POWER ELECTRONICS
(ELEC 3104)

Time Allotted : 2½ hrs **Full Marks : 60**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 4 (four) from Group B to E, taking one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A

1. Answer any twelve: **12 × 1 = 12**

Choose the correct alternative for the following

(i) Which method is mostly used to turn on a thyristor?
(a) Gate triggering (b) Forward voltage triggering
(c) Light triggering (d) Temperature triggering.

(ii) Snubber circuit is used to limit the rate of
(a) rise of current of SCR (b) conduction period of SCR
(c) rise of voltage across SCR (d) rise of current across SCR.

(iii) The maximum firing angle that can be obtained by a pure resistive trigger circuit used in phase control circuit is
(a) 45° (b) 90° (c) 135° (d) 180°.

(iv) A freewheeling diode is placed across the dc load
(a) to prevent reversal of load voltage
(b) to permit transfer of load current away from the source
(c) both (a) and (b)
(d) none of the above.

(v) A single phase full controlled bridge converter (B-2) uses
(a) 4 SCRs and 2 diodes (b) 4 SCRs
(c) 6 SCRs (d) 6 SCRs and 3 diodes

(vi) In PWM method of controlling the average output voltage in a chopper the on-time is varied but the chopping frequency is
(a) varied (b) kept constant
(c) either of these (d) none of these.

(vii) In a CSI if frequency of output voltage is f Hz, then frequency of voltage input to CSI is
(a) f (b) 2f (c) f/2 (d) 3f.

(viii) A single-phase AC voltage controller feeds power to a resistance of 10Ω. The source voltage is 200 sin314t. For a firing angle of 90°, the average value of thyristor current in amperes is
(a) $10/\pi$ (b) $5\sqrt{2}$ (c) 10 (d) $5\sqrt{2}/\pi$

(ix) In step down cycloconverter, output frequency, f_o and supply frequency, f_s relation is given as
(a) $f_o > f_s$ (b) $f_o = f_s$ (c) $f_o < f_s$ (d) f_o is independent of f_s

(x) A cycloconverter is a frequency converter from
1. higher to lower frequency with one stage conversion.
2. higher to lower frequency with two stage conversion.
3. lower to higher frequency with one stage conversion.
4. ac at one frequency to dc and then dc to ac at a different frequency.
From these the correct statements are:
(a) 2, 4 (b) 1 only (c) 2, 3 (d) 1, 3.

Fill in the blanks with the correct word

(xi) In a thyristor di/dt protection is obtained by connecting an _____ in series with the thyristor.

(xii) If gate current is increased, the anode-cathode voltage at which SCR conducts is _____.

(xiii) A single phase full-converter using R load is a _____ quadrant converter.

(xiv) For the 3ϕ full converter having resistive load, the ripple frequency f is _____ Hz.

(xv) Choppers are _____ converters.

Group - B

2. (a) Differentiate between Power BJT and Power MOSFET in terms of its switching losses, frequency of operation, voltage and current ratings. *[(CO1)(Understand/LOCQ)]*

(b) Derive the expression of resistance used in static equalising circuit for series operation of SCRs. *[(CO1)(Analyse/IOCQ)]*

(c) Draw the circuit of class D commutation of SCR and relevant waveforms. Hence calculate
(i) the peak value of currents through the capacitor and SCRs.
(ii) the turn-off time of the SCRs.
Given: the value of dc voltage source = 230V, L=20μH, C= 40μF and constant load current of 120A. *[(CO1)(Evaluate/HOCQ)]*

3 + 4 + 5 = 12

3. (a) Explain briefly about the basic structure of IGBT. Also draw its V-I characteristics. *[(CO1)(Understand/LOCQ)]*

(b) SCRs with a rating of 1kV and 200A are used in a string to withstand 6kV and 1kA. Determine the number of series and parallel units required if derating factor = 0.2. *[(CO1)(Analyse/IOCQ)]*

(c) Design UJT relaxation oscillator for triggering SCR. The UJT has following parameters:

V_{BB} = 20V, V_P = 13.2V, I_P = 50μA, V_V = 2V, I_V = 6mA, leakage current = 2.5mA, V_{gmin} = 0.7V, η = 0.63. *[(CO1)(Evaluate/HOCQ)]*

3 + 4 + 5 = 12

Group - C

4. (a) Explain the operation of a single phase half wave controlled rectifier with R load. Draw relevant waveforms. *[(CO2)(Understand/LOCQ)]*

   (b) Derive the expression for the average and rms value of output voltage for a single phase full wave controlled rectifier feeding a RL load? *[(CO2)(Apply/IOCQ)]*

   (c) A single phase 230V, 2 kW heater is connected across a 1 phase, 230V, 50 Hz supply through an SCR. For a firing angle delay of 30°, calculate the power absorbed by the heater element. *[(CO2)(Apply/IOCQ)]*

4 + 4 + 4 = 12

5. (a) Explain the operation of a single phase full wave controlled rectifier with RLE load. Draw relevant waveforms. *[(CO2)(Understand/LOCQ)]*

   (b) Point out the differences between fully-controlled converters and half-controlled converters. *[(CO2)(Remember/LOCQ)]*

   (c) The full-wave controlled bridge rectifier has an ac input of 230 V at 50 Hz and is connected to a 15Ω load resistor. The delay angle is 30°. Determine the average current in the load, power consumed by the load and the input power factor. *[(CO2)(Evaluate/HOCQ)]*

4 + 2 + 6 = 12

Group - D

6. (a) Explain the operation of a buck-boost converter. Draw relevant waveforms. *[(CO3)(Understand/LOCQ)]*

   (b) Explain the principle of current limit control with relevant waveforms. *[(CO3)(Understand/LOCQ)]*

   (c) A buck-boost converter has an input voltage of 14 V. The duty cycle is 0.6. If the average load current is 1.5 A with switching frequency 25 kHz and L = 180 μH, C = 220 μF. Calculate (i) Output voltage (ii) Ripple Current (iii) Ripple voltage (iv) Critical value of capacitance. *[(CO3)(Apply/IOCQ)]*

5 + 3 + 4 = 12

7. (a) Explain the operation of a Class C chopper. Draw relevant waveforms. *[(CO3)(Understand/LOCQ)]*

   (b) Analyze the operation of a three phase inverter for 180° conduction mode. *[(CO3)(Analyse/IOCQ)]*

   (c) What do you mean by cross conduction fault? *[(CO3)(Remember/LOCQ)]*

4 + 6 + 2 = 12

Group - E

8. (a) Explain the operation of single phase half wave ac voltage controller for R load along with necessary waveforms. *[(CO4)(Analyse/IOCQ)]*

(b) Derive the average and rms values of output voltage for the above case. *[(CO4)(Understand/LOCQ)]*

(c) What are the four different categories of SMPS? *[(CO4)(Remember/LOCQ)]*

5 + 5 + 2 = 12

9. (a) Explain in detail the operation of a single phase to single phase step down mid-point type cycloconverter. Draw relevant waveforms. *[(CO4)(Analyse/IOCQ)]*

(b) Write short note on static ac circuit breakers. *[(CO4)(Remember/LOCQ)]*

(c) Explain bipolar HVDC system with schematic diagram. *[(CO4)(Remember/LOCQ)]*

4 + 4 + 4 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	46.87	32.29	20.33