POWER ELECTRONICS
(ELE3104)

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) With gate open, SCR can be turned-on by making supply voltage
(a) minimum (b) reverse
(c) equal to cathode voltage (d) equal to cathode voltage

(iii) Schottky diodes have _____ reverse breakdown voltage and _____ switching time.
(a) low, fast (b) high, fast
(c) low, slow (d) high, slow

(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) In a B-2 type full controlled bridge converter
(a) one SCR conducts at a time (b) two SCRs conduct at a time
(c) three SCRs conduct at a time (d) four SCRs conduct at a time

(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 chopper circuit, fed from an input voltage of 20 V dc, delivers a load power of 16 watts. For a chopper efficiency of 0.8, the input current is

(a) 0.64 A (b) 0.8 A
(c) 1 A (d) 1.25 A

(ix) 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) $5\sqrt{2}/\pi$

(x) What is the primary purpose of an AC Voltage Controller?

(a) To convert DC voltage into AC voltage
(b) To regulate the output voltage supplied to an AC load by controlling the RMS voltage
(c) To store energy and release it when needed
(d) To convert AC voltage into DC voltage

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

(xiii) In single pulse modulated PWM inverter, third harmonic is eliminated by making pulse width equal to 120°. To eliminate seventh harmonic, the pulse width will be _____.

(xiv) _____ is used for critical loads where temporary power failure can cause a great deal of inconvenience.

(xv) The class A commutation of SCR is also known as _____ commutation.

Group - B

2. (a) Draw and explain the V-I characteristics of TRIAC. *[(CO1)(Understand/LOCQ)]*

(b) Derive the expression of anode current of SCR with the help of two transistor model. *[(CO1)(Analyse/IOCQ)]*

(c) Draw the circuit of class C commutation of SCR and relevant waveforms. Hence calculate

(i) the peak value of currents through the SCRs
(ii) the value of capacitor if each SCR has turn-off time of 60μs.

Given: the value of dc voltage source = 200V and the resistances are 100Ω each.

[(CO2)(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. *[(CO2)(Evaluate/HOCQ)]*

3 + 4 + 5 = 12

Group - C

4. (a) Explain the operation of a single phase half wave controlled rectifier with RL load and freewheeling diode. Draw relevant waveforms. *[(CO3)(Understand/LOCQ)]*

(b) What are the advantages of freewheeling diode? *[(CO3)(Remember/LOCQ)]*

(c) A single phase half wave converter is operated from a 120V, 50 Hz supply and supplies a load of 10Ω. If the average output voltage is 25% of the maximum possible average output voltage, calculate (i) Firing angle (ii) Average and rms output currents. *[(CO3)(Evaluate/HOCQ)]*

4 + 2 + (2 + 4) = 12

5. (a) Explain the operation of a single phase full wave controlled rectifier with RL load. Draw relevant waveforms. *[(CO3)(Understand/LOCQ)]*

(b) Derive the expression for the average and rms value of output voltage for a single-phase half wave-controlled rectifier feeding a R load? *[(CO3)(Apply/IOCQ)]*

(c) Determine the average value of the load current of a single phase full converter feeding a RLE load from a 240V, 50 Hz mains supply. Assume, R = 7Ω, L = 9mH and E = 40V. Assume continuous conduction mode and the firing angle is 30°. Also calculate the input power factor and minimum value of firing angle of the circuit. *[(CO3)(Evaluate/HOCQ)]*

4 + 4 + (2 + 2) = 12

Group - D

6. (a) Explain the operation of a buck converter. Draw relevant waveforms. *[(CO4)(Understand/LOCQ)]*

(b) A buck converter has an input voltage of 14 V. The required output voltage is 7 V. Peak to peak ripple voltage is 15 mV. The switching frequency is 25 kHz. If the peak to peak ripple current is limited to 0.5 A. Calculate (i) duty cycle (ii) Filter inductance (iii) Filter Capacitance (iv) Critical value of inductance. *[(CO4)(Apply/IOCQ)]*

(c) Explain the operation of a half bridge inverter feeding a R load with relevant waveforms. *[(CO5)(Understand/LOCQ)]*

4 + 4 + 4 = 12

7. (a) What are the disadvantages of frequency modulation scheme over pulse width modulation scheme? *[(CO4)(Analyse/IOCQ)]*

(b) Explain the principle of current limit control with relevant waveforms. *[(CO5)(Understand/LOCQ)]*

(c) Classify various types of inverters. How can harmonics in the inverter output be reduced using single pulse width modulation? *[(CO5)(Apply/IOCQ)]*

3 + 3 + 6 = 12

Group - E

8. (a) Explain the operation of single phase full wave ac voltage controller for R load along with necessary waveforms. *[(CO6)(Analyse/IOCQ)]*

   (b) Derive the average and rms values of output voltage for the above case. *[(CO6)(Understand/LOCQ)]*

   (c) What are the advantages of SMPS over conventional linear power supplies. *[(CO6)(Remember/LOCQ)]*

5 + 5 + 2 = 12

9. (a) Draw the circuit along with output voltage waveform comparing a single phase step down mid-point type cycloconverter with a step up mid-point type cycloconverter. *[(CO6)(Analyse/IOCQ)]*

   (b) What are the four different categories of SMPS. *[(CO6)(Remember/LOCQ)]*

   (c) Explain bipolar HVDC system with schematic diagram. *[(CO6)(Remember/LOCQ)]*

4 + 4 + 4 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	43.75	35.4	20.8