

SEMESTER 4

ELECTRICAL AND ELECTRONICS ENGINEERING

FOURTH SEMESTER (January-June)

Sl. No:	Slot	Course Code	Course Type	Course Category	Course Title (Course Name)	Credit Structure				SS	Total Marks		Credits	Hrs./ Week
						L	T	P	R		CIA	ESE		
1	A	GBMAT401	BSC	GC	MATHEMATICS FOR ELECTRICAL SCIENCE- 4	3	0	0	0	4.5	40	60	3	3
2	B	PC EET402	PC	PC	SYNCHRONOUS & INDUCTION MACHINES	3	1	0	0	5	40	60	4	4
3	C	PC EET403	PC	PC	POWER ELECTRONICS AND DRIVES	3	1	0	0	5	40	60	4	4
4	D	PB EET404	PC-PBL	PB	DIGITAL ELECTRONICS	3	0	0	1	5.5	60	40	4	4
5	E	PEXXT41N	PE	PE	PE-1	3	0	0	0	4.5	40	60	3	3
6	G	UCHUT346	HMC*	UC	Economics for Engineers	2	0	0	0	3	50	50	2	2
7	L	PC EEL407	PCL	PC	DC MACHINES & TRANSFORMERS LAB	0	0	3	0	1.5	50	50	2	3
8	Q	PC EEL408	PCL	PC	POWER ELECTRONICS AND DRIVES LAB	0	0	3	0	1.5	50	50	2	3
9	R/M/H		VAC		Remedial/Minor/Honours Course	3	1	0	0	5			4*	4*
Total											31/ 36		24/ 28*	26/ 30*

SEMESTER S4
MATHEMATICS FOR ELECTRICAL SCIENCE– 4
(B Group)

Course Code	GBMAT401	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	Basic calculus	Course Type	Theory

Course Objectives:

1. To familiarize students with the foundations of probabilistic and statistical analysis mostly used in varied applications in engineering and science.
2. To expose the students to the basics of random processes essential for their subsequent study of analog and digital communication.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Random variables, Discrete random variables and their probability distributions, Cumulative distribution function, Expectation, Mean and variance, Binomial distribution, Poisson distribution, Poisson distribution as a limit of the binomial distribution, Joint pmf of two discrete random variables, Marginal pmf, Independent random variables, Expected value of a function of two discrete variables. [Text 1: Relevant topics from sections 3.1 to 3.4, 3.6, 5.1, 5.2]	9
2	Continuous random variables and their probability distributions, Cumulative distribution function, Expectation, Mean and variance, Uniform, Normal and Exponential distributions, Joint pdf of two Continuous random variables, Marginal pdf, Independent random variables, Expectation value of a function of two continuous variables. [Text 1: Relevant topics from sections 3.1, 4.1, 4.2, 4.3, 4.4, 5.1, 5.2]	9

3	Confidence Intervals, Confidence Level, Confidence Intervals and One-side confidence intervals for a Population Mean for large and small samples (normal distribution and t -distribution), Hypotheses and Test Procedures, Type I and Type II error, z Tests for Hypotheses about a Population Mean (for large sample), t Test for Hypotheses about a Population Mean (for small sample), Tests concerning a population proportion for large and small samples. [Text 1: Relevant topics from 7.1, 7.2, 7.3, 8.1, 8.2, 8.3, 8.4]	9
4	Random process concept, classification of process, Methods of Description of Random process, Special classes, Average Values of Random Process, Stationarity- SSS, WSS, Autocorrelation functions and its properties, Ergodicity, Mean-Ergodic Process, Mean-Ergodic Theorem, Correlation Ergodic Process, Distribution Ergodic Process. [Text 2: Relevant topics from Chapter 6]	9

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Micropj	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
<ul style="list-style-type: none"> • 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks <p style="text-align: center;">(8x3 =24marks)</p>	<ul style="list-style-type: none"> • Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. <p style="text-align: center;">(4x9 = 36 marks)</p>	60

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Understand the concept, properties and important models of discrete random variables and to apply in suitable random phenomena.	K3
CO2	Understand the concept, properties and important models of continuous random variables and to apply in suitable random phenomena.	K3
CO3	Estimate population parameters, assess their certainty with confidence intervals, and test hypotheses about population means and proportions using z -tests and the one-sample t -test.	K3
CO4	Analyze random processes by classifying them, describing their properties, utilizing autocorrelation functions, and understanding their applications in areas like signal processing and communication systems.	K3

