POORNIMA
COLLEGE OF ENGINEERING

TUTORIAL SHEET

SHEET NO............

Class/Section:	**VII Sem/A**	**Campus:**	**PCE**	**Date:**	**27/9/2018**
Name of Faculty:		**Course :**	**EDC**	**Code:**	**8EE2A**

Date of Tut. Sheet Preparation: 17/9/2018Scheduled Date of Tut.: 27/9/2018.Actual Date of Tut. :...

FIRST 20 MT. CLASS QUESTIONS

1. A 80 kW, 440V, 800 rpm DC. Motor is operating at 600 rpm and developing 75 % rated torque when controlled by a 3-Ø, six-pulse thyristor converter. If the back emf at rated speed is 410 V, determine the triggering angle of the converter. The input to the converter is 3-Ø, 415 V 50 Hz a.c. supply. [CO1|PO1]
2. A 210 V, 1200 RPM, 10 A separately excited DC motor is controlled by a 1- phase fully controlled converter with an AC source voltage of 230V, 50 Hz. Assume that sufficient inductance is present in the armature circuit to make the motor current continuous and ripple free for any torque greater than 25% of rated torque. Ra = 1.5 Ω
   (a) What should be the value of the firing angle to get the rated torque at 800 rpm?
   (b) Compute the firing angle for the rated braking torque at -1200 rpm. [CO2|PO2]

2 HRS. SOLVABLE HOME ASSIGNMENT (H.A.) QUESTIONS

3. The speed of a 10 HP, 210 V, 1000 rpm separately excited D.C. motor is controlled by a single-phase full-converter. The rated motor armature current is 30 A, and the armature resistance is Ra = 0.25 Ω. The a.c. supply voltage is 230 V. The motor voltage constant is KaΦ = 0.172 V/rpm. Assume that sufficient inductance is present in the armature circuit to make the motor current continuous and ripple free. For a firing angle α = 450, and rated motor armature current, determine: 1) The motor torque 2) Speed of the motor at Rated armature current. [CO3|PO2]
4. A 220 V, 1500 RPM, 50 A DC separately excited motor with an armature resistance of 0.5 Ω is fed from a Dual converter with 3 **Φ** fully controlled rectifiers. Input supply is a.c. line voltage of 165V. Determine converter firing angles for the following operations. a) Motoring operation at rated motor torque and 1000 RPM in FW direction. b) Braking operation at rated motor torque and 1000 RPM in FW direction. c) Motoring operation at rated motor torque and 1000 RPM in REV direction. d) Motoring operation at rated motor torque and 1000 RPM in REV direction. [CO2|PO1]

OTHER IMPORTANT QUESTIONS

5. A separately excited d.c . Motor is fed from a 230 V, 50 Hz supply via a single-phase, half – controlled bridge rectifier. Armature parameters are: inductance 0.06 H, resistance 0.3 Ω, the motor voltage constant is Ka = 0.9 V/A rad/s and the field resistance is RF = 104 Ω. The filed current is also controlled by semi converter and is set to the maximum possible value. The load torque is TL = 50 N-m at 800 rpm. The inductances of the armature and field circuits are sufficient enough to make the armature and filed current continuous and ripple free. Compute :
   (i) The field current
   (ii) The firing angle of the converter in the armature circuit [CO3|PO2]

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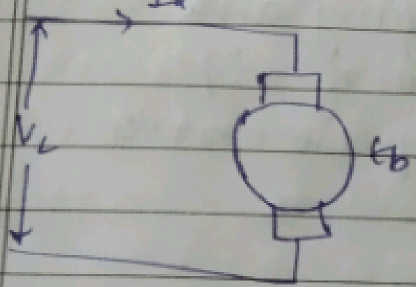
(1) A 80 kW, 440 V, 800 rpm DC Motor is operating at 600 rpm and developing 75% rated torque when controlled by a 3-ϕ, six-pulse thyristor converter. If the back emf at rated speed is 410 V, determine the triggering angle of the converter. The input to the converter is 3-ϕ, 415 V 50 Hz ac supply.

Sol:- 80 kW, 440 V, 800 rpm. DC motor

operating at 600 rpm & 75% torque

Consider DC motor relation,



$E_b \propto \phi N$; $T \propto \phi I_a$

ϕ = const, $E_b \propto N$ & $T \propto I_a$

given E_b at rated speed,

$E_{b1} = 410V$

$N_1 = 800$ rpm

$N_2 = 600$ rpm

$$\frac{E_{b2}}{E_{b1}} = \frac{600}{800} \Rightarrow E_{b2} = \frac{6}{8} \times 410$$

