

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) A triac is equivalent to
(a) two diodes in antiparallel (b) one thyristor and one diode in parallel
(c) two thyristors in parallel (d) two thyristors in antiparallel
- (ii) In a thyristor
(a) Latching current is associated with turn-off process and holding current with turn-on process.
(b) Both latching current and holding current are associated with turn-off process.
(c) Latching current is associated with turn-on process and holding current with turn-off process.
(d) Both latching current and holding current are associated with turn-on process.
- (iii) For an SCR, di/dt protection is achieved through the use of
(a) R in series with SCR (b) RL in series with SCR
(c) L in series with SCR (d) L across SCR.
- (iv) A single-phase full-wave mid-point thyristor converter uses a 230/200 V transformer with center tap on the secondary side. The PIV per thyristor is
(a) 100 V (b) 141.4 V (c) 200 V (d) 282.8 V
- (v) A buck converter has an input voltage of 16 V. The output voltage is 8 V. With switching frequency 20 kHz and peak to peak ripple current of inductor limited to 0.7 A. The load current is 0.8 A. Calculate the value of critical value of filter inductance (in mH)
(a) 0.125 (b) 1.25 (c) 0.0125 (d) 125
- (vi) A chopper, in which current remains positive but voltage may be positive or negative, is known as
(a) Class A (b) Class B (c) Class C (d) Class D

- (vii) In single-pulse modulation of PWM inverters, fifth harmonic can be eliminated if pulse width is equal to
(a) 30° (b) 72° (c) 36° (d) 108°
- (viii) A single-phase inverter has square wave output voltage. What is the percentage of the fifth harmonic component in relation to the fundamental component?
(a) 40% (b) 30% (c) 20% (d) 10%
- (ix) A single-phase AC voltage controller feeds power to a resistance of 10Ω . The source voltage is 200 V. For a firing angle of 90° , the rms value of thyristor current in amperes is
(a) 20 (b) 15 (c) 10 (d) 5
- (x) The cycloconverters require natural or forced commutation as under
(a) natural commutation in both step-up and step-down CCs.
(b) forced commutation in both step-up and step-down CCs.
(c) forced commutation in step-up CCs.
(d) forced commutation in step-down CCs.

Group - B

2. (a) Draw and explain the V-I characteristics of TRIAC with the help of a neat diagram. [(CO1) (Remember/LOCQ)]
- (b) Analyze the operation of the class B commutation circuit of SCR with a neat diagram and waveforms. [(CO1) (Analyze/IOCQ)]
- (c) Determine the value of firing angle in a resistance firing circuit of SCR. The following parameters are given:
 $I_{g(\min)} = 0.5\text{mA}$, $V_{g(\min)} = 0.7\text{V}$, supply voltage = 48V, 50Hz and resistance in gate current path = $70\text{k}\Omega$. [(CO1) (Evaluate/HOCQ)]

4 + 5 + 3 = 12

3. (a) With the help of a neat equivalent circuit diagram explain the structure and principle of operation of IGBT. [(CO1) (Remember/LOCQ)]
- (b) Derive the expression of anode current of SCR with the help of two transistor model. [(CO1) (Analyze/IOCQ)]
- (c) How many SCRs are required in a series string to withstand a dc voltage of 3500 V in steady state if the SCRs have a steady voltage rating of 1000 V and the steady state derating factor is 30%? 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 half wave rectifier using R-L load.
[(CO2) (Understand/LOCQ)]

- (b) Analyze the operation of a single phase asymmetrical converter as a first quadrant converter. Infer about the inherent freewheeling action present in it. [(CO2) (Analyze/IOCQ)]
- (c) A half controlled bridge rectifier feeds a load with ripple free current. At $\alpha = 60^\circ$, the input voltage is 240V, 50 Hz and the load resistance is 10Ω . Calculate the average load voltage, rms load current and average power dissipated in the load. [(CO2) (Evaluate/HOCQ)]
4 + 5 + 3 = 12
5. (a) Derive the average and rms value of a single phase full bridge converter with RL load. [(CO2) (Remember/LOCQ)]
- (b) Analyze the effect of source impedance on the performance of single phase full bridge inverter converters. [(CO2) (Analyze/IOCQ)]
- (c) A three phase fully controlled rectifier supplies a dc motor. The ac supply is 400V and the dc output voltage is 360V. Calculate the firing angle delay. [(CO2) (Evaluate/HOCQ)]
4 + 5 + 3 = 12

Group - D

6. (a) Explain the operation of a buck-boost converter. Draw the inductor voltage, inductor current and capacitor current waveforms. [(CO3) (Understand/LOCQ)]
- (b) Examine why a class C chopper is called a two quadrant chopper. [(CO3) (Analyze/IOCQ)]
- (c) A chopper is operating at a frequency of 2 kHz from a 230V dc input supply. If the load voltage is 150V. Calculate the duty cycle, conduction and non-conduction period of the thyristor in each cycle. [(CO3) (Evaluate/HOCQ)]
4 + 5 + 3 = 12
7. (a) Compare 180° and 120° mode of conduction in a three phase inverter. [(CO3) (Understand/LOCQ)]
- (b) Explain the operation of a full bridge VSI with RL load. [(CO3) (Analyze/IOCQ)]
- (c) A single phase full bridge inverter with RL load of $R = 20 \Omega$ and $L = 10 \text{ mH}$, produces a square wave. It is fed from a 120 V dc input. Find the rms load voltage, fundamental rms voltage and total harmonic distortion. [(CO3) (Evaluate/HOCQ)]
4 + 5 + 3 = 12

Group - E

8. (a) Derive the RMS value of output voltage for a full wave AC voltage controller employing integral cycle control. [(CO4) (Understand/LOCQ)]

- (b) Identify the types of HVDC transmission systems. Identify the advantages of bipolar HVDC transmission over monopolar HVDC transmission systems. [(CO4) (Apply/IOCQ)]
- (c) A single phase half-wave ac voltage controller has a load resistance of 10Ω . The AC input voltage is 120V. Calculate the rms output voltage, rms output current and input power factor for a firing angle delay of $\pi/2$. [(CO4) (Evaluate/HOCQ)]
4 + 5 + 3 = 12
9. (a) Explain the operation of a single phase to single phase step down bridge type cycloconverter. [(CO4) (Understand /LOCQ)]
- (b) Examine the functioning of a SMPS with the help of a block diagram. [(CO4) (Analyze/IOCQ)]
- (c) A three phase cycloconverter supplies a single phase load of 250V, 50A. Find the input voltage and rms voltage for a firing angle delay of $\pi/4$. [(CO4) (Evaluate/HOCQ)]
4 + 5 + 3 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	33.33%	41.67%	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

Department & Section	Submission Link
EE	https://classroom.google.com/c/NDA2MDA5MjQzNDgy/a/NDYyOTkzNDYyNDkz/details