Nirma University
Institute of Technology
Department of Electrical Engineering
Course Policy

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

Course Code & Name	:	**EE504: Power Electronic Converters**
Credit Details	:	Lectures: 3, LPW: 2, Tutorial: 0 Total Credits: 4
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Course Faculty	:	**1.Karri V V Satyanarayana** **Visiting Hours**: Every working day during recess hours Odd Saturdays: 11 AM to 4 PM
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Queries by emails are encouraged		
Course Blog	:	ee504cbb.wordpress.com

1. Introduction to Course

1.1 Importance of the course

Power electronic converters is the course offered to B.Tech. Sem. V Electrical Engineering students. This course talks about understanding of choppers, linear power supply, resonant converters and inverter circuits. 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 students a foundation for analysis and design of power electronic circuits as well as their applications for control of electrical systems.

1.2 Objective of the Course

The objective of the course is to make student aware about fundamentals of chopper, inverters and linear power supply and its operation under various loading conditions. It also covers different types of inverter circuits, chopper circuits and resonant circuits and finally student aware of power electronic converter application like grid connected photovoltaic system, grid connected wind farm system, and speed control of induction motor by inverter with its control strategy.

1.3 Pre-requisite:

The students are expected to have the prerequisite knowledge of fundamental of power electronics, Phase controlled rectifiers, AC voltage controllers, cyclo converters and basic operation of power semiconductor switches like thyristor, power MOSFET, IGBT, GTO.

2. Course Outcomes (CO)

COs are clear statements of the expectations for student achievements in the course.
At the end of the course, a student will be able to –

1. Suggest converter topology based on application
2. Analyze and implement various control techniques for power electronic Converters
3. Evaluate various performance parameters of converters

3. Syllabus

Unit	Content	Teaching Hours
Unit - 1	**Choppers:** Principle of step-down, Step-up and up-down choppers under various loading conditions, Analysis and design of chopper circuits.	07
Unit - 2	**Power Supplies:** Linear power supply, Switched mode power supply, Various isolated and non-isolated converter topologies, Uninterruptable power supply, Introduction to resonant converters, PWM converters	17
Unit - 3	**Inverters and PWM Techniques:** Single-phase and three-phase voltage source inverter, Current source inverter, Performance parameters of inverter, Square wave and quasi square wave operation, 120° and 180° mode of operation, Various PWM techniques and their comparative study.	13

Unit - 4	**Matrix Converters:** Introduction, Overview of different topologies and control schemes of matrix converters, Applications of matrix converters.	02
Unit - 5	**Applications of Converters:** Standalone solar inverter, Inverter for wind applications, Vehicle applications, Inverter for induction heating.	05

3.1. Self-Study

The self-study components of the syllabus are declared at the commencement of the semester. Basic principles and methodology will be explained in the class. It is expected that the students put in at least two hours of self-study for every one hour of class room teaching. Further, around 10% of the questions will be asked from following topics:

1. Advanced Pulse Width Modulation Techniques
2. Application of Power Electronics in Heating, Electric Vehicles

Students are expected to study above mentioned topics on their own. These topics will not be taught in the classroom. Students should refer books and other material available in the library for the same. Blogs and course website can also be referred for useful material on these topics.

3.2. References

1. Muhammed H. Rashid: Power Electronics: Circuits, Devices and Applications, 3rd Edition, Pearson Education, New Delhi, 2004.
2. Ned Mohan, Tore M. Undeland and William P. Robbins: Power Electronics: Converters, Applications and Design, John Wiley & Sons, Inc., New York, 2003.
3. L Umanand: Power Electronics, Essentials & Applications, Wiley India, 2011.
4. M. S. Jamil Asghar: Power Electronics, Prentice-Hall of India Pvt. Ltd., New Delhi, 2005.
5. M. D. Singh and K. B. Khanchandani: Power Electronics, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2001.
6. G. K. Dubey, S. R. Doradla, A. Joshi, R. M. K. Sinha: Thyristorized Power Controllers, New Age International, Delhi 1986.
7. B. Jayant Baliga: Power Semiconductor Devices, Thompson Course Technolog, Singapore, 2004.
8. Dr. P. S. Bhimbhara: Power Electronics, Khanna Publishers, New Delhi, 2001.
9. C. W. Lander: Power Electronics, Mc-graw Hill, UK, 1981.
10. P. C. Sen: Modern Power Electronics, S. Chand, New Delhi, 2005.
11. Mukund R. Patel: Wind and Solar Power Systems, CRC Press, Florida, 2000
12. Chetan Singh Solanki: Solar Photovoltaics: Fundamentals, Technologies and Applications, Prentice Hall, New Delhi, 2009

