ReModified

CBCS SCHEME

USN | | | | | | | | | | 17EE82

Eighth Semester B.E. Degree Examination, July/August 2021
Industrial Drives and Applications

Time: 3 hrs. Max. Marks: 100

Note: ***Answer any FIVE full questions.***

1 a. Explain the speed control conventions and four quadrant operation of motor driving a hoist load. **(08 Marks)**

b. Explain different power modulators that are used in drive system. **(04 Marks)**

c. A drive has the following parameters $J = 10$ kg-m^2, $T = 15 + 0.05N$, $T_l = 5 + 0.06N$ N-m. Initially drive is working in steady state. Now the drive is braked by electrical braking. Torque of the motor during braking is given by $T = -10 - 0.04N$ N-m. Calculate the time taken to stop. **(08 Marks)**

2 a. Obtain the fundamental torque equation of a motor load system. **(06 Marks)**

b. Explain closed loop speed control of drives. **(06 Marks)**

c. A weight of 500kg is being lifted up at a uniform speed of 1.5 m/sec by a winch driven by a motor running at a speed of 1000rpm. Moment of inertia of the motor and winch are 0.5 and 0.3 kg-m^2 respectively. Calculate the motor torque and equivalent moment of inertia referred to motor shaft. In the absence of weight motor develops a toque of 100Nm when running at 1000rpm. Assume efficiency of winch = 100%. **(08 Marks)**

3 a. Develop an expression of overloading factor K while selecting the motor rating for short time duty. **(10 Marks)**

b. A 220V, 960rpm, 12.8A separately excited dc motor has $R_a = 2\Omega$, $L_a = 150$mH. It is fed from a 1 ϕ half controlled rectifier with an AC source voltage of 230V, 50Hz. Calculate:

i) Motor torque for firing angle = 60° and speed = 600rpm

ii) Motor speed for firing angle = 60° and toque = 20Nm. **(10 Marks)**

4 a. Explain chopper control of DC series motor for motoring and regenerative operation. **(10 Marks)**

b. Select the motor for driving the equipment which has the load curve shown in Fig.Q.4(b). Last 46 sec torque is constant at 8N-m. **(10 Marks)**

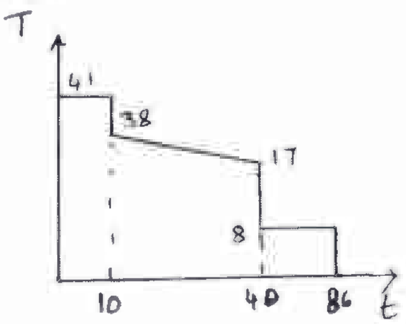

Fig.Q.4(b)

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

5 a. Describe the operation of induction motor operating with unbalanced voltages. **(10 Marks)**

b. A 400V, Y connected, 3 phase, 6 pole, 50Hz induction motor has following parameters referred to stator: $R_s = R'_r = 1\Omega$, $X_s = X'_r = 2\Omega$. For regenerative braking operation of this motor determine:

i) Maximum overhauling torque it can hold and range of speed for safe operation.

ii) Speed at which it will hold an overhauling load with a toque of 100N-m. **(10 Marks)**

6 a. Explain variable frequency control of induction motor with relevant diagram. **(08 Marks)**

b. A 2200V, 2600kW, 735rpm, 50Hz, 8pole, 3phase squirrel cage induction motor has following parameters referred to the stator $R_s = 0.075\Omega$, $R'_r = 0.1\Omega$, $X_s = 0.45\Omega$, $X'_r = 0.55\Omega$ stator winding is delta connected.

i) Calculate starting torque and maximum torque as a ratio of rated torque, if the motor is started by star delta starting what is the maximum value of line current during starting?

ii) Calculate transformation ratio of an auto transformer so as to limit the maximum starting current to twice the rated value. **(12 Marks)**

7 a. Explain the braking and multiquadrant operation of voltage source inverter fed induction motor. **(10 Marks)**

b. Explain pull in process in synchronous motor operation from fixed frequency supply. **(10 Marks)**

8 a. Describe the current source inverter control of induction motor. **(10 Marks)**

b. For inverter fed induction motor drive calculate approximate values of

i) Speed for a frequency of 30Hz and 80% of full load torque

ii) Frequency for a speed of 40Hz and speed of 1100rpm.

