Nirma University
Institute of Technology
Department of Electrical Engineering
Course Policy Template

B. Tech. Semester – IV(EE) **Academic Year: 2019-20**

Course Code & Name	**:**	2EE405: Power Electronic Converters and Applications
Credit Details	**:**	**Lectures: 3, LPW: 0, Tutorial:0** **Total Credits: 3**
Course Co-ordinator	**:**	Dr. Siddharthsingh K. Chauhan
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Office	**:**	PG-105
Course Faculty	**:**	1. Dr. Siddharthsingh K. Chauhan **Visiting Hours**: Every working day during recess hours Odd Saturdays: 11 AM to 4 PM
		2. Dr. M. T. Shah **Visiting Hours:** Every working day during recess hours Odd Saturdays: 11 AM to 4 PM
Course Blog	**:**	2ee405PECA.wordpress.com

1. Introduction to Course

1.1 Importance of the course

Power electronic converters and Applications is the course offered to B.Tech. Sem. IV Electrical Engineering students. This course talks about understanding of power electronic devices, rectifiers, switched mode power supply, inverter circuits and their applications in drives, renewable energy systems, electric vehicles, etc. Modern electrical energy systems are increasingly dominated by power electronics for energy processing and management. As most of the industrial processes demand automation based on Power Electronic Converters, this subject has great relevance with respect to industrial applications. The primary goal of the course is to give student a foundation for analysis and design of power electronic circuits for conversion and control of electrical systems.

1.2 Objective of the Course

The objective of the course is to make student aware about fundamentals of power electronic devices, power electronic converters – rectifiers, switched mode converters, inverters, cycloconverter and their operation under various loading conditions. It also covers different applications of these converters.

1.3 Pre-requisite: Fundamental of analog and digital electronics

2. Course Learning Outcomes (CLO)

CLOs are clear statements of the expectations for student achievements in the course.

At the end of the course, students will be able to-

1. analyze operation of devices and choose the same suitable for an application
2. evaluate various performance parameters of converters
3. implement and analyze different control techniques for power electronic converters
4. choose and apply converter topology suitable for an application

3. Syllabus

Unit-0: Introduction to Course
Overview of power electronic converters and their applications

Unit-1: Power Semiconductor Devices
Construction, characteristics and ratings of MOSFET, Insulated Gate Bipolar transistors (IGBTs), SCR, TRIACs, Light Activated SCRs (LASCRs), Unijunction transistor (UJT), Gate turn-off Thyristors (GTOs), Integrated Gate-Commutated Thyristors (IGCTs), MOS-controlled thyristor (MCT), Silicon carbide (SIC), Gallium nitride devices, Power Integrated circuits (PICs), Intelligent Modules

Unit-2: AC to DC Converters
Single Phase Half Wave and full wave Controlled Rectifiers with R, RL and RLE loads, Three Phase Half Wave and Full Wave Controlled Rectifier with R, RL, RLE loads, Dual Converter with circulating and non-circulating current mode, Effect of source inductance in controlled rectifiers, Introduction to PWM rectifiers

Unit-3: Non Isolated and Isolated DC-DC Converters
Importance & Requirement of DC Power Supply, Non-Isolated DC-DC Converters: Buck, Boost, Buck-Boost, Cuk, SEPIC and Zeta converters, Requirement and Importance of Isolation in Power Electronics Circuits – Advantages, Flyback – Forward – Push Pull, Half bridge, Full bridge converters

Unit-4: DC-AC Converter
Basic concept of inverters, three phase inverters (120° and 180° mode), Multilevel inverters- Diode Clamped, Flying Capacitor & Cascaded H-Bridge, Different types of PWM strategies-Multi carrier PWM, Single & Multiple PWM – Sine Triangle PWM (Bipolar & Unipolar), SVPWM

Unit-5: AC-AC Converters
Principle of Phase Control – Single Phase AC Voltage Controllers with R and RL loads, Three Phase AC Voltage Controllers with R and RL loads, Principle of On-Off (ICC) Control. Basic principle of operation-Single phase to single phase, Three phase to single phase Cycloconverter. Three phase to three phase cycloconverter

Unit-6: Electric Drives
Semi-converter and Fully Controlled converter based dc motor drives, chopper control based dc motor drives, Solar and battery powered drives

Unit-7: Power Electronic control for Utility Systems
High voltage DC Transmission, Power electronic transformer, Static excitation systems, Static VAR compensators, Static circuit breakers, Renewable energy based systems – solar & wind, Power Quality improvement devices – active power filter & active front end converter

Unit-8: E-mobility
Power Electronic converters & their control for Electric vehicles, Control of electric motors for traction

3.1. Self-Study

The self-study components of the syllabus will be declared at the commencement of the semester. Around 10% of the questions will be asked from self-study content.