$$E_{b2} = 307.5$$

given, $V_L = 440V \Rightarrow R_a$ not given

$$\frac{T_2}{T_1} = 0.75 \text{ given} \Rightarrow I_{a2} = 0.75\, I_{a1}$$

$$I_{a1} = \frac{V - 410}{R_a} = \frac{440 - 410}{R_a} = \frac{30}{R_a}$$

$$I_{a2} = 0.75 \times \frac{30}{R_a} = \frac{22.5}{R_a} \quad \text{---(3)}$$

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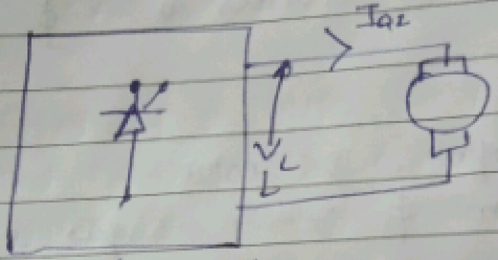
Voltage $V_{L2} = E_{b2} + I_{a2} \cdot R_a$

$V_{L2} = 307.5 + \frac{22.5}{R_a} \times R_a$

$\boxed{V_{L2} = 330V}$



3φ converter

$V_L = \frac{3V_{ml}}{\pi} \sin\alpha$ ← output of 3-φ six pulse converter

α is firing angle

$\frac{3 \times 415 \cdot \sqrt{2}}{\pi} \cdot \sin\alpha = 330$

$\sin\alpha = \frac{330 \times \pi}{3 \times 415 \times \sqrt{2}}$

$\sin\alpha = 0.5888$

$\boxed{\alpha = 36.073°}$

(2) A 210V, 1200 RPM, 10A separately excited DC motor is controlled by a 1-phase fully controlled Converter with an AC source Voltage of 230 V, 50HZ. Assume that sufficient inductance is present in the armature circuit to make the motor current continuous and ripple free for any torque greater than 25% of rated torque, $R_a = 1.5\Omega$.

(a) What should be the value of the firing angle to get the rated torque at 800 rpm?

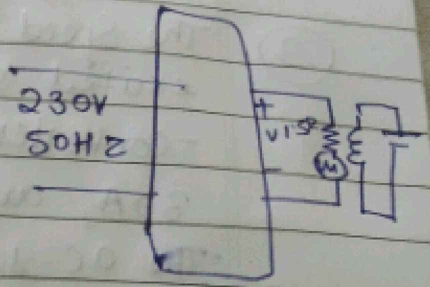
(b) Compute the firing angle for the rated braking torque at −1200 rpm.

Sol:- 210V, 1200 rpm, 10 A → motor $R_a = 1.5\,\Omega$

230, 50 Hz, AC → Rectifier.

(1) $\alpha = ?$ for $N = 800$ rpm

At rated torque



$$E_b = \frac{\phi Z N P}{60} \text{ = back emf}$$

$$N \propto \frac{E_b}{\phi} = \frac{ZP}{60A} = \text{Constant}$$

$E_{b_1} = V_{Rated} - I_{noload} \times R_a$ at 1200 rpm

$E_{b_1} = V - 0 = 210V$

$$\frac{N_1}{N_2} = \frac{E_{b_1}}{E_{b_2}} \times \frac{\phi_2}{\phi_1}$$

$$\frac{1200}{800} = \frac{210}{V - I_{F.L} \times R_a} \times \frac{\phi_2}{\phi_1}$$

Here flux constant in both cases because separately excited

$$\frac{3}{2} = \frac{210}{V - 10 \times 1.5}$$

$$V - 15 = \frac{420}{3} = 140$$

$V = 155V$ Rectifier out = motor input

1-ϕ full wave Rectifier output Average voltage

$$= \frac{2V_m}{\pi} \cos\alpha = 155V$$

$V_{rms} = 230$ $\quad V_m = \sqrt{2} \times V_{rms} = 325.26$

$\alpha = 41.53^\circ$

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(2) $N = -1200 rpm$

$\frac{N_1}{N_2} = \frac{E_{b1}}{E_{b2}} \Rightarrow \frac{1200}{-1200} = \frac{210}{V - 10 \times 1.5}$ ∴ $V = -195V$

$\frac{2V_m}{\pi} \cos\alpha = -195$ ∴ $\alpha = 160.343°$

(3) The Speed of a 10HP, 210V, 1000 rpm separately excited DC motor is controlled by a single-phase full converter. The rated motor armature current is 30A, and the armature resistance is $R_a = 0.25\Omega$. The ac supply voltage is 230V. The motor voltage constant is $K_a\phi = 0.172$ V/rpm. Assume that sufficient inductance is present in the armature circuit to make the motor current continuous & ripple free. For a firing angle $\alpha = 45°$, & rated motor armature current, determine: 1) The motor torque 2) Speed of the motor at Rated armature current.

Sol:- Given $K_a\phi = 0.172$ V/rpm.

