CMR INSTITUTE OF TECHNOLOGY

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InternalAssessmentTest -II

Sub:	**Industrial Drives and Applications**							Code:	17EE82
Date:	11/06/2022	Duration:	90mins	Max Marks:	50	Sem:	7^{th}	Branch:	EEE

AnswerAnyFIVEFULLQuestions

		Marks	OBE	
			CO	RBT
1.	With usual notations derive the expression for the temperature rise of a machine. Sketch temperature rise v/s time curve.	10	CO3	L2
2.	Explain with drive current and relevant waveforms (discontinuous current) a single phase fully controlled rectifier control of a separately excited Dc motor.	10	CO3	L1
3. a	Explain the multiquadrant operation of separately excited DC motor using dual converters.	5	CO3	L1
3.b	Describe the drive mechanism for textile mill.	5	CO6	L2
4.	A 220 V, 1500 rpm, 50 A separately excited motor with armature resistance of 0.5Ω, is fed from a 3-phase fully controlled rectifier. Available ac source has a line voltage of 440 V,50 Hz. A star-delta connected transformer is used to feed the armature so that motor terminal voltage equals rated voltage when converter firing angle is zero. (i) Determine the value of firing angle when motor is running at 1000 rpm and rated torque. (ii) When the motor is running at -700 rpm and twice the rated torque.	10	CO3	L3
5.	Explain the chopper control of separately excited dc motor for regenerative braking.	10	CO3	L1
6.a	Explain the drive requirements for steel rolling mills.	5	CO6	L2
6.b	A constant speed drive has the following duty cycle: (i) Load rising from 0 to 400 kw: 5 min (ii) Uniform load of 500 kw: 5 min (iii) Regenerative power of 400kw returned to the supply: 4 min (iv) Remains idle for: 2 min Estimate power rating of the motor. Assume losses to be proportional to $(power)^2$.	5	CO3	L3

HOD **CCI**

IDA IAT II solution

Q.1

Thermal Model of Motor for heating and Cooling

Assume m/c to be homogeneous body and cooling medium has the following parameters at time t.

p_1 – heat developed watts / joules/sec.
p_2 – heat dissipated to the cooling medium (watts)
W – weight of the active parts of machine kg.
h = Specific heat, Joules per kg per°c.
A = Cooling surface, m^2
d_1 - co-efficient of heat transfer or specific heat dissipation, joules/sec/m^2/°c
θ – mean temp rise, °c.

$$\therefore \quad p_1\,dt = Wh\,d\theta + \theta D\,dt$$

$$p_1\,dt = c\,d\theta + \theta D\,dt$$

$$c\,d\theta = p_1\,dt - \theta D\,dt \Rightarrow \boxed{c\frac{d\theta}{dt} = p_1 - D\theta} \quad \text{— (I)}$$

$$c\,d\theta = dt\,(p_1 - \theta D)$$

$$\frac{dt}{c} = \frac{d\theta}{p_1 - \theta D} \quad \text{— (2)}$$

(2) × $\frac{1}{D}$

$$\frac{dt}{c/D} = \frac{d\theta}{\frac{p_1}{D} - \theta}$$

$$\boxed{\frac{dt}{\tau} = \frac{d\theta}{\frac{p_1}{D} - \theta}} \quad \text{— (3)}$$

when steady state is reached, Let ...

heat gen = heat dissipated

$$p_1 \, dt = \theta_{ss} \, dA \, dt$$

$$\theta_{ss} = \frac{p_1}{dA} = \frac{p_1}{D}$$

$$\boxed{\theta_{ss} = \frac{p_1}{D}} \quad - (4).$$

(4) in (3),

$$\frac{dt}{\tau} = \frac{d\theta}{\theta_{ss} - \theta}$$

where $\tau = \frac{C}{D}$; $\theta_{ss} = \frac{p_1}{D}$

$$\frac{1}{\tau} \int dt = \int \frac{d\theta}{\theta_{ss} - \theta}$$

$$\boxed{\frac{t}{\tau} = -\log(\theta_{ss} - \theta) + K} \quad - (5)$$

To find K, at $t = 0$, $\theta = \theta_1$

$$0 = -\log(\theta_{ss} - \theta_1) + K$$

$$\boxed{K = \log(\theta_{ss} - \theta_1)} \quad - (6).$$

(6) in (5),

$$\frac{t}{\tau} = -\log(\theta_{ss} - \theta) + \log(\theta_{ss} - \theta_1)$$

$$\frac{t}{\tau} = \log \frac{(\theta_{ss} - \theta_1)}{(\theta_{ss} - \theta)}.$$

