Techno India NJR Institute of Technology

Course File

Power Electronics (4EE4-06)

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Syllabus:

RAJASTHAN TECHNICAL UNIVERSITY, KOTA

SYLLABUS

2nd Year - IV Semester: B.Tech. (Electrical Engineering)

4EE4-06: Power Electronics

Credit: 3 **Max. Marks: 150(IA:30, ETE:120)**

3L+0T+0P **End Term Exam: 3 Hours**

SN	CONTENTS	Hours
1	**Introduction:** Objective, scope and outcome of the course.	1
2	**Power switching devices** Diode, Thyristor, MOSFET, IGBT: I-V Characteristics; Firing circuit for thyristor; Voltage and current commutation of a thyristor; Gate drive circuits for MOSFET and IGBT.	5
3	**Thyristor rectifiers** Single-phase half-wave and full-wave rectifiers, Single-phase full-bridge thyristor rectifier with R-load and highly inductive load; Three-phase full-bridge thyristor rectifier with R-load and highly inductive load; Input current wave shape and power factor.	6
4	**DC-DC buck converter** Elementary chopper with an active switch and diode, concepts of duty ratio and average voltage, power circuit of a buck converter, analysis and waveforms at steady state, duty ratio control of output voltage.	5
5	**DC-DC boost converter** Power circuit of a boost converter, analysis and waveforms at steady state, relation between duty ratio and average output voltage.	5
6	**Single-phase voltage source inverter** Power circuit of single-phase voltage source inverter, switch states and instantaneous output voltage, square wave operation of the inverter, concept of average voltage over a switching cycle, bipolar sinusoidal modulation and unipolar sinusoidal modulation, modulation index and output voltage.	10
7	**Three-phase voltage source inverter** Power circuit of a three-phase voltage source inverter, switch states, instantaneous output voltages, average output voltages over a sub-cycle, three-phase sinusoidal modulation.	8
	Total	40

Course Overview:

The course discusses power processing electronic circuits like rectifiers, AC voltage controllers, Frequency converters, DC-DC converters and inverters apart from introducing the basics of power semiconductor devices like SCRs, power BJTs, IGBTs and MOSFETs in this 40-hours course. The analysis of these power circuits are presented in detail along with the waveforms and control techniques. Finally, applications of power electronic technology in generation sector, transmission sector and also in day-to-day applications like battery charger, motor drives, power supplies are described.

This course will make the student ready to solve the power and energy sector problems. Also, brigs opportunities from renewable energy sector. Students will be able to solve for the steady-state voltages and currents of step-down, step-up, inverting, and other power converters and knows how to derive an averaged equivalent circuit model and solve for the converter efficiency

Course Outcome:

CO. NO.	Cognitive Level	Course Outcome
1	Synthesis	Student will be able to select of modern power electronic devices based on the basic principle of operation of various power-electronic circuits.
2	Synthesis	Student will be able to understand the fundamental principles involved in the operation of power electronic switches and the different methods to control them.
3	Analysis	Students will be able to analyze and compare different types of phase-controlled single phase and three phase converters along with necessary protective circuits for application in different domains of engineering.
4	Application	Students will be able to use research-based knowledge for design of DC-DC converter and inverter and manipulate the load for response analysis. .
5	Application	Students will be able to Power circuit of a three-phase voltage source inverter, manipulate the load for response.

Prerequisites:

1. Basic Electrical Engineering, Circuit theory, signals and systems
2. Fundamentals of basic circuit elements and their properties.
3. Students should be efficient in applying basic laws of circuit analysis.
4. Students should be proficient in solving algebraic equations.
5. Students should be proficient in drawing waveforms.

