INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad -500 043

ELECTRICAL AND ELECTRONICS ENGINEERING

COURSE DESCRIPTOR

Course Title	**POWER ELECTRONICS**				
Course Code	**AEE010**				
Programme	**B.Tech**				
Semester	**V**	**EEE**			
Course Type	**Core**				
Regulation	**IARE - R16**				
Course Structure	**Theory**			**Practical**	
	Lectures	**Tutorials**	**Credits**	**Laboratory**	**Credits**
	3	1	4	3	2
Chief Coordinator	Mr. S. Srikanth, Assistant Professor				
Course Faculty	Dr. T. Devaraju, Professor Mr. S. Srikanth, Assistant Professor				

I. COURSE OVERVIEW:

Power Electronics course introduces the basic concepts of power semiconductor devices and power converters which is the foundation for power transmission, distribution and utilization of the Electrical Engineering discipline. The course deals with the basic analysis of ac-dc, dc-ac, dc-dc, ac-ac converters.

II. COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
UG	AEC001	III	Electronic devices and circuits	4
	AEE001	II	Electrical Circuits	4

III. MARKS DISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total marks
Power electronics	70 Marks	30 Marks	100

IV. DELIVERY / INSTRUCTIONAL METHODOLOGIES:

√	Chalk & talk	√	Quiz	√	Assignments	X	Moocs
√	LCD/ PPT	√	Seminars	X	Mini project	X	Videos
X	Open ended experiments						

V. EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into five units and each unit carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each unit. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.

The emphasis on the questions is broadly based on the following criteria:

50 %	To test the objectiveness of the concept.
50 %	To test the analytical skill of the concept OR to test the application skill of the concept.

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks (Table 1), with 25 marks for Continuous Internal Examination (CIE), 05 marks for Quiz/ Alternative Assessment Tool (AAT).

Table 1: Assessment pattern for CIA

Component	**Theory**		**Total marks**
Type of Assessment	CIE Exam	Quiz / AAT	
CIA Marks	25	05	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8th and 16th week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration consisting of two parts. Part–A shall have five compulsory questions of one mark each. In part–B, four out of five questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz / Alternative Assessment Tool (AAT):
Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are be answered by choosing the correct answer from a given set of choices (commonly four). Marks shall be awarded considering the average of two quizzes for every course. The AAT may include seminars, assignments, term paper, open ended experiments, five minutes video and MOOCs.

VI. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes		**Level**	**Proficiency assessed by**
PO1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2	Laboratory Practice

Program Outcomes		Level	Proficiency assessed by
PO2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	3	Seminar
PO3	**Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.	2	Laboratory Practice
PO4	**Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	3	Seminar

3= High; 2 = Medium; 1 = Low

VII. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes		Level	Proficiency assessed by
PSO1	**Professional Skills:** Able to utilize the knowledge of high voltage engineering in collaboration with power systems in innovative, dynamic and challenging environment, for the research based team work.	2	Paper presentation
PSO2	**Problem-Solving Skills:** To explore the scientific theories, ideas, methodologies and the new cutting edge technologies in renewable energy engineering, and use this erudition in their professional development and gain sufficient competence to solve the current and future energy problems universally.	2	Seminar
PSO3	**Successful Career and Entrepreneurship:** To be able to utilize of technologies like PLC, PMC, process controllers, transducers and HMI and design, install, test, maintain power systems and industrial applications.	-	--------

3= High; 2 = Medium; 1 = Low

VIII. COURSE OBJECTIVES:

The course should enable the students to:	
I	Integrate the revolutionary development in power transmission, distribution and utilization with the advent of semiconductor devices.
II	Demonstrate rectifiers, choppers and various schemes of pulse width modulated inverters.
III	Explain AC voltage converters and cycloconverters.
IV	Outline complete range of power supplies, including switched mode regulators and applications

IX. COURSE OUTCOMES (COs):

COs	Course Outcome	CLOs	Course Learning Outcome
CO 1	Describe the characteristics of basic elements, turn on and turn off methods of SCR, protection, ratings of SCRs and series parallel operations of SCRs.	CLO 1	Understand the characteristics of basic elements of power electronics
		CLO 2	Discuss various turn on and turn off methods of Silicon controlled rectifier
		CLO 3	Describe the protection and ratings of thyristors
		CLO 4	Apply the series parallel operations of thyristors

