EEE4117F: ONLINE QUIZ 1

ELECTRICAL MACHINES AND POWER ELECTRONICS

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PART A – ELECTRICAL MACHINES

Question 1:

PART A:

Question 1:

a> Match between motor and Load

b> Thermal consideration in motor selection

c> Control and current limiting.

⇒ Motor current ripple can be reduced by either adding a capacitor or providing ramp limiters which helps to prevent drives from tripping under sudden changes.

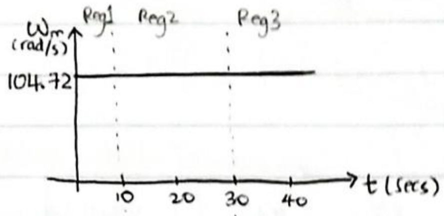
Question 2:

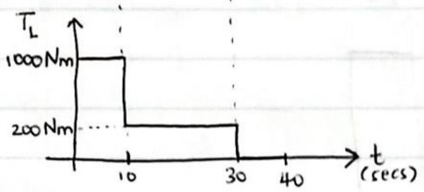
Question 2:

$\omega_m = 1000\,rpm \rightarrow 1000 \times \frac{2\pi}{60} = \underline{104.72\ rad/s}$

$T = 40\ secs$

$\dot{\omega}_m = 0$ ⟨constant speed⟩





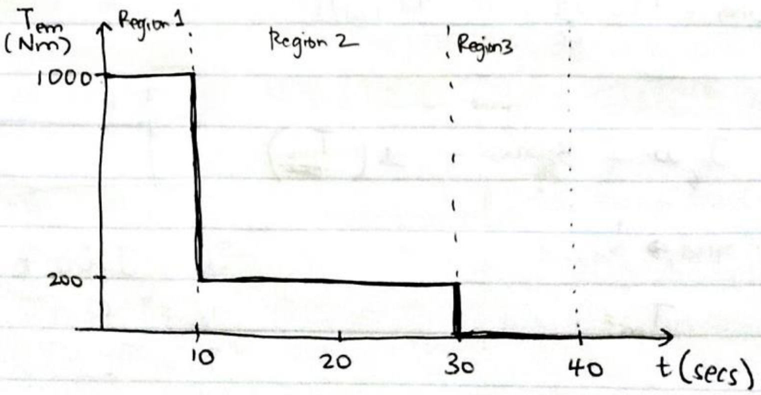
Q2 (1.1) $T_{em} = J\dot{\omega}_m + B\omega_m + T_L$

Ignoring Damping effects:

$T_{m_1} = 0 + 0 + T_{L_1} = T_{L_1} = \underline{\underline{1000\,Nm}}$

$T_{em_2} = 0 + 0 + T_{L_2} = T_{L_2} = \underline{\underline{200\,Nm}}$

$T_{em_3} = 0 + 0 + T_{L_3} = T_{L_3} = \underline{\underline{0\,Nm}}$



Torque profile of motor-Load System

Q2 (1.2) $T_{rms} = \frac{1}{T_{period}} \int_0^{T_{period}} T_{em}^2(t) \cdot dt$

$$T_{rms} = \sqrt{\frac{(T_{em_1}^2 \cdot t_1) + (T_{em_2}^2 \cdot t_2) + (T_{em_3}^2 \cdot t_3)}{t_1 + t_2 + t_3}}$$

$$T_{rms} = \sqrt{\frac{1000^2(10) + (200)^2 20 + 0^2(10)}{10+20+10}}$$

$$\boxed{T_{rms} = 519.6 \text{ Nm}}$$

$$P = T_{rms} \cdot \omega_m$$

$$P = 519.6\ (104.72) = 54.4 \text{ kW}$$

$$\boxed{P = 54.4 \text{ kW}}$$

Q2(1.3) $P_{rot} \approx 0.1\,(54.4\text{kW}) \approx \underline{5.44\text{kW}}$

$k = 4\text{Nm/A}$; $R_m = 0.267\,\Omega/\text{phase}$ $\Rightarrow$ For 3 phase: $R_m = 3(0.267)\Omega$

$$I_{Rms} = \frac{T_{rms}}{k} = \frac{519.6\text{Nm}}{4\text{Nm/A}} = \underline{129.9\text{ A}}$$

$$P_{cu} = I_{rms}^2 \cdot R_m$$

$$P_{cu} = (129.9)^2 \cdot 3(0.267) = \underline{13.52\text{ kW}}$$

$$\boxed{P_{cu} = 13.52\text{kW}}$$

$$P_{Loss} = P_{rot} + P_{cu} = 5.44\text{kW} + 13.52\text{kW} = \underline{18.96\text{kW}}$$

$$\boxed{P_{Loss} = 18.96\text{kW}}$$

PART B – POWER ELECTRONICS

Question 1:

