Electric Drives

Test 1

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Q1. Given conditions:

$R_2 = 0.18\ \Omega$ (referred to stator)

The IM produces rated torque at $\frac{1}{2}$ rated speed.

$\omega_{syn} = 2\pi \times \frac{2f}{p} = 2\pi \times \frac{2 \times 50}{4} = 50\pi$ rad/s

$s_{rated} = 0.03$

$s\omega_{syn} = 0.03 \times 50\pi = 1.5\pi$

$\omega_{rotor,\,rated} = 50\pi - 1.5\pi = 48.5\pi$

Operated at $\frac{1}{2}$ speed { Given above }

$\therefore\ \omega_{rotor,\,rated} = \frac{48.5\pi}{2} = 24.25\pi$

$T \propto s\omega$ = constant

$\omega_{syn} = 24.25\pi + 1.5\pi = 25.75\pi$

ϕ is same

$V_{L-L} = \frac{415 \times 25.75\pi}{50} = 213.725\ V$

$\therefore\ V_{per\ phase} = \frac{213.725}{\sqrt{3}}\ V = 123.39\ V$

$\simeq 123.4\ V$

$$f_{stator} = \frac{25.75\pi}{2\pi} = 12.875 \text{ Hz}$$

(i°)

$$V_{L-L} = 213.725 \text{ V}$$

$$f_{stator} = 12.875 \text{ Hz}$$

(ii°)

$$\frac{V_{DC}}{2} \times m = \frac{V_{L-L}}{\sqrt{3}} \times \sqrt{2}$$

$$\Rightarrow \frac{750}{2} \times m = \frac{213.725}{\sqrt{3}} \times \sqrt{2}$$

$$\Rightarrow m = 0.46534$$

$$\therefore \frac{V_m}{V_T} = m$$

$$\Rightarrow V_m = mV_T = 0.46534 \times 10\text{V} \quad \{\because V_m = 10\text{V (Given)}\}$$

$$= 4.6534 \text{ V}$$

$$\therefore V_m = 4.653\text{V}$$

(iii) Here, duty cycle = $D = \frac{1}{2}(1 + m\sin\omega t)$

$$\Rightarrow D = \frac{1}{2}(1 + 0.4653\sin\omega t)$$

Since phase sequence is RYB.

$$V_y = m\frac{V_{dc}}{2}\sin\left(\omega t - \frac{2\pi}{3}\right)$$

To maximize V_y,

$$\omega t - \frac{2\pi}{3} = \frac{\pi}{2} \Rightarrow \boxed{\omega t = \frac{7\pi}{6}}$$

Then, $D = \frac{1}{2}\left(1 + 0.4653\alpha \sin\left(\frac{7\pi}{6}\right)\right)$

$$= \frac{1}{2}\left(1 + 0.4653\alpha\left(-\frac{1}{2}\right)\right)$$

$$= 0.383675$$

Also, $D = \frac{T_{ON}}{T_s}$ & $f_s = 10\,kHz$

$$T_{ON} \propto f_s = D$$

$$T_{ON} = \frac{D}{f_s} = D T_s = \frac{0.383675}{10\times10^3}\,s$$

$$= 38.3675\,\mu s.$$

$$T_{OFF} = T_s - T_{ON} = \frac{(1 - 0.383675)}{10\times10^3}\,s$$

$$= 61.6325\,\mu s$$

Q2. Given, the IM produces the rated torque at $\frac{2}{3}$rd the rated speed.

(a) $\omega_{sync} = 50\pi$

$\omega_{motor,rated} = (50 - 1.5)\pi = 48.5\pi$ } from Q1.

$T \propto \omega_S$

$\omega_S = 1.5\pi$

at $T = \frac{2}{3}$

$\omega_S = \left(1.5 \times \frac{2}{3}\right)\pi = \pi$

$\therefore \omega_{sync} = \omega_{rotor} + \omega_S = (48.5 + 1)\pi = 49.5\pi$ rad/s

V_{input} for the IM

$= 415 \times \frac{49.5}{50} = 410.85\,V = V_{L-L}$ (rms)

$f_{stator} = \frac{49.5\pi}{2\pi} = 24.25$ Hz

Now, since ϕ is constant,

$|\overline{V}| = \frac{3}{2} \times 410.85 \times \frac{\sqrt{2}}{\sqrt{3}} = \boxed{503.186\,V}$

