CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET425	INTRODUCTION TO POWER PROCESSING	OEC	2	1	0	3

Preamble: The recent advances in power electronics has resulted in the development of various industrial and household devices/equipment that employ power processing. It is important for engineering professionals to understand the fundamental principles behind such devices/systems. This course provides an overview of various essential elements of power electronics used for power processing, and their principle of operation. Power electronics deals with the processing and control of 'raw' electrical power from an electrical source. The power levels handled can vary from a few watts to several hundreds of megawatts. It is an enabling technology with a very wide range of applications. The course contents enable the students to understand the principles of power electronics and provide an introduction to various applications such as industrial drives, renewable energy, power supplies and electrical /hybrid vehicles.

Prerequisite: EST 130 Basics of Electrical and Electronics Engineering

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

CO 1	Explain different elements of power electronics.
CO 2	Explain various power electronic converters.
CO 3	Describe the basic principles of ac and dc motor drives.
CO 4	Describe the structure of power processing systems in power supplies, renewable energy conversion and EVs.

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	2											
CO 2	2											
CO 3	2								2			
CO 4	2						2		2			

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	20	20	40
Understand	30	30	60
Apply			
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

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 a maximum of 2 subdivisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Explain the principle of operation of MOSFET. (K2, PO1)
2. What is the difference between thyristors and controllable switches? (K1, PO1)
3. Why are IGBTs becoming popular in their applications to controlled converters ?
4. Enumerate some applications of IGBTs. (K1, PO1)
5. What are the applications of power electronic systems? (K1, PO1)

Course Outcome 2 (CO2)

1. With a neat circuit and waveforms, explain the working of a boost DC-DC converter.(K2, PO1)
2. With the help of waveform explain sinusoidal pulse width modulation used in single phase inverter. (K2, PO1)
3. Explain the working of a single-phase half bridge square wave inverter with pure R load. Draw the output voltage and output current waveforms.(K2, PO1)
4. Illustrate how a thyristor based 1-phase fully controlled rectifier can be used to convert ac into variable dc. Draw the waveforms of output voltage and output current for both R and RL load at α= 30 degree.(K2, PO1)

Course Outcome 3(CO3):

1. Give the classification of DC motors based on their field winding excitation with neat diagrams.(K2, PO9)
2. What is meant by armature reaction? What are its effects on main field flux? (K1, PO9)
3. Explain V/F control of induction motor drives. (K2, PO9)
4. Explain why we use starters for starting a DC motor. (K2, PO9)

Course Outcome 4 (CO4):

1. Explain a standalone solar PV system with a block diagram. (K2, PO7, PO9)
2. Explain the components of a linear power supply. (K2, PO7, PO9)
3. Distinguish between HEV and PHEV. (K2, PO7, PO9)
4. Explain the powertrain in an EV. (K2, PO7, PO9)

Model Question Paper

QP CODE:

PAGES:

Reg. No:_____

Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SEVENTH SEMESTER B.TECH DEGREE EXAMINATION,

MONTH & YEAR Course Code: EET425

Course Name: INTRODUCTION TO POWER PROCESSING

Max. Marks: 100 **Duration: 3 Hours**

PART A (3 x 10 = 30 Marks)

Answer all Questions. Each question carries 3 Marks.

1. Explain the principle of operation of SCR.
2. What are wide bandgap devices? What are its advantages?
3. With a neat circuit explain the working of single phase fully controlled SCR based bridge rectifiers with R load.
4. With neat circuit, explain the working of a boost DC-DC converter
5. Differentiate between voltage source inverter and current source inverter.
6. With the help of waveform explain sinusoidal pulse width modulation used in single phase inverter.
7. What is meant by armature reaction?
8. Explain why we use starters for starting a DC motor.
9. What is the difference between on grid and off grid Solar PV installations?
10. Give three advantages of electric vehicles over the conventional IC engine driven vehicles.

PART B (14 x 5 = 70 Marks)

Answer any one full question from each module. Each question carries 14 Marks

Module 1

11. (a) What are the advantages, disadvantages and applications of power electronic systems? (10)

(b)Compare a diode and a thyristor. (4)

12. (a) Describe the working of IGBT. How does latch-up occur in an IGBT? Why are IGBTs becoming popular in their applications to controlled converters? Enumerate some applications of IGBTs. (10)

(b) With a neat block diagram, explain a typical power electronic system. (4)

Module 2

13. (a) Illustrate how a thyristor based 1-phase fully controlled rectifier can be used to convert ac into variable dc. Draw the waveforms of output voltage and output current for RL load at α= 30 degree. (10)

(b) Discuss the significance of a freewheeling diode. (4)

14 (a) Explain with a circuit diagram and necessary waveforms, the working of a buck regulator for continuous current mode. (10)

(b) Explain the phenomenon of inductive kick. (4)

Module 3

15 (a) Explain the working of a single-phase half bridge square wave inverter with pure R load. Draw the output voltage and output current waveforms. (10)

(b) What is its main drawback? Explain how this drawback is overcome. (4)

16 (a) What is an ac voltage controller? List some of its industrial applications. Enumerate its merits and demerits. (7)

(b) Describe the operation of a single phase ac voltage controller with R load with necessary waveforms. (7)

Module 4

17. (a)With a neat schematic explain the components of an electric drive system (7)

(b)Explain the four-quadrant operation of a dc motor (7)

18 (a) List various control strategies used in induction motor drives (4)

(b) ExplainV/F control of induction motor drives. (10)

Module 5

19. (a) Explain the operation of a grid connected solar PV system with a neat block schematic (7)
    (b) Explain the components of a linear power supply. (7)

20. (a) Distinguish between HEV and PHEV (4)

    (b)Explain different energy storage systems used in Electric Vehicles (10)

Syllabus

Module 1

Introduction to power processing, elements of power electronics, power semiconductor devices. Uncontrolled, Semicontrolled and Fully controlled switches: Diode, SCR, MOSFETs and IGBTs- principle of operation. Advantages of wide bandgap devices-SiC, GaN.

