REF: PE/PC/B/T/226/2024

Bachelor in Power Engineering 2nd Year 2nd Semester Examination 2024

Sub: ELECTRICAL MOTORS AND DRIVES

Full Marks: 100 (50 Marks for each Part) **Time: 3 hours**

Use separate answer script for each Part

PART I (50 Marks)

Q1. Answer **any six** of the following: (6×1=6)

(a) Where injected emf is provided for speed control in IM?
(b) What are the factors for determination of Motor Ratings?
(c) What is Cumilatively compounded DC motors?
(d) How speed variations can be realized by flux control in DC motor
(e) Why chopper based DC drives give better performance than rectifier controlled drives.
(f) Write the relation between starting torque and maximum torque in case of three phase IM.
(g) List the methods under armature voltage control of DC motors?
(h) What are the effects of harmonics in VSI fed induction motor drive?
(i) What is split phasing for single phase Induction Motor?
(j) What is Shaded Pole Starting of 1 Phase IM?

Q2. Answer **any four** of the following: (4×2=8)

(a) For three phase fully controlled rectifier control how the thyristor is fired? What is the phase difference and what is the gate pulse duration?
(b) What are the different classes of Motor Duty?
(c) Derive the expression for induction motor torque in terms of supply voltage from the equivalent circuit. Assume the parameters and mention them precisely.
(d) Explain the torque speed characteristics of DC Series Motor
(e) Show and the Induction generator region of the Torque Speed Characteristics of 3 Phase IM
(f) Discuss Speed control of induction motor by Cycloconverter.
(g) Derive the expression $V_a = 2V_m/\Pi \cos\alpha$ for continuous conduction in case of single phase fully controlled rectifier control of DC separately excited motor.
(h) What are the different methods of speed control for a three phase induction motor?
(i) Draw and explain the Plugging of separately excited DC motor with chopper control.

Q3. Answer **any three** of the following: (3×4=12)

(a) Draw the drive circuit for Dynamic braking control of chopper based separately excited DC motor drive and discuss its operation
(b) Draw the circuit diagrams for no load and block rotor test in case of an induction motor, How the mechanical load is represented in Equivalent circuit
(c) With a suitable block diagram, explain the closed loop control of current regulated voltage source inverter drive.
(d) Explain the operation of Star Delta Starter in case of 3-phase Induction motor.
(e) Explain in brief with a diagram the dual converter scheme for Multiquadrant Operation of DC Separately Excited motor fed from a fully controlled rectifier.
(f) Draw driver circuit for single-phase fully controlled rectifier fed separately excited DC motor. Explain continuous conduction for this case.

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Q4. Answer **any four** of the following: (4×6=24)

(1) A three-phase, 400 V, 50 Hz, 980 rpm, six-pole, star-connected, squirrel-cage induction motor has the following parameters per phase referred to the stator:

R1= 0.20 W, R2= 0.12 W, X1= 0.18 W, X2= 0.4 W, and Xm= 10.3 W.

The current source inverter controls the motor. At the rated value, flux is maintained constant. Compute the following:

(a) The stator current and DC. link current, when the machine operates at rated torque and 50 Hz.

(b) The inverter frequency and DC. link current for a speed of 500 rpm and rated torque.

(2) A 3-phase, star-connected, 440volts, 50Hz, 4-pole induction motor has the following per phase constants in ohms referred to stator: r_1=0.20, x_1=0.40, r_2=0.12, x_2=0.50, X_m=32. Stator to rotor effective turns ratio is 1.4. Determine:

(a) The slip at which maximum toque occurs, the maximum torque and the corresponding power output;

(b) The internal power developed for a slip of 0.06;

(3) A 220 V, 24A, 1000 RPM, 140 A DC separately excited motor has an armature resistance of 2 Ω. The motor is controlled by a Chopper with a frequency of 500 Hz from a supply of 220 V. Assuming continuous conduction Calculate the duty ratio δ for braking torque 1.2 times the rated Torque at 500 RPM.