Topics/content for self-study are as listed below:

1. Solar and battery powered drives
2. Power electronic transformer, Static excitation systems and Static circuit breakers

Students are expected to study above mentioned topics on their own. These topics will not be taught in the classroom. Students should refer to books available in the library for the same.

3.2. References

1. Muhammad H. Rashid, Power Electronics: Circuits, Devices and Applications, Pearson Education, New Delhi
2. Ned Mohan, Tore M. Undeland and William P. Robbins, Power Electronics: Converters, Applications and Design, John Wiley & Sons, Inc., New York
3. L Umanand, Power Electronics, Essentials & Applications, Wiley India
4. M. S. Jamil Asghar, Power Electronics, Prentice-Hall of India Pvt. Ltd., New Delhi
5. M. D. Singh and K. B. Khanchandani, Power Electronics, Tata McGraw-Hill Publishing Company Ltd., New Delhi
6. G. K. Dubey, S. R. Doradla, A. Joshi, R. M. K. Sinha, Thyristorized Power Controllers, New Age International, Delhi
7. B. Jayant Baliga, Power Semiconductor Devices, Thompson Course Technology, Singapore.
8. P. S. Bhimbra, Power Electronics, Khanna Publishers, New Delhi
9. C. W. Lander, Power Electronics, McGraw-Hill, UK
10. P. C. Sen, Modern Power Electronics, S. Chand, New Delhi
11. Mukund R. Patel, Wind and Solar Power Systems, CRC Press, Florida
12. Chetan Singh Solanki, Solar Photovoltaics: Fundamentals, Technologies and Applications, Prentice Hall, New Delhi
13. Joseph Vithayathil, Power Electronics, Principles and Applications, Indian Edition, McGraw- Hill
14. Research Papers on IEEE/IET/Science Direct etc.
15. Product Literatures

Note: The latest edition of books should be referred.

4. Term assignments details

Tutorials – NA

Term Assignments: Two term assignments will be given to students for entire subject. First covers about devices, rectifiers, and switched mode dc-dc converters. Second covers about inverters, cycloconverters and different applications. First assignment will be given in the first week of February and second will be given in first week of March. Each carry 15 marks so total 30 marks.

6. Assessment Policy

6.1 Component wise Continuous Evaluation (CE), Laboratory and Project Work (LPW) & Semester End Examination (SEE) weightage

I. (Course with Laboratory component)

Assessment scheme	**CE**			**SEE**
Component weightage	0.6 100 marks			0.4 100 marks
	Class Test 30% (30 marks)	Sessional Exam 40% (40 marks)	Two assignments 30% (30 marks)	

6.2 Assessment Policy for Continuous Evaluation (CE)

Assessment of Continuous Evaluation comprises of three components.

1. Class Test will be conducted as per academic calendar. It will be conducted online/ offline for the duration of 1 hour and will be of 30 marks.
2. Sessional Exam will be conducted as per academic calendar. It will be conducted offline for the duration of 1 hour and 15 minutes and will be of 40 marks.
3. There will be two assignments each carrying weightage of 15 marks. Assessment of Term Assignment will be carried out based on parameters like timely submission, neat and clean work, originality, involvement of the student, regularity, discipline etc.

6.3 Assessment Policy for Semester End Examination (SEE)

A written examination of 3 hour duration will be conducted for the course as per academic calendar. It will carry 100 marks and marks obtained out of 100 will be converted as per weightage assigned.

