

6 $\delta = 0.5$, therefore the o/p voltage should have been 50V, if the converter operates under continuous mode of conduction.

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

$$I_{Lp} = \frac{20}{2.5 \times 10^{-3}} T \times 0.5$$



$$T = \frac{1}{5 \times 10^{+3}}$$

$$= 2 \times 10^{-4}.$$

$$\therefore I_{Lp} = \frac{20}{2.5 \times 10^{-3}} \times 2 \times 10^{-4} \times 0.5$$

$$= 0.8\,A$$

Average voltage drop across the inductor is zero

$$\therefore \quad 20 \times 1 \times 10^{-4} - 80\,t_1 = 0$$

$$\therefore \quad t_1 = \frac{20 \times 10^{-4}}{80} = 0.25 \times 10^{-4}$$

$$\therefore \overline{i_L} = I_o = \frac{1}{2} \times \left(1.25 \times 10^{-4}\right) \times 0.8 \times \frac{1}{2 \times 10^{-4}}$$

$$= 0.25\,A$$

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