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 MOSFET is a _____ controlled device, also in power applications the drain-source voltage of the device must be _____ to reduce the conduction losses.
   (A) current, large   **(B)** voltage, small
   (C) current, very small   **(D)** voltage, very large

b.   The maximum output voltage obtainable from a 3-phase fully controlled converter which is fed by a 3-phase source having an rms value of 'V' volts as the phase to neutral voltage is

   (A) $\dfrac{4\sqrt{3}}{3\Pi}V$ **(B)** $\dfrac{6\sqrt{2}}{\Pi}V$

   (C) $\dfrac{2\sqrt{2}V}{\Pi}$ **(D)** $\dfrac{3\sqrt{6}}{\Pi}V$

c.   The transformer in Fig.1 delive~~~~ ~~~~ load current of 20 A at the loa~~~~ has a DC load voltage of 115~~~~ If it is supplied from a single p~~~~ transformer of ratio 5 : 1 the p~~~~ voltage and current are respec~~~~ _____ and _____
   (A) 445.8 V, 5.25A
   (B) 638.5V, 4.44A
   (C) 714.0 V, 4.96 A
   (D) 512.5 V, 6.23 A

Fig.1

d.   For the inverting mode of a converter the firing angle α is _____ and _____ has to be in series with the load.

   (A) less than $90°$, a large capacitor in series with a battery

   (B) more than $120°$, a battery

   (C) less than $135°$, a small capacitor

   (D) more than $90°$, a battery
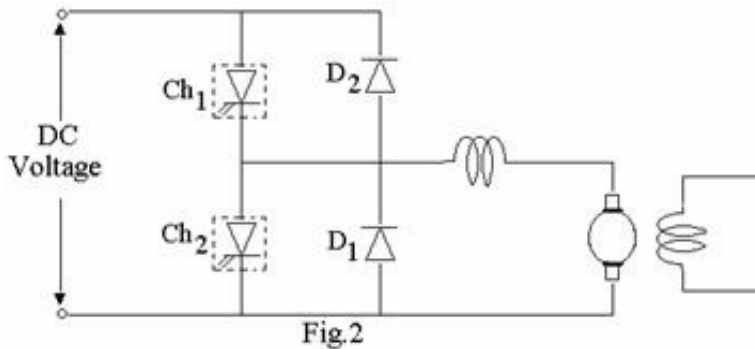
e.   In the two quadrant chopper shown in Fig.2 the devices_____ are connected to the source for
     one part of the period τ and the devices _____ for the other part.

   (A) Ch_1 and D_1, Ch_2 and D_2 **(B)** D_1 and D_2, Ch_1 and Ch_2
   (C) Ch_1 and D_2, Ch_2 and D_1 **(D)** none of these.

Fig.2

f.   For the single phase chopper of Fig.3, the control of load voltage is possible for a firing angle that
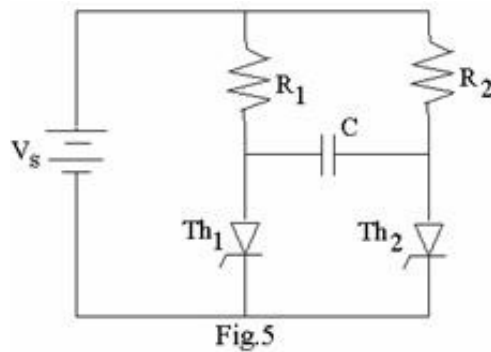   approximately obeys the inequality

Fig.3
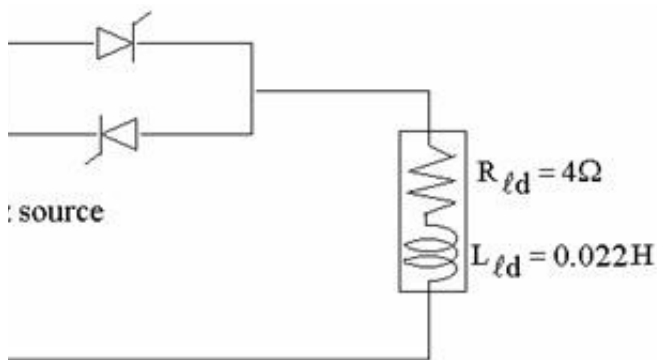
   (A) $\alpha > \dfrac{\pi}{4}$

   (B) $\alpha > \dfrac{\pi}{3}$

   (C) $\alpha > \dfrac{\pi}{2}$

   (D) $\alpha > \dfrac{2\pi}{5}$

g.   As compared to simultaneous control of a cycloconverter, nonsimultaneous control has the
     drawback of_____ .

