MACHAKOS UNIVERSITY

University Examinations for 2021/2022

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

FIFTH YEAR SECOND SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (ELECTRICAL AND ELECTRONICS ENGINEERING)

EEE 508: POWER ELECTRONICS AND VARIABLE SPEED DRIVES

DATE: **TIME:**

INSTRUCTIONS:

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**. Attempt any other **two** questions.
Do not write on the question paper.

QUESTION ONE (COMPULSORY) (30 MARKS)

a) State the three conventional methods of speed control in D.C motors. (3 marks)

b) The speed of a 20hp, 300volts, 900rpm separately excited D.C motor is controlled by a three phase full wave converter. The field circuit is also controlled by a three phase full wave converter. The A.C input to the armature and field converter is three phase, star connected 208 volts, 60 HZ. The armature resistance is R_a = 0.25Ω, the field resistance R_f = 145Ω and motor constant K_m = 1.2V/A-rads/sec. the viscous friction and no load losses are negligible. The armature and field currents are continuous and ripple free. If the field converter is operated at the maximum field current and developed torque is 116NM at 900rpm, determine;

(i) Delay angle of the armature converter
(ii) Speed of the D.C motor for maximum field current at an armature delay angle of 0^0.

(iii) The delay angle of the field converter if the speed has to be increased to 1800rpm. (12 marks)

c) With the aid of a circuit diagram of a single phase fully controlled rectifier fed D.C drive and output waveforms, show that the steady state continues voltage applied to the armature terminal of is given by

$V_a = \frac{2V_{max}}{\pi} \cos \alpha$ (10 marks)

d) State any five applications of D.C choppers (5 marks)

QUESTION TWO (20 MARKS)

a) Draw a circuit diagram of anti-parallel SCR, hence describe its operation as applied in reversal of speed of D.C motor. (8 marks)

b) A D.C series motor is powered by a D.C chopper shown in Fig 2Q(b) from a 600 volts D.C source. The armature resistance R_a = 0.02Ω and field resistance R_f = 0.03Ω. The back emf constant K_v = 15.27mv/A-rads/sec. The average armature current is 250 Amperes. The armature current is continuous and has negligible ripple. If the duty cycle is 60%, determine;

(i) Input power from the source
(ii) Equivalent input resistance
(iii) Motor speed
(iv) Developed torque (12 marks)

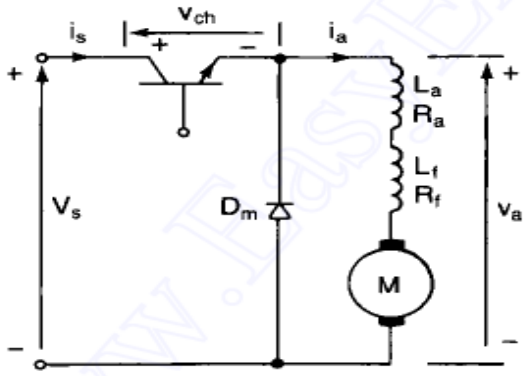

Fig Q2(b)

QUESTION THREE (20 MARKS)

a) With an aid of a diagram, describe the operation of a microcomputer control of D.C drives. (10 marks)

b) The speed of a separately excited D.C motor is controlled by a single phase semi converter shown in Fig Q3(b). The field current is also controlled by the semi converter is set at it,s maximum value. The A.C supply voltage to the armature and field converter is 208 volts, 60HZ. The armature resistance R_a = 0.25Ω, the field resistance R_f = 147Ω and the motor constant K_m = 0.7032 V/A-rads/sec. the load torque T_L = 45NM at 1000rpm. The viscous friction and no load losses are negligible. The inductances of armature and field circuits are enough to make the armature and field currents continuous and ripple free. Determine;

(i) Field current

(ii) Delay angle of the converter in armature circuit

(iii) Input power factor of armature circuit converter (8 marks)

c) State any two advantages of D.C motor drive. (2 marks)

QUESTION FOUR (20 MARKS)

a) Draw a closed loop control system of a D.C drive (5mks)

b) A 50kw, 240volts, 1700pm separately excited D.C motor is controlled by a converter shown in Fig Q4(b). the field current is maintained constant at I_f = 1.4 A and the machine back emf constant K_v = 0.91V/A-rads/sec. the armature resistance R_m = 0.1Ω and viscous friction constant B = 0.3NM/rads/sec. The amplification of speed sensor is K_1 = 95mv/rads/sec and gain power controller K_2 = 100. Determine;

(i) Rated torque of the motor

(ii) Reference voltage V_r to drive the motor at the rated speed

(iii) Speed when the motor develops the rated torque

(iv) Motor speed if the load torque is increased by 10% of the rated value

(v) Speed regulation with closed loop control. (15 marks)

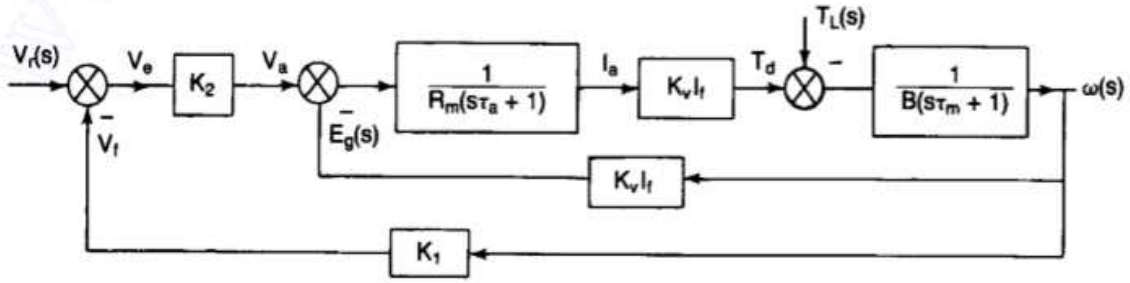

Fig Q4(b)

QUESTION FIVE (20 MARKS)

a) State the four advantages of a closed loop control system of a three phase synchronous motor. (4 marks)

b) With an aid of a schematic block diagram, describe the frequency and voltage control of a three phase induction motor (8 marks)

c) A three phase 11.2kw, 1750rpm, 460Volts, 60HZ, 4-pole star connected induction motor has the following parameters; R_s = 0.66Ω, R_r'= 0.38Ω, X_r' = 1.71Ω, X_m = 33.2Ω. the motor is controlled by varying both the voltage and the frequency. The volts/Hertz ratio which corresponds to the rated voltage and voltage is maintained constant. Determine the maximum torque and maximum speed for a frequency of 60 HZ. (8 marks)