

90  
100

□ Inertia referred to the motor shaft

⊗ Energy conversion equation

$$\frac{1}{2} m v^2 = \frac{1}{2} J_{ref} \omega_m^2$$

$$J_{ref} = m \left( \frac{v}{\omega_m} \right)^2 = m \left( \frac{\omega_m r}{\omega_m} \right)^2 = m r^2$$

$$J_{ref} = (1520)(0.62)^2 \\ = 584.288 \text{ kg.m}^2$$

$$J_{ref} = \frac{J_{ref}}{\tau^2} \quad \therefore \tau = \frac{N_2}{N_1} = \frac{1}{7.94}$$

$$= 36835.6 \text{ kg.m}^2$$

$$\frac{584}{7.94^2}$$

$$J_{tot} = J_{ref} + J_m$$

$$= 36836.92 \text{ kg.m}^2$$

□

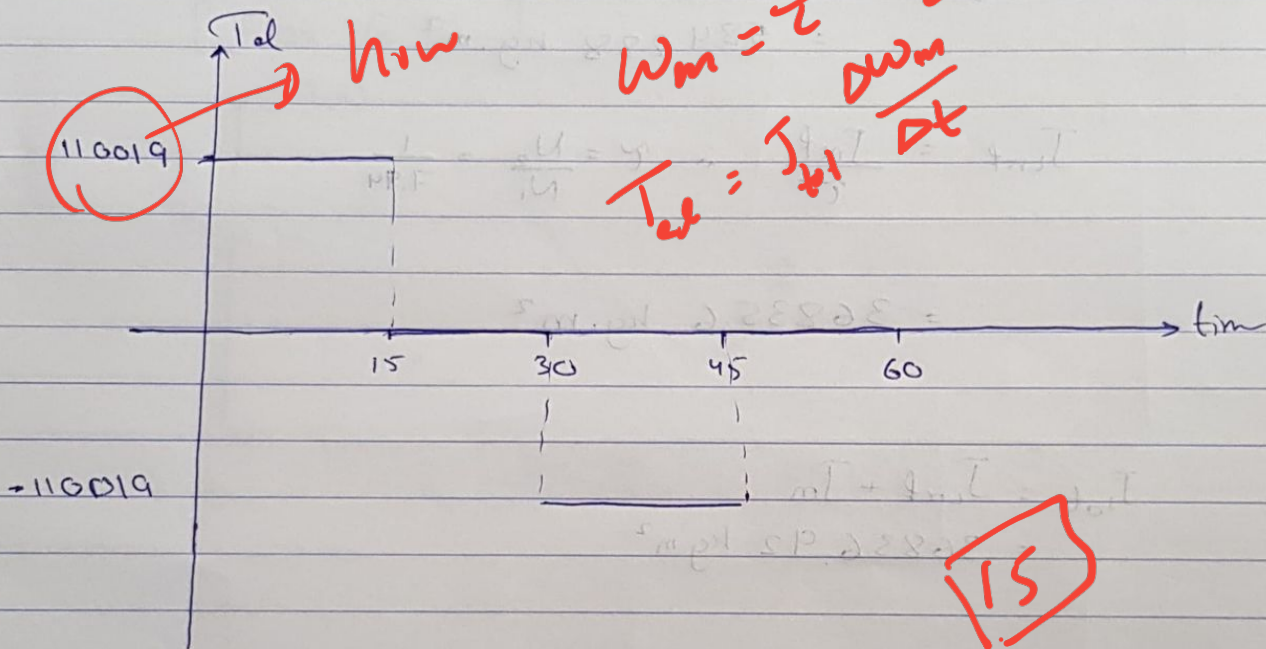
Q1.(b)

The velocity given in km/h, it should turn to m/s then to rad/s.

