# TECHNICAL UNIVERSITY OF MOMBASA

FACUULTY OF ENGINEERING AND TECHNOLOGY

ELECTRICAL ENGINEERING DEPARTRMENT

## UNIVERSITY EXAMINATION FOR:

BACHELOR OF SCIENCE IN ELECTRICAL AND ELECTRONIC ENGINEERING

EEE2513: ELECTRICAL MACHINE DRIVES

END OF SEMESTER EXAMINATION

**SERIES: MAY 2016**

**TIME:** 2 HOURS

**DATE:**Pick DateSelect MonthPick Year

**Instructions to Candidates**

You should have the following for this examination

*-Answer Booklet, examination pass and student ID*

This paper consists of **five** Questions; Question ONE is compulsory. In addition attempt any Other TWO Questions.

**Do not write on the question paper.**

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**Question ONE (Compulsory 30 marks)**

a) Define the following terms:
   i. Drive
   ii. Electrical drive
   iii. Prime mover

**(3 Marks)**

b)
   i. Sketch the block diagram of a general electrical drive system and explain the purpose of each block.
   ii. State any FOUR advantages of electrical drives over mechanical counterparts

**(11 Marks)**

c)
   i. Compare and contrast features of scalar drives with those of vector drives
   ii. Distinguish between Vector Control (Field Oriented Control) and Direct Torque control in electrical drives

**(6 Marks)**

d) Balanced three phase currents having maximum values of 100A are supplied to a machine via a **αβo** vector drive. Sketch the layout of the drive system and determine:
   i. **αβγ** components applied
   ii. **dqo** components required to feed the **αβγ** block

**(10 Marks)**

**Question TWO**

a) State TWO:
   i. advantages of electronic drive signals over direct mains
   ii. disadvantages of permanent magnet motor drives over reluctance type counterparts

**(4 Marks)**

b) A bi-polar wave drive is required to rotate a disc at a speed of 3000rev/minute. A PWM sinusoidal output fed to a 3 phase permanent magnet synchronous motor having 6 poles on the stator and 4 poles on the rotor. Estimate the total number of pulses required for 100 revolutions to be completed in 5 seconds, and the drive phase frequency.

**(5 Marks)**

c)
   i. Draw a sketch showing armature current control in DC machines
   ii. Show that the transfer function of Armature Controlled DC Motor above is

$$\frac{\omega_o(s)}{V_a(s)} = \frac{K_{ma}/R_a D_m}{(\tau_m s + 1)(\tau_a s + 1) + K_b}$$

   iii. Determine the steady state speed for the motor in b(i) above having the parameters $L_a$= 10H, $R_a$=1kΩ, $K_{ma}$ =100, Jm=0.05Kgm$^2$s$^{-2}$, D=0.2N/ms$^{-1}$, $K_m$=500; $K_b$=20 and supplied with a 200V step input.

**(11 Marks)**

**Question THREE**

a) State TWO
   i. Applications of DC chopper Drives
   ii. Disadvantages of 1-φ SCR drives

**(4 Marks)**

b)
   i. Draw a chart showing 4-Quadrant operation of drives
   ii. Draw a 3-φ SCR circuit applied for 4–Quadrant operation above

**(6 Marks)**

c) A 1000r.p.m. field controlled DC motor having field resistance of 1.2kΩ and maximum field voltage of 60V is to be connected to a 1φ, 240V mains through a limp of Y-Y step down transformer, a rectifier and a DC chopper with fixed ON time of 100μs. Determine transformer ratio applied and the duty cycle corresponding to:
   i. Reverse motoring at -500rpm
   ii. Regenerative braking at -600rpm at twice rated torque

**(10 Marks)**

**Question FOUR**

a) Define the following terms pertaining to drives:
   i. Stability
   ii. Transient characteristics
   iii. Passive load

**(3 Marks)**

b) State
   i. TWO advantages of a constant voltage drive over constant frequency counterpart
   ii. FOUR advantages of AC drives over DC counterparts

**(6 Marks)**

c) 3 phase induction motor parameters are:
   $V_s=415V_{LL}$ $R_s=3.5\Omega$, $L_s=10H$, $R_r'=0.5\Omega$, $L_r'$ 0.5H, slip=5%, f=50Hz, poles = 6
   i. Sketch the equivalent circuit and show through derivation the relationship between Torque and Frequency, hence determine the torque output with ½ and 4/3 of the rated frequency
   ii. Sketch the Torque speed characteristic of the drive above assuming it is a NEMA class A motor

**(11 Marks)**

**Question FIVE**

a) State special applications of each of the following power electronic devices in electrical drives:
   i. Bipolar Junction Transistor (BJT)
   ii. Insulated Gate Bipolar Transistor(IGBT)
   iii. Power Metallic Oxide Semiconductor Field Effect Transistor(MOSFET)

**(3 Marks)**

b) Sketch a Voltage Source Inverter circuit(VSI) that is applied to 3-φ induction motor and explain corresponding circuit operation

**(7 Marks)**

c) A $300V_{ll}$,40A, 60Hz, 3- φ, 0.8pf motor is fed via a six step inverter circuit from a 3- φ, 415 $V_{ll}$ supply. Assuming infinite modulating index $m_a$ , calculate:
   i. The DC section voltage and current
   ii. The source side fundamental current and power factor
   iii. The source side fundamental current and power factor if source is replaced by $240V_{l\text{-}n,}$ 1- φ supply, and explain what happens

**(10 Marks)**