13. Joseph Vithayathil: Power Electronics, Principles and Applications, Indian Edition, McGraw Hill, 5th Edition, 2013.

Note: The latest edition of books should be referred.

4. Laboratory details

Laboratory experiments should be completed as per the given schedule. It is expected that a student does the same with full understanding of the concept, procedure and application involved.

Laboratory work will be based on above syllabus with minimum 12 experiments to be performed.

Sr. No.	Schedule*	List of Experiments	Mapped CO
1	Week1	Simulation and Analysis of Multipulse Converters using PSIM®/MATLAB®	1,2,3
2	Week2	Analyze and Evaluate Operation of Jones Chopper under Different Loading Conditions	1,2
3	Week3	Simulation and Analysis of Non Isolated Topologies of dc to dc Converters using PSIM®/MATLAB®	1,2,3
4	Week4	Simulation and Analysis of Isolated Topologies of dc to dc Converters using PSIM®/MATLAB®	1,2,3
5	Week5	(i) Analyze Gate Triggering Circuit of dc to dc Converter (ii) Analyze Operation of Buck Converter in Open Loop Condition	1,2
6	Week6	Simulation and Analysis of Single Phase Voltage Source Inverter using Single Pulse and Multiple Pulse Width Modulation Techniques in PSIM®/MATLAB®	1,2,3
7	Week7	Simulation and Analysis of Single Phase Full Bridge Inverter using SPWM (unipolar and bipolar) Techniques in PSIM®/MATLAB®	1,2,3

8	Week8	Simulation and Analysis of Three Phase Inverter for 120^0 and 180^0 Mode of Operation using PSIM®/MATLAB®	1,2,3
9	Week9	(i) Analyze and Evaluate Operation of Single Phase Half and Full Bridge Inverter using Single and Multi Pulse PWM (ii) Analyze and Evaluate Operation of Single Phase Full Bridge Inverter using Sinusoidal PWM	1,2
10	Week10	Analyze the Operation of Uninterrupted Power Supply (UPS) for Single Phase Operation	1,2
11	Week11	Analyze the operation of Three-phase inverter	1,2
12	Week12	Analyze the operation of boost rectifier with power factor correction	1,2

* Schedule is based on academic calendar.

5. Term assignments details

Tutorials – NA

Term Assignments: Two term assignments will be given to students for entire subject. First covers about choppers, linear power supplies and dc-dc converters. Second covers about inverters, resonance converters and application of converter. First assignment will be given in the first week of September and second will be given in first week of November. Each carry 15 marks so total 30 marks.

Note: Wherever other components like Term Assignments/Innovative Assignments/Term Papers are applicable, three-four line description about it to be mentioned including type of topics, expected work, assessment etc

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**			**LPW**		**SEE**
Component weightage	0.4 100 marks			0.2 100 marks		0.4 100 marks
	Class Test 30% (30marks)	Sessional Exam 40% (40marks)	Term Assignment 30% (30 marks)	Continuous Evaluation 75% (120 marks)	Viva Voce 25% (25 marks)	100 Marks (40%)

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 a 2 assignment. Each assignment carry 15 marks and at the end of the course, marks obtained out of 30 will be converted according to weightage assigned. Assessment of term assignment will be carried out based on parameters like originality and novelty in work (10 marks), involvement of the student (10 marks), timely submission neat and clean work(10 marks).

6.3 Assessment Policy for Laboratory and Project Work (LPW)

Assessment of Laboratory and Project Work comprises of two components.

