MACHAKOS UNIVERSITY

University Examinations for 2023/2024 Academic Year

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

FIFTH YEAR FIRST SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE IN ELECTRICAL AND ELECTRONICS ENGINEERING

EEE508: 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 (30MARKS)

a) With an aid of a diagram, describe the flux speed control method of D.C Motors. (6marks)

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. (12marks)

c) With an aid of a circuit diagram of a three phase fully controlled bridge rectifier with highly inductive load and output waveforms, show that:
$V_{d.c} = \frac{3\sqrt{3}V_{max}}{\pi} \cos \alpha$ (13marks)

QUESTION TWO

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

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
(12marks)

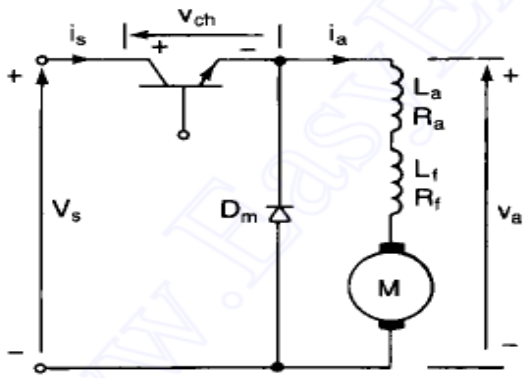

Fig Q2(b)

QUESTION THREE

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

b) The speed of a separately excited D.C motor is controlled by a single phase full wave converter shown in Fig Q3(b). The field current is also controlled by the full wave converter and set at it's maximum value. The A.C supply voltage to the armature and field converter is 440 volts, 60HZ. The armature resistance R_a = 0.25Ω, the field resistance R_f = 175Ω and the motor constant K_m = 1.4 V/A-rads/sec. The armature current corresponding to the load demand is 45 A, 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. If the delay angle of the armature converter is 60^0. Determine;

(i) Torque developed by the motor
(ii) Armature voltage
(iii) Back EMF
(iv) Angular speed
(v) Input power factor of the drive. (10marks)

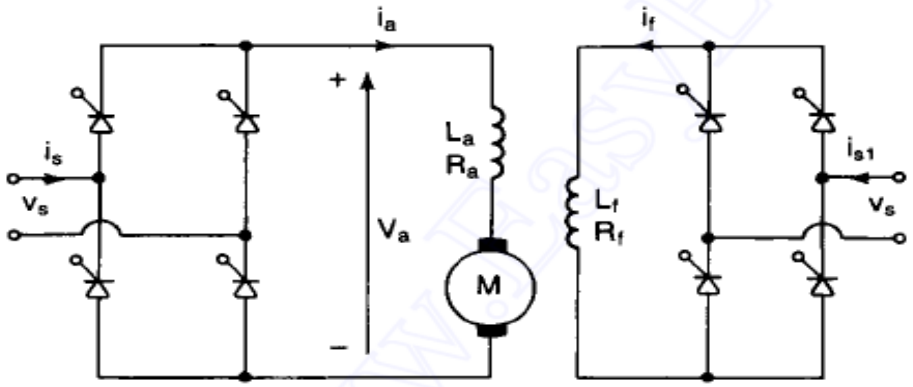

Fig Q3(b)

QUESTION FOUR

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

b) Figure 4Q(b) represents the steady state equations of a closed loop system determine the following transfer functions.

(i) $\frac{\omega_{(s)}}{V_{r(S)}}$

(ii) $\frac{\omega_{(s)}}{T_{l(S)}}$ (15marks)

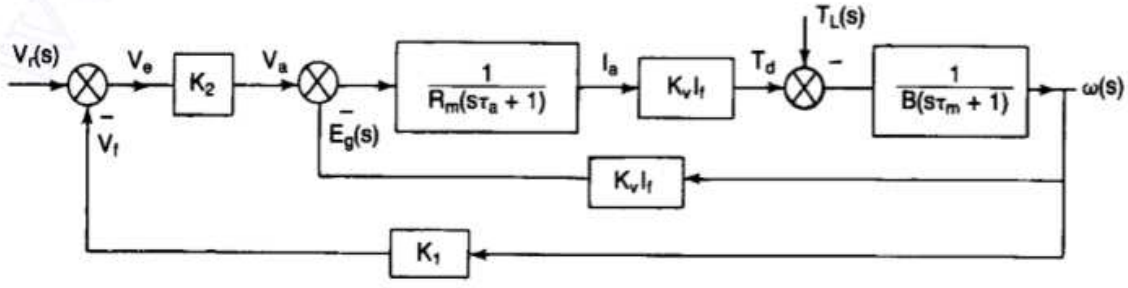

Fig Q4(b)

QUESTION FIVE

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

b) A three phase 460 volts, 60HZ, four pole, Star connected induction motor has the following equivalent circuit parameters: $R_s = 0.42\Omega$, $R_r = 0.23\Omega$, $X_s = X_r = 0.82\Omega$ and $X_m = 22\Omega$. The no load loss which is constant is 60 watts. The rotor speed is 1750 rpm. With an aid of approximate circuit diagram shown in Fig 5Q(b), determine:

(i) Synchronous speed
(ii) Slip
(iii) Input current
(iv) Input power
(v) Input power factor of supply
(vi) Air gap power
(vii) Developed torque
(viii) Maximum regenerative developed torque. (16marks)

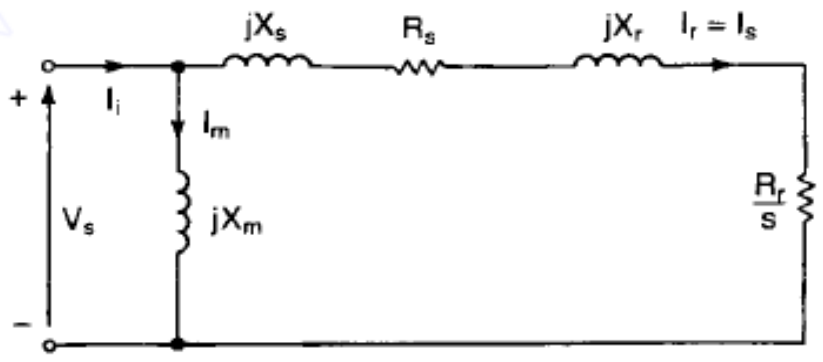

Fig 5Q(b)