$$V(\text{m/s}) = 27.778 \text{ m/s}$$

$$\omega = \frac{V}{r} = 44.8$$

$$T_{\text{tot}} = T_c + J \frac{d\omega}{dt} \quad \therefore T_c = 0$$



$$T_{\text{eff}} = \sqrt{\frac{(110019)^2(15) + (110019)^2(15)}{60}}$$

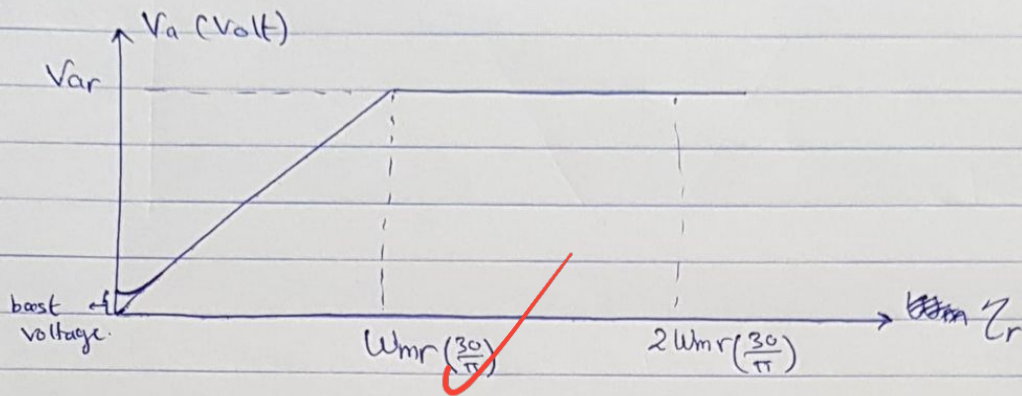
$$= 77795 \text{ N.m. } 04$$

2

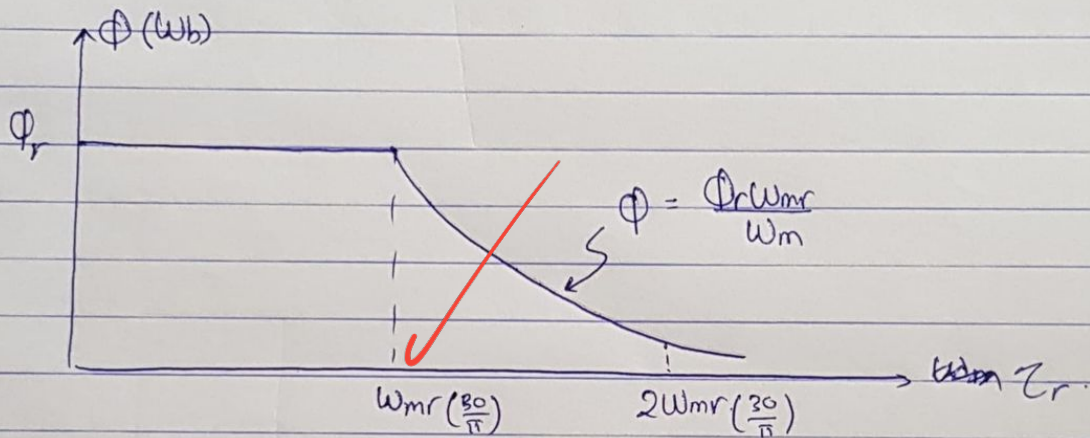
Q2:

Speed range [rpm] =  $[-2\omega_r + 2\omega_r] \Rightarrow$

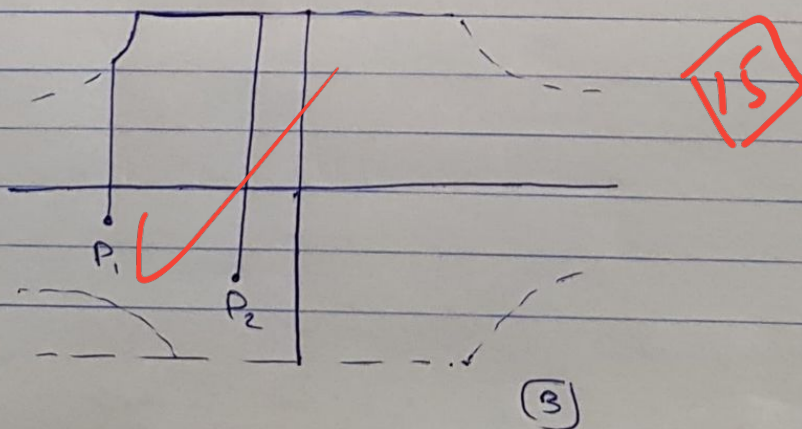
①



[ Flux Vs  $\omega_m$  ]



② Since point (P<sub>1</sub>) is at higher speed than Point (P<sub>2</sub>) so, it should move from the (RM)-Quad to the (RR)-Quad then accelerate back to the third.