COs	Course Outcome	CLOs	Course Learning Outcome
CO 2	Discuss the operation of single phase, three phase rectifiers and single phase, three phase dual converters.	CLO 5	Analyze the operation of single phase and three phase rectifiers with different loads
		CLO 6	Describe the operation of single phase and three phase dual converter
CO 3	Analyze the principle of operation of AC voltage controllers and cycloconverters	CLO 7	Understand the principle of operation of AC voltage controller and modes of operation
		CLO 8	Compute input power factor, total harmonic distortion of various input and output waveforms of AC voltage controllers
		CLO 9	Describe the principle of operation and classification of cycloconverters
CO 4	Discuss the principle of operation of chopper, classification of choppers, AC chopper and switched mode regulators	CLO 10	Understand the principle of operation and control strategies of chopper
		CLO 11	Describe the classification of choppers
		CLO 12	Analyze the importance of AC chopper and switched mode regulators
CO 5	Describe the operation of series, parallel inverters, single phase inverters, three phase inverters, voltage source inverters and current source inverters	CLO 13	Discuss the principle of operation of series and parallel inverters
		CLO 14	Understand the principle of operation of three phase inverters with different modes of operation
		CLO 15	Analyze the principle of operation of voltage source inverters and current source inverters

X. COURSE LEARNING OUTCOMES:

Students, who complete the course, will have demonstrated the ability to do the following:

CLO Code	CLO's	At the end of the course, the student will have the ability to:	PO's mapped	Strength of mapping
AEE010.01	CLO 1	Understand the characteristics of basic elements of power electronics	PO1	2
AEE010.02	CLO 2	Discuss various turn on and turn off methods of Silicon controlled rectifier	PO1, PO3	2
AEE010.03	CLO 3	Describe the protection and ratings of thyristors	PO3	2
AEE010.04	CLO 4	Apply the series parallel operations of thyristors	PO2, PO3	3
AEE010.05	CLO 5	Analyze the operation of single phase and three phase rectifiers with different loads	PO2	3
AEE010.06	CLO 6	Describe the operation of single phase and three phase dual converter	PO1, PO4	2
AEE010.07	CLO 7	Understand the principle of operation of AC voltage controller and modes of operation	PO2, PO4	2
AEE010.08	CLO 8	Compute input power factor, total harmonic distortion of various input and output waveforms of AC voltage controllers	PO3	3
AEE010.09	CLO 9	Describe the principle of operation and classification of cycloconverters	PO1, PO2	2
AEE010.10	CLO 10	Understand the principle of operation and control strategies of chopper	PO2, PO3	2
AEE010.11	CLO 11	Describe the classification of choppers	PO1, PO4	2
AEE010.12	CLO 12	Analyze the importance of AC chopper and switched mode regulators	PO3	3
AEE010.13	CLO 13	Discuss the principle of operation of series and parallel inverters	PO1, PO2	3

CLO Code	CLO's	At the end of the course, the student will have the ability to:	PO's mapped	Strength of mapping
AEE010.14	CLO 14	Understand the principle of operation of three phase inverters with different modes of operation	PO3, PO4	3
AEE010.15	CLO 15	Analyze the principle of operation of voltage source inverters and current source inverters	PO1, PO4	2
AEE010.16	CLO 16	Apply the concept of power electronics and converters to solve real time world applications	PO2, PO3	3
AEE010.17	CLO 17	Explore the knowledge and skills of employability to succeed in national and international level competitive examinations	PO3, PO4	2

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XI. MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES

Course Outcomes (COs)	Program Outcomes (POs)					
	PO 1	PO 2	PO 3	PO 4	PSO1	PSO2
CO 1	2	1	3		2	1
CO 2	2	2		2	1	2
CO 3	1	2	2		1	1
CO 4	1	1	2	1	1	1
CO 5	2	1	1	1	2	2

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XII. MAPPING COURSE LEARNING OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