Note: *K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	-	-	-	-	-	-	-	2
CO2	3	3	2	2	-	-	-	-	-	-	-	2
CO3	3	3	2	2	-	-	-	-	-	-	-	2
CO4	3	3	2	2	-	-	-	-	-	-	-	2

Text Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Probability and Statistics for Engineering and the Sciences	Devore J. L	Cengage Learning	9 th edition, 2016
2	Probability, Statistics and Random Processes	T Veerarajan	The McGraw-Hill	3 rd edition, 2008

Reference Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Probability, Random Variables and Stochastic Processes,	Papoulis, A. & Pillai, S.U.,	McGraw Hill.	4 th edition, 2002
2	Introduction to Probability and Statistics for Engineers and Scientists	Ross, S. M.	Academic Press	6 th edition, 2020
3	Probability and Random Processes	Palaniammal, S.	PHI Learning Private Limited	3 rd edition, 2015
4	Introduction to Probability	David F. Anderson, Timo, Benedek	Cambridge	1 st edition, 2017

Video Links (NPTEL, SWAYAM...)	
Module No.	Link ID
1	https://archive.nptel.ac.in/courses/117/105/117105085/
2	https://archive.nptel.ac.in/courses/117/105/117105085/
4	https://archive.nptel.ac.in/courses/117/105/117105085/

SEMESTER S4
SYNCHRONOUS & INDUCTION MACHINES

Course Code	PCEET402	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:1:0:0	ESE Marks	60
Credits	4	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	PCEET303	Course Type	Theory

Course Objectives:

1. Describe the constructional details, working and analyse the performance of synchronous machines and induction machines under various load conditions.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	<p>Principle of Operation of 3-phase alternators – classification - constructional features - types of armature windings – winding diagram of a 3-phase, 12 slot, 2-pole, single layer full-pitched armature winding (winding diagram not for evaluation) – coil-span factor and distribution factor (sinusoidal flux distribution only) - EMF equation – numerical problems</p> <p>Cylindrical-rotor type synchronous generator on no-load – open circuit characteristics - Synchronous generator on load – armature reaction – effect of armature reaction - synchronous impedance - Equivalent circuit - phasor diagram – numerical problems Voltage regulation – OC and SC tests – emf and mmf methods – ZPF test - Potier method – numerical problems</p>	12

2	<p>Power flow equations in cylindrical-rotor type synchronous generator – numerical problems</p> <p>Parallel operation - synchronous generator on infinite bus-bar – conditions – methods of synchronisation – effect of change of mechanical input – effect of change of excitation - V-curves and inverted V curves – numerical problems</p> <p>Salient-pole synchronous generator - two reaction theory – phasor diagram – slip test for determination of X_d and X_q - numerical problems</p> <p>Synchronous motor – rotating magnetic field - principle of operation – starting methods</p> <p>Power developed (both cylindrical rotor type and salient-pole type) – excitation power & reluctance power – power angle characteristics - losses and efficiency – numerical problems</p> <p>V-curves and inverted V curves</p>	12
3	<p>3-phase Induction motor – principle of operation - classification - constructional features – torque equation - torque-slip characteristics – relation between starting torque, maximum torque and full-load torque - numerical problems</p> <p>Phasor diagram - equivalent circuit</p> <p>Power flow diagram - losses and efficiency – numerical problems</p> <p>No-load and blocked-rotor tests – circle diagram – numerical problems</p> <p>Starting of induction motors – types of starters – DOL starter, autotransformer starter, star-delta starter – numerical problems - rotor resistance starter (no design)</p>	11
4	<p>Braking of Induction motors – plugging, dynamic braking, regenerative braking (concepts only)</p> <p>Speed control – stator voltage control, V/f control, rotor resistance control</p> <p>Induction generator – line excited and self-excited induction generators (principle of operation only) – torque-slip characteristics for braking, motoring and regeneration</p> <p>Single-phase induction motors – double revolving field theory – equivalent circuit – torque slip characteristics</p> <p>Types of 1-phase induction motors – split-phase, capacitor-start induction-run, permanent capacitor types – applications</p>	9

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
<ul style="list-style-type: none"> • 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks <p style="text-align: center;">(8x3 =24marks)</p>	<ul style="list-style-type: none"> • Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. <p style="text-align: center;">(4x9 = 36 marks)</p>	60

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Describe the constructional details and analyse the performance of synchronous generators under various load conditions.	K3
CO2	Analyse the performance of synchronous motors under various load conditions	K3
CO3	Describe the constructional details and analyse the steady-state performance of induction motors under various load conditions	K3
CO4	Analyse the various starting, braking and speed control methods of 3-phase induction motors.	K3
CO5	Explain the construction details and working of various types of single-phase induction motors.	K2

