



MACHAKOS UNIVERSITY

University Examinations for 2022/2023

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 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**. Attempt any other **two** questions.

Do not write on the question paper.

QUESTION ONE (COMPULSORY) (30 MARKS)

- a) State the five main functions of a microcomputer in D.C drive control. (5 marks)
- b) A 15hp, 220v, 2000rpm separately excited D.C motor controls a load requiring a torque of 45Nm at a speed of 1200rpm. The field circuit resistance is 147Ω , the armature circuit resistance is 0.25Ω and the voltage constant of the motor is 0.7032V/A rads/s . The field voltage is 220 volts. The viscous friction and no load losses are negligible. The armature current may be assumed continuous and ripple free. Determine:
- (i) The back emf
 - (ii) The required armature voltage
 - (iii) The rated armature current of the motor. (9 marks)

- c) Draw a circuit diagram of a buck converter and waveforms used to control the speed of a D.C motor hence show that the maximum speed of the motor is given by;

$$\omega_m = \frac{\delta V_s}{K_m} - \frac{R_a}{K_m^2} T$$
 (10 marks)
- d) Draw a schematic rotor circuit diagram of a three phase wound rotor type motor and its torque –rotor resistance characteristic curve used in demonstrating speed control of these motors. (6 marks)

QUESTION TWO (20 MARKS)

- a) Draw schematic diagram of SCR- contactor connection used to illustrate the following speed reversal in D.C motor.
 (i) Forward monitoring
 (ii) Reverse braking (6mks)
- b) A D.C chopper is used in rheostatic braking of a D.C series motor shown in Figure Q2(b). The armature resistance is 0.02Ω and field resistance is 0.03Ω . The braking resistance is 5Ω , the back emf constant is 15.27mV/A-rad/s . The average armature current is maintained constant at 150A . the armature current is continuous and has negligible ripple. If the duty cycle is 40% , determine:
 (i) Average voltage across the chopper
 (ii) The power dissipated in the braking resistor
 (iii) Equivalent load resistor of the motor acting as a generator
 (iv) Motor speed
 (v) Peak chopper voltage (10 marks)

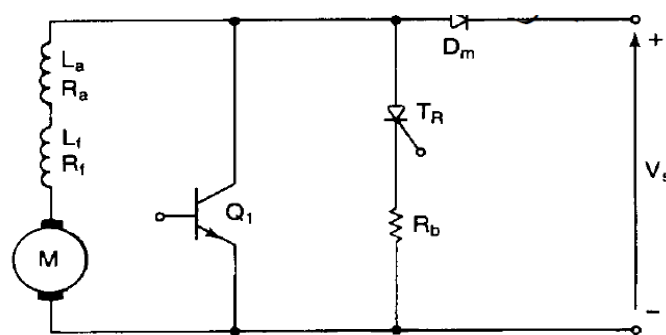


Fig Q2(b)

- c) Draw a block diagram of a closed loop converter fed D.C motor drive. (4 marks)

QUESTION THREE (20 MARKS)

- a) A three phase 11.2kw, 1750rpm, 460volts, 60HZ, four pole star connected induction motor has the following parameters: $R_s = 0\Omega$, $R_r = 0.38\Omega$, $X_s = 1.14\Omega$, $X_r = 1.71\Omega$ and $X_m = 33.2\Omega$. The motor is controlled by varying the supply frequency. If the break down torque requirement is 35Nm, determine:
- (i) Supply frequency
 - (ii) Speed of the motor (8mks)
- b) With the aid of a schematic block diagram, describe the operation of voltage and frequency speed control method of three phase induction motor. (8 marks)
- c) State the four disadvantages of D.C motor drives. (4 marks)

QUESTION FOUR

- a) A separately excited D.C motor is driven from a three phase fully controlled converter with a contactor for speed reversal. The line voltage is 440 volts, 50HZ. The motor armature resistance is 0.12Ω and the armature voltage constant is 2V/rad/sec at the rated field current. Determine:
- (i) The firing angle necessary at the rated field current for armature current of 40A at a speed of 1500rpm.
 - (ii) Required delay angle to get back armature current to 40A for regenerative braking if the contactor is operated after a delay angle control is used to bring the armature current to zero at the start of the sequence of speed reversal. (8 marks)
- b) A D.C chopper is used for regenerative braking a D.C series motor. The D.C supply voltage is 600 volts and the motor has armature resistance of 0.02Ω and field resistance of 0.03Ω . The back emf constant is 15.27 mV-A rad/sec. The average armature current maintained at 250A. The armature current is continuous and has negligible resistance. For a duty cycle of 60%, determine;
- (i) Average voltage across the chopper
 - (ii) Power generated to the D.c supply
 - (iii) Equivalent load resistance of the motor acting as a generator
 - (iv) Minimum permissible speed
 - (v) Maximum permissible speed
 - (vi) Motor speed (12 marks)

QUESTION FIVE (20 MARKS)

- a) With the aid of a schematic diagram of Figure Q5(a)
- Draw a closed loop block diagram of speed control using sub-unit expressions.
 - Derive the transfer function of the block diagram in (i) relating motor speed to load torque $\left(\frac{\omega(s)}{T_L(s)}\right)$ (13 marks)

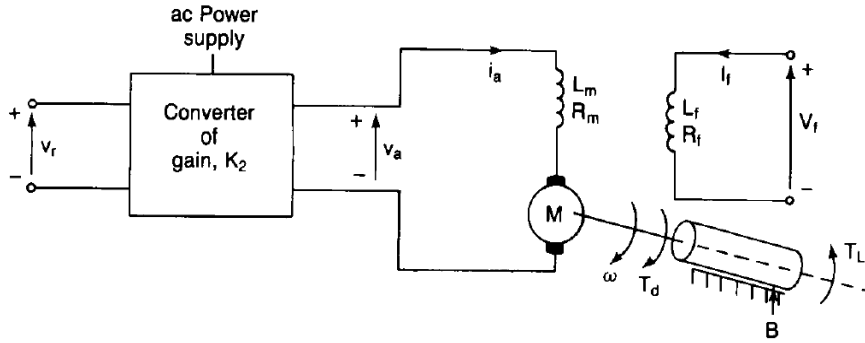


Fig Q5(a)

- b) Draw a block diagram of a power factor speed control method of three phase synchronous motor. (7 marks)