Code: A-26 Subject: POWER ELECTRONICS
Time: 3 Hours Max. Marks: 100

**NOTE: There are 11 Questions in all.**

   Question 1 is compulsory and carries 16 marks. Answer to Q. 1. must be written in the space provided for it in the answer book supplied and nowhere else.

   Answer any THREE Questions each from Part I and Part II. Each of these questions carries 14 marks.

   Any required data not explicitly given, may be suitably assumed and stated.

Q.1 Choose the correct or best alternative in the following: (2x8)

   a.   The maximum permissible frequency of the a.c. voltage source whose voltage is to be rectified by a thyristor with t_{off} of $175\,\mu sec$. is _____ Hz.

(A) 2500 **(B)** 2857
         (C) 3334 **(D)** 4572

b. As compared to the thyristors, the merit of power transistors is that they have _____ but their disadvantage is that they have _____.
   (A) a requirement of continuous base drive, a positive temperature coefficient.
   (B) a low switching frequency, a low conduction drop.
   (C) a high switching frequency, a negative temperature coefficient.
   (D) a low conduction drop, a low switching frequency.

c. A 3-phase controlled rectifier feeds a purely resistive load $(R_{\ell d})$. If the supply voltage is $V_s = 240V(RMS)$ at 50 Hz, $(R_{\ell d})$ is 16Ω and the firing angle is $50°$, then the duration of conduction of a device (viz. thyristor) will be _____.

   (A) $110°$. **(B)** $100°$.
   (C) $95°$. **(D)** $105°$.

d. In the step-down chopper the load current ripple can be reduced by _____.
   (A) increasing the load resistance.
   (B) decreasing the chopper frequency.
   (C) increasing the load inductance.
   (D) using a freewheeling diode with high reverse voltage capability.

e. If the load resistance of the single phase bridge rectifier shown in Fig.1 is 4Ω, then the average load current with an α of $0°$ will be _____.
   (A) 59.7 A. **(B)** 30.2 A.
   (C) 61.0 A. **(D)** 49.5 A.


Fig.1
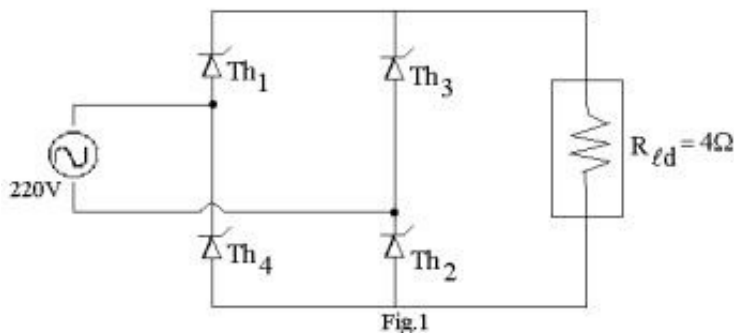
f. The bridge type of voltage source   of
         inverter has the advantage namely _____.

(A) switching losses are low, harmonic content of any order can be eliminated.
(B) low order harmonics can be eliminated, switching losses are low.
(C) high order harmonics can be eliminated, only low order harmonics can be eliminated.
(D) harmonics of any order can be eliminated, switching losses are low.

g. For the AC controller of Fig.2 the RMS load current with an α of $\dfrac{\pi}{2}$ rad will be nearly _____.

(A) 28.3 A.
(B) 30.8 A.
(C) 21.2 A.
(D) 41.6 A.

Fig.2
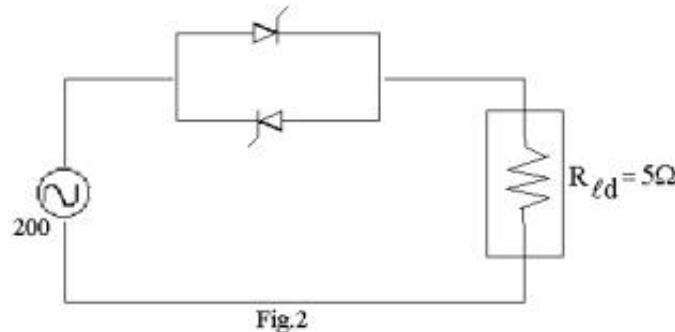
h. A 3 phase six pole induction motor is having a supply frequency of 50 Hz and a slip of 0.02, then the speed of its rotor in mechanical radians per sec will be nearly

(A) 153.9. (B) 128.8.
(C) 104.7. (D) 138.2.

