

POWER ELECTRONICS
(ELEC 3104)

Time Allotted : 3 hrs

Full Marks : 70

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

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

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**
- (i) Reverse recovery current in a diode depends upon
(a) forward field current (b) storage charge
(c) temperature (d) PIV.
- (ii) Snubber circuit consists of
(a) R in series with SCR (b) RL in series with SCR
(c) RC in series with SCR (d) RC 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 single phase full converter operates as an inverter when,
(a) $0^\circ \leq \alpha \leq 90^\circ$
(b) $90^\circ \leq \alpha \leq 180^\circ$
(c) it supplies to a back-emf load
(d) $90^\circ \leq \alpha \leq 180^\circ$ and there is suitable dc source in the load circuit.
- (v) If gate current is increased, the anode-cathode voltage at which SCR conducts is
(a) increased (b) decreased (c) maximum (d) least.
- (vi) The most efficient gate-triggering signal for SCR is
(a) a steady de level (b) a short duration pulse
(c) a high-frequency pulse train (d) a low-frequency pulse train.
- (vii) Which of the following is incorrect? A thyristor may be turned on by applying
(a) temperature (b) light (c) dv/dt (d) di/dt .
- (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) In single-pulse modulation of PWM inverters, the pulse width is 120° . For an input voltage of 220V dc the RMS value of output voltage is
(a) 179.63 V (b) 254.04 V (c) 185.04 V (d) 127.02 V.
- (x) 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) $3f$.

Group - B

2. (a) Name the different turn on methods of SCR. [(CO1)(Remember/LOCQ)]
(b) Analyse the operation of the class C commutation circuit of SCR with a neat diagram and waveforms. [(CO1)(Analyze/IOCQ)]
(c) The reverse recovery time of a power diode is $3\mu\text{s}$ and the rate of fall of diode current is $30\text{A}/\mu\text{s}$. Determine the storage charge and peak reverse current. [(CO1)(Evaluate/HOCQ)]
3 + 6 + 3 = 12
3. (a) Draw and explain the V-I characteristics of SCR with the help of a neat diagram. [(CO1)(Understand/LOCQ)]
(b) "The MOSFET cell embeds a parasitic BJT in its structure". Justify the statement. [(CO1)(Analyze/IOCQ)]
(c) How many SCRs are required in a series string to withstand a dc voltage of 4500 V in steady state if the SCRs have a steady voltage rating of 1000 V and the steady state derating factor is 20%? Assuming the maximum difference in the leakage current of the SCR to be 100mA. Calculate the value of the voltage sharing resistor to be used. [(CO1)(Evaluate/HOCQ)]
4 + 5 + 3 = 12

Group - C

4. (a) Explain the operation of a single phase full wave rectifier (midpoint type) using R load. [(CO2)(Understand/LOCQ)]
(b) Analyze the operation of a single phase half wave rectifier with RL load and freewheeling diode. What are the advantages of using freewheeling diode? [(CO2)(Analyze/IOCQ)]
(c) A single phase half wave rectifier alongwith a freewheeling diode is used to supply a heavily inductive load from a 220V ac supply. Assuming the load current to be 10 A find the average load voltage for firing angle of 60° . Also calculate the load resistance. [(CO2)(Evaluate/HOCQ)]
4 + (3 + 2) + 3 = 12
5. (a) Derive the average and rms value of a single phase half wave converter with RL load. [(CO2)(Remember/LOCQ)]
(b) For a 3 phase full converter explain how output voltage wave for a firing angle of 30° is obtained from the phase and line voltages. [(CO2)(Analyze/IOCQ)]

- (c) A three phase full wave controlled rectifier is fed by a 400V, 50 Hz supply. The average load current is 150 A and the load is highly inductive. The firing angle is 60° . Calculate the output power, average and peak current flowing through the thyristor.

[(CO2)(Evaluate/HOCQ)]

4 + 5 + 3 = 12

Group - D

6. (a) Explain the operation of a boost converter. Draw the inductor voltage, inductor current and capacitor current waveforms. [(CO3)(Understand/LOCQ)]

- (b) Examine why a class A chopper is called a one quadrant chopper.

[(CO3)(Analyze/IOCQ)]

- (c) A step down chopper is connected to a 230V dc input. The load voltage is of a rectangular pulse duration of 1ms and overall time period of 5ms. Calculate the average and rms value of load voltage. [(CO3)(Evaluate/HOCQ)]

4 + 5 + 3 = 12

7. (a) Define the following terms: (i) Harmonic factor (ii) Total Harmonic Distortion.

[(CO3)(Remember/LOCQ)]

- (b) Analyze the operation of a 180° mode three phase inverter with a star connected resistive load. Draw only the phase voltage waveforms. [(CO3)(Analyze/IOCQ)]

- (c) Explain the concept of single pulse modulation.

[(CO3)(Evaluate/HOCQ)]

2 + 7 + 3 = 12

Group - E

8. (a) Explain the operation of a single phase voltage controller with RL load.

[(CO4)(Understand/LOCQ)]

- (b) Analyze the operation of static DC circuit breakers. Compare it with static AC circuit breakers. [(CO4)(Analyze/IOCQ)]

- (c) A single phase full-wave ac voltage controller has a load resistance of 10Ω . The AC input voltage is 230V. Calculate the rms output voltage, rms output current and input power factor for a firing angle delay of $\pi/3$. [(CO4)(Evaluate/HOCQ)]

4 + 5 + 3 = 12

9. (a) Explain the operation of a single phase to single phase step down mid-point type cycloconverter. [(CO4)(Understand /LOCQ)]

- (b) List down the functions of a UPS (Uninterruptible Power Supply).

[(CO4)(Analyze/IOCQ)]

- (c) A three phase six-pulse, 50 kVA, 415 V cycloconverter is operating at a firing angle of 45° and supplying a load of 0.8 power factor. Determine input current to the converters. [(CO4)(Evaluate/HOCQ)]

4 + 5 + 3 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	30.20	44.79	25

Course Outcome (CO):

After the completion of the course students will be able to:

1. Understand the basic theory and characteristics of power semiconductor devices.
2. Acquire knowledge about the operation of single-phase and three-phase thyristorized rectifiers and learn to design them.
3. Analyze basic DC-DC, DC-AC converter topologies.
4. Learn the operation of various AC-AC converters and understand the role of Power Electronics in utility-related applications.

*LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question