

**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) If gate current is increased, the anode-cathode voltage at which SCR conducts is
(a) Decreased (b) Increased
(c) Maximum (d) Doubled
- (ii) Rise time of SCR is the time taken by
(a) the anode current to rise from 10% to 90% of its final value
(b) the gate current to rise from 10% to 90% of its final value
(c) the anode current to rise from 10% to 50% of its final value
(d) the anode voltage to rise from 10% to 90% of its final value.
- (iii) Snubber circuit is used to limit the rate of
(a) rise of voltage across SCR (b) conduction period of SCR
(c) rise of current through SCR (d) firing angle of SCR
- (iv) A voltage source inverter is used when load and source inductances are respectively
(a) small and large (b) large and small
(c) large and large (d) small and small
- (v) A single phase full bridge inverter has $R=2\Omega$ and dc voltage source of 230V. The rms value of fundamental load current is
(a) 96A (b) 0A (c) 103.5A (d) 110A
- (vi) The voltage in a single phase half wave inverter varies between
(a) V_s and 0 (b) $V_s/2$ and 0
(c) $V_s/2$ and $-V_s/2$ (d) $-V_s/2$ and 0?
- (vii) In a single phase semi-converter, for continuous conduction, each SCR conducts for
(a) α (b) $\pi+\alpha$ (c) π (d) $\pi-\alpha$
- (viii) In a dual converter, if the firing angle of one bridge is 30° , then the firing angle of the second bridge will be
(a) 30° (b) 180° (c) 120° (d) 150°

- (ix) In a three phase half wave rectifier each diode is subjected to a PIV of:
(a) V_m (b) $V_m/\sqrt{2}$ (c) $\sqrt{2}V_m$ (d) $\sqrt{3}V_m$
- (x) Which of the following converter has output frequency constant?
(a) Rectifier (b) Inverter
(c) AC Voltage regulator (d) Cycloconverter.

Fill in the blanks with the correct word

- (xi) _____ diode has the lowest reverse recovery time.
- (xii) The di/dt protection of SCR is achieved by connecting _____ in series with SCR.
- (xiii) Power MOSFET is a _____ controlled device.
- (xiv) The peak value of inductor current in a boost converter is _____ for a ripple current of 0.5A and an input current of 1A.
- (xv) A cycloconverter is an ac-ac converter at _____ frequency.

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. *[[CO1](Evaluate/HOCQ)]*
3 + 4 + 5 = 12

- 3. (a) Draw and explain the reverse recovery characteristics of power diode. *[[CO1](Understand/HOCQ)]*
(b) A 100A SCR is used in parallel with a 150A SCR. The on-state voltage drops of the SCRs are 2.1V and 1.75V respectively. Calculate the value of series resistance to be connected in series with each SCR so that the SCRs can share the total current of 250A in proportion to their ratings. *[[CO1](Analyse/IOCQ)]*
(c) Design a gate triggering circuit of SCR using resistor. The supply voltage = 24V AC. The SCR has the following parameters: $I_{gmin} = 0.1mA$, $I_{gmax} = 12mA$, $V_{gmin} = 0.6V$ and $V_{gmax} = 1.5V$. *[[CO1](Evaluate/HOCQ)]*
3 + 4 + 5 = 12

Group - C

- 4. (a) Explain the operation of a half wave controlled rectifier with RLE load. Draw relevant waveforms. *[[CO2](Understand/LOCQ)]*
(b) A half wave controlled rectifier feeds a load with a ripple free current. At $\alpha = 60^\circ$, the input voltage is 240V, 50Hz and load resistance is 10Ω. Calculate

- (i) average load current
- (ii) rms load current
- (iii) rectification efficiency
- (iv) form factor
- (v) ripple factor.

[[CO2](Evaluate/HOCQ)]

$$(3 + 2) + (2 + 2 + 1 + 1 + 1) = 12$$

5. (a) Explain the operation of a three phase fully controlled converter with R load at a firing angle of 30° . [[CO2](Analyze/IOCQ)]
- (b) A single phase semiconverter is fed from a 230V, 50Hz single phase mains. The firing angle is 90° . Calculate (i) RMS value of load voltage (ii) Average value of load voltage (iii) form factor (iv) ripple factor. [[CO2](Evaluate/HOCQ)]

$$6 + (2 + 2 + 1 + 1) = 12$$

Group - D

6. (a) Explain with relevant waveforms the operation of Class D chopper when $T_{ON} < T/2$. [[CO3](Analyze/IOCQ)]
- (b) A boost converter has an input voltage of 5V. The required output voltage is 15V. Peak to peak ripple voltage is 10mV. The switching frequency is 30 kHz. If the peak to peak ripple current is limited to 0.5A. Calculate (i) duty cycle (ii) filter inductance (iii) filter capacitance (iv) peak value of inductor current. [[CO3](Evaluate/HOCQ)]
- (c) Explain single pulse modulation technique. [[CO3](Understand/LOCQ)]

$$5 + 4 + 3 = 12$$

7. (a) A step down chopper has a resistive load of $R = 10\Omega$ and input voltage of 180V. When the chopper remains ON the voltage drop across it is 1.25V. The chopper frequency is 2 kHz. The duty cycle is 50%. Calculate
 (i) average output voltage
 (ii) RMS output voltage
 (iii) chopper efficiency. [[CO3](Evaluate/HOCQ)]
- (b) Explain the operation of a full bridge voltage source inverter feeding an R-L load. [[CO3](Understand/LOCQ)]
- (c) Compare 180° and 120° modes of operation in a three phase inverter. [[CO3](Remember/LOCQ)]

$$(1 + 1 + 3) + 4 + 3 = 12$$

Group - E

8. (a) Explain the operation of full wave AC voltage controller with R load. Draw relevant waveforms. [[CO4](Understand/LOCQ)]
- (b) A single phase half wave regulator has an input voltage of 150V and a load resistance of 8 ohms. The firing angle of the thyristor is 60° in each positive cycle. Find (i) average output voltage (ii) rms output voltage (ii) power output (iii) input power factor (iv) average input current over one cycle. Neglect losses. [[CO4](Evaluate/HOCQ)]

- (c) Name the various configurations of switch mode power supply. Draw the circuit for any one of them. [[CO4](Remember/LOCQ)]
4 + 5 + 3 = 12
9. (a) Explain the operation of bridge type step up cycloconverter with R load. Draw relevant waveforms. [[CO4](Analyze/IOCQ)]
- (b) A three pulse cycloconverter supplies a single phase load of 250V, 50A. Find the input voltage and rms voltage. [[CO4](Apply/IOCQ)]
- (c) Describe the operation of Off line UPS in detail. [[CO4](Remember/LOCQ)]
4 + 5 + 3 = 12
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Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	29.16	29.16	41.67

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.