Note: *K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2										3
CO2	3	2										3
CO3	3	2										3
CO4	3	2										3
CO5	3	2										3

Note: 1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation

Text Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Electrical Machinery	P.S. Bhimbra	Khanna	7 th edition 2021
2	Performance & Design of AC Machines	M.G. Say	CBS	3 rd edition 2002
3	Electric Machines	Kothari & Nagrath	Tata McGraw-Hill	5 th edition 2017
4	Induction & Synchronous Machines	K Murugesh Kumar	Vikas	11 th edition 2000
5	Theory & Performance of Electrical Machines	J.B. Gupta	S.K. Kataria	15 th edition 2022

Video Links (NPTEL, SWAYAM...)	
Module No.	Link ID
1	https://archive.nptel.ac.in/courses/108/105/108105131/

SEMESTER S4
POWER ELECTRONICS AND DRIVES

Course Code	PCEET403	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:1:0:0	ESE Marks	60
Credits	4	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	PCEET303, PCEET304	Course Type	Theory

Course Objectives:

1. To give a strong foundation on power converters, power quality and electric drives
2. To enable the students to select suitable power devices and passive components for target applications
3. To motivate students to design and implement power electronic converters having high efficiency, small size, high reliability and low cost

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	<p>Role of Power Electronics, Motivation, Objectives and Challenges, Power Electronics Vs Linear Electronics, Ideal and real switches- Static and dynamic Performance – Power losses- Temperature rise- Thermal Analogy- Use of Heat sinks- Need for high efficiency, small size, high reliability and low cost- Overview of Applications</p> <p>Uncontrolled Switch: Power Diodes – Types- Characteristics (Static and Dynamic) –Effects of Reverse Recovery Transient- Ratings-Schottky Diodes – Features & Applications</p> <p>Semi-controlled switch: SCR (Thyristor) – Symbol, Structure, Characteristics (Static and dynamic) – Turn-on and Turn-off phenomena – Ratings- Gate control of SCR – Gate pulse magnitude and duration requirements- Typical gate drive circuits – Gate synchronisation – Isolated gate drives</p>	11

	<p>Fully-controlled switches: MOSFETS and IGBTs: Symbol, Structure, Characteristics (Static and Dynamic) -Device ratings -Gate drive requirements-Typical gate drive circuits</p> <p>Modern power devices: Introduction to Wide Bandgap Devices – SiC MOSFET and GaN HEMT – Features and advantages</p> <p>Suggestions: Reading and interpreting datasheets are to be encouraged [To be tested through assignments] –Possibility of simulation assignments/homework may be explored- Design of MOSFET/IGBT gate drives – need/requirement of isolation in certain circuits- Use of pulse transformers/ opto-isolators – sample circuits [Design assignments may be given using popular driver ICs for MOSFETs/SCRs – not to be tested in ESE]</p>	
2	<p>Controlled Rectifiers (Single Phase) – Fully controlled and half-controlled rectifiers (semi-converter)with RL and RLE loads- Rectifier and inverter modes of operation- waveforms (continuous & discontinuous conduction)– Output voltage, Input line current, Real Power, Power factor and THD(Continuous conduction, ripple free current)- Effect of source inductance(Full converter in continuous conduction, ripple free current)</p> <p>Controlled Rectifiers (3-Phase) - Fully controlled & Half-controlled bridge converter with RLE load (continuous conduction, ripple free current)– Waveforms- Output voltage equation</p> <p>AC voltage controllers (ACVC) – 1-phase full-wave ACVC with R & RL loads – waveforms – RMS output voltage - applications</p> <p>DC-DC Switching Regulators- Buck, Boost & Buck-Boost– Operation with Continuous conduction Waveforms– Effect of non-idealities such as capacitor ESR and inductor resistance (qualitative treatment only)- Design of filter inductance and capacitance- Selection of power devices</p>	12
3	<p>Switch mode DC-AC Voltage Source Inverters (VSI)- Single phase Half-Bridge and Full-Bridge configurations- Sinusoidal Pulse Width Modulation (PWM) - Control of Fundamental output voltage- Harmonic spectrum- Bipolar and Unipolar PWM- Linear, Over Modulation and Square wave modes -Merits and demerits- Need for blanking time (dead-time)</p> <p>Three-Phase Pulse Width Modulated VSI - Fundamental Output voltage- Linear, Over Modulation and Square wave modes – Third harmonic Injection PWM</p> <p>Single phase current regulated VSI –Tolerance band current control- Fixed</p>	11