CLOs	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CLO 1	2												2		
CLO 2	2		3										2	2	
CLO 3			2												
CLO 4		2	3												
CLO 5		2											2	3	
CLO 6	2			2											
CLO 7		2		2											
CLO 8			3											2	
CLO 9	2	2											2		
CLO 10		2	2												
CLO 11	2			2									2	2	
CLO 12			3											3	
CLO 13	2	3													
CLO 14			3	2									2	3	

CLOs	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CLO 15	2			2											
CLO 16		2	3												
CLO 17			3	2									2	2	

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XIII. ASSESSMENT METHODOLOGIES – DIRECT:

CIE Exams	PO1 PO2 PO3 PO4 PSO1	SEE Exams	PO1 PO2 PO3 PO4 PSO1 PSO2	Assignments	PO1 PO2 PO3 PO4 PSO1 PSO2	Seminars	PO1 PO2 PO3 PO4 PSO2
Laboratory practices	PO3 PO4	Student viva	PO1 PO2 PO3 PO4 PSO1	Mini project	-	Certification	-
Term paper	-						

XIV. ASSESSMENT METHODOLOGIES – INDIRECT:

✔	Early Semester Feedback	✔	End Semester OBE Feedback
✘	Assessment of Mini Projects by Experts		

XV. SYLLABUS:

UNIT - I	POWER SEMICONDUCTOR DEVICES AND COMMUTATION CIRCUITS
Power semiconductor devices and commutation circuits: Thyristors, principle of operation of silicon controlled rectifiers (SCR), bipolar junction transistor (BJT), power metal oxide semiconductor filed effect transistor (MOSFET), power insulated gate bipolar transistor (IGBT), gate turnoff thyristor (GTO) and characteristics, turn on and turnoff methods, dynamic characteristics of SCR, two transistor analogy, unijunction transistor firing circuit, series and parallel operation of SCR's, design of snubber circuit; Specifications and ratings: Ratings of SCR, BJT and IGBT, line commutation and forced commutation circuits, numerical problems.	
UNIT - II	**SINGLE PHASE AND THREE PHASE CONTROLLED RECTIFIERS**
AC - DC converters: Phase control technique, single phase line commutated converters, midpoint and bridge connections, half controlled converters and semi converters with R, RL and RLE loads, derivation of average load voltage and current, active and reactive power inputs to the converters without and with freewheeling diode, numerical problems; Fully controlled converters: Midpoint and bridge connections with R, RL loads and RLE load, derivation of average load voltage and current, line commutated inverters, active and reactive power inputs to the converters without and with freewheeling diode, derivation of load voltage and current, numerical problems; Three phase converters: Three pulse and six pulse converters, midpoint and bridge connections, average load voltage with R and RL loads, effect of source inductance, operation of single phase and three phase dual converters, numerical problems.	
UNIT – III	**AC VOLTAGE CONTROLLERS AND CYCLOCONVERTERS**
AC - AC controllers: Introduction, single phase two SCR's in anti-parallel, with R and RL loads, modes of operation of triac, triac with R and RL loads, derivation of RMS load voltage, current and power factor, wave forms, numerical problems; Cycloconverters: Principle of operation of single phase midpoint and bridge type cycloconverters with resistive and inductive loads, continuous and discontinuous mode of operation.	
UNIT - IV	**DC – DC CONVERTERS**
DC - DC converters: Principle of operation of choppers, time ratio control and current limit control strategies, types of choppers, derivation of load voltage and currents with R, RL and RLE loads, AC	

chopper, problems; Switched mode regulators: Study of buck, boost and buck - boost regulators, Cuk regulators.	
UNIT - V	**INVERTERS**
DC - AC converters: Single phase inverter, basic series inverter, parallel inverter, operation and waveforms, voltage source inverter (VSI), three phase inverters 180, 120 degrees conduction modes of operation, voltage control techniques for inverters, pulse width modulation techniques, reduction of harmonics, current source inverter (CSI) with ideal switches, capacitor commutated type CSI, numerical problems.	
Text Books:	
1. M D Singh, K B Kanchandhani, "Power Electronics", Tata Mc Graw Hill Publishing Company, 2nd Edition, 1998. 2. Dr. P S Bimbhra, "Power Electronics", Khanna Publishers, 5th Edition, 2012. 3. Ned Mohan, Tore M Undeland, William P Robbins, "Power Electronics: Converters, Applications, and Design", 3rd Edition, John Wiley and sons, 2002. 4. M H Rashid, "Power Electronics, Circuits, Devices and Applications", Pearson, 3rd Edition, 2001.	
Reference Books:	
1. Vedam Subramanyam, "Power Electronics", New Age International Limited, 2nd Edition, 2006. 2. P C Sen, "Power Electronics", Tata McGraw-Hill Publishing, 1st Edition, 1987. 3. G K Dubey, S R Doradra, A Joshi, R M K Sinha, "Thyristorised Power Controllers", New Age International Limited, 2nd Edition, 2008. 4. V R Moorthi, "Power Electronics Devices", Oxford University Press, 4th Edition, 2005.	

