

2521/304

2601/304

**POWER ELECTRONICS, MACHINES  
AND UTILIZATION**

**June/July 2023**

**Time: 3 hours**



**THE KENYA NATIONAL EXAMINATIONS COUNCIL**

**DIPLOMA IN ELECTRICAL AND ELECTRONIC  
ENGINEERING  
(POWER OPTION)  
MODULE III**

**POWER ELECTRONICS, MACHINES AND UTILIZATION**

**3 hours**

**INSTRUCTIONS TO CANDIDATES**

*You should have the following for this examination:*

*Non-programmable electronic calculators;*

*Drawing instruments.*

*This paper consists of TWO sections; A and B.*

*Answer FIVE questions choosing THREE questions from section A and TWO questions from section B in the answer booklet provided.*

*Maximum marks for each part of a question are as indicated.*

*Candidates should answer the questions in English.*

*Take:  $\epsilon_0 = 8.85 \times 10^{-12} \text{ F/M}$*

**This paper consists of 5 printed pages.**

**Candidates should check the question paper to ascertain that  
all the pages are printed as indicated and that no questions are missing.**



## SECTION A: MACHINES AND UTILIZATION

Answer **THREE** questions from this section.

1. (a) List four construction parts of an induction motor. (4 marks)
- (b) (i) Draw the torque/speed characteristics of a loaded three-phase induction motor. (6 marks)
- (ii) Describe the nature of the curve in (b)(i).
- (c) A 3-phase, 6-pole, star connected stator winding induction motor runs on a 415 V, 50 Hz supply. The rotor resistance and standstill reactance are  $0.14 \Omega$  and  $0.8 \Omega$  per phase. The ratio of stator to rotor turns is 2.0 and full load slip is 5%. Determine the:
- (i) transformation ratio;  $\frac{1}{2.0}$
- (ii) synchronous speed;  $\frac{120 \times 50}{6} = 1000 \text{ rpm}$
- (iii) rotor e.m.f.;  $E_r = \frac{E_s}{2.0}$
- (iv) full load torque;  $T_{sh} = \frac{9.55 \times P_m}{n_s}$
- (v) slip at maximum torque;  $s_{Pr}$  (10 marks)
2. (a) (i) Draw a labelled construction diagram of a 3-phase synchronous motor. (8 marks)
- (ii) List four areas of application of the motor in (a)(i).
- (b) A 6.6 kV, 3-phase, star connected synchronous motor has a resistance of  $0.25 \Omega$  per phase and a synchronous reactance of  $2.25 \Omega$  per phase. If the motor is operating at 0.5 p.f leading with a line current of 175 A; determine the:
- (i) torque angle;
- (ii) phase voltage;
- (iii) resultant voltage;
- (iv) generated e.m.f per phase. (9 marks)
- (c) State three methods of synchronization of synchronous machines used for parallel operation. (3 marks)
3. (a) List five construction parts of a d.c generator. (5 marks)
- (b) With aid of a labelled equivalent circuit diagram, describe the shunt d.c generator connection. (5 marks)
- (c) Sketch the armature torque/armature current characteristics of a series d.c motor. (2 marks)



- (d) A 200 V d.c shunt motor has armature resistance and shunt field resistance of  $0.2 \Omega$  and  $150 \Omega$  respectively. The motor takes a no load current of 8 A and a current of 85 A when loaded. Determine the:

- (i) no load shunt current;
- (ii) no load armature current;
- (iii) back e.m.f developed at no load;
- (iv) power input to motor.

(8 marks)

4. ✓ (a) Explain the following terms as used in stepper motors:

- (i) detent angle;
- (ii) holding torque.

(4 marks)

- (b) (i) Draw a labelled torque-speed characteristics of a reluctance motor.

- (ii) State **four** areas of application of the motor in (b)(i).

(8 marks)

- (c) (i) List **two** factors that affect the choice of a particular electric drive.

- (ii) The initial temperature of an electric machine is  $30^\circ\text{C}$ . When the machine is run it attains a final steady temperature of  $100^\circ\text{C}$ . If the heating time constant is 4 hours and the ambient temperature is  $20^\circ\text{C}$ , determine the temperature rise of the machine after 2 hours.

(8 marks)

5. ✓ (a) List **four** properties of good refrigerant. ✓

(4 marks)

- (b) (i) ✓ Outline **four** functions of an air conditioning system.

- (ii) ✓ State the **four** main components of a refrigeration system.

