20

(*University of Choice*)

MASINDE MULIRO UNIVERSITY OF SCIENCE AND TECHNOLOGY (MMUST)

MAIN CAMPUS

SUPPLEMENTARY/SPECIAL UNIVERSITY EXAMINATIONS

2021/2022 ACADEMIC YEAR

FOURTH YEAR SECOND SEMESTER EXAMINATIONS

FOR THE DEGREE OF BACHELOR OF SCIENCE IN ELECTRICAL AND COMMUNICATION ENGINEERING

COURSE CODE: ECE 424

COURSE TITLE: POWER ELECTRONICS II

DATE: OCTOBER 7TH, 2022 **TIME: 3:00PM - 5:00PM**

INSTRUCTIONS TO CANDIDATES

ANSWER QUESTION ONE AND ANY OTHER TWO QUESTIONS.
QUESTION ONE CARRIES 30 MARKS AND ALL OTHERS 20 MARKS EACH.

TIME: 2 Hours

MMUST observes ZERO tolerance to examination cheating

This Paper Consists of 4 Printed Pages. Please Turn Over.

QUESTION ONE

1. A full-bridge inverter is operated from d.c. supply of 400 V and in a unipolar PWM mode. Determine:
   a) Fundamental output voltage at $M = 0.5$
   b) The first-five dominant harmonic order if $M = 12$.

[4 Marks]

2. Briefly explain why voltage control is necessary in inverter circuits and the various methods of voltage control in inverter circuits.

[4 Marks]

3. Discuss two (2) techniques applied to obtain variable d.c. voltage from a fixed d.c. voltage

[4 Marks]

4. The single-phase half-bridge inverter has a resistive load of 5 Ω and the center-tap dc input voltage is 12 V. Compute:
   a) RMS value of the output voltage.
   b) Fundamental component of the output voltage waveform.
   c) Fundamental power consumed by the load.
   d) The IGBT ratings
   e) Total harmonic distortion THD
   f) The distortion factor DF

[12 Marks]

5. Briefly highlight on three (3) converter classifications

[6 Marks]

QUESTION TWO

1. In a table format, highlight the differences between circulating current and non-circulating current schemes of dual converters.

[2 Marks]

2. Design a dual converter to achieve at four-quadrant operation for $I_d = 10\ A$ at 240 V. The converter is supplied from 420 V, three-phase and 50 Hz supply. **[8 Marks]**

3. Consider a $20\ HP$, $240\ V$, $1200\ rpm$ series motor whose combined field and armature resistance is 0.25 Ω. Motor constants are $K_{af} = 0.03\ NmA^2$ and $K_{res} = 0.0075\ Vsrad^{-1}$. The supply voltage is 240 V. Assuming a continues and ripple free motor current, determine the following:
   a) Motor torque
   b) Motor current
   c) Supply power factor

   For the case in which the motor is controlled by a single-phase
   i. Semiconverter
   ii. Full conveter

[10 Marks]

QUESTION THREE

1. For a three-phase bridge inverter operating in 120° conduction mode, determine:
   a) The dc voltage for a fundamental line voltage of 415 V
   b) The rms line and phase voltage
   c) The device voltage rating.

[6 Marks]

2. A three phase six-pulse, 55 kVA, 415 V cycloconverter is operating at a firing angle of 60° and supplying load of 0.9 power factor. Determine input current to the converters.

[4 Marks]

3. The speed of a 120 kw, 1800 rpm, separately excited d.c. motor is controlled by three-phase full converter. The specifications of the converter are 460 V, 280 A. The input to the converter is a three-phase, 415 V, 50 Hz a.c. supply. Neglect the system losses and effect of commutation angle, determine:

   a) Firing angle of the converter and power factor at rated speed.
   b) Firing angle and power factor at 10% rated speed.
   c) Active and reactive power drawn from the system at rated speed.
   d) Active and reactive power drawn from the system at 10% rated speed.
   e) Ratio of reactive power drawn at 10% and rated speed.

[10 Marks]

QUESTION FOUR

1. A 6-pole, 50 Hz slip-ring induction motor is controlled by a static Scherbius drive. Determine the angle of firing advance in the inverter at
   a) 600 rpm
   b) 800 rpm

   If the open circuit standstill slip-ring voltage is 660 V, and the inverter is connected to a 415 V, three-phase system. Neglect overlaps and losses.

[8 Marks]

2. A three-phase, three-wire bidirectional controller supplies a star-connected resistive load of $R = 3\ \Omega$ and the line-to-line input voltage is 240 V (RMS) 50 Hz. The firing angle is $\alpha = \frac{\pi}{3}$. Determine:

   a) The RMS output phase voltage, E_o.
   b) The input power factor, P_f
   c) The expression for the instantaneous output voltage of phase 1.

[8 Marks]

3. Discuss two (2) power semiconductor speed control methods of induction motor drives.

[4 Marks]

QUESTION FIVE

1. List at most two (2) classifications of power semiconductor devices and give 2 examples in each classification.

[2 Marks]

2. A three phase to single phase cycloconverter employs six pulse positive and negative group converters. Each converter is supplied from delta/star transformer with per phase turns ratio of 3:1. The supply voltage is 415 V, 60 Hz. The R_L load has $R = 20\Omega$ and at low output frequency, $\omega\, oL = 5\Omega$. The commutation overlap and thyristor turn-off time limit the firing in the inversion mode to 160°. Determine:

    a) The value of the fundamental RMS output voltage,
    b) The RMS output current,
    c) The output power.

[8 Marks]

4. A two-quadrant chopper operating in the first and fourth quadrant is operated from a 300 V battery. The load is dc motor with $R = 10.1\,\Omega$, $L = 10\,mH$ and $E_b = 50\,V$, determine:
    a) Duty cycle am for motoring mode
    b) Critical duty cycle for regenerative braking
    c) Duty-cycle to achieve regenerative braking at the rated current of 10 Amp
    d) Power returned to the source during braking
    e) The switching frequency of the devices if the output frequency is 5 kHz.

[10 Marks]