$$e^{t/\tau} = \frac{\theta_{ss} - \theta_1}{\theta_{ss} - \theta}.$$

$$\theta_{ss} - \theta = \frac{\theta_{ss} - \theta_1}{e^{t/\tau}}$$

$$\theta_{ss} - \theta = (\theta_{ss} - \theta_1)\, e^{-t/\tau}$$

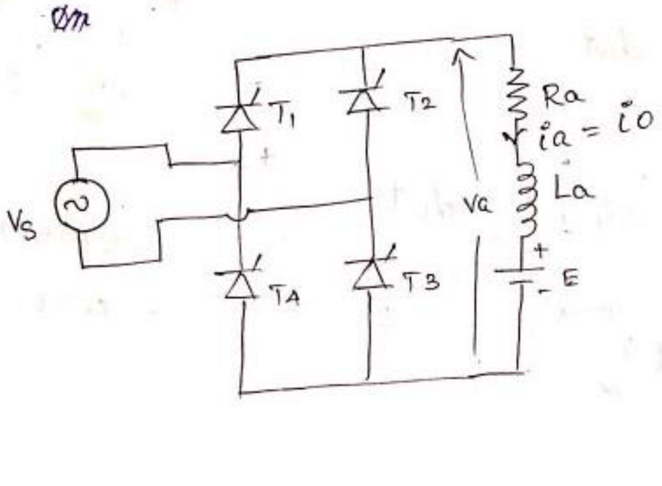
$$\theta_{ss} - \theta = \theta_{ss}\, e^{-t/\tau} - \theta_1 e^{-t/\tau}$$

$$\theta = \theta_{ss} - \theta_{ss}\, e^{-t/\tau} + \theta_1 e^{-t/\tau}$$

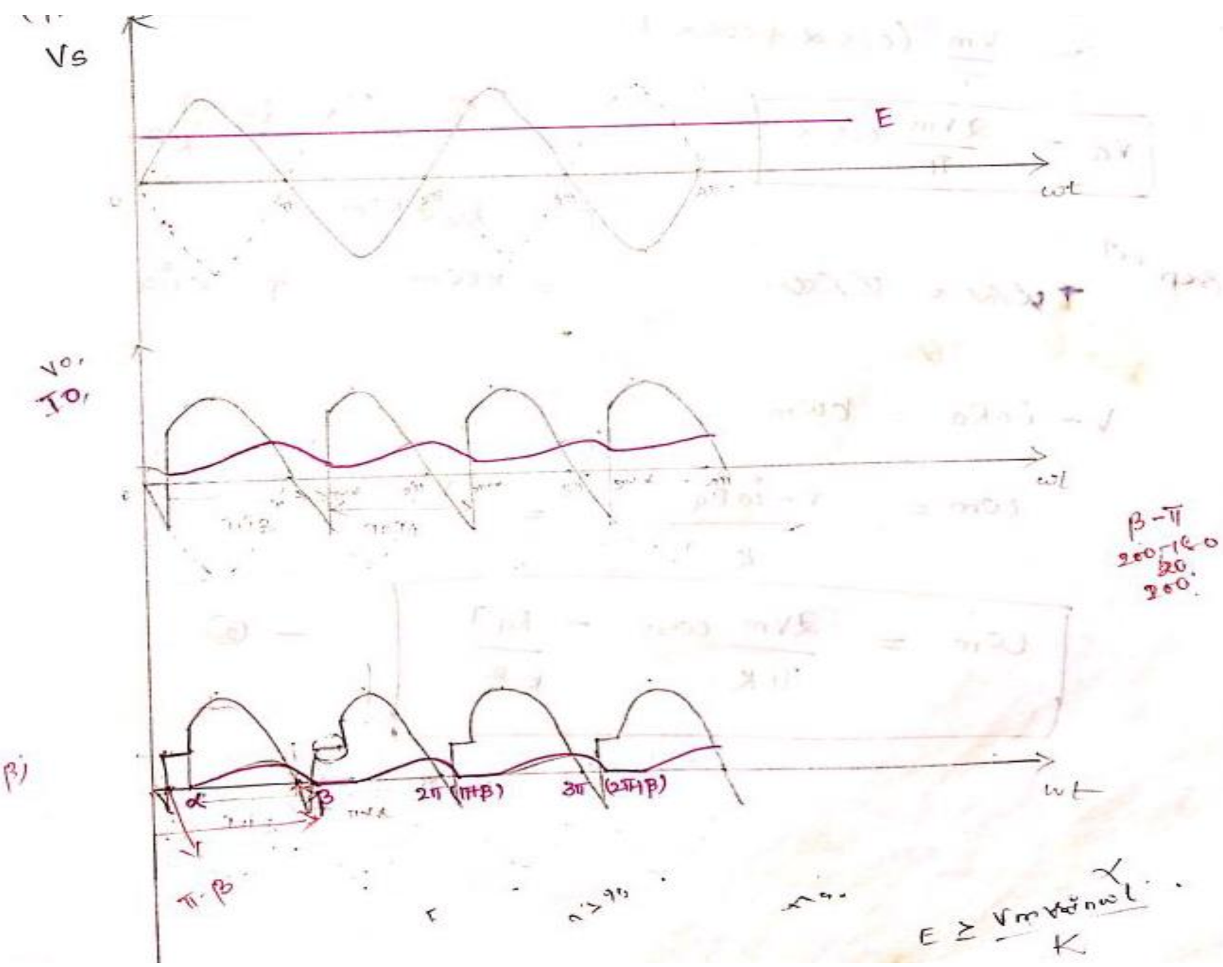
$$\boxed{\theta_h = \theta_{ss}(1 - e^{-t/\tau}) + \theta_1 e^{-t/\tau}} \quad - (4).$$

