EEE4117F: ONLINE QUIZ 3

ELECTRICAL MACHINES AND POWER ELECTRONICS

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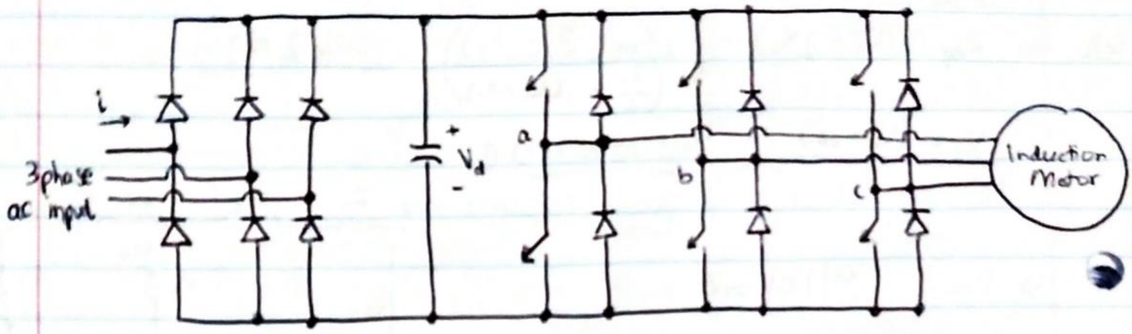
PART A – ELECTRICAL MACHINES

Question 1:

Part A

Question 1:

i) IM drive with diode bridge rectifier:

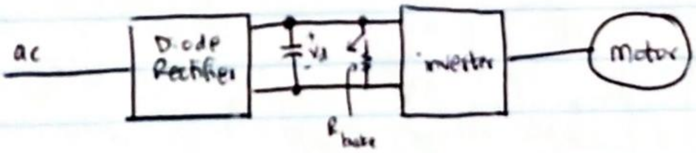


Modes achieved with this drive:

i) V/f control (cause it allows Unidirectional Power flow)

ii) Vector control (cause it allows Unidirectional Power flow)

iii) Dynamic braking mode



Question 2:

Question 2: Part A

(2.1) @ rated frequency (ie: 50 Hz)

$$N_s = \frac{120f}{P} = \frac{120(50)}{4} = 1500\,rpm$$

Slip Speed, $N_{SL} = N_s - N_r = 1500 - 1370\,rpm = 130\,rpm$

also: @ constant flux :

$$T_{em} = k\omega_{sl} = k n_{sl}$$

@ 80% of full Load Torque:

if Load Torque = 80%, then n_{sl} = 80% (directly proportional)

$\therefore$ n_{sl} @ 80% of full Load Torque = 0.8 * 130 rpm

$n_{sl_{new}}$ = 104 rpm

~~$N_r = N_s$~~ @ 30 Hz:

$$N_{s_1} = \frac{120(30)}{4} = 900\,rpm$$

$$N_{r_1} = N_{s_1} - N_{sl_{new}}$$

$$= 900\,rpm - 104\,rpm = 796\,rpm$$

$$\therefore \boxed{N_{r_1} = 796\,rpm}$$

(2.2) @ full-Load torque: $N_{sl} = 130\,rpm$

$$N_s = N_r + N_{sl}$$

$$= 1000\,rpm + 130\,rpm$$

$$\therefore N_s = 1130\,rpm$$

$$N_s = \frac{120f}{P} \Rightarrow f = \frac{N_s * P}{120} = \frac{(1130)(4)}{120} = 37.67\,Hz$$

$$\therefore \boxed{f = 37.67\,Hz}$$

Part A - Question 2:

(2.3) $f = 40Hz$, $N_r = 1100rpm$

$$N_s = \frac{120(40)}{4} = 1200rpm$$

$$N_{SL} = N_s - N_r = 1200 - 1100 = \underline{\underline{100rpm}}$$

@ Full Load ; $N_{SL} = 130rpm$

@ ? Load ; $N_{SL} = 100rpm$

$$100\% \, T_{em} = 130rpm$$

$$?\, T_{em} = 100rpm$$

$$= \frac{100}{130} \times (100\%) T_{em}$$

$$= \underline{\underline{76.92\% \text{ of } T_{em}}}$$

$\therefore$ 76.92% of Full-Load Torque is delivered.