PART B:

Question 1

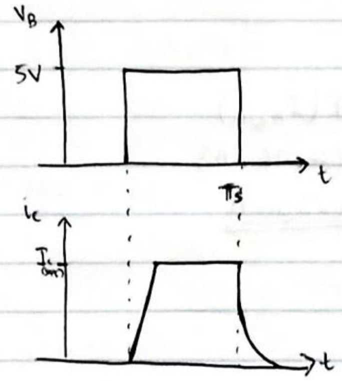
$V_{CE(sat)} = 0.2V$

$V_{BE(sat)} = 0.7V$

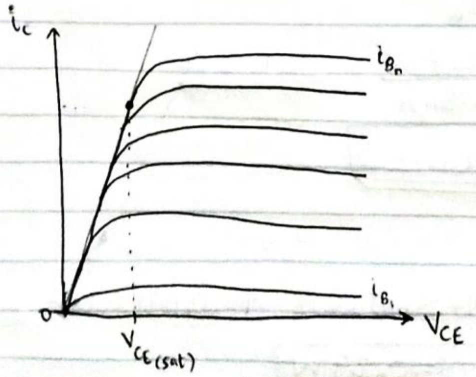
$\beta = 25-40$

(1.1) The diode, D allows the current to only pass through one direction and thus blocking current in opposite direction if leakage current is available which might be harmful for the transistor and can also lead to breakage of the transistor.

(1.2)



(1.3)



(1.4) From KVL:

$$V_{CC} = I_{C(sat)}R_C + V_{CE(sat)}$$

$$I_{C(sat)} = \frac{V_{CC} - V_{CE(sat)}}{R_C}$$

$$I_{C(sat)} = \frac{(24 - 0.2)V}{200\Omega} = 0.119\,A$$

$$\boxed{I_{C(sat)} = 0.119\,A}$$

(1.5) ODF = 3

$$I_{B(sat)} = \frac{I_{C(sat)}}{\beta} = \frac{0.119}{25} = \underline{\underline{4.76\,mA}}$$

$$ODF = \frac{I_B}{I_{B(sat)}} \Rightarrow I_B = ODF(I_{B(sat)})$$

$$= 3(4.76\,mA)$$

$$\underline{\underline{I_B = 14.28\,mA}}$$

From KVL:

$$V_B = I_BR_B + V_{BE(sat)}$$

$$R_B = \frac{V_B - V_{BE}}{I_B}$$

$$R_B = \frac{(5 - 0.7)V}{14.28\,mA} = \underline{\underline{301.12\,\Omega}}$$

$$\therefore \boxed{R_B = 301.12\,\Omega}$$

(1.6)

$$P_{total} = P_{R_B} + P_{R_C}$$

$$= I_B^2R_B + I_{C(sat)}^2R_C = (14.28mA)^2\,301.12 + (0.119)^2\,200 = \underline{\underline{2.89W}}$$

$$\boxed{P_{Tot} = 2.89\,W}$$

Question 2:

PART B:

Question 2

(2.1) ~~R_S~~ $THD = \sqrt{\left(\frac{I_{sh}}{I_{s1}}\right)^2} * 100\%$

$$= \sqrt{\left(\frac{1}{3}\right)^2+\left(\frac{1}{5}\right)^2+\left(\frac{1}{7}\right)^2+\left(\frac{1}{9}\right)^2+\left(\frac{1}{11}\right)^2+\left(\frac{1}{13}\right)^2} * 100\%$$

$$\boxed{THD = 44.5\%}$$

(2.2) $PF = \frac{1}{\sqrt{1+THD^2}} \cdot DPF$

$$PF = \frac{1}{\sqrt{1+0.445^2}} \cdot 1 = \cancel{0.835}\ 0.914$$

$$\boxed{PF = 0.914}$$