Q. 2

1φ Fully controlled Rectifier control of dc separately excited motor



Controlled rectifier fed dc drives are known as Static Ward - Leonard drives.



Discontinuous conduction.

(i) duty interval $(\alpha \le \omega t \le \beta)$ $V_a = V_s$.

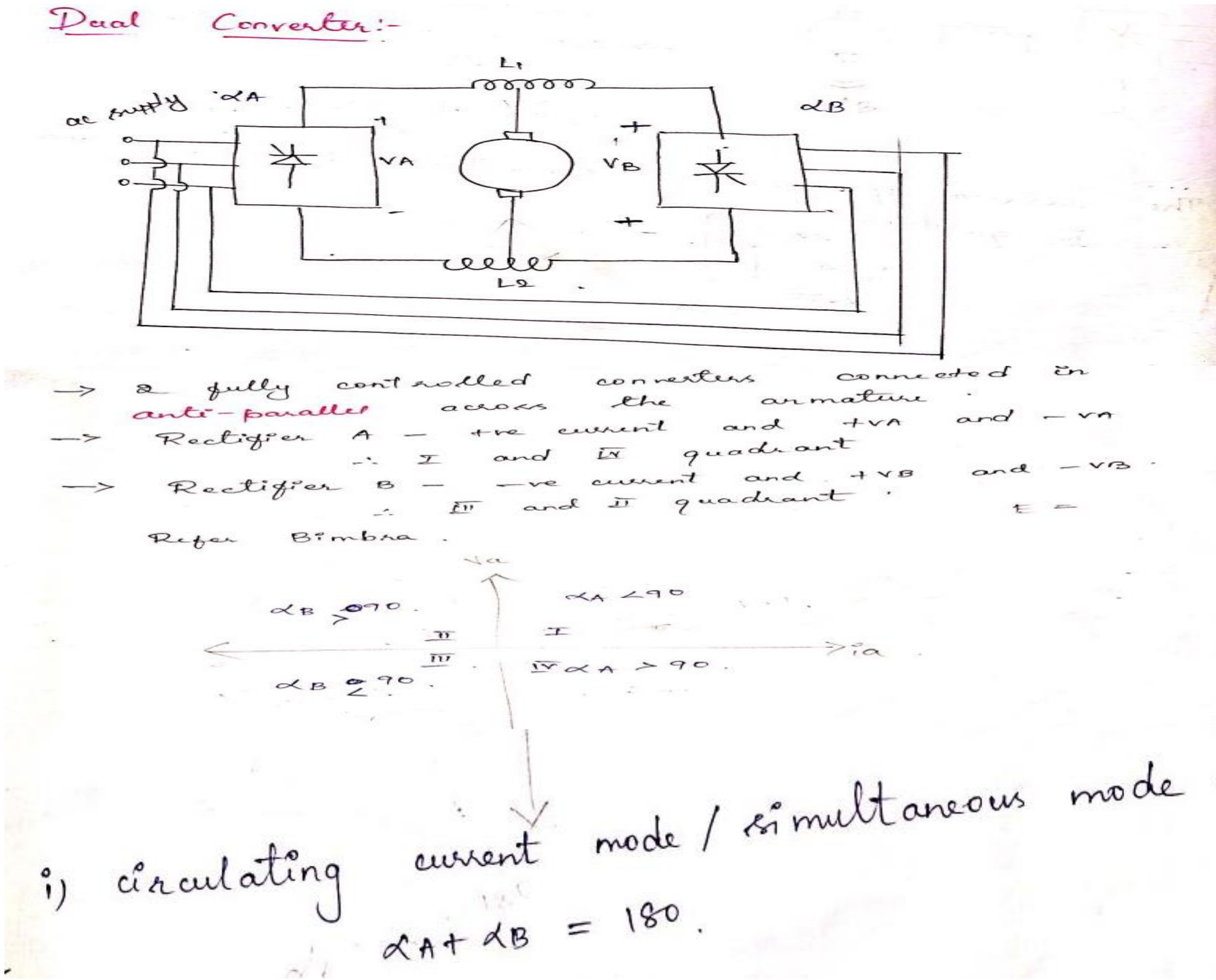
(ii) zero current interval $(\beta \le \omega t \le \pi + \alpha)$