1. Continuous assessment for laboratory experiments will be conducted. There will be 12 experiments, each carrying weightage of 10 marks. At the end of the course total marks obtained out of 120 will be converted according to weightage assigned. Assessment of Experiment will be carried out based on parameters like Completion of lab work file, understanding of the experiment performed, originality, involvement of the student, regularity, discipline etc. during the session.
2. A Viva voce examination for LPW component will be conducted as per academic calendar. It will carry a weightage of 25 marks.

6.4 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

Session	Topic	CO Mapped with Topic
Unit-1	**CHOPPERS**	
1	Introduction and principle of choppers	**1, 2, 3**
2	Various control strategies – Time ratio control and Current-limit control	**1, 2, 3**
3	Analysis of step up/step down chopper	**1, 2, 3**
4	Class A, B, C choppers	**1, 2, 3**
5	Class D & Class E chopper	**1, 2, 3**
6	Voltage commutated chopper	**1, 2, 3**
7	Current commutated chopper	**1, 2, 3**
Unit-2	**LINEAR POWER SUPPLY**	**1, 3**
8	Concept of series pass transistor in linear power supply	**1, 3**
9	Design of linear power supply without protection	**1, 3**
10	Design of linear power supply with protection	**1, 3**
11	Comparison between linear and switched mode power supply	**1, 3**
Unit-3	**SWITCHED MODE POWER SUPPLIES**	
12	Introduction and generation of duty cycle	**1, 2, 3**
13	Analysis of Buck converter	**1, 2, 3**
14	Analysis of Boost converter	**1, 2, 3**
15	Analysis of Buck-Boost Converter	**1, 2, 3**
16	Analysis of Buck-Boost Converter with non-idealities	**1, 2, 3**
17	Analysis of Cük Converter	**1, 2, 3**
18	Need of isolated converter	**1, 2, 3**
19	Analysis of Forward Converter	**1, 2, 3**
20	Analysis of Flyback Converter	**1, 2, 3**
21	Analysis of Push-Pull Converter	**1, 2, 3**
22	Analysis of Half Bridge Converter	**1, 2, 3**
23	Analysis of Full Bridge Converter	**1, 2, 3**
24	Examples on dc to dc converters	**1, 2, 3**
Unit-4	**INVERTERS and PWM TECHNIQUES**	
25	Need of inverter circuit in view of induction motor	**1, 2, 3**
26	Introduction, Concept of VSI and CSI, Principle of Operation	**1, 2, 3**

27	Single Phase Half Bridge and Full Bridge Configuration	**1, 2, 3**
28	Analysis of Various Waveforms of Single Phase Inverters	**1, 2, 3**
29	Three Phase Full Bridge Configuration for 180^0 Mode of Operation	**1, 2, 3**
30	Three Phase Full Bridge Configuration for 120^0 Mode of Operation	**1, 2, 3**
31	Analysis of Various Waveforms of Three Phase Inverters	**1, 2, 3**
32	Discussion on Selective Harmonic Elimination Technique	**1, 2, 3**
33	Analysis of Inverter with Selective Harmonic Elimination	**1, 2, 3**
34	Concept of quarter wave and half wave symmetry	**1, 2, 3**
35	Analysis of Inverter with Single and Multiple Pulse Width Modulation	**1, 2, 3**
36	Analysis of Inverter with Sinusoidal Pulse Width Modulation (Unipolar, Bipolar) Part-I	**1, 2, 3**
37	Analysis of Inverter with Sinusoidal Pulse Width Modulation (Unipolar, Bipolar) Part-II	**1, 2, 3**
38	Introduction to Space Vector Pulse Width Modulation Technique	**1, 2, 3**
Unit-5	**RESONANT CONVERTERS**	
39	Introduction and Analysis of Zero Voltage Switching Converter	**1, 2**
40	Analysis of Zero Current Switching Converter	**1, 2**
Unit-6	**VARIOUS POWER ELECTRONIC APPLICATIONS**	
41	Introduction and Various Types of Uninterrupted Power Supply	**1, 2, 3**
42	Photovoltaic Systems & Maximum power point tracking in photovoltaic system	**1, 2, 3**
43	Grid Connected Photovoltaic Systems	**1, 2, 3**
44	Grid Connected Wind Farm Systems	**1, 2, 3**
45	Analysis of Single Phase Active Rectifier	**1, 2, 3**
	Total	

