CODE	COURSE NAME	CATEGORY	L	T	P	CREDITS
EET396	ANALYSIS OF POWER ELECTRONIC CIRCUITS	VAC	3	1	0	4

Preamble: To impart knowledge about analysis and design of various power converters.

Prerequisite : Electric circuit theory

Course Outcomes : After the completion of the course the student will be able to:

CO 1	Choose appropriate power semiconductor device along with its driver circuits and protection.
CO 2	Analyse the operation of controlled rectifier circuits and PWM rectifiers.
CO 3	Analyse inverter circuits with different modulation strategies.
CO 4	Analyse the operation of DC-DC converters andAC voltage controllers.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3										2
CO 2	3	3										2
CO 3	3	3										2
CO 4	3	3										2

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember (K1)	10	10	20
Understand (K2)	20	20	40
Apply (K3)	20	20	40
Analyse (K4)			
Evaluate (K5)	-	-	-
Create (K6)	-	-	-

End Semester Examination Pattern : There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which

student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1): Choose appropriate power semiconductor device along with its driver circuits and protection.

1. Compare ideal and real power electronic switches. (K1)
2. Explain the static and dynamic characteristics MOSFET and IGBT. (K2)
3. Choose the appropriate power electronic switch for a converter. (K3)
4. Illustrate the operation of driver and snubber circuits for power electronic switches. (K2)
5. Design a heat sink for a power electronic switch. (K3)

Course Outcome 2 (CO2): Analyse the operation of controlled rectifier circuits and PWM rectifiers.

1. Analyse the operation of full and semi converters for single and three phase applications working with RLE loads. (K2), (K3)
2. Analyse the effect of source inductance in full converters. (K2), (K3)
3. Explain the operation of phase controlled rectifiers in inversion mode.(K2)
4. Explain the different topologies and control of PWM rectifiers. (K2)
5. Mathematically show the effect of single phase rectifiers on neutral currents in three phase four wire systems. (K2), (K3)
6.

Course Outcome 3 (CO3): Analyse inverter circuits with different modulation strategies.

1. Analyse the operation of single and three phase inverters with RL loads. (K2), (K3)
2. Explain unipolar and bipolar sinusoidal pulse width modulation. (K2)
3. Design output filters for inverters. (K3)
4. Describe the types and working of multilevel inverters. (K1), (K2)
5. Explain the various current control methods of voltage source inverter. (K2)

Course Outcome 4 (CO4): Analyse the operation of DC- DC converters and AC voltage controllers.

1. Analyse the operation of single, two and four quadrant dc choppers. (K4)
2. Describe the control methods of dc choppers. (K2)
3. Design input filter for dc choppers. (K4)

4. Explain the working of multiphase choppers. (K2)

5. Analyse the operation of three phase ac voltage controllers with R load. (K4)

Model Question paper

QP CODE:

PAGES: 2

Reg. No:_____
Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SIXTH SEMESTER B.TECH DEGREE EXAMINATION
MONTH & YEAR
Course Code: EET396

Course Name: ANALYSIS OF POWER ELECTRONIC CIRCUITS

Max. Marks: 100 Duration: 3 Hours

PART A (3 x 10 = 30 Marks)

Answer all Questions. Each question carries 3 Marks

1. Draw and explain a snubber circuit for a power MOSFET.
2. Compare the characteristics of ideal and real switches.
3. Why do the triple harmonics dominate in three phase four wire system with balanced rectifier loads?
4. Derive the expression for output voltage of half wave controlled rectifier with resistive load.
5. What is the significance of common mode voltage in inverters.
6. What are the merits of unipolar modulation technique for inverters over bipolar.
7. Derive an expression for average output voltage in terms of input dc voltage andduty cycle for a step down dc chopper.
8. Using a two phase dc chopper, bring out its advantages compared to a single chopper.
9. Develop the expression for power factor for an ac voltage controller using integral cycle control.
10. List the merits and demerits of Hysteresis current controller.