$i_a = 0, \quad V_a = E.$

$$V_a = \frac{V_m(\cos\alpha - \cos\beta) + (\pi + \alpha - \beta)E}{\pi}$$

$$\omega_m = \frac{V_m(\cos\alpha - \cos\beta)}{K(\beta - \alpha)} - \frac{R_a T \pi}{K^2(\beta - \alpha)}$$

Q.3.a



Q. 3 b

Drive Considerations for Textile Industry

Ginning: The process of separating seeds from the raw cotton picked from the field is called ginning.

No speed control is required.

Commercially available squirrel cage induction motors may be employed.

Blowing: The ginned cotton in the form of bales is opened up and is cleaned up very well. No speed control is required. The motors having synchronous speed of 1000 or 1500 rpm may be employed.

Cording: The process of converting cleaned cotton into laps is done by lap machines which are normal three-phase standard squirrel cage motors. The motor selected must have a very high starting torque and low starting current so that starting losses are kept to a minimum. Normally, three-phase totally enclosed or totally enclosed fan cooled squirrel cage induction motors with high starting torque may be employed.

slivers are converted to uniform straight fibre by means of drawing machines. The slivers are converted into laps before combing.

The next process is spinning. A motor with smooth acceleration is necessary to drive in this frame. The drive motor should be capable of working in high ambient temperatures. The motor must be totally enclosed, with a clean floor construction.

Looms: The weaving of yarn into cloth is done in looms.

i. high starting torque

From the foregoing discussion it is clear that the motors used for textile applications must have. Torque control providing uniform acceleration so that the breakage of the yarn is minimum and the quality of the product is improved

Q. 4

(1) $E = \frac{1000}{1500} \times 195$ $\quad E = 220 - 0.5 \times 50 = 195\,V$

$= 130$

$V_a = E + I_a R_a$

$= 130 + 50 \times 0.5$

$= 155$

$V_a = \frac{3}{\pi} V_m \cos\alpha$

$\cos\alpha = \frac{\pi}{3} \cdot \frac{V_a}{V_m}$

$= \frac{\pi}{3} \times \frac{155}{230.4}$

$= 0.704$

$\alpha = 45.28°$

(2) $E = \frac{-700}{1500} \times 195$

$= -91\,V$

$V_a = E + I_a R_a$

$= -91 + 100 \times 0.5$

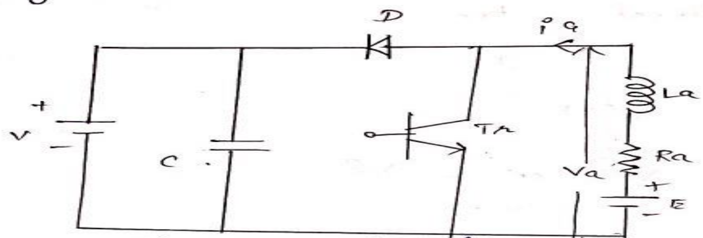
$= -41$

$\cos\alpha = \frac{\pi}{3} \cdot \frac{V_a}{V_m} = \frac{\pi}{3} \times \frac{-41}{230.4} = -0.186$

$\alpha = 100.71°$

Q.5

Regenerative Braking.



Energy Storage interval

→ When Tr is on ($0 \le t \le t_{on}$), the o/p voltage is zero. $V_o = V_a = 0$.

