Quiz – 1.

Q1. Equilibrium speed $= T = T_L$

$\therefore 10 = 0.1\,\omega_m$ or $\omega_m = 100$

(Steady state speed can be considered to be achieved when the speed is between 90 rad/s to 98 rad/sec.)

2 marks

$$T = T_L + J\frac{d\omega_m}{dt} \quad \text{or} \quad \frac{d\omega_m}{dt} = \frac{T - T_L}{0.1}$$

$$\text{or,} \quad \frac{d\omega_m}{dt} = \frac{10 - 0.1\,\omega_m}{0.1}$$

$$dt = \frac{d\omega_m}{100 - \omega_m} \quad \text{or} \quad t = \int_0^{95} \frac{d\omega_m}{100 - \omega_m}$$

1 mark.

Substituting $100 - \omega_m = z$, $\therefore -d\omega_m = dz$.

when $\omega_m = 0$, $z = 100$

" $\omega_m = 95$, $z = 5$

$$\therefore -\int_{100}^{5} \frac{dz}{z} = \int_{5}^{100} \frac{dz}{z} = \left[\ln(100) - \ln(5)\right]$$

$$= 2.99 \text{ sec} \simeq 3 \text{ sec.}$$

2 marks

Full credit to be given if the steady state speed is considered to be any value lying between 90 rad/sec to 99 rad/sec.

If the final answer is written as 'infinity' no credit (0 marks to be awarded) to be given.

Q2. let the wt. of the locomotive = coach = W

For the locomotive driven train :

$$\text{Max}^{m}.\ T.E = C_\mu \times \text{Wt. on the driving wheels} \quad N.$$

$$= C_\mu \times \frac{W}{20} \times 10 \quad N.$$

$$= C_\mu \frac{W}{2} \ N.$$

1 mark

For the EMU

$$\text{Max}^{m}.\ T.E = C_\mu \times \frac{12}{30} \times 3 \times W = \frac{36}{20} C_\mu W \ N$$

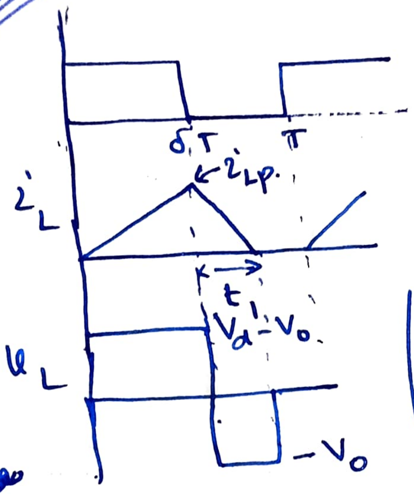
3 marks.

$$\therefore \ \% \text{ increment in TE} = \frac{\frac{36}{20} - \frac{1}{2}}{\frac{1}{2}} \times 100 \ \%$$

$$= 260\%.$$

1 mark.

Q3



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

$$i_{Lp} - \frac{V_o}{L}t_1 = 0$$

or, $\frac{V_o}{L}t_1 = i_{Lp}$

or $t_1 = \frac{i_{Lp}L}{V_o} = \frac{\cancel{L}}{V_o}\frac{V_d - V_o}{\cancel{L}}\delta T$

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

$$= \frac{100 - V_o}{V_o}\delta T$$

Ans

$f_s = 5$ kHz, $T = 0.2\times10^{-3}$ s 1 mark

Let us assume the converter is operating in cont^n mode ∴ o/p voltage $= 100\times0.5 = 50$V

∴ $\bar{i}_L = \bar{i}_o = \frac{50}{400} \simeq 0.125$ A

the boundary current required for cont^n mode of operation $= \frac{100\times0.2\times10^{-3}}{8\times2.5\times10^{-3}} = 1$ A. Hence it is operating in discontinuous mode.