PART I
Answer any THREE Questions. Each question carries 14 marks.

Q.2 a. Enumerate the advantageous features of a GTO over :
(i) a thyristor and (ii) a power transistor.
Also give a typical gate control circuit for a GTO and explain its operation. **(6)**

b. Design the UJT triggering circuit of Fig.3 with the following data : $V_s = 36V, \eta = 0.65,$ $V_p = 16.4V, I_p = 12\mu A, V_v = 4.2V$ and $I_v = 9mA$. The frequency of oscillation is f =7.5 Hz

and the wic'' ^{c11} $^+$ $^-$ $^{A8_{110}}$

Fig.3
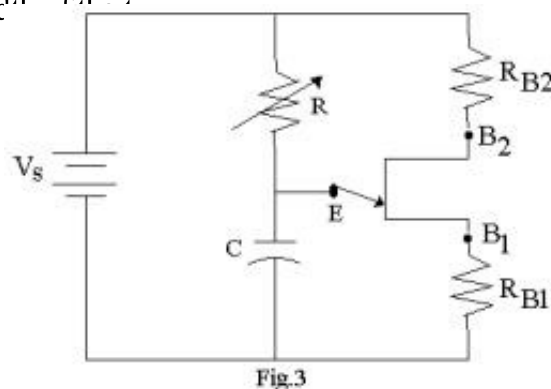
Q.3 a. Draw the circuit and sketch the relevant waveforms for a bipolar half-wave circuit. Determine the mean values of load voltage and current for a bi-phase half-wave circuit having the following data : $V_1 = V_2 = 140V (RMS)$ at 50Hz, load resistance $(R_{\ell d}) = 4.2\Omega$ and firing angle $\alpha = 60°$. **(10)**

b. With the help of the equivalent circuit of a typical rectifier that is operated with load, describe the main sources that contribute to loss of output voltage. **(4)**

Q.4 a. Give the waveforms and describe the operation of a step-down chopper with an RL load. Derive an

expression for the peak-to-peak ripple current for the same. **(6)**

b. The boost regulator of Fig.4 has an input voltage V_s of 6V. The average output voltage (V_a) is 16V and the average load current I_a is 0.45A. The switching frequency is 30 KHz. If $L = 180\mu H$ and $C=200\mu F$, determine the ripple current (Δi) of inductor and the ripple voltage (Δv_c) of the filter capacitor. **(8)**

Fig.4
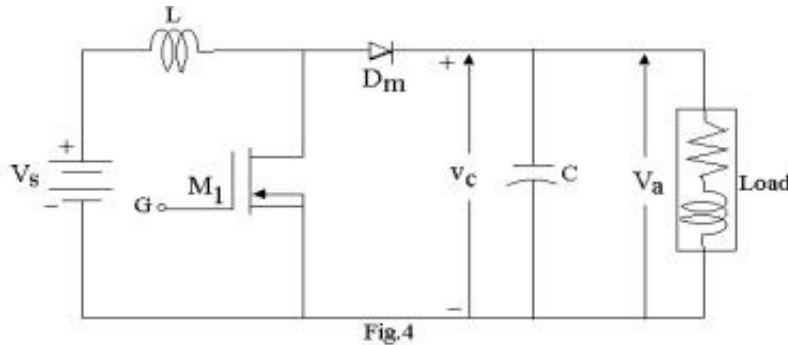
Q.5 a. With the help of a circuit and waveforms explain the operation of a single phase cycloconverter constituted by two single phase bridge type controlled converters. **(6)**

b. Give the diagram of a line-side commutation circuit and derive an expression for the circuit turn-off time. How does this operation differ from that of the load-side commutation circuit? **(8)**

Q.6 a. Explain the operation of a single phase AC controller with an RL type of load. Derive the expressions for :-

(i) the RMS output voltage and

(ii) the average value of the thyristor current. **(6)**

b. The AC voltage controller of Fig.5 has a resistive load $(R_{\ell d})$ of $12\,\Omega$ and an RMS input voltage (V_s) of 125 V at 50 Hz. The delay angles of thyristors Th_1 and Th_2 are $\alpha_1 = \alpha_2 = \frac{\pi}{4} rad.$ Determine

    (i)   the RMS output voltage $V_{\ell d}$.