Module 2

Basic power conversion circuits- converter circuits: Controlled rectifiers: Single- phase fully controlled SCR based bridge rectifier with R and RL load (continuous mode only). Principle of operation and waveforms (No analysis required).

DC-DC Converters (Non-isolated) : Buck, Boost and Buck-Boost converter. Circuit operation, voltage gain and waveforms in continuous conduction mode (No analysis required).

Module 3

Single phase half and full bridge Inverter: Square-wave operation with R load. Types of PWM - single pulse, multiple pulse and sinusoidal PWM. Total Harmonic Distortion(THD).

Three phase voltage source inverter with R load- 120 and 180 degree conduction mode - waveforms

Single phase AC voltage controller with R load- waveforms.

Module 4

Applications: 1. *Motor drives*:

Introduction to electric motor drive- Block diagram

4-quadrant operation of a separately excited dc motor (circuit diagram and waveforms only).

Induction motor drives: Principle of operation- v/f control

Module 5

Applications 2: *Renewable energy*- solar PV installations-off grid and on grid systems: Principle of operation - Block diagram.

Applications 3: *Power supplies* - Principle of operation of linear and switched mode power supply- requirements of power supplies- Isolation, protection and regulation.

Applications 4: *Electric vehicles* - Introduction to HEV, PHEV and BEV-Block schematic of power train. Introduction to energy storage in EVs - Li Batteries, Hydrogen Fuel Cell.

Text/Reference Books

1. Ned Mohan, Tore m Undeland, William P Robbins, "Power electronics converters applications and design", John Wiley and Sons, 2003.
2. Muhammad H. Rashid, Power Electronics Circuits, Devices and Applications, Pearson Education, 2009.
3. P.S. Bimbhra, Power Electronics, Khanna Publishers, New Delhi, 2012.
4. Dubey G. K. "Fundamentals of Electrical drives" Narosa Publishing House, 1995.
5. Andrzej M. Trzynadlowski, Introduction to Modern Power Electronics, 3rd Edition, Wiley, 2015.
6. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.
7. Abbasi S. A. and N. Abbasi, Renewable Energy Sources and Their Environmental Impact, Prentice Hall of India, 2001.
8. Sawhney G. S., Non-Conventional Energy Resources, PHI Learning, 2012.
9. Non conventional energy sources, NPTEL lecture by Prof.Prathap Haridoss, IIT Chennai.
10. Abad, Gonzalo, ed. Power electronics and electric drives for traction applications. USA: Wiley, 2017.

Course Contents and Lecture Schedule

No.	Topic	No. of Lectures
1	**Introduction to power processing (6 hours)**	
1.1	Introduction to power electronics and its objectives, Advantages, disadvantages, applications, typical power electronic system	1
1.2	Elements of power electronics, power semiconductor devices.	1
1.3	Symbol and principle of operation of diode and SCR	1
1.4	Symbol and principle of operation of MOSFET	1
1.5	Symbol and principle of operation of IGBT	1
1.6	Advantages of wide bandgap devices- SiC, GaN	1
2	**Basic power conversion circuits (6 hours)**	
2.1	Converter circuits	1
2.2	Single- phase fully controlled SCR based bridge rectifier with R (continuous mode only), Principle of operation and waveforms (No analysis required)	1
2.3	Single- phase fully controlled SCR based bridge rectifier with RL load (continuous mode only), Principle of operation and waveforms (No analysis required)	1
2.4	DC-DC Converters (Non-isolated) : Buck converter. Circuit operation, voltage gain and waveforms in continuous conduction mode (No analysis required).	1
2.5	Boost converter. Circuit operation, voltage gain and waveforms in continuous conduction mode (No analysis required).	1
2.6	Buck-Boost converter. Circuit operation, voltage gain and waveforms in continuous conduction mode (No analysis required).	1
3	**Inverter circuits, AC voltage controllers (6 hours)**	
3.1	Voltage source inverters	1
3.2	Single phase half and full bridge Inverter-Square-wave operation	1

	with R load	
3.3	Types of PWM - single pulse, multiple pulse and sinusoidal PWM Total Harmonic Distortion (THD)	1
3.4	Three phase voltage source inverter with R load- 120 degree conduction mode - waveforms	1
3.5	Three phase voltage source inverter with R load- 180 degree conduction mode - waveforms	1
3.6	Single phase AC voltage controller with R load- waveforms.	1
4	**Applications of power processing in Drives (9 hours)**	
4.1	Introduction to electric drives, components of electric drive, advantages of electric drives.	1
4.2	DC motor – principle of operation – back emf – necessity of motor starter-classification,	2
4.3	Four quadrant operation of separately excited DC Motor	2
	Three phase induction motor-squirrel cage and slip ring induction motor, Working principle-synchronous speed, slip	2
4.4	Induction Motor Drives, V/F control	2
5	**Applications of power processing in renewable energy generation, power supplies and EVs (5 hours)**	
5.1	Solar PV installations-Off grid and On grid	1
5.2	Linear and Switch Mode Power Supplies, Functional Block Diagram and operation	2
5.3	Introduction to Electric Vehicle, Various Types, Types of Energy Storage	2