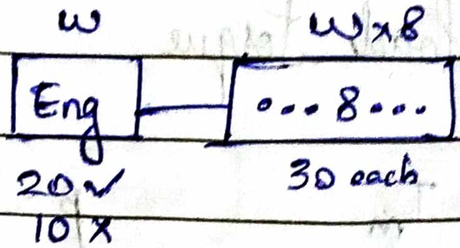
EE238

Assignment - 1

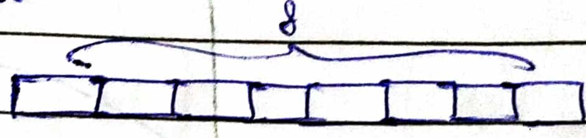
1] Initially :



Here, maximum tractive effort of Locomotive :

$$F_{E(MAX)} = C_{\mu} \cdot \frac{w}{30} \times 20 \checkmark$$

Finally :



30 wheels on each

Reqd MAX tractive effort $= 4 \times C_{\mu} \frac{w}{30} \times 20$

$= \boxed{80} \times C_{\mu} \frac{w}{30}$

⇒ We need 80 motorised wheels in total.

∵ There are 30 wheels for every coach of the suburban, and as there are 8 coaches,

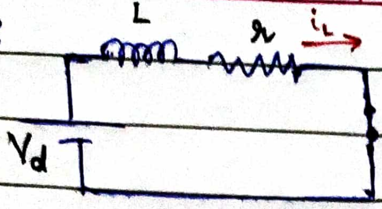
$\therefore \frac{80}{8} = $ 10 motorised wheels per coach

∴ Configuration :

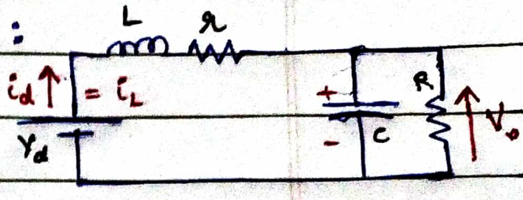
80 motorized wheels (10 on each coach)

160 dummy wheels (20 on each coach)

2] Sw – ON :



Sw – OFF :



$$\overline{V_L} = 0 \Rightarrow (V_d - i_L r)\delta T + (V_d - V_o - i_L r)(1-\delta)T = 0$$

$$\Rightarrow \cancel{V_d\delta} - \cancel{i_L r\delta} + V_d - V_o - i_L r - \cancel{\delta V_d} + V_o\delta + \cancel{i_L r\delta} = 0$$

Assumption : $i_L \approx \overline{i_L} = \overline{i_d} = \dfrac{I_o}{(1-\delta)} = V_o/R \times \dfrac{1}{(1-\delta)}$

$$\Rightarrow V_d = V_o - \delta V_o + \frac{V_o r}{R(1-\delta)} \Rightarrow \frac{V_o}{V_d} = \frac{1}{\frac{r}{R(1-\delta)} + (1-\delta)} = \frac{1-\delta}{\frac{r}{R} + (1-\delta)^2}$$

B) for MAX of $\dfrac{V_o}{V_d}$, we require min of its denominator.

$\therefore$ using AM $\geq$ GM on D_r :

$$\frac{\frac{r}{R(1-\delta)} + (1-\delta)}{2} \geq \sqrt{\frac{r}{R\cancel{(1-\delta)}} \times \cancel{(1-\delta)}}$$

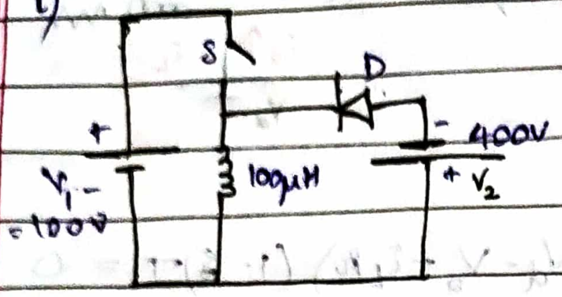
$$\Rightarrow D_r\Big|_{min} = 2\sqrt{\frac{r}{R}} \Rightarrow \boxed{\frac{V_o}{V_d}\Big|_{MAX} = \frac{1}{2}\sqrt{\frac{R}{r}}}$$

δ should be such that both terms are equal for AM = GM

$$\therefore \frac{r}{R(1-\delta)} = (1-\delta) \Rightarrow \boxed{\delta = 1 - \sqrt{\frac{r}{R}}}$$

A) $$V_o\Big|_{D=0} = \frac{1-0}{\frac{r}{R} + (1-0)^2} = \boxed{\frac{R}{R+r}} \qquad V_o\Big|_{D=1} = \boxed{0}$$