(2.4) In regenerative breaking mode; N_r exceeds N_s

$$N_s = \frac{120(30)}{4} = \underline{900rpm}$$

from (2.1): $N_{SL,new} = \underline{104rpm}$ (@ 80% of full-load Torque)

$$N_r = N_s + N_{SL,new}$$

$$= 900 + 104$$

$$= \underline{\underline{1004rpm}}$$

$$\boxed{N_r = 1004 \text{ rpm}}$$

PART B – POWER ELECTRONICS

Question 1:

Part B:

Question 1

Data:

$V_o = -12V$

$0.46 \leq D \leq 0.545$

$R = 15\Omega$

$f = 50kHz$

$\frac{\Delta V_o}{V_o} < 0.01$

(1.1) $$D = \frac{|V_o|}{V_d + |V_o|} \Rightarrow V_d = \frac{|V_o| - D|V_o|}{D}$$

$$V_{d_{max}} = \frac{|V_o| - D_{min}|V_o|}{D_{min}} = \frac{12 - 0.46(12)}{0.46} = \underline{\underline{14.09V}}$$

$$V_{d_{min}} = \frac{12 - 0.545(12)}{0.545} = \underline{\underline{10.02V}}$$

$$\boxed{10.02V \leq V_d \leq 14.09V}$$

Part B. Question 1:

(1-2) $R_L \neq \cancel{\frac{V_o^2}{P_o}} =$

$$R_L = \frac{V_o^2}{P_o} = \frac{(-12)^2}{15} = \underline{\underline{9.6\,\Omega}}$$

$$L_{min} = \frac{(1-D)^2 R}{2f}$$

1) $L_{min} = \frac{(1-0.46)^2 9.6}{2(50k)} = 28\,\mu H$

2) $L_{min} = \frac{(1-0.545)^2 9.6}{2(50k)} = 19.87\,\mu H$

$\therefore L_{min}$ selected $= 28\,\mu H$

But: $L = 1.25 L_{min}$

$= 1.25(28\,\mu H)$

$\underline{\underline{L = 35\,\mu H}}$

$\therefore$ The best inductor is $\boxed{35\,\mu H}$

(1-3) (i) $C_{min} = \frac{D}{R\left(\frac{\Delta V_o}{V_o}\right)f} = \frac{0.46}{9.6(0.01)(50k)} = \underline{\underline{95.83\,\mu F}}$

(ii) $C_{min} = \frac{0.545}{9.6(0.01)(50k)} = \underline{\underline{113.5\,\mu F}}$

$\therefore$ Best Capacitor is $\boxed{113.5\,\mu F}$

(1-4) ~~The~~ Both provides a "Negative Polarity" regulated output Voltage with respect to the ~~common terminal~~ input.

Question 2:

Part B: Question 2:

2.1) $D = 1 - \frac{V_d}{V_o}$

$D_{max} = 1 - \frac{2.7}{8} = 0.6625$

$D_{min} = 1 - \frac{4.2}{8} = 0.475$

$\therefore 0.475 \leq D \leq 0.6625$

$\Delta I_L = 0.45 I_L$

$I_L = \frac{V_o I_o}{V_d}$

$I_L = \frac{8(1)}{2.7} = 2.963A$

$I_L = \frac{8(1)}{4.2} = 1.905A$

$\Delta I_L = 0.45 I_L$:

$0.857A \leq \Delta I_L \leq 1.333A$

$L_{min} = \frac{(V_d)D}{(\Delta I_L)f}$

For a Max L_{min}, V_d must be Max, D must be Max and ΔI_L must be Min

$L_{min} = \frac{(V_{d_{max}})D_{max}}{(\Delta I_{L_{min}})f} = \frac{(4.2)(0.6625)}{(0.857)(100k)} = 32.47 \mu H$

$\therefore \boxed{L_{min} = 32.47 \mu H}$

Part B: Question 2:

(2.2) $C = \dfrac{D}{R\left(\frac{\Delta V_o}{V_o}\right)f}$; $R = \dfrac{V_o}{I_o} = \dfrac{8V}{1A} = 8\Omega$

For ~~op~~ optimal Capacitance:

D must Max. ~~and~~

$C = \dfrac{0.6625}{(8)(0.01)(100k)} = 82.8\,\mu F$

NB: when D is min:

$C = \dfrac{0.475}{(8)(0.01)(100k)} = 59.4\mu$

Which is NOT Ideal

$\therefore \boxed{C = 82.8\,\mu F}$