$f = \boxed{24.25\,Hz}$

20 (ii) $|\overline{V}_{SVM}|_{max} = V_{dc} \propto \frac{\sqrt{3}}{2}$

$V_{LL,max} = V_{dc} \propto \frac{\sqrt{3}}{2} \propto \frac{2}{3} \propto \sqrt{2}$

$V_{LL,rms} = V_{dc} \propto \frac{\sqrt{3}}{2} \propto \frac{2}{3} \propto \frac{1}{\sqrt{2}} \propto \sqrt{2}$

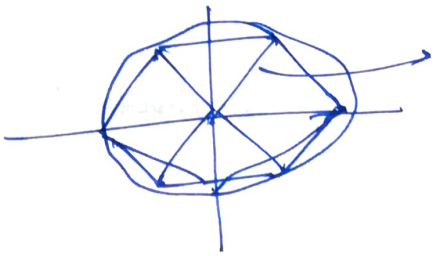
$= \frac{V_{dc}}{\sqrt{2}}$.

$\frac{V_{dc,min}}{\sqrt{2}} = V_{LL,rms}$.

$V_{dc,min} = 410.85 \times \sqrt{2}$

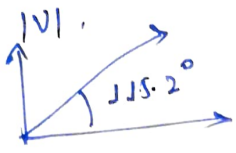
$V_{dc,min} = 581.03\ V$

For minimum V_{dc} we consider maximum of SVM.



$|V_m| = V_{dc} \frac{\sqrt{3}}{2}$.

(iii)



$f_s = 50kHz$, $\rightarrow T_s = 100\mu s$.

$f = 49.5Hz$. $\rightarrow T = 0.025$.

Steps $= \frac{0.02}{100 \times 10^{-6}} = 200$ steps

$$\Delta\phi = \frac{360}{200} = 1.8^\circ$$

$$\alpha^\circ = \frac{115}{1.8} = 63.88.$$

$$\theta = 64 \times 1.8 = 115.2$$

$$|V| \cos 55.2 T_3 = |V_2| T_1 + |V_3| \cos 60^\circ T_2$$

$$|V| \sin 55.2 T_3 = |V_3| \sin 60^\circ T_2$$

$$T_2 = \frac{50.3 \times 10^6 \sin 55.2}{581.03 \sin 60^\circ} T_3$$

$$= 0.821 T_3$$

$$= 82.1 \mu s.$$

$$58.2 T_3 = |V_2| \alpha T_1 - V_3 \cos 60^\circ T_2$$

$$T_1 = 8.375 \mu s.$$

$$T_{01} = \frac{T_0}{2} = 4.7625 \mu s.$$

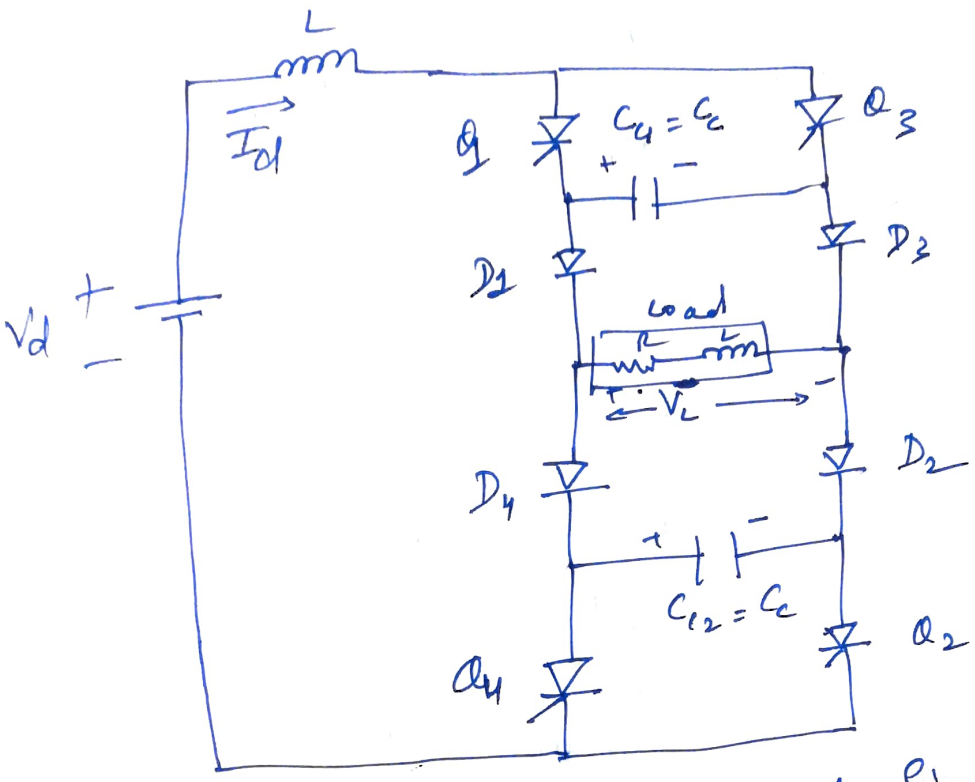
Top width of R is um for = ~~92.13~~

~~92.2~~.