Q3:

$$V_r = 200$$

$$\omega_{mr} = \frac{200\pi}{3} \text{ rad/s} \rightarrow \omega_r = 2000 \text{ rpm}$$

Single phase:  
(230 volt rms), 50 Hz

$$R_a = 50 \text{ m}\Omega$$

$$k\phi = 0.0975 \frac{\text{V}}{\text{rpm}}$$

b) The rated current

$$\begin{aligned} e_{\text{rated}} &= (k\phi)\omega_{mr} \Rightarrow (k\phi)\omega_r \text{ since } (k\phi) = \frac{V}{\text{rpm}} \\ &= (0.0975)(2000) \\ &= 195 \end{aligned}$$

$$\begin{aligned} V_r &= R_a I_{ar} + e_{ar} \\ 200 &= (50\text{m}) I_{ar} + 195 \\ I_{ar} &= 100 \text{ A} \end{aligned}$$

c) rated torque & rated power.

$$\textcircled{1} T_r = (k\phi) I_{ar} \text{ but } k\phi = 0.0975 \frac{\text{V}}{\text{rpm}} = 0.0975 \times \frac{60}{2\pi} = 0.931 \frac{\text{V}}{\frac{\text{rad}}{\text{s}}}$$

$$\begin{aligned} T_r &= (0.931)(100) \\ &= 93.1 \text{ N.m} \end{aligned}$$

$$\begin{aligned} \textcircled{2} P_m &= e_{ar} I_{ar} \\ &= (195)(100) \\ &= 19500 \text{ W} \end{aligned}$$

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d)  $V = Ra I_a + (k\phi) \omega_m$

$\frac{2V_m \cos(\alpha)}{\pi} = (50m)(10) + 0.0975 \omega_m$

$\frac{2(280)\sqrt{2} \cos(60)}{\pi} = \frac{500}{1000} + 0.0975 \omega_m$

~~$\omega_m = 918.27 \text{ rpm}$~~

$\omega_m = 1056.78 \text{ rpm}$

~~$\omega_m = 96 \text{ rad/s}$~~

$\omega_m = 110.66 \text{ rad/s}$

e)  $\frac{2(280)\sqrt{2} \cos(\alpha)}{\pi} = (50m)(100) + (0.0975)(2000)$

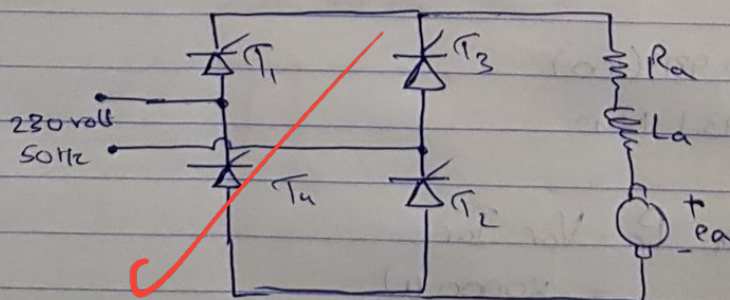
~~$\cos(\alpha) = \frac{200}{460\sqrt{2}}$~~

$\cos(\alpha) = \frac{200}{\frac{460\sqrt{2}}{\pi}} = 0.9658$

$\alpha = 15.027^\circ$

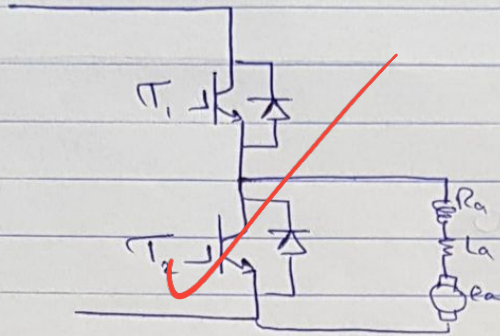
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a) Drive circuit:

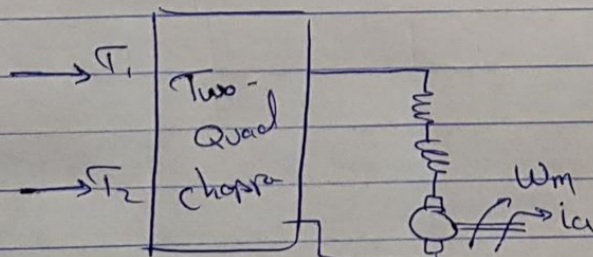
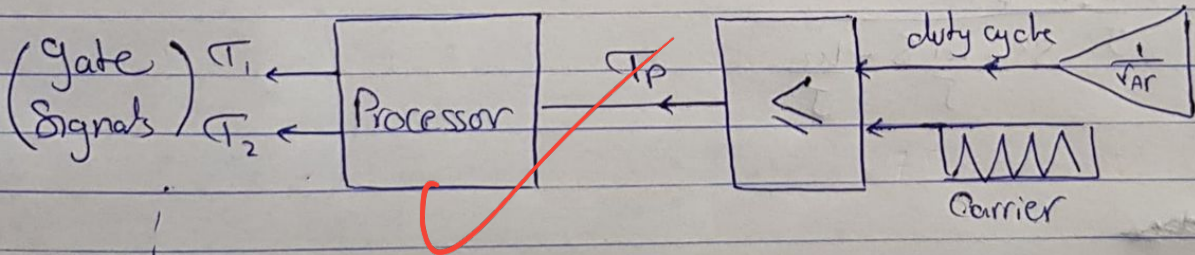
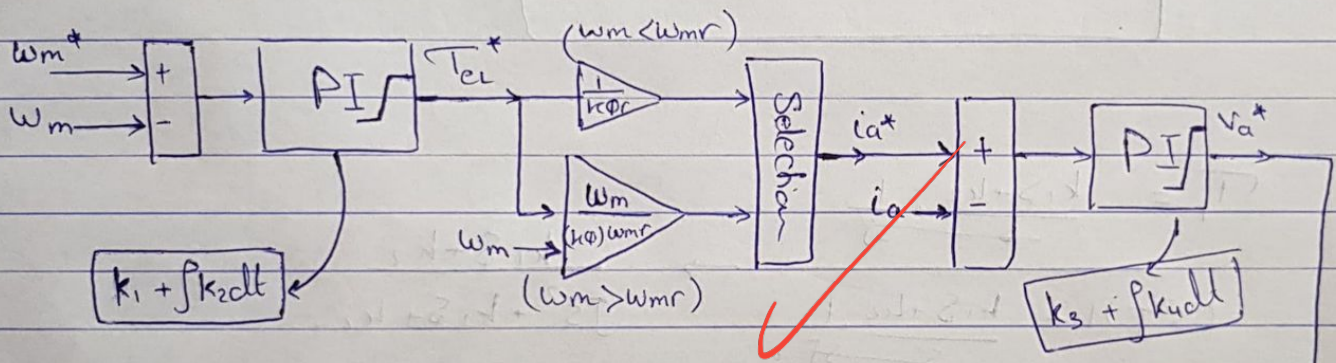


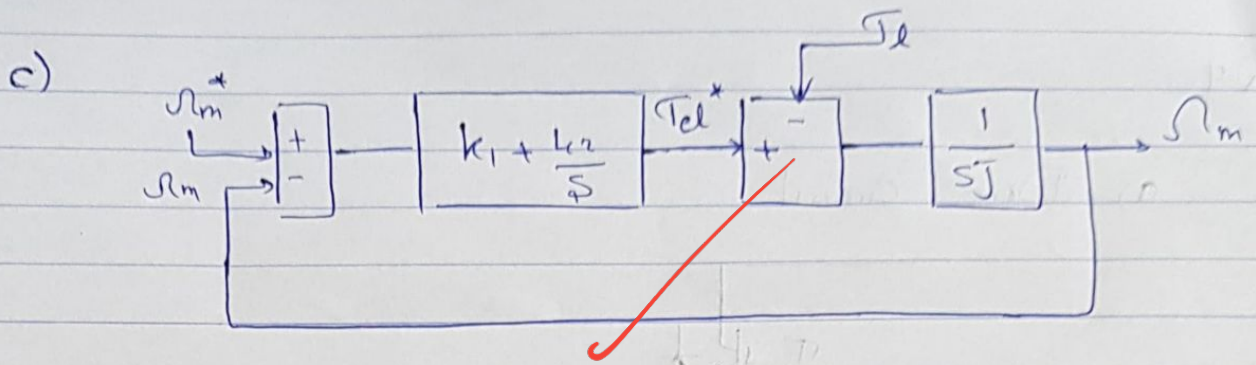
Q4:

a) Drive circuit.