$I_o = 30A$

$R_a = 0.25\Omega$

$V_{ac} = 230$ V rpm

1-ϕ full converter

$V_o = \frac{2V_m}{\pi} \cos\phi$

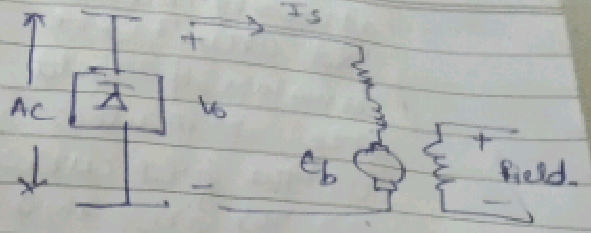
(1)

(2)

(4)

(1) $\cos\alpha = \cos 45^\circ = \frac{1}{\sqrt{2}}$

$V_0 = \frac{2 \times \sqrt{2} \times 230}{\pi} \times \frac{1}{\sqrt{2}}$



$V_0 = 146.43V$

$E_b = V_0 - I_a R_a$

$= 146.43 - 30 \times 0.25$

$E_b = 138.93V$

$E_b = k\phi N$

$N = \frac{138.93}{0.172} = 807.73$ rpm

$I = \frac{P}{V_{on}} = \frac{E_b \times I_a}{2\pi N/60} = \frac{138.93 \times 30}{2\pi \times 807.73} \times 60$

$z = 49.27.$

(2) $N = 807.73$ rpm

(4) A separately excited dc motor is fed from a 230V 50Hz supply via a single-phase, half controlled bridge rectifier. Armature parameters are inductance 0.06H, resistance 0.3 Ω, the motor voltage constant is $K_a = 0.9$ V/A rad/s and the field resistance is $R_F = 104$ Ω. The field current is also controlled by semi converter & is set to the maximum possible value. The load torque is $T_L = 50$Nm

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at 800rpm. The inductances of the armature & field circuit are sufficient enough to make the armature & field current continous & ripple free. compute :-

(1) The field current

(2) The firing angle of the converter in the armature circuit.

Sol:- Given data

$V_s = 230V$

$f = 50Hz$

$L_0 = 0.06H$

$R_a = 0.3\Omega$

$K_v = 0.9V-S/A-rad$

$R_f = 104\Omega$

$T_L = 50Nm$

$N = 800$ rpm

Angular speed $\omega_m = \frac{2\pi N}{60} = \frac{2\pi \times 800}{60}$

$= 83.776$ rad/s

As armature & field are controlled by 2 separate converter, let the first converter is connected across the armature & second across the field.

(1) As it is mentioned in question that field

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Converter is set to provide maximum possible current, the firing angle of the field converter should be 0° ie $\alpha_2 = 0°$

for semiconverter dc voltage is given as:

$$V_{dc} = \frac{V_m}{\pi}(1+\cos\alpha)$$

where V_m is peak value of supply voltage.

voltage across the field winding is given as

$$V_f = \frac{\sqrt{2}V_s}{\pi}(1+\cos\alpha_2)$$

$$V_f = \frac{\sqrt{2}\times 230}{\pi}(1+\cos 0)$$

$$V_f = 207.07V$$

field current is given as:-

$$I_f = \frac{V_f}{R_f} = \frac{207.07}{104}$$

$$I_f = 1.99A \approx 2A$$

(2) Back emf of motor can be given in terms of motor voltage constant as

$$E_b = K_V I_f W_m$$

$$E_b = 0.9 \times 2 \times 83.776$$

$$E_b = 150.8V$$

Torque of the motor can be expressed in terms of motor voltage constant & armature current I_a as

$$T_L = K_V I_f I_a.$$

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Armature current is given as:-

$$I_a = \frac{T_L}{K_v I_f} = \frac{50}{0.9 \times 2} = 27.778A$$

Terminal voltage of motor is given as.

$$V_t = E_b + I_a R_a = 150.8 + 27.778 \times 0.3$$

$$V_t = 159.1334 V$$

Terminal voltage of motor is dc voltage of first converter given as

$$V_t = \frac{\sqrt{2} V_s}{\pi} (1 + \cos \alpha_1)$$

$$159.1334 = \frac{\sqrt{2} \times 230}{\pi} (1 + \cos \alpha_1)$$

$$159.1334 = 103.5364 (1 + \cos \alpha_1)$$

$$\frac{159.1336}{103.5364} = (1 + \cos \alpha_1)$$

$$1.537 = 1 + \cos \alpha_1$$

$$0.537 = \cos \alpha_1$$

$$\alpha_1 = \cos^{-1}(0.537) = 57.52.$$

firing angle of the converter in armature circuit is

$$\alpha_1 = 57.52^\circ.$$

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