PART B (14 x 5 = 70 Marks)
Answer any one full question from each module. Each question carries 14 Marks

Module 1

11. a) A 100 V dc supply is connected to a resistance of 7 Ohms through a series static controlled switch. The ON state forward voltage drop of the switch is 2 V. Its forward leakage current in the OFF state is 2 mA. It is operated with a switching frequency of 1 kHz and a duty cycle of 30%. Neglect the switching transition times

and determine the peak and average power dissipation in the switch. Also find the proportion in which this power dissipation is shared between the ON state dissipation and OFF state dissipation. **(5)**

b) Draw and explain the static and dynamic characteristics of IGBT. **(9)**

12. a) Explain the design of a driver circuit for MOSFET. **(7)**

b) A MOSFET that is used in a dc-dc converter is dissipating 50W. The thermal resistance to conduction from the junction to the case is 0.5 deg K/W and the thermal resistance to conduction from the case to the heat sink is 1.5 deg K/W. If the ambient temperature in the neighbourhood of the heat sink is 50 deg C, then calculate the thermal resistance requirement for the heat sink if the junction temperature does not exceed 100 deg C. **(7)**

Module 2

13. a) Derive the input PF of a single phase controlled rectifier with continuous and ripple-free load current. **(6)**

b) With necessary mathematical analysis, show the effect of source inductance on the output voltage of a single phase controlled bridge rectifier. **(8)**

14. a) Describe the working of 3-phase fully controlled converter with the help of circuit diagram. **(6)**

b) A three phase fully controlled bridge converter is connected to 415 V supply, having a reactance of 0.3 Ohm/phase and resistance of 0.05 Ohm/phase. The converter is working in the inversion mode at a firing advance angle of 35 deg. Compute the average generator voltage. Assume I_d = 60 A and thyristor drop = 1.5 V. **(8)**

Module 3

15. A single phase bridge inverter supplies an R-L load with R=10 Ohms and L=50mH from a 220 V dc supply. If the inverter frequency is 50 Hz, calculate i) rms value of fundamental component of load current ii) THD of load current iii) total power delivered to the load and iv) fundamental power output. **(14)**

16. Three single phase H bridge inverter circuits are available. What is the level of multilevel inverter that can be formed using them? Draw its circuit diagram and the important waveforms. Give a table showing the switch combination to be turned ON to get each level. **(14)**

Module 4

17. With a neat circuit diagram and waveforms, explain how four-quadrant operation is achieved in a Type-E Chopper. **(14)**

18. a) Explain the working of two quadrant type-A chopper with relevant waveforms. **(8)**

b) A step up chopper has input voltage of 120V and output voltage of 360 V. Ifthe conducting time of the thyristor chopper is 100 μs, compute the pulse width of output voltage. **(6)**

Module 5

19. A three phase three wire bidirectional controller supplies a star connected resistive load of R=5 Ohms and the line to line input voltage is 210 V, 50 Hz. The firing angle is π/3. Determine i) the rms output phase voltage ii) the input power factor and iii) the expression for the instantaneous output voltage of phase a. **(14)**

20. (a) What are the challenges faced by the conventional rectifier circuits? Justify. **(5)**
(b) Explain the working of any two PWM rectifier circuits to mitigate these issues. With block diagrams, discuss their control strategy. **(9)**

Syllabus

Module 1 (8 hours)

Overview of solid state devices

Characteristics of Ideal and Real switches - Static and Dynamic Characteristicsfor MOSFET and IGBT, Driver circuit and Snubbers for MOSFET and IGBT – Conduction and Switching loss - Power dissipation and selection of heat sink.

Module 2 (10 hours)

Phase controlled Rectifiers

Single-phase converter - full converter and semi converter - analysis with RLE loads – input PF with continuous and ripple free load current - inversion mode – effect of source inductance – Effect of single phase rectifiers on neutral currents in three phase four wire systems.

Three-phase converter - Full converter & semi converter – analysis with RLE loads – continuous conduction only – inversion mode - effect of source inductance –line notching and distortion.