Course Outcome Mapping with Program Outcome:

Course Outcome	Program Outcomes (PO's)											
CO. NO.	Domain Specific (PSO)					Domain Independent (PO)						
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	1	1	1	-	-	-	-	-	-	-
CO2	1	2	1	2	-	-	-	-	-	-	-	-
CO3	1	1	2	1	1	-	-	-	-	-	-	-
CO4	2	1	1	2	1	-	-	-	-	-	-	-
CO5	1	1	2	2	1	-	-	-	-	-	-	-
1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High)												

Course Coverage Module Wise:

Lect. No.	Unit	Topic
1	**1**	**INTRODUCTION** Objective, scope and outcome of the course.
2	**2**	POWER SWITCHING DEVICES DIODE, THYRISTOR,
3	2	MOSFET, IGBT:
4	2	I-V Characteristics; Firing circuit for thyristor;
5	2	Voltage and current commutation of a thyristor
6	2	Gate drive circuits for MOSFET and IGBT
7	2	Gate drive circuits for MOSFET and IGBT
8	3	**THYRISTOR RECTIFIERS** Single-phase half-wave and full-wave rectifiers
9	3	Thyristor rectifiers Single-phase half-wave and full-wave rectifiers
10	**3**	Phase full bridge thyristor rectifier with R-load
11	3	Highly inductive load;
12	3	Three-phase full-bridge thyristor rectifier with R-load
13	3	Highly inductive load;
14	3	Input current wave shape and power factor
15	**4**	**DC-DC BUCK CONVERTER** Elementary chopper with an active switch & diode
16	4	Concepts of duty ratio
17	4	Average voltage,
18	4	Power circuit of a buck converter
19	4	Power circuit of a buck converter
20	4	Analysis and waveforms at steady state
21	4	Analysis and waveforms at steady state
22	4	Duty ratio control of output voltage.
23	4	Duty ratio control of output voltage
24	**5**	**DC-DC BOOST CONVERTER** Power circuit of a boost converter,
25	5	DC-DC boost converter Power circuit of a boost converter,
26	5	Analysis and waveforms at steady state
27	5	Analysis and waveforms at steady state
28	5	Relation between duty ratio and average output voltage.

29	5	Relation between duty ratio and average output voltage.
30	**6**	**SINGLE-PHASE VOLTAGE** Source Inverter
31	6	Power circuit of single-phase voltage source inverter
32	6	Switch states and instantaneous output voltage
33	6	Square wave operation of the inverter
34	6	Concept of average voltage over a switching cycle
35	6	Concept of average voltage over a switching cycle
36	6	Bipolar sinusoidal modulation
37	6	Unipolar sinusoidal modulation
38	6	Unipolar sinusoidal modulation
39	6	Modulation index
40	6	Modulation index and output voltage.
41	**7**	**THREE-PHASE VOLTAGE** Source Inverter
42	7	Power circuit of a three-phase voltage source inverter
43	7	Power circuit of a three-phase voltage source inverter
44	7	Switch states
45	7	Instantaneous output voltages
46	7	Average output voltages over a sub-cycle, three-phase sinusoidal modulation.
47	7	Average output voltages over sub-cycle, three-phase sinusoidal modulation.
48		Revision to course work.

Text/Reference Books:

1. M. D. Singh and K. B. Khanchandani: Power Electronics 2/e, MGH. 2008
2. M. H. Rashid: Power Electronics, Circuits Devices and Applications, Pearson. 2011
3. V. R. Moorthi: Power Electronics-Devices, Circuits and Industrial Applications, Oxford. 2005
4. Theodore Wildi: Electrical Machines, Drives and Power Systems, Pearson. 2007
5. Ned Mohan: Power Electronics, John Wiley. 2013

Teaching and Learning resources:

NPTEL Course Link	https://nptel.ac.in/courses/108/102/108102145/
Quiz	https://quizizz.com/admin/quiz/5c9480fa0d3459001a4e41c7/power-electronics
Notes	http://www.svecw.edu.in/Docs%5CEEEPELNotes2013.pdf https://sites.google.com/site/eeenotes2u/courses/power-electronics

Assessment Methodology:

1. Assignments one from each unit.
2. Midterm subjective paper where they have to solve the given problem. (Twice during the semester)
3. Final paper at the end of the semester subjective

Previous Year Question Paper

4E1227

Roll No.