XVI. COURSE PLAN:

The course plan is meant as a guideline. There may probably be changes.

Lecture No	Topics to be covered	Course Learning Outcomes (CLOs)	Reference
1.	Describe the basic elements of power electronics and devices	CLO1	T2: 1.1 R2: 1.1
2.	Understand the Thyristors (SCR's) characteristics	CLO1	T2: 4.1 R2: 1.6
3.	Discuss the Two transistor analogy of SCR	CLO1	T2: 4.2 R2: 1.6
4.	Realize the theory of operation of SCR and Turn on methods	CLO2	T2: 5.1 R2: 1.7
5.	Describe turn off method of SCR class A and Class B commutation	CLO2	T2: 5.3 R2: 1.7
6.	Analyze the turn off method of SCR class C and Class D commutation	CLO2	T2: 5.5 R2: 1.7
7.	Understand turn off method of SCR class E and natural commutation	CLO2	T2: 4.3 R2: 1.7
8.	Discuss the Dynamic characteristics of SCR	CLO1	T2: 4.5 R2: 1.7.1
9.	Describe the operation of UJT firing circuit	CLO2	T2: 4.12 R2: 1.15
10.	Understand the operation Series and parallel connections of SCR's	CLO4	T2: 4.9 R2: 1.8
11.	Analyze the numerical problems on Series and parallel connections of SCR's	CLO4	T2: 4.9 R2: 1.10
12.	Design the Snubber circuit for SCR	CLO3	R2: 2.7
13.	Discuss the characteristics of BJT and Power MOSFET	CLO1	T2: 2.3 R2: 1.4
14.	Understand the characteristics of Power IGBT and GTO	CLO1	T2: 2.5 R2: 1.4
15.	Describe the specifications and ratings: Ratings of SCR, BJT and IGBT	CLO1	T2: 4.6 R2: 1.4