Module 3 (10 hours)

Inverters

Single phase full Bridge Inverters –Analysis with RL load - Three phase bridge inverter - Analysis with delta and star connected RL loads – Common mode voltage; PWM principle - Sinusoidal pulse width modulation- Unipolar and Bipolar modulation, Effect of blanking time on voltage of PWM inverter, output filter design.

Multilevel Inverters

Introduction to Multilevel Inverters – Types – Diode clamped, flying capacitor and cascaded multilevel inverters

Module 4 (7 hours)

DC Choppers

Analysis of DC choppers; Single quadrant, two quadrant and four quadrant choppers, PWM control-Time ratio control – Current limit control, Source filter and its design, multiphase chopper.

Module 5 (6 hours)

AC voltage controllers

Three phase AC Voltage Controllers-Principle, operation and analysis with R loads

Current control of VSI

Current Regulated PWM Voltage Source Inverters - Hysteresis Control - Variable Band Hysteresis Control, Fixed Switching Frequency Current Control

PWM rectifiers

Single phase PWM rectifiers –Basic topologies and control

Text Books

1. Joseph Vithayathil, Power Electronics: Principles and Applications, Tata McGraw Hill 2010.
2. Mohan, Undeland, Robbins, Power Electronics; Converters, Applications and Design. -3rd edition, John Wiley and Sons, 2003.
3. Muhammad H. Rashid, Power Electronics: Circuits, Devices and Applications, Pearson Education, 2013.

Reference Books

1. Krein P. T., Elements of Power Electronics, Oxford University Press, 1998.
2. L. Umanand, Power Electronics – Essentials & Applications, Wiley-India, 2009.
3. M H Rashid (Ed), Power Electronics Handbook: Devices, Circuits and Applications,Academic Press 2010.
4. José Rodríguez, *et al,* Multilevel Inverters: A Survey of Topologies, Controls, and Applications, IEEE Transactions on Industrial Electronics, vol. 49, no. 4, August 2002.

Total Lecture Hours: 45

Course Contents and Lecture Schedule:

No	Topic	No. of Lectures
1	**Overview of solid state devices (8 hours)**	
1.1	Characteristics of Ideal and Real switches	1
1.2	Static and Dynamic Characteristics for MOSFET and IGBT	2
1.3	Driver circuit and Snubbers for MOSFET and IGBT	2
1.4	Conduction and Switching loss	1
1.5	Power dissipation and selection of heat sink	2
2	**Phase controlled Rectifiers (10 hours)**	
2.1	Single-phase converter - full converter and semi converter - analysis with RLE loads	2
2.2	Input PF with continuous and ripple free load current - inversion mode	1
2.3	Effect of source inductance.	1
2.4	Effect of single phase rectifiers on neutral currents in three phase four wire system	1
2.5	Three-phase converter - Full converter & semi converter – analysis with RLE loads - continuous conduction only	2
2.6	Inversion mode - Effect of source inductance	2
2.7	line notching and distortion	1
3	**Inverters (10 Hours)**	
3.1	Single phase full Bridge Inverters – Analysis with RL load	1
3.2	Three phase bridge inverter - Analysis with delta and star connected RL loads – Common mode voltage	2
3.3	PWM principle - Sinusoidal pulse width modulation - Unipolar and Bipolar modulation	2
3.4	Effect of blanking time on voltage of PWM inverter, output filter design	2
	Multilevel Inverters	
5.2	Introduction to Multilevel Inverters – Types – Diode clamped, flying capacitor and cascaded multilevel inverters	3
4	**DC Choppers (7 Hours)**	
4.1	Analysis of DC choppers; Single quadrant, two quadrant and four quadrant choppers	3
4.2	PWM control-Time ratio control – Current limit control	2

4.3	Source filter and its design	1
4.4	Multiphase chopper	1
5	**AC voltage controllers (6 Hours)**	
5.1	Three phase AC Voltage Controllers - Principle, operation and analysis with R loads	2
	Current control of VSI	
5.3	Current Regulated PWM Voltage Source Inverters – Hysteresis Control - Variable Band Hysteresis Control, Fixed Switching Frequency Current Control	2
	PWM rectifiers	
5.4	Single phase PWM rectifiers –Basic topologies and control	2