Given data for induction motor:

Y connected, 400V, 50Hz, 4 pole, 1370rpm. **(10 Marks)**

9 a. Explain the self controlled synchronous motor drive, employing load commutated thyristor inverter. **(10 Marks)**

b. Explain brushless DC motor drive for servo applications. **(10 Marks)**

10 a. With a neat block diagram, explain the true synchronous mode variable frequency control of multiple synchronous motor drive. **(10 Marks)**

b. Explain the drive requirements of cranes and hoist drive. **(10 Marks)**

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1 a) Quadrantal diagram —

Operation in quadrant 1, 2, 3, 4 —

example of hoist load —

1. b) Rectifier

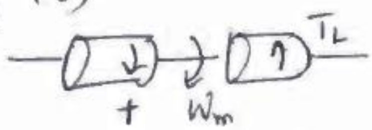
Inverter

AC voltage controller

Chopper

1. c) (PTO)

2 a)



$$T - T_L = \frac{d}{dt}(J \omega_m)$$

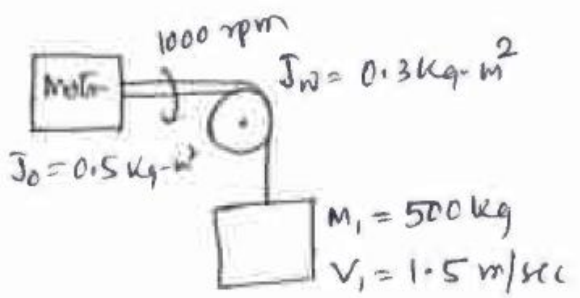
$$T = T_L + J\frac{d\omega_m}{dt}$$

2 b) Diagram ———

Explanation – speed controller, current limiter,

Inner current loop, outer speed loop.

2 c)



$\omega_m = 104.7$ rad/sec

$$J_{eq} = 0.5 + 0.3 + 500\left(\frac{1.5}{104.7}\right)^2$$

$$\boxed{J_{eq} = 0.903 \text{ Kg-m}^2}$$

$$T_{Leq} = 100 + \frac{500 \times 9.81}{1} \times \frac{1.5}{104.7} = \boxed{170.259 \text{ Nm}}$$

1.c) $T = T_l \Rightarrow 100 - 0.1N = 0.05N$

$\Rightarrow N = 666.7$ rpm

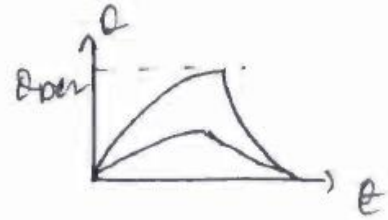
After reversal $N = -666.7$ rpm

$$J\frac{d\omega_m}{dt} = T - T_l \Rightarrow t = \int_{666.7}^{-0.95\times 666.7} \frac{dN}{(-95.49 - 0.143N)}$$

$$\boxed{t = 25.43 \text{ sec}}$$

3a)

$$\frac{\theta_{ss}}{\theta_{per}} = \frac{1}{1 - e^{-t_r/\tau}} = \frac{P_{1s}}{P_{1r}}$$



$P_{1r} = P_{cu}(\alpha + 1)$ $\alpha = \frac{P_c}{P_{cu}}$

$P_{1s} = P_c + K^2 P_{cu}$

$$\boxed{k = \sqrt{\frac{1 + \alpha e^{-t_r/\tau}}{1 - e^{-t_r/\tau}}}}$$

3b) $$\omega_{mc} = \frac{R_a V_m}{KZ}\left[\frac{\sin\phi\, e^{-\alpha\cot\phi} - \sin(\alpha - \phi)\, e^{-\pi\cot\phi}}{1 - e^{-\pi\cot\phi}}\right]$$

$= 77.76$ rad/sec or 742.54 rpm

i) $V_a = \frac{V_m}{\pi}(1 + \cos\alpha) = 155.3$ V

$E_{rated} = 194.4$ V

At 600 rpm $E = 121.5$ V

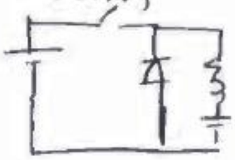
$$\boxed{T = 32.68 \text{ Nm}}$$

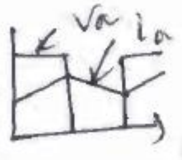
ii) $E_c = 150.37$ V $T_c = 4.77$ Nm

$E = V_a - I_a R_a = 134.6$ V

Speed $= \boxed{664.8 \text{ rpm}}$

4a) Motoring

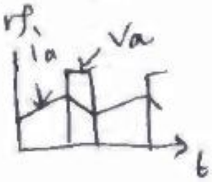




$\delta = \frac{t_{on}}{T}$

$V_a = \delta V \quad I_a = \frac{\delta V - E}{R_a}$

Regenerative braking.