→ Though $V_a = 0$, voltage E drives current thro La and Tr.

→ La stores energy during t_{on}.

→ i_a ↑s from i_{a1} to i_{a2}.

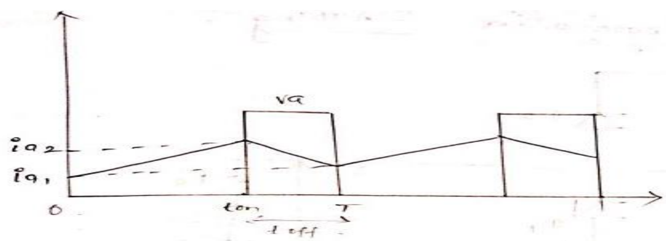
Duty interval:- ($t_{on} \le t \le T$)

→ When Tr is off, $V_o = E + L_a \frac{di_a}{dt} = V$

∴ ~~Vo > V~~

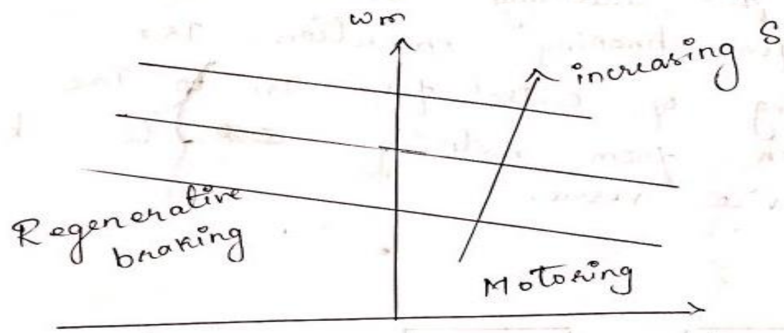
bcoz of this, D is forward biased and begins conduction, thus allowing power flow to the source.

→ i_a flows thro D, and source V and reduces from i_{a2} to i_{a1}.



$$\delta = \frac{\text{duty interval}}{T} = \frac{t_{off}}{T} = \frac{T - t_{on}}{T}$$

$$V_a = \frac{1}{T}\int_{t_{on}}^{T} \qquad V_a = \frac{1}{T}\int_{t_{on}}^{T} v\, dt = \frac{V}{T}(T - t_{on})$$



$$V_a = V\left(1 - \frac{t_{on}}{T}\right) = V(1-\delta) \qquad V_a = V\delta$$

where $\delta = 1 - \frac{t_{on}}{T}$.

$E_g = K\omega_m$

$T = -K I_a$ ($\because I_a$ is reversed)

$$\omega_m = \frac{V_a + i_a R_a}{K} = \frac{V(1-\delta)}{K} + \frac{R_a T}{K^2}$$

$$\omega_m = \frac{V\delta}{K} + \frac{R_a T}{K^2}$$

Q.6.a

The drive requirements immediately following the above process are the following:

I I. The drive must be capable of reverse rotation. A four quadrant operation must be possible.

II II. One or two individually driven motors may be used. The work rolls may be driven directly. The backup rolls are provided with motion whereas the working rolls move by friction.

I III. The coiling motors besides the driving toilers ensure the desired tension of the strip between the toilers and mill-stand. This is necessary to prevent looping of the strip and/or breaking.

II IV. The gap adjustment must be made simultaneously with the reversing. The latter is accomplished by screwing down the upper rolls.

III V. The inertia of the motor must be kept low and lower than that of the rollers

IV VI. Torque control as well as speed control must be possible to maintain constant tension of the strip. In a dc motor the torque control is possible both by field control as well as armature current control. As the diameter of the roller decreases the torque must also decrease. This is achieved by field However, field weakening in dc motors is limited by commutation and armature reaction effects. It is also limited by stability conditions of the motor. The armature current control may be employed beyond this limit.

V VII. The acceleration of the drive must be uniform to avoid breaking.

Q. 6 b

Solution

Rated power = rms value of power P_{rms}. Now the rms value of the power in interval (i)

$$P_1 = \sqrt{\frac{1}{5}\int_0^5 \left(\frac{400}{5}x\right)^2 dx} = \frac{400}{\sqrt{3}\text{ kW}}$$

$$P_{rms} = \sqrt{\frac{\left(\frac{400}{\sqrt{3}}\right)^2 \times 5 + 500^2 \times 5 + 400^2 \times 4}{16}} = 367 \text{ kW}$$

Since P_{max} = 500 kW is less than two times P_{rms}, motor rating = 367 kW.