   **(A)** large ratings of the thyristor   **(B)** more I^2R loss

(C) high circuit cost   (D) large voltage rating for thyristors

h. If the turn off time $\left(t_{off}\right)$ of a thyristor is 2.5 m sec, then the maximum permissible frequency of the single-phase a.c.-voltage source whose voltage is to be rectified is _____ Hz.
(A) 400   (B) 125
(C) 200   (D) 250

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

Q.2 a. Define the terms 'recombination time' and 'turn off time' of a thyristor. Explain the process of turn-off of a thyristor.   **(6)**

b. A resonant pulse commutation circuit has a capacitor with $C = 25\mu F$ and inductance $L = 5\mu H$. The initial capacitor voltage V_c (0) = 220 V. Determine the circuit turn-off time $\left(t_{off}\right)$ if the load current I_{ld} is 60 A.   **(8)**

Q.3 a. With the help of waveforms discuss the effect of source inductance on the average output voltage of a three phase full bridge converter.   **(6)**

b. A three phase full bridge converter is supplied from a 300V, 50 Hz a.c. supply. If the average load current $\left(I_{dc}\right)$ is 180A and the commutator inductance $\left(L_c\right)$ is 0.12 mH, determine the overlap angle when α is $35°$.
(8)

Q.4 a. Fig.4 shows the circuit of a two-quadrant chopper. Describe its operation.   **(4)**

Fig.4

b. Give the circuit of a buck-boost regulator and derive the expressions for
    (i)   peak-to-peak ripple current and
    (ii)   peak-to-peak ripple voltage.

    With source voltage V_s as 15, duty cycle k of 0.3, switching frequency f of 30 KHz and L of 120 μH determine the peak-to-peak ripple current.
(10)

Q.5 a. With the help of the circuit diagram of a three-pulse single phase cyclo converter discuss how the positive and negative groups are controlled to provide maximum possible output voltage. **(6)**

b. For the complementary commutation circuit of Fig.5 derive expressions for the capacitor current, capacitor voltage and compute the turn-off time for $R_1 = 6\Omega$ and $C = 12\mu F$. Also draw the

relevant   explain   the
operation.   **(8)**

Fig.5

Q.6   a.   For the circuit of Fig.6 derive the expressions for the output voltages for the following two conditions:

(i)   the input voltage is connected to the load for n cycles and disconnected for m cycles.

(ii)   a bi-directional control is implemented with a firing angle of α.

Derive the expressions for the output voltages in both the cases.   **(6)**

Fig.6
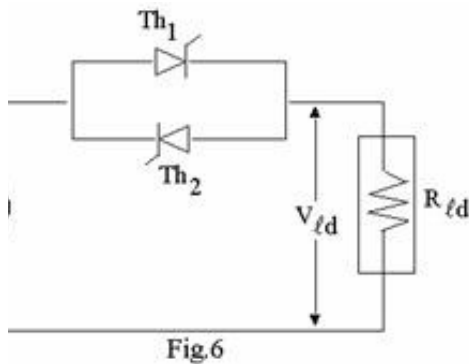
b.   With the help of a block diagram describe the features of a switch mode regulator. Explain the part played by the control voltage and the saw tooth waveform in this regulator.   **(8)**

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

Q.7   a.   Describe the features of a PWM in which a sinusoidal reference signal is compared with a triangular wave. With the help of waveforms explain its merits with respect to multiple PWM.   **(8)**

b.   Describe the phase-displacement technique that is applied for the voltage control of a single-phase inverter.   **(6)**

Q.8   a.   Give the circuit and waveforms of a three-phase inverter in which 180-degree conduction type of control is applied.   **(6)**

b.   The buck regulator in Fig.7 has an input voltage (V_s) as 16V. The required average output voltage (V_a) is 7V. The peak-to-peak output ripple voltage is 22mV and the switching frequency is 28 KHz. If the peak-to-peak ripple current of the inductor is limited to 0.75A, determine the sizes of the filter inductor L and the filter capacitor C.   **(8)**

Fig.7
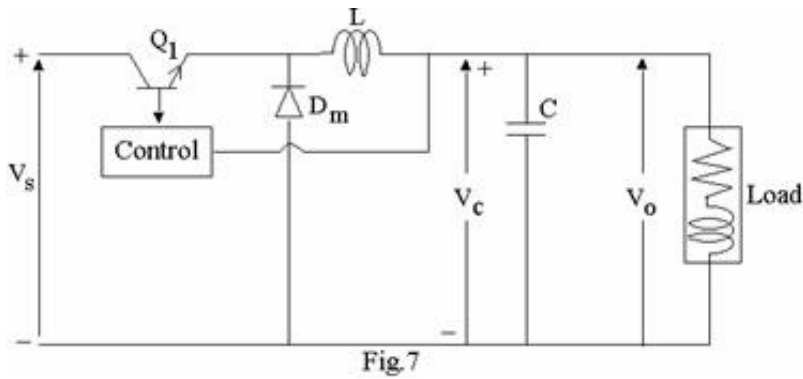
Q.9   a.   Explain the principle of a Current Source Inverter (CSI); also describe the operation of a single phase CSI.   **(8)**

       b.   In a typical UJT triggering circuit R is given as a 50 KΩ pol and V_{B1} as 18.2V, given $V_s = 35V, \eta = 0.53, I_p = 12\mu A, V_v = 3.8V \ I_v = 9mA$. Check the correctness of R and V_{B1} ; and in the latter case compute the percentage error with respect to the correct value.   **(6)**

Q.10   a.   Give the circuit of a dual converter which is constituted of two three phase bridge converters and explain how it is made free of circulating current. Discuss any other uses of the dual converter.   **(8)**

     b.   Write briefly as to how constant Torque and constant power operation can be obtained from a separately excited DC motor using a solid-state converter, for a wide range of speed.   **(6)**

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

          (i) $\dfrac{di}{dt}$ and $\dfrac{dv}{dt}$ protection of a thyristor.

          (ii)   IGBT vs MOSFET.

          (iii)   PUT.   **(2x7)**