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

Session No.	**Session Learning Outcomes:** **After successful completion of the session, student will be able to**	**CO**
1.	Understand importance, scope and policy of the course	
2.	**Understand** principle of choppers	1,2,3
3.	**Explain** Various control strategies – Time ratio control and Current-limit control	1,2,3
4.	**Build** step up/step down chopper	1,2,3

5.	**Interpret** Class A, B, C choppers	1,2,3
6.	**Compare** Class D & Class E chopper	1,2,3
7.	**Analyze** Voltage commutated chopper	1,2,3
8.	**Examine** Current commutated chopper	1,2,3
9.	**Construct** Concept of series pass transistor in linear power supply	1,3
10.	**Determine** linear power supply without protection	1,3
11.	**Distinguish** linear power supply with protection and without protectio	1,3
12.	**Demonstrate** linear and switched mode power supply	1,3
13.	**Categorize** generation of duty cycle	1,2,3
14.	**Understand** Analysis of Buck converter	1,2,3
15.	**Develop** the Boost converter	1,2,3
16.	**Relate** Buck-Boost Converter Circuit	1,2,3
17.	**Discuss** Buck-Boost Converter	1,2,3
18.	**Formulate** Buck-Boost Converter with non-idealities	1,2,3
19.	**Understand** the Analysis of Cük Converter	1,2,3
20.	**Build** Forward Converter	1,2,3
21.	**Select** Flyback Converter and its importance	1,2,3
22.	**Evaluate** Push-Pull Converter	1,2,3
23.	**Analyze** Half Bridge Converter	1,2,3
24.	**Identify** Full Bridge Converter	1,2,3
25.	**Understand** Need of inverter circuit in view of induction motor	1,2,3
26.	**Construct** VSI and CSI	1,2,3
27.	**Interpret** Single Phase Half Bridge and Full Bridge Configuration	1,2,3
28.	**Divide** Various Waveforms of Single Phase Inverters	1,2,3
29.	**Evaluate** Three Phase Full Bridge Configuration for 180^0 Mode of Operation	1,2,3
30.	**Identify** Three Phase Full Bridge Configuration for 120^0 Mode of Operation	1,2,3
31.	**Inspect** Waveforms of Three Phase Inverters	1,2,3
32.	**Criticize** Selective Harmonic Elimination Technique	1,2,3
33.	**Distinguish** quarter wave and half wave symmetry	1,2,3
34.	**Understand** Analysis of Inverter with Single and Multiple Pulse Width Modulation	1,2,3
35.	**Decide** Inverter with Sinusoidal Pulse Width Modulation (Unipolar, Bipolar) Part-I	1,2,3
36.	**Apply** Space Vector Pulse Width Modulation Technique	1,2,3
37.	**Elaborate** Zero Voltage Switching Converter	1,2
38.	**Judge** The Zero Current Switching Converter	1,2
39.	**Test** The Various Types of Uninterrupted Power Supply	1,2,3
40.	**Justify** Photovoltaic Systems	1,2,3
41.	**Explain** the Op-amp as comparator, zero crossing detector and Schmitt trigger	1,2,3
42.	**Examine** Maximum power point tracking in photovoltaic system	1,2,3
43.	**Discuss** Grid Connected Photovoltaic Systems	1,2,3
44.	**Infer** Grid Connected Wind Farm Systems	1,2,3
45.	**Formulate** Single Phase Active Rectifier	1,2,3

46.	**summarize** topics covered in the course and **express** the linkages with other course/'s	

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.
2. Tutorial: Emphasis will be on one to one interaction with students for clearing their doubts and problem solving.
3. Laboratory: Explanation of Experiment to be performed along with co-relation with theory will be given. At the end of each session assessment will be carried out based on parameters like completion of lab work that includes observations, calculations, graphs and conclusions, individuality and involvement of the student, regularity, discipline etc. Students will be quizzed to check their understanding of the experiment/exercise conducted.

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.

Activity 3 – solvation of logical thinking multiple choice question and numericals

Activity 4 – Simulation and design of power electronic converters

11. Course Material

Following course material is uploaded on the course blog website: https://ee504cbb.wordpress.com

- 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, tutorials, laboratory work, 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 and LPW 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.