$$\bar{i}_L = \frac{1}{2}\times\left(0.5T + \frac{100-V_o}{V_o}0.5T\right)\times\frac{V_d - V_o}{L}0.5\cancel{T}\times\frac{1}{\cancel{T}} = \frac{V_o}{400}$$

or, $\frac{1}{2}\times\frac{1}{2}\times\frac{1}{2}\left(T + \frac{100-V_o}{V_o}T\right)\times\frac{100-V_o}{L} = \frac{V_o}{400}$ 3 marks

or, $\frac{1}{8}\left(1 + \frac{100-V_o}{V_o}\right)T\times\frac{100-V_o}{2.5\times10^{-3}} = \frac{V_o}{400}$

or, $\frac{1}{8}\left(\frac{\cancel{V_o} + 100 - \cancel{V_o}}{V_o}\right)\frac{0.2\times\cancel{10^{-3}}\times(100-V_o)}{2.5\times\cancel{10^{-3}}} = \frac{V_o}{400}$

or, $\frac{1}{8}\left(\frac{100}{V_o}\right)(100-V_o)\frac{0.2}{2.5} = \frac{V_o}{400}$

or, $100(100-V_o) = \frac{V_o^2\times8\times2.5}{400\times0.2} = 0.25V_o^2$

or $0.25V_o^2 = 100^2 - 100V_o$.

or $0.25V_o^2 + 100V_o - 100^2 = 0$

$$V_0 = \frac{-100 \pm \sqrt{100^2 + 4 \times 0.25 \times 100^2}}{0.5}$$

$$= \frac{-100 \pm \sqrt{10{,}000 + 10{,}000}}{0.5}.$$

$$= \frac{-100 \pm 100\sqrt{2}}{0.5} = -200 \pm 200\sqrt{2}$$

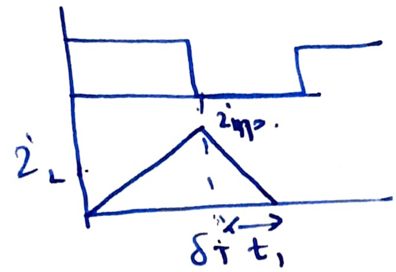
1 mark.

Discarding the negative voltage

$200(\sqrt{2} - 1)$ V $= 82.8$ V

Q4

$$T = \frac{1}{5\times10^{3}}\ s = 0.2\times10^{-3}\ s.$$



i) Assuming discontinuous conduction

$$i_{Lp} = \frac{100}{5\times\cancel{10^{-3}}} \times 0.2 \times 0.2\times\cancel{10^{-3}}$$

$$= 0.8\ A.$$

$$0.8 - \frac{50}{5\times10^{-3}} \times t_1 = 0$$

3 marks

or, $t_1 = .08\times10^{-3}\ s$

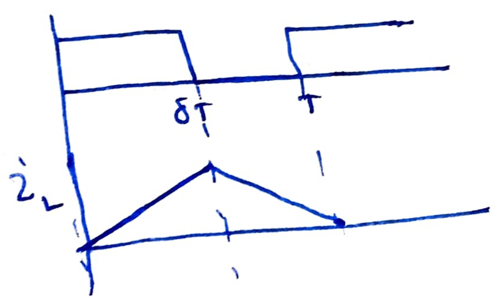
$$\therefore \bar{i}_L = \frac{1}{2}\times(.08 + 0.2\times0.2)\times\cancel{10^{-3}}\times 0.8 \times \frac{1}{0.2\times\cancel{10^{-3}}}$$

$$= \frac{1}{2}\times 0.12 \times \frac{0.8}{0.2}\ A = 0.24\ A.$$

$\therefore$ the power transfered to B_2 is 50×0.24 W $= 12$ W.

2 marks

2) The circuit will become uncontrollable once it starts operating in continuous mode of operation.



At the boundary of cont^n and discont^n mode of operation:

$$i_{Lp} = \frac{100}{L}\delta T$$

Further,

$$i_{Lp} - \frac{50}{L}(1-\delta)T = 0$$

5 marks

or, $\frac{100}{\cancel{L}}\delta\cancel{T} - \frac{50(1-\delta)\cancel{T}}{\cancel{L}} = 0$

or, $100\delta - 50 + 50\delta = 0$

or, $150\delta = 50$ or $\delta = \frac{1}{3} = 0.33$

$\therefore \delta_l = 0.33$