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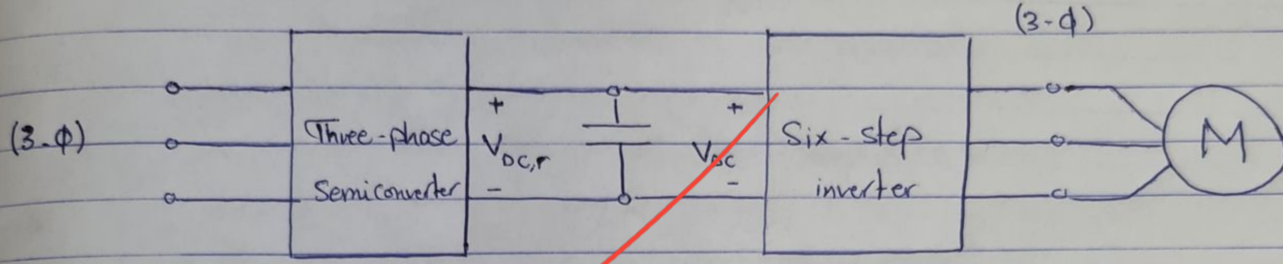
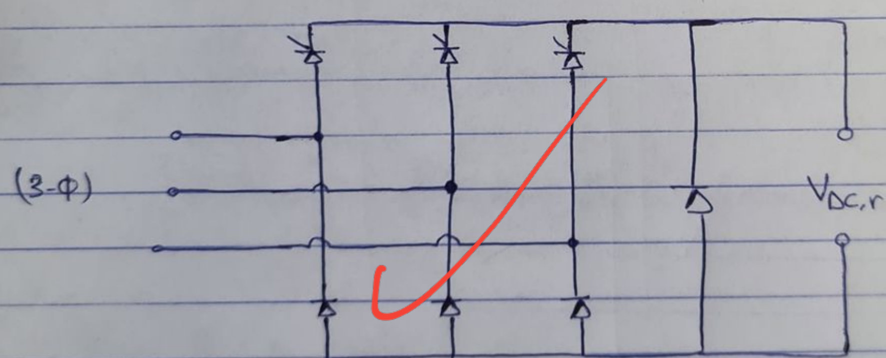
Q1: a) Draw the Drive circuit



* Where : $V_{DC,r}$ ⇒ The DC voltage with ripple.
  V_{DC} ⇒ The DC voltage after filtering. [approximatly Pure DC]

* The Three-phase semi converter:



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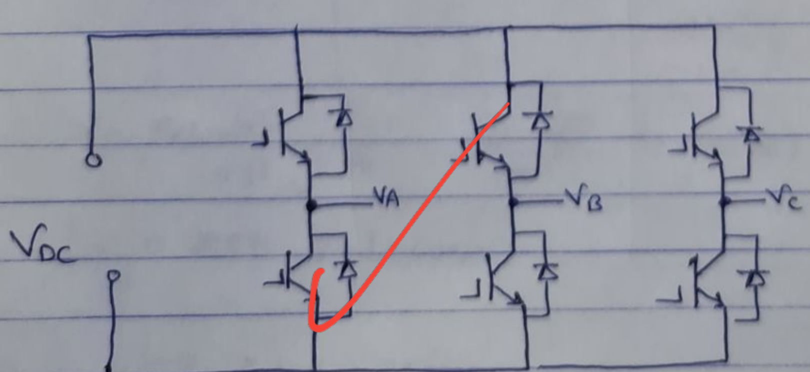
* Six-step inverter:



Q1: B) Motor operates at 20 Hz, then the firing angle of the controlled rectifier is:

stage 1: input: $V_{L-L} = 420$ volt (rms)

$f = 50$ Hz

V_{DC} of the rectified signal is:

$$V_{DC} = \frac{3\sqrt{3}}{2\pi}\left(420\sqrt{\frac{2}{3}}\right)(1+\cos(\alpha))$$

$$= \frac{1260\sqrt{2}}{2\pi}(1+\cos(\alpha))$$

$$= \frac{630\sqrt{2}}{\pi}(1+\cos(\alpha)) \quad \text{——— (1)}$$

stage 2: The peak of the (Line to neutral) fundamental voltage Harmonic:

$$V_{1,Peak\ L-N} = \frac{2}{\pi} \times \frac{630\sqrt{2}}{\pi}(1+\cos(\alpha))$$

Since $\frac{V}{f}$ is constant:

$$\frac{V_{L-N\,(Nominal)}}{f} = \frac{V_{L-N}}{f} \longrightarrow \frac{440\left(\frac{\sqrt{2}}{\sqrt{3}}\right)}{50} = \frac{V_{1,Peak\ L-N}}{20}$$

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$$\Rightarrow 176\frac{\sqrt{2}}{\sqrt{3}} = \frac{2}{\pi} \times \frac{630\sqrt{2}}{\pi}(1+\cos(\alpha))$$