(8 marks)

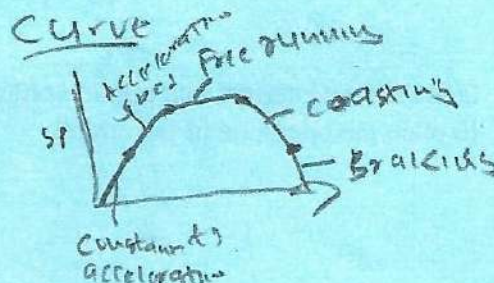
- (c) ✓ Name **three** methods used to supply power to railway trams.

(3 marks)

- (d) (i) Draw a labelled speed-time curve for an electric traction drives. ✓

- (ii) List **two** methods of controlling the speed of a d.c traction motors.

(5 marks)





## SECTION B: POWER ELECTRONICS

Answer **TWO** questions from this section.

6. (a) Draw a labelled construction diagram of a gate turn-off (GTO) thyristor. (4 marks)
- (b) Outline **five** areas of application of power bipolar junction transistor. (5 marks)
- (c) State **three** disadvantages of single phase half-wave uncontrolled rectifier. (3 marks)
- (d) A controlled half-wave rectifier has a forward breakdown voltage of 120 V when a gate current of 2 mA flows in the gate circuit. If a sinusoidal voltage of 360 V peak is applied, determine the:
- (i) firing angle;
  - (ii) average output voltage;
  - (iii) output average current when a load of  $130\ \Omega$  is connected. (8 marks)
7. (a) State **four** areas of application of cycloconverters. (4 marks)
- (b) Draw a labelled diagram describing the three-phase to single phase cycloconverter. (4 marks)
- (c) **Figure 1** shows a single phase voltage source inverter circuit.

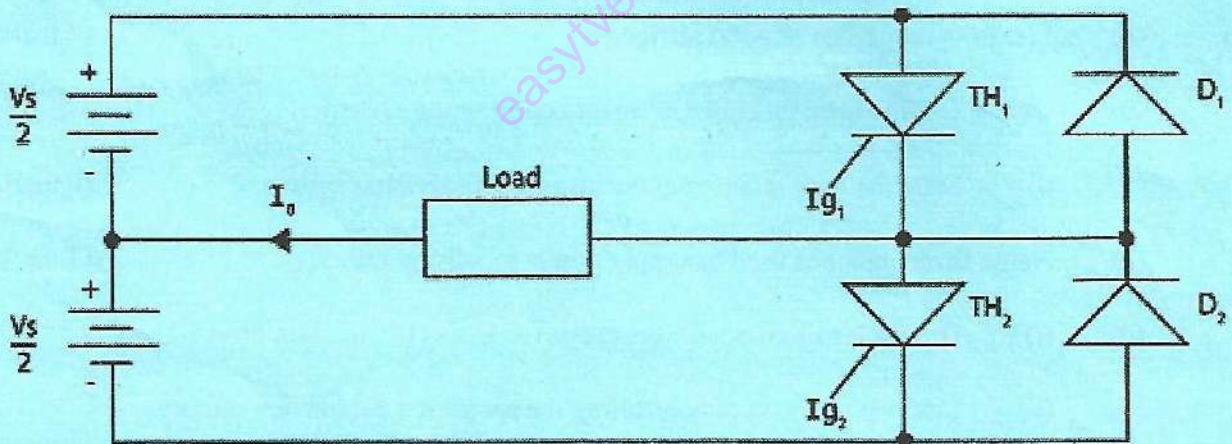


Fig. 1

- (i) Draw the gate current and output voltage waveforms on the same axis.
- (ii) Explain the operation of the circuit. (6 marks)



(d) A single phase half bridge inverter has a resistive load of  $R = 10 \Omega$  and the d.c input voltage  $V_{dc} = 80 V$ . Determine the:

- (i) rms value of output voltage;
- (ii) output power;
- (iii) average peak current of each thyristor. (6 marks)

8. ✓

- (a) (i) Explain **five** advantages of electric drives in industries.
- (ii) State **three** methods used to control speed of d.c motors for electric drives. (6 marks)

- (b) (i) Draw a labelled diagram of a coreless induction furnace.
- (ii) Describe the operation of the furnace in (b)(i). (6 marks)

- (c) ✓ Outline **four** properties of a good heating element used in resistance heating. (4 marks)

- (d) List **two** areas of application of dielectric heating. ✓ (4 marks)

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