(4) A 220 V D.C shunt motor has an armature resistance of 0.5 ohm and a field resistance of 250 ohm. When driving a constant torque load at 600rpm, the motor draws 21 A. What will be the new speed of the motor if an additional 220 ohm resistance is inserted in the field?

(5) A 4-pole, 50Hz, 3 phase induction motor develops a maximum torque at a speed of 1400 rpm and has per phase rotor resistance of 0.25Ω. Calculate the value of external resistance that must be inserted in series with each rotor phase to produce a starting torque equal to half of maximum torque. Neglect the stator impedance.

(6) A 3-phase, delta-connected, 8 pole, 50Hz, 440V, 1025rpm, squirrel-cage induction motor has the following parameters:

$R_S = 0.2\Omega$, $R_R` = 0.4\Omega$, $X_S = 0.7\Omega$, $X_R` = 1.2\Omega$

The motor is fed from a voltage source inverter with a constant V/f ratio from 0 to 50Hz and constant voltage of 440V above 50Hz frequency.

(j) Determine the breakdown torque for a frequency of 100Hz as a ratio of its value at 50Hz.

(ii) Obtain the torque at the rated motor current and 75Hz as the ratio of rated full-load torque of the motor.

(6) A 230 V, 4-pole, 50 Hz split phase induction motor has following impedance at standstill :

Main Winding : r = 2.8 ohm , x= 4.0 ohm

Starting Winding : r =2.2 ohm , x = 6.0 ohm

Determine the value of capacitance to be inserted in series with the starting winding to get (i) maximum starting torque (ii) maximum torque per ampere at starting.

(8) A 440 V, 50 Hz, 6-pole, 1400 rpm, Y-connected wound rotor motor has the following parameters:

$R_s = 0.50\ \Omega$, $R_r' = 0.40\ \Omega$, $X_s = X_r' = 1.2\ \Omega$ and $X_m = 70\ \Omega$

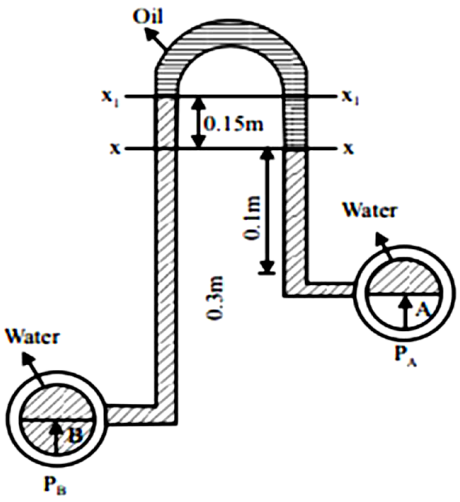
Motor is controlled by injecting a voltage into its rotor.

(k) Calculate motor torque for a speed of 1300 rpm when a voltage $25\angle 0^\circ$ (phase is measured with respect to the source voltage) is injected into the rotor. Ignore X_m.

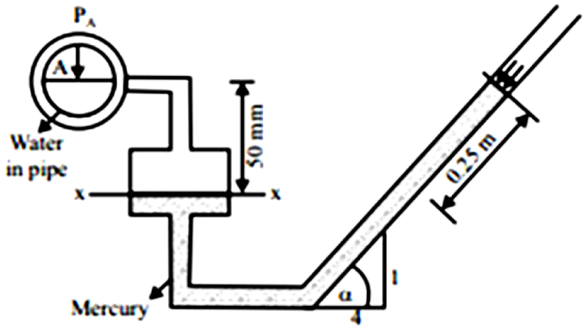
(9) A 220V, 970 RPM, 100 A DC separately excited motor has an armature resistance of 0.05 Ω. It is braked by plugging from an initial speed of 1000 RPM. Calculate: a) Resistance to be placed in the armature circuit to limit braking current to twice the full load value. b) Braking torque c) Torque when the speed has fallen to zero.

f) What are the fundamental principles underlying the measurement of position, displacement, velocity, and acceleration using sensors and transducers?
What do you understand by *Inductive Coupling* ?