7. Lesson Plan

Sr.No.	Topic	Reference Book	Hours	CLO Mapped with Topic
0	**Introduction to Course**		**01**	
	Overview of power electronic converters and their applications			
1	**Power Semiconductor Devices**	**7**	**08**	**1**
1.1	Thyristor family, Silicon Control Rectifier (SCR) and its construction		1	
1.2	V-I characteristics and two transistor analogy of SCR		1	
1.3	Turn–On and Turn-Off Characteristics of SCR		1	
1.4	Various Ratings of SCR and its Datasheet interpretation		1	
1.5	Construction, characteristics and ratings of MOSFET		1	
1.6	Insulated Gate Bipolar transistors (IGBTs)		1	
1.7	Gate turn-off Thyristors (GTOs), Integrated Gate-Commutated Thyristors (IGCTs), MOS-controlled thyristor (MCT),		1	
1.8	Silicon carbide (SIC), Gallium nitride devices, Power Integrated circuits (PICs), Intelligent Modules		1	
2	**AC to DC Converters**	**1, 2, 3**	**07**	**2, 3**
2.1	Single Phase Half Wave and full wave Controlled Rectifiers with R, RL and RLE loads		2	
2.2	Three Phase Half Wave and Full Wave Controlled Rectifier with R, RL, RLE loads		2	
2.3	Dual Converter with circulating and non-circulating current mode		2	
2.4	Effect of source inductance in controlled rectifiers, Introduction to PWM rectifiers		1	
3	**Non Isolated and Isolated DC-DC Converters**	**2, 3, 4**	**6**	**2, 3**
3.1	Importance & Requirement of DC Power Supply		1	
3.2	Analysis of Buck converter, Boost converter, Buck-Boost Converter		2	
3.3	Analysis of Cük Converter, SEPIC and Zeta converters		1	
3.4	Need of isolated converter, Analysis of Forward Converter, Flyback Converter, Push-Pull Converter		1	
3.5	Analysis of Half Bridge Converter, Full Bridge Converter and examples on dc to dc converters		1	
4	**DC-AC Converter**	**2, 5, 8, 9**	**7**	**1, 2, 3**
4.1	Basic concept of inverters – Single phase inverters, Three Phase Full Bridge Configuration for 180^0 and 120^0 Mode of Operation		2	
4.2	Multilevel inverters- Diode Clamped, Flying Capacitor & Cascaded H-Bridge		2	

4.3	Analysis of Inverter with Single and Multiple Pulse Width Modulation, Sinusoidal Pulse Width Modulation (Unipolar, Bipolar)		2	
4.4	Analysis of Inverter with Multi carrier PWM and introduction to Space Vector Pulse Width Modulation Technique		1	
5	**AC-AC Converters**	**1, 2, 8, 10**	**5**	**2, 3**
5.1	Principle of Phase Control – Single Phase AC Voltage Controllers with R and RL loads		1	
5.2	Three Phase AC Voltage Controllers with R and RL loads, Principle of On-Off (ICC) Control.		2	
5.3	Basic principle of operation-Single phase to single phase, Three phase to single phase Cycloconverter, Three phase to three phase cycloconverter		2	
6	**Electric Drives**	**2, 5, 8**	**3**	**1, 2, 3, 4**
6.1	Analysis of Semi-converter and Fully Controlled converter based dc motor drives		2	
6.2	Analysis of chopper control based dc motor drives		1	
7	**Power Electronic control for Utility Systems**	**6, 8, 11, 12, 13**	**5**	**1, 2, 3, 4**
7.1	Operation of High voltage DC Transmission		1	
7.2	Operation of Static VAR compensators		1	
7.3	Analysis of Renewable energy based systems – solar & wind		1	
7.4	Analysis of Power Quality improvement devices – active power filter & active front end converter		2	
8	**E-mobility**	**2, 14, 15**	**3**	**2, 3, 4**
8.1	Power Electronic converters & their control for Electric vehicles		2	
8.2	Control of electric motors for traction applications		1	
	Total		**45**	

8. Mapping of Session Learning Outcomes (SLO) with Course Learning Outcomes (CLO)

Session No.	Session Learning Outcomes: After successful completion of the session, student will be able to	CLO
1.	Understand the basic idea of power electronic converters and their applications	1,2,3,4
2.	Understand the Silicon Control Rectifier (SCR) and its construction	1
3.	Understand V-I characteristics and two transistor analogy of SCR	1
4.	Interpret Turn–On and Turn-Off Characteristics of SCR	1