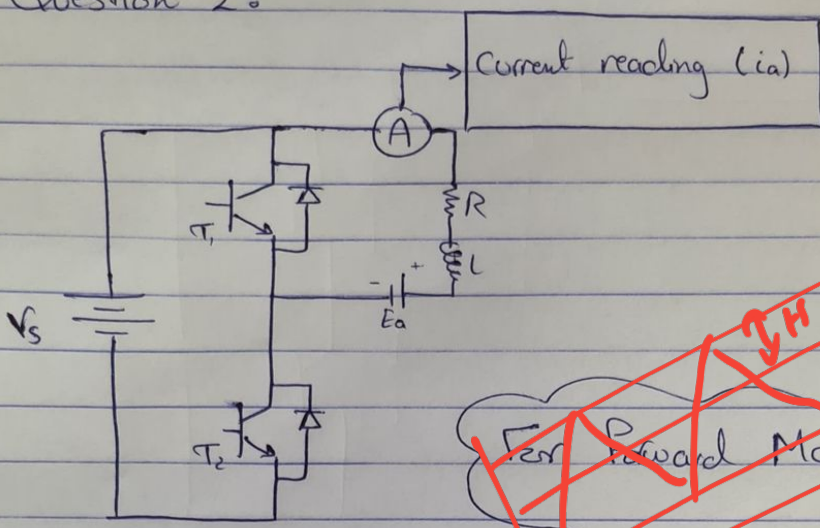
$$0.7959 = 1+\cos(\alpha)$$

$$-0.204 = \cos(\alpha)$$

$$\alpha = 101.77^\circ$$

[2]

Question 2:



For Forward Motoring V positive
i positive

a) Operation & implementation of current controller:

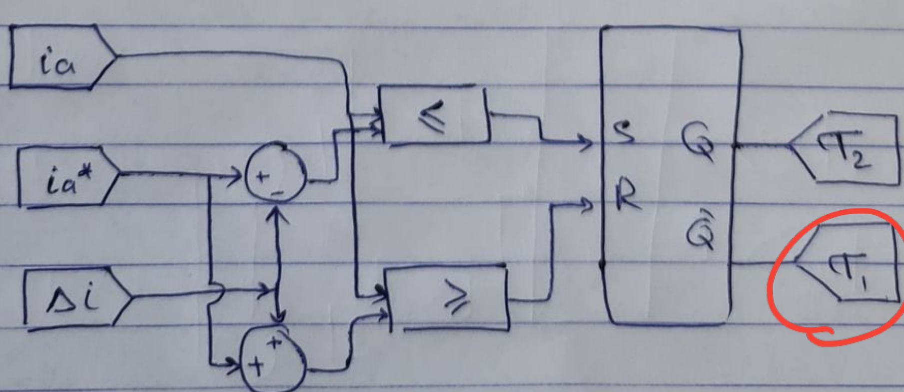
1) Setting a reference current equals to:

$$\frac{V_s - E_a}{\sqrt{R^2 + (\omega L)^2}} = \boxed{i_a^*}$$ "The reference current"

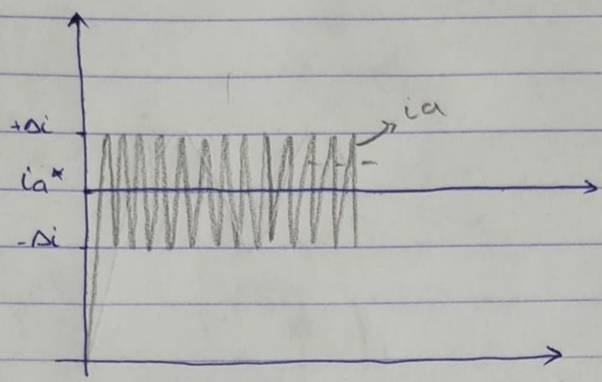
2) define the delta region of oscillation for the current
let it be Δi

$\boxed{\Delta i}$ ⇒ For example $\boxed{0.01\, i_a^*}$

3) Gate control:



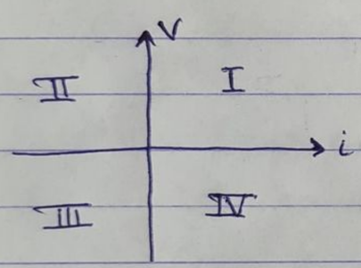
The current sketch



In the period where $i_a < i_a^* + \Delta i \rightarrow T_2$ is on ✓
" " " " $i_a > i_a^* - \Delta i \rightarrow T_1$ is on

(1)

b)



V_a	i_a	Quadrant	T_1	T_2	
V_s	−	~~IV~~	0	~~1~~ 0	✗
V_s	+	I	0	1	✓
0	+	I	~~1~~ 0	0	✗
0	−	~~III~~ IV	1	0	✓

(2)