Total No of Pages: 4

4E1227

B. Tech. IV - Sem. (Main) Exam., May - 2019
PCC Electrical Engineering
4EE4 – 06 Power Electronics
EE, EX

Time: 3 Hours

Maximum Marks: 120

Instructions to Candidates:

Attempt all ten questions from Part A, five questions out of seven questions from Part B and four questions out of five from Part C.

Schematic diagrams must be shown wherever necessary. Any data you feel missing may suitably be assumed and stated clearly. Units of quantities used /calculated must be stated clearly.

Use of following supporting material is permitted during examination. (Mentioned in form No. 205)

1. NIL

2. NIL

PART – A

(Answer should be given up to 25 words only) **[10×2=20]**

All questions are compulsory

Q.1 Explain the safe operating areas of an IGBT.

Q.2 What do you mean by commutation of SCR? What are the different classes of forced commutation method?

Q.3 Explain the effect of freewheeling diode. Also justify the statement "Freewheeling diode improves the power factor of the system."

Q.4 Explain the working of single phase fully controlled bridge converter in rectifying mode.

Q.5 Why forced commutation is necessary for Chopper?

Q.6 What are the merits and demerits of voltage commutated chopper?

Q.7 Explain the time ratio control and current limit control of chopper.

Q.8 What are the differences between Series inverter and Parallel inverter?

Q.9 How are inverters classified?

Q.10 Explain 3-d current source inverters.

PART – B

(Analytical/Problem solving questions) [5×8=40]

Attempt any five questions

Q.1 A SCR has a V_g - I_g characteristics given as $V_g = 1.5 + 8\ I_g$. In a certain application, the gate voltage consists of rectangular pulses of 12V and of duration 50μs with duty cycle 0.2 –

(i) Find the value of R_g series resistor in gate circuit to limit the Peak Power dissipation in the gate to 5W.

(ii) Calculate the average power dissipation in the gate.

Q.2 A full wave full converter is having RE load (R = 100Ω, E = 50V). Determine the current through 100Ω load, if the thyristors are triggered at 30°. The converter is connected to a 20V 50Hz source. **http://rtuonline.com**

Q.3 A Chopper circuit is operating on TRC principle at a frequency of 1 kHz on a 220V d.c supply. If the load voltage is 180V, calculate the conducting and blocking period of thyristor in each cycle.

Q.4 A buck boost converter is operated from a 24V battery and supplies an average load current of 2A. Its switching frequency is 50 kHz. Neglecting diode and switch drop, determine:

(i) Range of duty – cycle variation required to maintain the output voltage at 15V given that the battery voltage ranges from 26V in the fully charged state to 21V in the discharged state.

(ii) The Peak to Peak Choke ripple current for the nominal supply voltage given that the choke value is 500μH.

Q.5 The single phase half bridge inverter has a resistive load of 10Ω and the center tap dc input voltage is 96V. Compute-

(i) RMS value of the output voltage.

(ii) Fundamental component of the output voltage waveform.

(iii) First five harmonics of the output voltage waveform.

(iv) Fundamental Power consumed by the load.

(v) RMS Power consumed by the load.

Q.6 Design a single phase parallel inverter to feed a load at 220V, 50Hz and Peak load current is 2A.

V_{dc} = 40V, Specify the ratings of commutating component.

Q.7 For a three phase bridge inverter operating in 120° conduction mode, determine:

(i) dc voltage for a fundamental line voltage of 415V

(ii) rms line and phase voltage

(iii) Device voltage rating

PART – C

(Descriptive/Analytical/Problem Solving/Design Questions) **[4×15=60]**

Attempt any four questions

Q.1 (a) Explain the working of SCR on the basis of two transistor analogy.

(b) In brief explain turn – on and turn – off switching characteristics of IGBT.

Q.2 A three phase bridge rectifier using diodes, delivers power to a load of R = 10Ω at a dc voltage of 400V. Determine the ratings of the diodes and of the three phase delta – star transformer when TUF = 0.9541.

Q.3 (a) With the help of circuit diagram, explain the working of Step up / Step down Chopper.

(b) Enumerate the merits and demerits of load commutated chopper.