5.	Interpret various Ratings of SCR and its Datasheet	1
6.	Demonstrate the construction, characteristics and ratings of MOSFET	1
7.	Analyze the operation of insulated Gate Bipolar transistors (IGBTs)	1
8.	Analyze the working of Gate turn-off Thyristors (GTOs), Integrated Gate-Commutated Thyristors (IGCTs), MOS-controlled thyristor (MCT),	1
9.	Analyze the working of Silicon carbide (SIC), Gallium nitride devices, Power Integrated circuits (PICs), Intelligent Modules	1
10.	Distinguish Single Phase Half Wave and full wave Controlled Rectifiers with R, RL and RLE loads	2,3
11.	Analyze the functioning of Single Phase Half Wave and full wave Controlled Rectifiers with R, RL and RLE loads	2,3
12.	Distinguish Three Phase Half Wave and Full Wave Controlled Rectifier with R, RL, RLE loads	2,3
13.	Analyze the functioning of Three Phase Half Wave and Full Wave Controlled Rectifier with R, RL, RLE loads	2,3
14.	Distinguish Dual Converter with circulating and non-circulating current mode,	2,3
15.	Understand working of dual Converter with circulating and non-circulating current mode,	2,3
16.	Understand the effect of source inductance in controlled rectifiers, Introduction to PWM rectifiers	2,3
17.	Understand the importance & Requirement of DC Power Supply	2,3
18.	Analyze the behavior of Buck converter, Boost converter, Buck-Boost Converter	2,3
19.	Draw the waveforms of Buck converter, Boost converter, Buck-Boost Converter	2,3
20.	Analyze the behavior and characteristics of Cük Converter, SEPIC and Zeta converters	2,3
21.	Identify the need of isolated converter, Analysis of Forward Converter, Flyback Converter, Push-Pull Converter	2,3
22.	Analyze the behavior and characteristics of Half Bridge Converter, Full Bridge Converter and examples on dc to dc converters	2,3
23.	Understand the basic concept of inverters – Single phase inverters	1,2,3
24.	Understand the three phase full bridge configuration for 180^0 and 120^0 mode of operation	1,2,3
25.	Appreciate the need of multilevel inverters for various applications.	1,2,3
26.	Elaborate the multilevel inverters-Diode Clamped, Flying Capacitor & Cascaded H-Bridge	1,2,3
27.	Compare the working of Inverter with Single and Multiple Pulse Width Modulation	1,2,3
28.	Understand Sinusoidal Pulse Width Modulation (Unipolar, Bipolar) PWM techniques	1,2,3

29.	Analyze the concept of Inverter with Multi carrier PWM and introduction to Space Vector Pulse Width Modulation Technique	1,2,3
30.	Understand the principle of Phase Control – Single Phase AC Voltage Controllers with R and RL loads	2,3
31.	Distinguish the Three Phase AC Voltage Controllers with R and understand the Principle of On-Off (ICC) Control.	2,3
32.	Distinguish the Three Phase AC Voltage Controllers RL loads and understand the Principle of On-Off (ICC) Control.	2,3
33.	Understand the basic principle of operation of Single phase to single phase cycloconverter,	2,3
34.	Understand three phase to single phase Cycloconverter, Three phase to three phase cycloconverter	2,3
35.	Analyze the behavior of Semi-controlled converter based dc motor drives	1,2,3,4
36.	Analyze the behavior of Fully Controlled converter based dc motor drives	1,2,3,4
37.	Analyze the working of chopper control based dc motor drive	1,2,3,4
38.	Interpret the operation of High voltage DC Transmission	1,2,3,4
39.	Interpret the operation of Static VAR compensators	1,2,3,4
40.	Analyze the requirement of renewable energy based systems – solar & wind	1,2,3,4
41.	Discuss the function of Power Quality improvement devices – active power filter	1,2,3,4
42.	Discuss the function of Power Quality improvement devices – active front end converter	1,2,3,4
43.	Explain the types of Power Electronic converters & their control for Electric vehicles	2,3,4
44.	Understand the various functional blocks of Electric vehicles	2,3,4
45.	Inspect the control of electric motors for traction applications	2,3,4

9. Teaching-learning methodology

1. Lectures: Primarily Chalk and Black board will be used to conduct the course. However, where required, Power Point Presentations (PPTs), Video Lectures, Simulations / Animations etc. will be used to enhance the teaching-learning process.

10. Active learning techniques

Active learning is a method of learning in which students are actively or experientially involved in the learning process. Following active learning techniques will be adopted for the course.

Activity 1 – Muddiest point method: Students will be asked about most difficult part at the end of every session and further elaboration will be done on that.

Activity 2 – Discussion method: Few topics of syllabus will be preassigned and same will be discussed in coming sessions.

11. Course Material

Following course material is uploaded on the course blog website: https://mypeca.design.blog/

- Course Policy
- Lecture Notes
- Books / Reference Books / NPTEL video lectures
- Assignments, Tutorials, Lab Manuals
- Question bank
- Web-links, Blogs, Video Lectures, Journals
- Animations /Simulations, Softwares
- Advanced topics

12. Course Learning Outcome Attainment

Following means will be used to assess attainment of course learning outcomes.

- Use of formal evaluation components of continuous evaluation, semester end examination
- Informal feedback during course conduction

13. Academic Integrity Statement

Students are expected to carry out assigned work under Continuous Evaluation (CE) component independently. Copying in any form is not acceptable and will invite strict disciplinary action. Evaluation of corresponding component will be affected proportionately in such cases. Turnitin software will be used to check plagiarism wherever applicable. Academic integrity is expected from students in all components of course assessment.