3] 1)

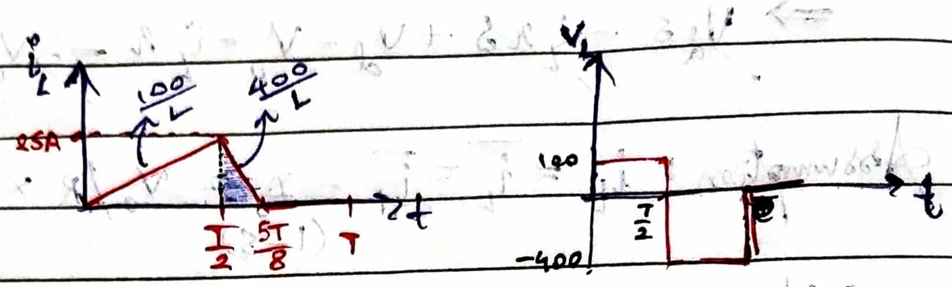


δ at boundary of CCM would be same as δ at CCM ~~continuous~~ $\therefore$ using $\overline{V_L} = 0$,

$$\underset{100}{V_1}\,\delta T = \underset{400}{V_2}(1-\delta T)$$

$$\therefore \boxed{\delta = 0.8}$$

2) $D = 0.5$:



Note that :

$$V_L = L\frac{di}{dt} \Rightarrow \int_0^{T/2} \frac{V_L}{L}\,dt = \int di$$

$$\therefore \frac{100}{L}\cdot\frac{T}{2} = i_{MAX}$$

Now, the time in which this current dies out of the inductor :

$$\frac{400}{L}(\text{time}) = i_{MAX} \Rightarrow t = \frac{100T}{L\cdot 2} \times \frac{L}{400} = \frac{T}{8} < \frac{T}{2}$$

$\therefore$ ckt is in DCM.

$\therefore$ Power transferred to $V_2 = V_2 \cdot i_{avg}\Big|_{\text{during action of } V_2}$

$$= V_2 \cdot \frac{\int i\,dt}{\int dt} = V_2\left(\int_{T/2}^{5T/8} (\;)\,dt + \int_{5T/8}^{T} 0\,dt\right) \quad \text{ar (A)}$$

$$\int_{T/2}^{T}$$

$$= 400 \cdot \left(\frac{1}{2}\,(T/8)\cdot\left(\frac{100}{L}\cdot\frac{T}{2}\right)\right) = 1250\,\frac{T}{L}$$

$$= 1250 \times \frac{1}{20} \times 10^{-3} \times \frac{10^6}{100} = \boxed{625\,W}$$

c) @ Steady state, $\Delta V_L = 0$.
Assuming CCM,

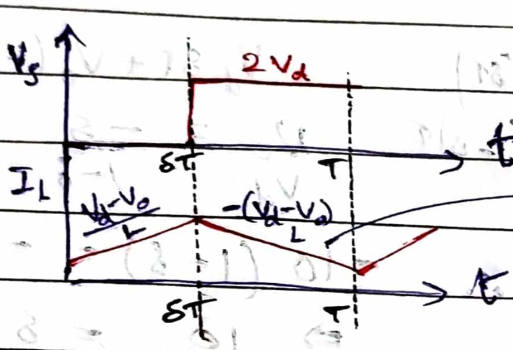
$$V_L = \begin{cases} 100 & (\delta T) \text{ — ON} \\ -400 & (1-\delta)T \text{ — OFF} \end{cases} \quad \therefore 100\delta T + (-400)(1-\delta)T = 0 \Rightarrow \delta = 0.8$$

If $\delta < 0.8 \rightarrow$ Discontinuous mode
If $\delta > 0.8 \rightarrow$ Not steady state.

If at all it can attain steady state with itself being in continuous mode, that would correspond to critical conduction mode.

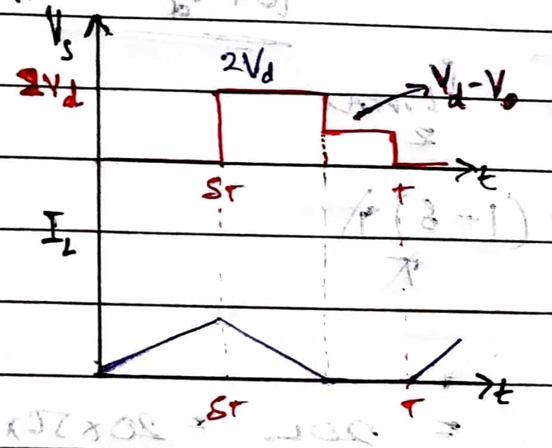
4] 1] a) CCM

$V_L = L\frac{di_L}{dt}$



(It and soon reverse polarity!)

b) DCM.



