



# **MURANG'A UNIVERSITY OF TECHNOLOGY**

## **SCHOOL OF ENGINEERING AND TECHNOLOGY**

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

UNIVERSITY ORDINARY EXAMINATION

2023/2024 ACADEMIC YEAR

**FIFTH YEAR SECOND SEMESTER EXAMINATION FOR BACHELOR OF  
SCIENCE IN ELECTRICAL AND ELECTRONICS ENGINEERING**

EES 146: ELECTRICAL MACHINE DRIVE

DURATION: 2 HOURS

### **INSTRUCTIONS TO CANDIDATES:**

1. Answer Question one and any other two questions.
2. Mobile phones are not allowed in the examination room.
3. You are not allowed to write on this examination question paper.

## SECTION A: ANSWER ALL QUESTIONS IN THIS SECTION

### QUESTION ONE (30 MARKS)

- a) Define the following terms
- i. Electrical machine drive (2marks)
  - ii. Permanent-magnet synchronous motor (2marks)
  - iii. Open-loop transfer function of a dc motor drive (2marks)
- b) Briefly outline the functional parts of an electrical drive system. (4marks)
- c) A 400v,60Hz, 4-poles, star connected inductin motor has its rotor running at a speed of 1750rpm. Determine
- i. Synchronous speed (3marks)
  - ii. Slip (1mark)
- d) i. Determine the value of VR in fig 1.
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- ii. With the aid of an output waveforms, explain the operation of a three phase fully controlled converter. (4marks)
- e) A 15hp,220v,200r.p.m. separately excited dc motor controls a load requiring a torque of 43 N-M at a speed of 1200r.p.m. The field circuit resistance  $R_f = 147\Omega$ , the armature circuit resistance  $R_a = 0.25\Omega$  and the voltage constant of the motor  $K_v=0.7032$ . The field voltage  $V_f=220V$ . the viscous friction and no load losses are negligible. The armature current may be assumed continuous and ripple free. Determine
- i. Back e.m.f. (2marks)
  - ii. Required armature voltage (2marks)
- f) With the aid of an output waveform, explain the operation of a tachogenerator in machine drive speed control. (4marks)
- g) Using a block diagram, explain closed loop control of inductin motors by ac voltage controlllers at a fixed frequency (3marks)

## SECTION TWO: ANSWER ANY TWO QUESTIONS

### QUESTION TWO (20 MARKS)

- a) A single phase ac input voltage is controlled by one silicon controlled rectifier (SCR) fired at  $75^\circ$  firing angle to power ac motor to drive a hoist machine
- i. Define firing angle (2marks)
  - ii. Draw and discuss the dc output waveform of the system (5marks)
- b) Using a circuit diagram, explain the operation of a two-quadrant dc chopper drive as applied to a separately excited dc motor. (7marks)
- c) Explain any three functional parts of a microprocessor control system drives (6marks)

### QUESTION THREE (20 MARKS)

- a) With the aid of circuit diagram explain electronic speed control of a three phase synchronous motor by current-fed Dc link method. (8marks)
- b) A three phase 430v, 50Hz, 4-pole star connected reluctance motor has  $X_d=8\Omega, X_q=2\Omega$  and negligible armature resistance for a load torque of 80N-m, neglecting rotational losses calculate the
- i. Load angle (4marks)
  - ii. Line current (3marks)
  - iii. Input power factor (2marks)
- c) Outline the advantages of using a constant voltage Dc link converter in ac synchronous speed control. (3marks)

### QUESTION FOUR (20 MARKS)

- a) State three advantages of DC machine variable speed drives in electric traction. (3marks)
- b) Explain the characteristic curves of armature current, field and armature voltage against the speed when the speed of a separately excited dc motor is varied below and above the base speed indicating the region of constant torque drive and constant power drive regions. (7marks)
- c) The speed of a separately excited dc motor is controlled by a single-phase semiconverter. The field current which is also controlled by a semiconductor is set to the maximum possible value. The ac supply voltage to the armature and field converters is single-phase, 230v, 60Hz. The armature resistance  $R_a=0.25\Omega$ , the field resistance  $R_f=147\Omega$  and the

motor voltage constant  $K_v=0.7032$ . The load torque  $T_l=43\text{N} - \text{m}$  at  $1000\text{r.p.m}$ . The viscous friction and no-load losses are negligible. Assuming a ripple free armature and field currents.

Determine the

- i. Field current (5marks)
- ii. Delay angle of the converter in the armature circuit (5marks)