    (ii)   input power factor.

   (iii)   RMS current of thyristors. **(8)**

Fig.5
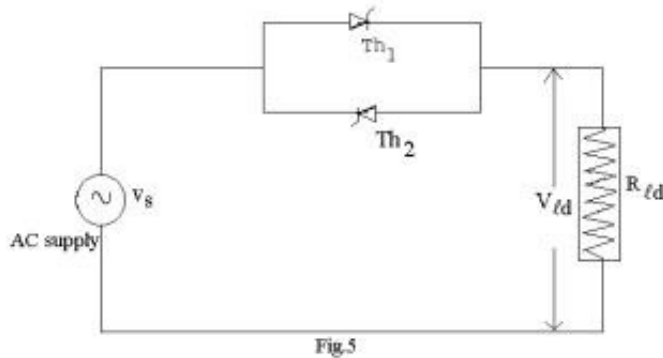
Answer any THREE Questions. Each question carries 14 marks.

Q.7 a. Give the circuit and describe the operation of a three phase inverter with 120-degree conduction. Compare its features with an inverter having 180-degree conduction. **(6)**

b. The single phase full-bridge inverter in Fig.6 has a resistive load $R_{\ell d}$ of $3.0\,\Omega$ and a DC input voltage, V_s of 54V. Determine :

    (i)   The RMS output voltage $(V_{\ell d_1})$ at fundamental frequency.

    (ii)   The average and peak currents of each transistor.

(iii)   The peak reverse blocking voltage of each transistor. **(8)**

Fig.6
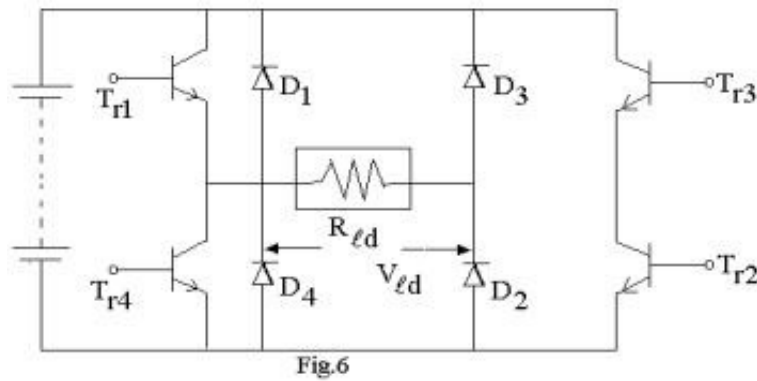
Q.8 a. Explain the terms :

       (i)   current-limit control and

       (ii)   time-ratio control as applied to the firing schemes of DC drives. **(6)**

b. With the help of a circuit diagram describe the operation of a chopper- controlled DC motor. Give the advantages of this drive as compared to a phase-controlled converter drive. **(8)**

Q.9 a. Give the circuit for the speed control of an induction motor by variation of rotor resistance. Also draw the relevant speed-torque characteristics. **(7)**

b. A three phase 410V, 50 Hz, four pole, star-connected induction motor is having the following data :
$R_s = 0.3\Omega, R_r = 0.15\Omega, X_s = 0.83\Omega. X_r = 0.77\Omega, \quad X_m = 22\Omega,$ all parameters being referred to the stator. If the angular speed of the rotor is 153.41 mech. rad /s, determine :

(i) the slip (ii) torque developed by the motor (iii) max. torque. **(7)**

Q.10 a. Explain the terms carrier signal and modulation index as applied to the PWM technique. Also describe the multiple PWM method of voltage control of a single phase inverter. **(6)**

b. Give the circuitry and waveforms and expressions for the load current of the class B-type of choppers. **(8)**

Q.11 Write notes on any **TWO** of the following :

       (i)   Chopper circuit design.

       (ii)   Blocked group operation of a cycloconverter.

       (iii)   Transformer ratings for rectifier circuits. **(2x7)**

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