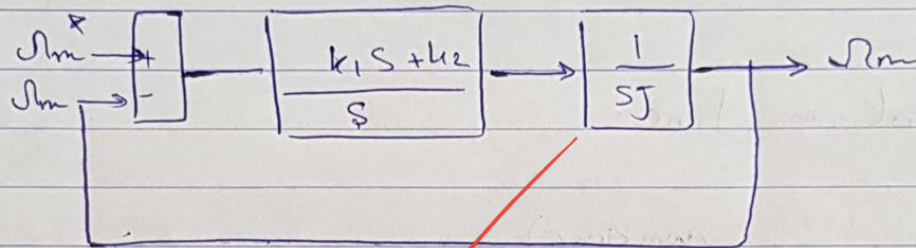


b) Control in time:





d) When  $T_i = T_d = 0$



$$T_i = \frac{k_1 s + k_2}{s} \cdot \frac{1}{sJ}$$

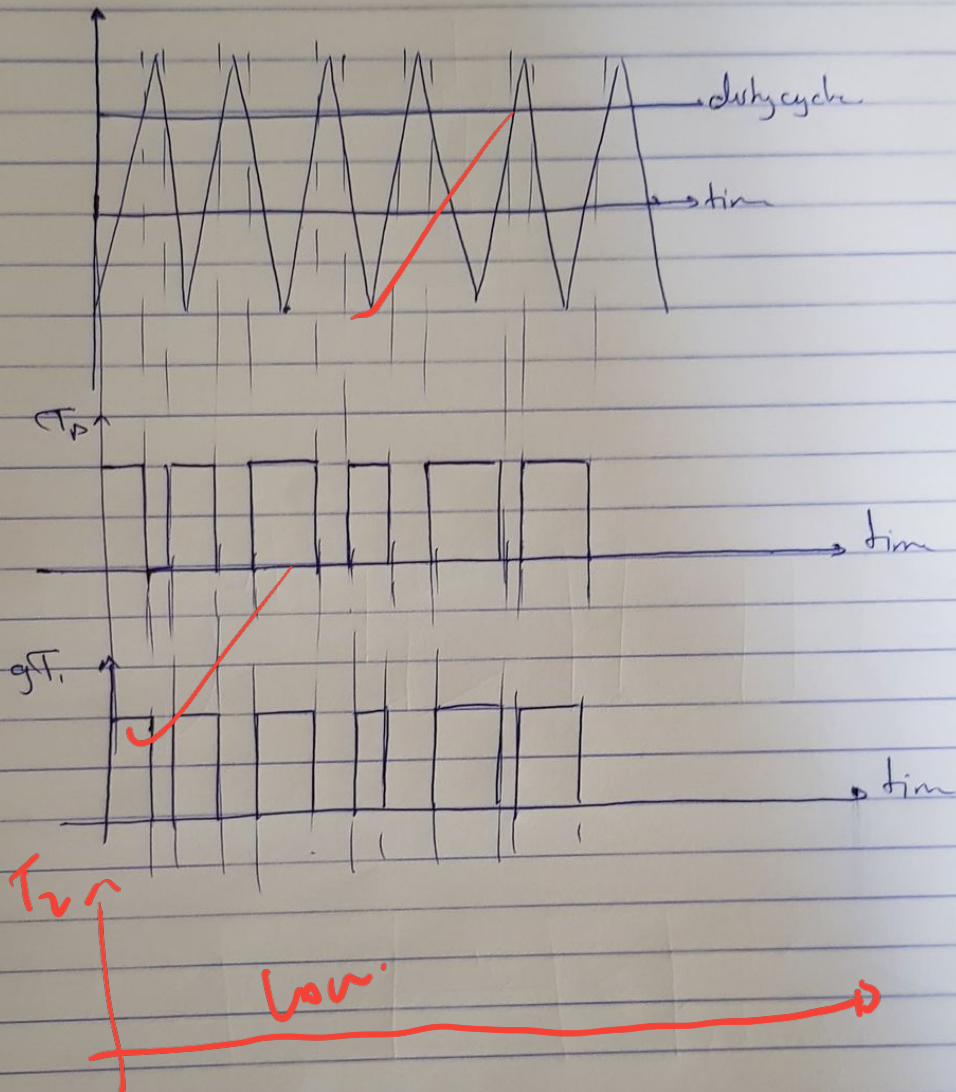
$$\frac{(s^2 J) \cdot 1 + \frac{k_1 s + k_2}{s} \cdot \frac{1}{sJ}}{\frac{k_1 s + k_2}{s} \cdot \frac{1}{sJ}}$$

$$\frac{J s^2 + k_1 s + k_2}{k_1 s + k_2}$$

$$T_i = \frac{1 \cdot k_1 s + k_2}{J \left( s^2 + \frac{k_1 s + k_2}{J} \right)}$$

e) For Forward motoring.

$$T_p = T_s$$



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