95.237 μs.

Q4 =

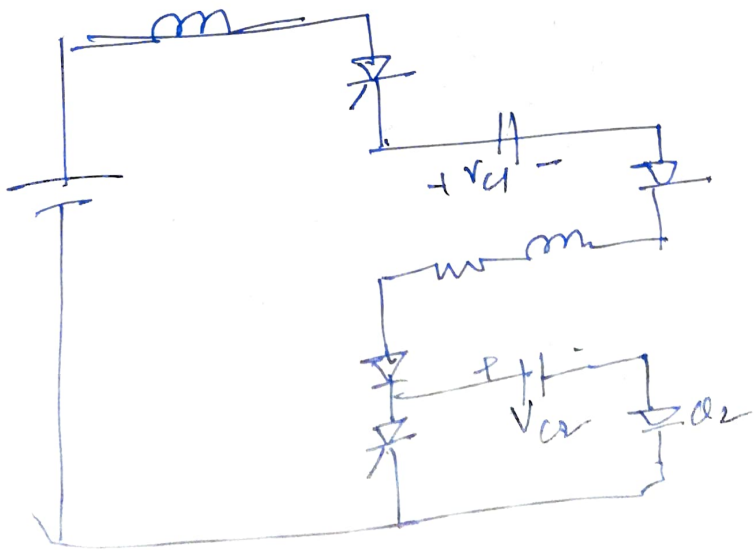
(i)

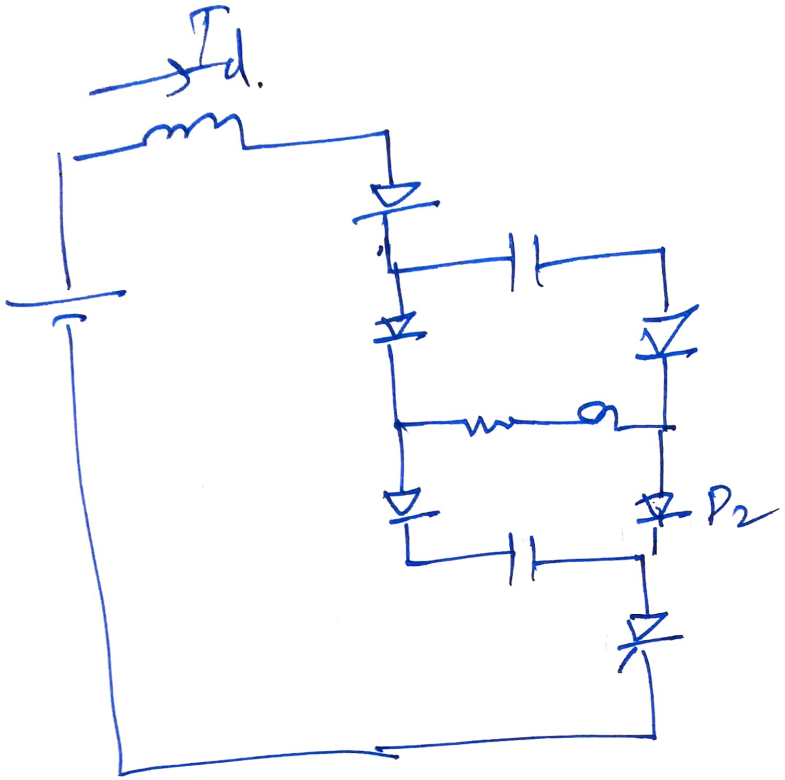


~~Fig~~ Circuit Schematic of Single Phase Full Bridge ASCI.

(ii) Mode-1.

Thyristor pairs a_3 & d_4 are turn OFF & Q_1 & Q_2 turns ON.





$V_4 = V_{C2}$.

$= V_{CD} + \frac{I_d t}{C}$

$V_L = - I_d R$.

$0 = V_{CD} + \frac{I_d t_1}{C} + I_d R$.

$V_C = -I_d R$ at $t = t_1$

Mode 2 :

When,