

CHUKA



UNIVERSITY

**UNIVERSITY EXAMINATIONS  
EXAMINATION FOR THE AWARD OF DEGREE OF BACHELOR OF SCIENCE IN  
ELECTRICAL AND ELECTRONIC ENGINEERING.**

**EENG 343: ELECTRICAL MOTORS I**

**STREAMS: EENG**

**TIME:2 HOURS**

**DAY/DATE: TUESDAY 17/12/2024**

**8.30 A.M. –10.30 A.M**

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**INSTRUCTIONS**

- **Answer question one and any other two questions**
- **Do not write on the question paper**

**QUESTION ONE (30 MARKS)**

- Explain the principle of operation of 3 phase induction motor (2 Marks)
- Give one advantage and one disadvantage of thermocouples (2 Marks)
- With the aid of a diagram, describe a three-point dc motor starter (4 Marks)
- Discuss any four safe practices when working with motors (4 Marks)
- A three phase, 4-pole, induction motor is supplied from a three phase, 50 Hz, ac supply. Calculate
  - The synchronous speed (1 Mark)
  - The rotor speed when slip is 4% (1 Mark)
  - The rotor current frequency when the rotor runs at 600 rpm (3 Marks)
- A full bridge inverter has bi-directional switches employed in a manner that their switching sequence produces a square wave voltage across a series R-L load. If the switching frequency is 50 Hz,  $V_s = 100$  V,  $R = 10 \Omega$  and  $L = 25$  mH, evaluate the RMS value of the fundamental component of load current. (5 Marks)

g. A 220V DC shunt motor has an armature resistance of  $0.8 \Omega$  and field winding resistance of  $220 \Omega$ . The motor field characteristic [ $k\phi$  versus field current] is shown in Figure Q1 (g) below. If the motor drives a constant load torque of  $17.5\text{Nm}$ , calculate

- (i) Calculate the field current (1 Mark)
- (ii) armature current (2 Marks)
- (iii) speed (1 Mark)

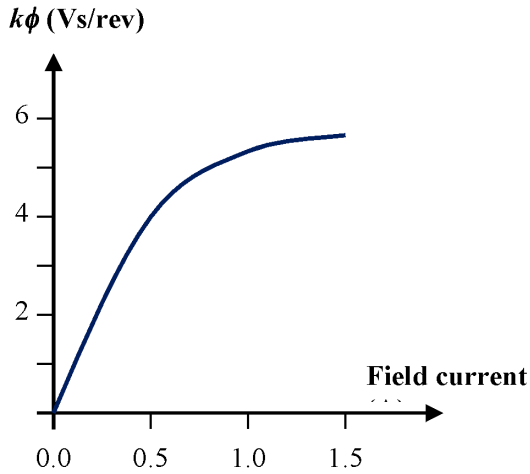


Figure Q1(g)

h. The stepper motor whose cross-section is shown in figure Q1 (h) below is operated in single phase on mode. Determine,

- (i) Resolution (3 Marks)
- (ii) Number of steps required for the shaft to make 10 revolutions (1 Mark)

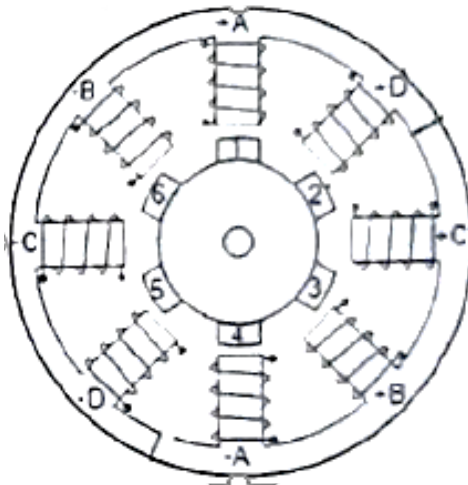


Figure Q1(h)

**QUESTION TWO** (20 MARKS)

- Give the main drawback of a single-phase half bridge inverter (1 Mark)
- Give two advantages of CSI (2 Marks)
- In order to effectively design with D.C. motors, it is necessary to understand their characteristic curves. Sketch the Torque-Speed characteristic of a DC motor and briefly describe it. (3 Marks)
- A 12-pole, 3-phase alternator driven at a speed of 500 rpm supplies power to an 8-pole, 3-phase induction motor. If the slip of the motor at full load is 3 %, calculate the full-load speed of the motor. (3 Marks)
- A 250-W, 230-V, 50Hz capacitor-start motor has the following constants for the main and auxiliary windings: main winding,  $Z_m=(4.5+j3.7)$  ohm. Auxiliary winding  $Z_a=(9.5+j3.5)$  ohm. Determine the value of the starting capacitor that will place the main and auxiliary winding currents in quadrature at starting (4 Marks)
- A three-phase distribution network is given in figure Q2(f) below. Determine, the resistance across the terminals RB, BY and RY. (7 Marks)

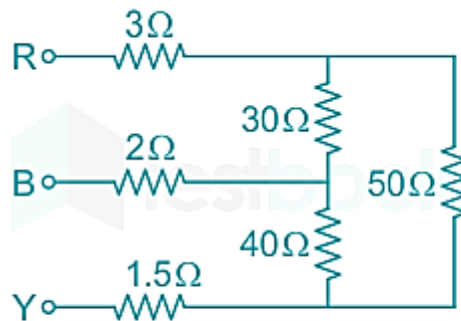


Figure Q2(f)

**QUESTION THREE** (20 MARKS)

- Give one main drawback of speed control of a DC shunt motor using armature resistance variation method (1 Mark)
- Give two uses of a motor control centre. (2 Marks)
- Discuss four disadvantages of harmonics in an inverter system (4 Marks)
- List four applications of fiber optic sensors (4 Marks)
- Highlight five advantages of hybrid stepper motors (5 Marks)

- f. A 220 V, 200 A, 800 rpm separately excited DC motor has an armature resistance of  $0.06 \Omega$ . The motor armature is fed from a variable voltage source with an internal resistance of  $0.04 \Omega$ . Calculate internal voltage of the variable source when the motor is operating in regenerative braking at 80% of the rated motor torque and 600 rpm. (4 Marks)

**QUESTION FOUR** **(20 MARKS)**

- a. Briefly explain the reason as to why a single-phase induction motor does not self-start (1 Mark)
- b. Highlight three advantages of controlling the speed of dc motors using flux control method (3 Marks)
- c. A stepper motor has a step angle of  $2.5^\circ$ . Determine
- (i) Resolution (1 Mark)
  - (ii) Number of steps required for the shaft to make 25 revolutions (1 Mark)
  - (iii) Shaft speed, if the stepping frequency is 3600 pps (1 Mark)
- d. A 3-phase, 400-V, star-connected induction motor has a star-connected rotor with a stator to rotor turn ratio of 6.5. The rotor resistance and standstill reactance per phase are  $0.05 \Omega$  and  $0.25 \Omega$  respectively. What should be the value of external resistance per phase to be inserted in the rotor circuit to obtain maximum torque at starting and what will be rotor starting current with this resistance? (4 Marks)
- e. A 220 V, 500 A, 600 rpm separately excited DC motor has an armature and field resistance of  $0.02 \Omega$  and  $10 \Omega$  respectively. The load torque is given by the expression  $T_L = 2000 - 2N$ , N-m, where N is the speed in rpm. Speed below the rated speed is obtained by armature voltage control and speeds above the rated speed are obtained by field control method. Calculate;
- (i) Motor terminal voltage and armature current when the speed is 450 rpm (6 Marks)
  - (ii) Field winding voltage and armature current when the speed is 750 rpm (3 Marks)
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