## SECTION A: MACHINES AND UTILIZATION

*Answer any **THREE** questions from this section.*

1. (a) With reference to three phase induction motors, state any **two**:

(i) reasons for skewing the rotor slots;
(ii) methods of starting.

(4 marks)

(b) Sketch the "exact" equivalent circuit of an induction motor on load with parameters referred to the stator. (3 marks)

(c) A three phase 415 V, 50 Hz, 6 pole, delta connected induction motor has the following parameters per phase on load referred to the stator:

$R_1 = 0.13\Omega, X_1 = j0.6\Omega, R'_2 = 0.13\Omega, X'_2 = j0.6\Omega$ and the magnetizing circuit admittance $Y_m = 0.004 - j0.05$ siemens. If the full load slip is 4%, use the "Approximate" equivalent circuit to determine:

(i) stator input line current and its power factor;
(ii) input power in kW;
(iii) electromagnetic torque developed in kN-M.

(13 marks)

2. (a) Sketch the phasor diagrams of a synchronous motor when operating on full load at the following power factors:

(i) unity;
(ii) lagging;
(iii) leading.

(6 marks)

(b) With reference to three phase synchronous motor, state any **two** of its suitable applications. (2 marks)

(c) A three phase, 25 Horse Power, 415 V, 50Hz, 4 - pole, star-connected synchronous motor operating on full load with 90% efficiency and unity power factor, has a synchronous reactance per phase of 15 times its armature resistance. If the rotational losses are assumed negligible, use the vector diagram to determine:

(i) induced line back e.m.f;
(ii) the load angle.

(12 marks)

3. (a) With the aid of torque-pulse rate characteristic curve and in reference to stepper motor, explain the following:

(i) slew range;
(ii) pull-in-rate.

(6 marks)

(b) With the aid of construction diagram, describe the principle of operation of shaded type hysteresis motor. (8 marks)

(c) A 3-phase 50 Hz linear induction motor has a pole pitch of 0.8 m. If the speed of the primary side of the motor and the developed thrust are 250 km/hr and 120 KN respectively, determine:

(i) the mechanical power developed;
(ii) input power to the secondary;
(iii) the rotor copper loss in the secondary.

(6 marks)

4. (a) State any **three** desirable characteristics for an ideal refrigerant. (3 marks)

(b) With the aid of a labelled diagram, explain the functions of the component parts of a vapour compression refrigeration system. (11 marks)

(c) State any causes of the following symptoms for refrigeration and air conditioning:

(i) when the compressor motor runs continuously;
(ii) refrigeration section too hot;
(iii) compressor unit very noisy when operating.

(6 marks)

5. (a) Explain why d.c. motors of medium sizes are fitted with starters. (4 marks)

(b) A 15 kW, 220 V d.c. shunt motor having an armature and shunt field circuit resistances of 0.2 Ω and 179 Ω respectively operates on full load with an efficiency of 80%. If the motor is to be braked at full load speed by plugging method, determine the value of the external resistance required to be inserted into the armature circuit to limit the braking armature current to twice its full load current. (8 marks)

(c) Derive an expression for the cooling temperature of an electric motor and hence sketch the cooling temperature characteristic curve. (5 marks)

(d) The heating time constant and cooling time constant of an electric motor are 50 minutes and 100 minutes respectively. If the cycle is repeated indefinitely, and the maximum temperature attained by the motor is 50°C; determine the temperature of the motor when run on full load for 20 minutes and then remain idle for 10 minutes.

(3 marks)

## SECTION B : POWER ELECTRONICS

*Answer any **TWO** questions from this section.*

6. (a) Figure 1 shows a relaxation oscillator circuit. Use it to answer the following:

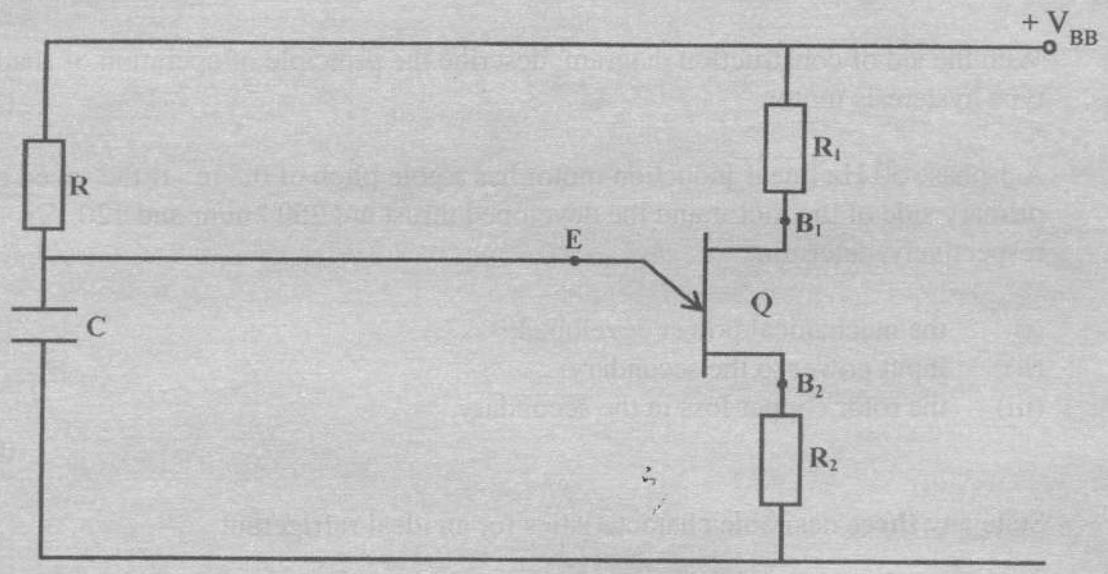


Fig. 1

(i) Draw the V-I characteristic curve of device Q and explain the negative resistance region;

(ii) Derive the expression for the frequency of oscillation of the circuit;

(iii) Sketch the expected waveforms at point E and $B_2$.

(10 marks)

(b) With the aid of input and output waveforms, show that the expression for the mean out put voltage of a six phase half wave uncontrolled rectifier with overlap is given by

$V_{dc} = \frac{3Vm}{2\pi}[1 + \cos\gamma]$ where:

Vm = maximum peck voltage

$\gamma$ = overlap angle.

(10 marks)

7. (a) With the aid of a diagram, describe the operation of a magnetron used for high frequency generation in induction heating. (10 marks)

(b) A metallic conductor of resistivity $1.5 \times 10^{-5}$ Ω M and relative permeability of 5 is to be heated by induction heating at a frequency of 400 kHz. Determine:

(i) depth of heat penetration;

(ii) frequency required if the depth of penetration is to be doubled;

(iii) explain the effect associated with the results in b(i) and (ii).

(7 marks)

(c) State any **three** classifications of inverters. (3 marks)

8. (a) With reference to d.c. motor drives, state any **two** of its:

(i) merits;
(ii) demerits.

(4 marks)

(b) In design of resistance heating element, show that: $\frac{d}{l^2} = \frac{4\rho H}{V^2}$ where:

d = diameter of the element
l = length of the element
$\rho$ = resistivity of the element material
H = heat produced
V = supplied voltage

(6 marks)

(c) With the aid of a circuit diagram of a cycloconverter speed control of a single phase motor, describe how the motor speed can be reduced to a third of full load speed.

(10 marks)

**THIS IS THE LAST PRINTED PAGE.**