Lecture No	Topics to be covered	Course Learning Outcomes (CLOs)	Reference
16.	Discuss the fundamentals of phase controlled rectifiers (1ph)	CLO5	T2: 6.1 R2: 5.1
17.	Understand the operation of half converter with R and RL loads	CLO5	T2:6.1.1
18.	Realize the operation of Half controlled converters with RLE load	CLO5	T2: 6.1.2 R2: 5.1.2
19.	Analyze the numerical problems on half controlled converters	CLO5	T2: 6.1.2 R2: 5.1.2
20.	Describe the operation of fully controlled converters with Resistive load	CLO5	T2: 6.3.1 R2: 5.2
21.	Understand the operation of fully controlled converter with RL and RLE loads	CLO5	T2: 6.3.2 R2: 5.4
22.	Derive Active and Reactive power equation for Line commutated converters	CLO5	T2: 6.3.2 R2: 5.4
23.	Describe the Effect of source inductance on converter	CLO5	T2: 6.7.1 R2:5.5
24.	Analyze the numerical problems on fully controlled converters	CLO5	T2: 6.9 R2:5.4
25.	Understand fundamentals, phase controlled rectifiers (3ph) and line commutated inverters	CLO5	T2: 6.5 R2:6.1
26.	Realize the operation of 3-ph Half controlled converters with Resistive RL load and necessary derivations for analysis	CLO5	T2: 6.6.2 R2: 6.1
27.	Analyze the numerical problems on three phase half controlled converters	CLO5	T2: 6.6.2 R2:6.1
28.	Explain the operation of 3-ph fully controlled converters with R & RL load and necessary derivations	CLO5	T2: 6.6.3 R2: 6.4
29.	Discuss the operation of 3-ph full controlled converters with RLE load and necessary derivations	CLO5	T2: 6.6.3 R2: 6.4
30.	Understand the Effect of source inductance	CLO5	T2: 6.7.2 R2: 4.11
31.	Describe the introduction to Dual Converters	CLO6	T2: 6.8 R2: 6.11
32.	Explain the operation of single phase and three phase dual converter operation	CLO6	T2: 6.9 R2: 6.11
33.	Analyze the AC-AC converters: AC voltage controllers	CLO7	T2: 9.1 R2: 8.1
34.	Understand the principle of operation of single phase AC voltage controller	CLO7	T2: 9.2 R2: 8.5
35.	Describe principle of operation of single phase AC voltage controller	CLO7	T2: 9.3 R2: 8.4
36.	Explain the Modes of operation of Triac	CLO7	T2: 9.3.2 R2: 8.12
37.	Analyze the numerical problems on AC voltage controller	CLO8	T2: 9.3.2 R2: 8.4
38.	Discuss the principle of operation and control strategies of Cyclo converters	CLO9	T2: 10.1 R2: 9.41
39.	Understand the principle of operation of Single phase midpoint Cyclo converters with resistive load	CLO9	T2: 10.1.1 R2: 9.42
40.	Describe the principle of operation of Single phase Cyclo converter Bridge configuration Waveforms	CLO9	T2: 10.1.2 R2: 9.42.1
41.	Analyze the numerical problems on cyclo converters	CLO9	T2: 10.1.2 R2: 9.42.2
42.	Explain the principle and control strategies of choppers	CLO10	T2: 7.1 R2: 9.40
43.	Realize the operation of Step down choppers	CLO10	T2: 7.2 R2: 9.40.1

Lecture No	Topics to be covered	Course Learning Outcomes (CLOs)	Reference
44.	Describe the operation of Step up choppers	CLO10	T2: 7.3 R2: 9.40.2
45.	Discuss the operation of class A chopper	CLO11	T2: 7.4.1 R2: 9.40.3
46.	Understand the operation of class B and class C chopper	CLO11	T2: 7.4.2 R2: 9.40.4
47.	Describe the operation of class D and class E chopper	CLO11	T2: 7.4.4 R2: 9.40.5
48.	Analyze the numerical problems on choppers	CLO11	T2: 7.7 R2: 9.40.1
49.	Describe the switched mode regulators	CLO12	T2: 7.6 R2: 10.3
50.	Discuss the switched mode regulators	CLO12	T2: 7.6.2 R2: 10.4
51.	Analyze the numerical problems on choppers	CLO11	T2: 7.5 R2: 10.5
52.	Analyze 1ph inverter (DC-AC Converter)	CLO13	T2: 8.1.1 R2: 9.1
53.	Understand the operation of single phase full bridge inverter and series inverter	CLO13	T2: 8.9 R2: 9.2
54.	Discuss the operation of parallel Capacitor inverter	CLO13	T2: 8.10 R2: 9.6
55.	Describe the operation of Three phase Voltage source inverter	CLO14	T2: 8.4.1 R2: 9.32
56.	Explain the operation of Three phase Voltage source inverter	CLO14	T2: 8.4.2 R2: 9.33
57.	Understand the Voltage control and PWM techniques for inverters	CLO14	T2: 8.5 R2: 9.36
58.	Explain the operation of sinusoidal pulse width modulation	CLO15	T2: 8.6.3 R2: 9.37
59.	Describe the operation of current source inverter with ideal switches	CLO15	T2: 8.8.1 R2: 9.38
60.	Understand the operation of commutated type CSI	CLO15	T2: 8.8.2 R2: 9.17

XVII. GAPS IN THE SYLLABUS - TO MEET INDUSTRY / PROFESSION REQUIREMENTS:

S. No	Description	Proposed actions	Relevance with POs	Relevance with PSOs
1	Gate characteristics and different gating schemes	Discussions	PO2, PO4	PSO2
2	R and RC triggering circuits of SCR	Discussions	PO2, PO4	PSO2
3	Jones and Morgan chopper	Discussions	PO2, PO4	PSO1

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