2] ~~When SW is on,~~ We will use $\overline{V_L} = 0$ to find V_o.
So,
When SW is on, $V_L = V_d - V_o$
" " " OFF, $V_L = -(V_d + V_o)$

$$\therefore (V_d - V_o)\delta T - (V_d + V_o)(1-\delta)T = 0 \Rightarrow \boxed{V_o = (2\delta - 1)V_d}$$

3) $i_{L_{pk-pk}} = \Delta i_L = i_{L_{MAX}} - i_{L_{min}}$

$$= \frac{(V_d - V_o)}{L}\delta T - \frac{(V_d - V_o)}{L}(1-\delta)T$$

$$= \frac{T}{L}\{\cancel{V_d\delta} - \cancel{V_o\delta} - V_d + \cancel{V_o} - V_d\delta + \cancel{V_o\delta}\}$$

$(2\delta - 1)V_d$

$$= \boxed{\frac{2(\delta-1)V_d T}{L}}$$

5] Given $f_{sw} = 50\,kHz \Rightarrow T = 20\,\mu s$.

$$V_L = \begin{cases} V_d & \text{on } (\delta T) \\ V_o & \text{off } (1-\delta)T \end{cases}$$

$V_d \delta T + V_o(1-\delta)T = 0$

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

Given $V_o = -10V$, $\therefore$ $-10(1-\delta) = -\delta V_d$

$$\Rightarrow \frac{10}{10+V_d} = \delta$$

$i_o = -V_o/R_L$, $i_o = \bar{i_L} = \frac{i_{L_{MAX}}}{2}$

$$\Rightarrow \frac{-V_o}{R_L} = \frac{1}{2}\frac{V_D}{L} \times \delta T(1-\delta)\cancel{T}/\cancel{T}$$

$$\Rightarrow V_d = \frac{-2LV_o}{R\delta T(1-\delta)} = \frac{20L}{\delta(1-\delta)T} = \frac{20 \times 50 \times 10^{-6}}{20 \times 10^{-6} \times 10 \times V_d}(10+V_d)^2$$

$$\Rightarrow R_L V_d^2 = 5(10+V_d)^2 \Rightarrow V_d = \frac{\sqrt{5}(10+V_d)}{\sqrt{R_L}}$$

$$\Rightarrow \boxed{V_d = \frac{10\sqrt{5}}{\sqrt{R} - \sqrt{5}}}$$

$$i_{d(pk)} = \frac{V_d}{L}\delta T = \frac{V_d T}{L}\cdot\frac{10}{10+V_d} = \frac{V_d}{(10+V_d)}\cdot\frac{\cancel{10}\times 2\cancel{0}\times 10^{-6}}{5\cancel{0}\times 10^{-6}}$$

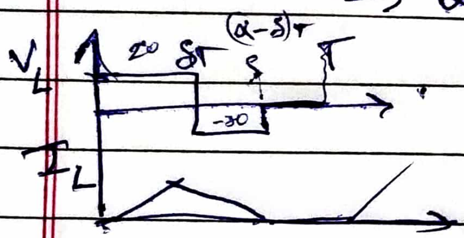
$$= \frac{4V_d}{10+V_d} = \frac{40\sqrt{5}}{10\sqrt{R} - \cancel{10\sqrt{5}} + \cancel{10\sqrt{5}}} = \boxed{\frac{4\sqrt{5}}{\sqrt{R_L}}}$$

6] $T = 200\mu s$, $D = 0.5$,
$L = 2.5\,mH$, $V_d = 100V$, $V_o = 80V$

Using $\bar{V_L} = 0$, $(V_d - V_o)\delta T - V_o \alpha T = 0$

$\Rightarrow 20\times 0.5 - 80\alpha = 0$

$\Rightarrow \alpha = 1/8$.



$$i_{Lpk} = \frac{V_d - V_o}{L}\times \delta T$$

$$= \frac{20}{2.5\times 10^{-3}} \times \underset{(T)}{0.2\times 10^{-3}} \times \underset{(\delta)}{0.5}$$

$$= 0.8A$$

$$\therefore I_o = \bar{I_L} = \cancel{\frac{1}{2} I_{Lpk}} \quad \frac{i_{Lpk}}{2}\times\frac{(\delta+\alpha)T}{T}$$

$$= \frac{0.8\left(0.5 + \frac{1}{8}\right)}{2} = 1/4$$

$$\therefore I_o = \frac{V_o}{R_L} = 0.25 \Rightarrow R_L = 4V_o = \boxed{320\Omega}$$