g) An inverted differential U-tube manometer having an oil of specific gravity 0.8 as manometric liquid is connected to two different pipes carrying water under pressure . Determine the pressure in pipe B , if the pressure head in the pipe A is 2.0 m of water in figure below



h) An inclined micromanometer having a ratio of reservoir to limb areas as 10 was used to determine the pressure in a pipe containing water. Determine the pressure in the pipe for manometer reading , if the inclination of the manometer limb has a slope of 4:1 as shown in figure below



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B.E. POWER ENGINEERING SECOND YEAR SECOND SEMESTER - 2024

Subject: ELECTRICAL MOTORS AND DRIVES **Part-II (50 Marks)** **Full Marks :100**

Q1. Answer any three questions: 3×2

(a) Classify the power modulators and discuss the role of the switching circuit in motor and electrical drives.
(b) Explain the reverse motoring and forward braking through the four quadrant operation of a motor driving a hoist load.
(c) Draw the circuit diagram of a three phase to three phase Cycloconverter and mention its function.
(d) Name the components of the load torque and write the corresponding expressions.
(e) What are the advantages of a PWM inverter over a stepped wave inverter? Explain.

Q2. Answer any three questions 4×3

(a) Develop the armature current locus of the synchronous motor for constant power operation.
(b) Derive the voltage phasor equation of cylindrical rotor synchronous motor operating at lagging power factor. Also draw the corresponding phasor diagram.
(c) Explain its operation of a synchronous condenser the help of phasor diagram.
(d) How does a Reluctance Motor operate? Explain with diagram.
(e) Discuss two important functions of the damper winding in synchronous motor.
(f) Derive the expression of the torque develop in a salient pole synchronous motor.
(g) What are the significant features of a Hysteresis motor? Write down the applications of the Hysteresis motor.

Q3. Answer any two questions: 2×4

(a) Draw the equivalent circuit of dynamic braking of a synchronous motor and develop the expression of the braking torque. Why dynamic braking is suitable for stopping this motor?
(b) Explain the operation the self-controlled synchronous motor drive with load commutated thyristor inverter for motoring operation.
(c) How a Cyclo-converter based self-controlled synchronous motor drives operates? Discuss with suitable circuit diagram.
(d) Explain the operation of a Brushless DC Motor when supplied from a current regulated voltage source inverter. Derive its torque expression.

Q4. Answer any two questions: 2×7

(a) The synchronous reactance per phase of a 3 phase star connected 2000 V synchronous motor is 2.2 ohms. The power input is 800 kW at a rated voltage and the line value of the induced emf is 1500 V. Calculate the line current and the power factor. Neglect resistance.
(b) A 3-phase star connected, 50 Hz, 200 kW, 10 pole, 11 kV salient pole synchronous motor has reactances of X_d = 1.0pu and X_q = 0.8pu. Calculate the excitation emf and power angle when the motor is supplying rated power at 0.8 pf leading. Also calculate the maximum mechanical torque.

(c) A synchronous motor improves the power factor of a load of 750 kW from 0.7 pf lagging to 0.95 pf lagging. Determine the kVAr supplied by the motor and the kVA rating of the motor.

(d) A 3 phase, 50 kW, 400V,s 50 Hz star connected synchronous motor has an efficiency of 90%. The synchronous reactance and the resistance are 10 ohm and 0.5 ohm per phase respectively. The field current of the motor is so adjusted that the motor is operating at 0.8 leading pf. Find the induced emf and the mechanical power developed at full load.

(e) A 5 MW, 6.6 kV, 50 Hz, 6 pole, UPF star connected synchronous motor is controlled by a load commutated inverter and line commutated converter. Load commutated inverter works at 130^0 and rectifies at 10^0. The DC link inductor resistance is 0.2 ohm. The drive operates in self-controlled mode with constant (V/f) ratio. Determine the source side firing angle when (i) the synchronous motor is operating at 500 rpm with full load and (ii) the regenerative braking operation is imposed with rated current at 500 rpm. Synchronous reactance is 5 ohm and the resistance is considered to be negligible.