$\delta = \frac{T - t_{on}}{T}$

$\boxed{V_a = \delta V} \quad \boxed{I_a = \frac{E - \delta V}{R_a}}$

$E_a = k I_a \omega_m \quad \boxed{T = k I_a^2}$

4b) $T_{eq} = \sqrt{\dfrac{41^2 \times 10 + \frac{38^2 + 17^2 + 38 \times 17}{3} \times 30 + 8^2 \times 46}{10 + 30 + 46}}$

$= 22.5$ N-m

Assuming $\lambda = 2$, $\frac{41}{2} < 22.5$ N-m

Rating of motor $\geq \boxed{22.5 \text{ N-m}}$

5a) $V_p = \frac{1}{3}(V_a + \alpha V_b + \alpha^2 V_c)$

$V_n = \frac{1}{3}(V_a + \alpha^2 V_b + \alpha V_c)$

$V_0 = \frac{1}{3}(V_a + V_b + V_c)$

$I'_{rp} = \dfrac{V_p}{\left(R_s + \frac{R_r'}{s}\right) + j(X_s + X_r')}$

$T_p = \dfrac{3}{\omega_{ms}} I_{rp}'^2 R_r'/s$

$s_n = \dfrac{-\omega_{ms} - \omega_m}{-\omega_{ms}} = 2 - s$

$T_n = -\dfrac{3}{\omega_{ms}} \left[\dfrac{V_n^2 R_r'/(2-s)}{\left(R_s + \frac{R_r'}{2-s}\right)^2 + (X_s + X_r')^2}\right]$

$\boxed{T = T_p + T_n}$

5b) $\omega_{ms} = 104.7$ rad/sec

i) $s_m = -\dfrac{R_r'}{\sqrt{R_s^2 + (X_s + X_r')^2}} = -0.242$

$I_r' = 45.5$ A $\quad \boxed{T_{max} = -244.5 \text{ Nm}}$

$s = -0.957$ or $s = -0.063$ $\boxed{s = -0.063}$

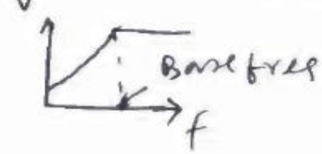
Speed $= \boxed{1063 \text{ rpm}}$

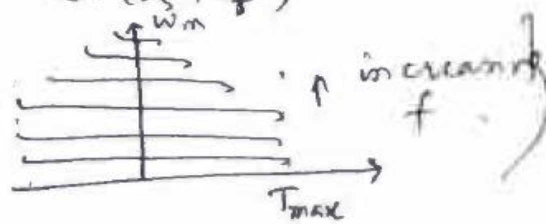
6 a)

$$T_{max} = \frac{k\left(\frac{V}{f}\right)^2}{\frac{R_s}{f} \pm \left[\left(\frac{R_s}{f}\right)^2 + 4\pi^2 (L_s + L_r')^2\right]^{1/2}} \rightarrow 2m$$

When f is not low, $\frac{R_s}{f} << 2\pi(L_s + L_r') \rightarrow 1m$

$$\therefore T_{max} = \pm \frac{k\,(V/f)^2}{2\pi(L_s + L_r')} \rightarrow 2m$$





3M

b) $N_s = 750$ rpm, $s_{fl} = 0.02$ $I_p = 425.3$ A

$I_L = \sqrt{3} I_p = 736.7$ A

$T_{fl} = 34545.5$ Nm $\omega_{ms} = 78.54$ rad/sec

i) During starting $I_L = 1251$ A

$$T_{st} = \frac{3 \times 1251^2 \times 0.1}{78.54} = 5979.3 \text{ Nm}$$

$\boxed{\frac{T_{st}}{T_L} = 0.173}$ $\boxed{\frac{T_{max}}{T_L} = 0.83}$

ii) Direct online starting $\rightarrow I_L = 3753.5$ A

$a_T^2 \times 3753.5 = 2 \times 736.7 \Rightarrow a_T = 0.627$

7 a) $P_{in} = 3 V I_s \cos\phi$

Dynamic Braking –

Regenerative braking –

Multiquadrant operation –

7b) Operation with fixed frequency —
Starting of synchronous motor —
Pull in process —

8 a) CSI feed IM → circuit diagram —
Wave form — Explanation —
$I_s = \frac{\sqrt{2}}{K} I_d$.
Motoring operation & braking opn

b) $N_{ms} = \frac{120 \times 50}{4} = 1500$ rpm $N_{fl} = 1370$ rpm

i) Drop in speed from no load to 80% full load
$= 130 \times 0.8 = 104$ rpm

At 30 Hz, $N_{ms} = \frac{120 \times 30}{4} = 900$ rpm

Motor speed $= 900 - 104 = \boxed{796 \text{ rpm}}$

ii) Sync speed = 1630 rpm

$\boxed{f = 36.67 \text{ Hz}}$

9a) circuit dia. —
operates as inv, $-ve\ V_{dl}$ & $+ve\ I_d$.
for $90° \leq \alpha_l \leq 180°$, ...
For $0° < \alpha_l < 90°$ ⇒ operates as rectifier
$\beta_l = 180° - \alpha_l$, $\gamma = \beta_l - u$

b) Circuit diagram —
Waveform —
Explanation —

10 a) Block diagram —
Explanation —

10 b)

Drive for crane and hoist

DC system ——

AC system ——

Q.No 10 a)

Out of syllabus. Grace marks can be awarded for those who attended question 10. a