	<p>frequency operation - Single phase current source Inverters (IGBT based)- Comparison</p> <p>Need for improved utility interface- Generation of current harmonics- Power factor- Harmonics and IEEE 519 standard- Active shaping of the input line current- Single-phase front end boost converter(circuit diagram, operation, block diagram of the control scheme)</p>	
4	<p>Introduction to Electric Drives- Advantages of adjustable speed electric drives –Block diagram, Types of loads – Classification of load torque- Motor torque-load combination: characteristics and dynamic equation- Steady state stability</p> <p>DC Drives- Chopper control of Separately Excited DC drives (SEDC) –One quadrant, Two quadrant and four quadrant Chopper fed drives(Continuous conduction only)- Motoring and Regenerative braking – Speed-Torque characteristics – Speed control- Controlled rectifier fed separately excited DC motor drive- Single phase and three phase (Continuous conduction only)- Speed-Torque characteristics- Speed control –Dual converter drives (single phase) - Circulating current Type and Non-circulating current - Static four-quadrant operation with SEDC</p> <p>Three-phase VSI fed induction motor drives: Stator Voltage control - V/F speed control– Speed-Torque characteristics- Speed control – operation below and above base speed – Braking: dynamic and regenerative</p>	10

Course Assessment Method

(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
<ul style="list-style-type: none"> • 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks <p>(8x3 =24marks)</p>	<ul style="list-style-type: none"> • Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. <p>(4x9 = 36 marks)</p>	60

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Understand the operation of modern power semiconductor devices, its characteristics and select suitable gate driver circuits & heatsinks	K3
CO2	Understand the features of phase-controlled rectifiers, AC voltage Controllers &Switching Regulators and analyse the operation	K3
CO3	Understand the features of different types of switch mode DC-AC Inverters and analyse the operation	K3
CO4	Understand the need for improved efficiency, improved reliability, improved load &source waveforms and improved utility interface	K2
CO5	Understand the features of adjustable speed drives and analyse the Basic drive schemes for DC motors and Induction Motors	K3

Note: *K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3									2
CO2	3	1	3									2
CO3	3	1	3									2
CO4	3	1	3									2
CO5	3	1	3									2

Note: 1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation

Text Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Power Electronics- Converters, Applications and Design, 3ed(Indian Adaptation) by Mohan, Undeland, Robbins, Wiley India, 2022	Ned Mohan, Undeland, Robbins	Wiley-India	2022
2	Power Electronics- Principles and Applications	Joseph Vithayathil	Tata McgrawHill	2010
3	Power Electronics	Cyril W Lander	McGrawHill	1993
4	Power Electronics – Circuits, Devices and Applications	Muhammad H. Rashid	Pearson Education	2014
5	Power Electronics	D.W. Hart	McGrawHill	2010
6	Power Electronics – Essentials & Applications	L. Umanand	Wiley-India	2009
7	Fundamentals of Electric Drives	G K Dubey	Narosa	2001

Reference Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Elements of Power Electronics	Philip T Krein	Oxford	2017
2	Power Electronics Handbook-5e	Muhammad H. Rashid	Butterworth	2024

Video Links (NPTEL, SWAYAM...)	
Module No.	Link ID
1	Lecture Series on Power Electronics by Prof. G. Bhuvaneswari , IIT Delhi https://www.youtube.com/watch?v=Z2CORFayCv0&list=PLp6ek2hDcoND7i5-DAD9mPmYF1Wg6ROdO&index=3
2	NPTEL Lecture Series on Power Electronics by Prof. L. Umanand , IISc Bangalore https://www.youtube.com/watch?v=eLIdqiPMjBs&list=PLgMDNELGJ1CaXa4sX6QSrkhu-yP_Wu2EN&index=26
3	NPTEL Lecture Series by Prof. Shabari Nath , IIT Guwahati https://www.youtube.com/watch?v=S_UXW2UzAi8&list=PlwdnzlV3ogoWVgA9fHBV36L_bxWZlpa7X&index=7

SEMESTER S4

DIGITAL ELECTRONICS

Course Code	PBEET404	CIE Marks	60
Teaching Hours/Week (L: T:P: R)	3:0:0:1	ESE Marks	40
Credits	4	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	None	Course Type	Theory

Course Objectives:

1. Explain the various number systems, Digital logic gates and Boolean expressions
2. Design and implement different types of combinational and sequential logic circuits
3. Design and implement digital circuits using Hardware Descriptive Language.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	<p>Number Systems and Codes – binary, octal and hexadecimal – conversions – ASCII code, Excess – 3 code, Gray code, BCD code</p> <p>Signed numbers – 1's complement and 2's complement – addition and subtraction</p> <p>Basic logic gates – universal gates – TTL – CMOS – Internal diagram of TTL NAND gate and CMOS NOR gate – comparison of CMOS and TTL performance.</p> <p>Boolean laws and theorems – Sum of products and Product of sums forms – K map representation and simplification (up to four variables) – pairs, quads, octets – don't care conditions.</p>	9
2	<p>Combinational circuits – half adder and full adder, half subtractor and full subtractor – 4-bit parallel binary adder/subtractor.</p> <p>Comparators – parity generators and checkers – encoders – decoders – BCD to seven segment decoder.</p> <p>Multiplexers – implementation of boolean expressions using multiplexers – demultiplexers.</p>	9

3	<p>Flip-Flops – SR, JK, D and T flip-flops – characteristic table and excitation table – JK Master Slave Flip-flop – Conversion of flip-flops – SR to JK and JK to SR only.</p> <p>Up/Down counters – asynchronous counters – mod-6 and mod-10 counters.</p> <p>Synchronous counters – design of synchronous counters – Ring counter – Johnson Counter.</p> <p>Shift registers - SISO, SIPO, PISO, PIPO.</p>	10
4	<p>State Machines – state transition diagram – Moore and Mealy machines.</p> <p>Digital to Analog converter – weighted resistor type, R-2R Ladder type.</p> <p>Analog to Digital Converter – flash type, successive approximation type.</p> <p>Introduction to Verilog – Implementation of AND, OR, half adder and full adder.</p>	8

Suggestion on Project Topics

Course Assessment Method
(CIE: 60 marks, ESE: 40 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Project	Internal Ex-1	Internal Ex-2	Total
5	30	12.5	12.5	60

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
<ul style="list-style-type: none"> 2 Questions from each module. <p>Total of 8 Questions, each carrying 2 marks</p> <ul style="list-style-type: none"> (8x2 =16 marks) 	<ul style="list-style-type: none"> 2 questions will be given from each module, out of which 1 question should be answered. Each question can have a maximum of 2 sub divisions. Each question carries 6 marks. <p>(4x6 = 24 marks)</p>	40

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Identify various number systems, binary codes and formulate digital functions using Boolean algebra.	K2
CO2	Design combinational logic circuits.	K3
CO3	Design sequential logic circuits.	K3
CO4	Describe the operation of various analog to digital and digital to analog conversion circuits.	K2
CO5	Explain the basic concepts of programming using Verilog HDL	K2
CO6	Design and realize medium complexity practical digital hardware circuits.	K6

Note: *K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2										3
CO2	3	2		2	2			2	2			3
CO3	3	2		2	2			2	2			3
CO4	3	2										3
CO5	3	2		2	2			2	2			3
CO6	3	3	3	3	3	2	2	3	3		2	3

Text Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Digital Fundamentals	Floyd T.L	Pearson Education	11/e, 2017
2	Digital Principles and Applications	Albert Paul Malvino & Donald P. Leach	Mc-GRAW Hill International Editions	4/e, 2018
3	Digital Design: With an Introduction to the Verilog HDL, VHDL, and System Verilog	M. Morris Mano, Michael D. Ciletti	Pearson Education	6/e, 2018
4	Digital Integrated Electronics	Herbert Taub and Donald Schilling	McGraw Hill Education	2017

Reference Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Fundamentals of Digital Logic with Verilog Design	Stephen Brown	McGraw Hill Education	2 nd Edition
2	Fundamental of Digital Circuits	A Anand Kumar	Prentice Hall	4/e, 2023
3	Digital Circuits and Design	S. Salivahanan	Oxford University Press	2018
4	Digital Design Verilog HDL and Fundamentals	Joseph Cavanagh	CRC Press	1 st Edition, 2008

Video Links (NPTEL, SWAYAM...)	
Module No.	Link ID
1	https://archive.nptel.ac.in/courses/108/105/108105132/ https://archive.nptel.ac.in/courses/18/106/108106177/
2	https://archive.nptel.ac.in/courses/108/105/108105132/ https://archive.nptel.ac.in/courses/108/106/108106177/
3	https://archive.nptel.ac.in/courses/108/105/108105132/ https://archive.nptel.ac.in/courses/108/106/108106177/
4	https://archive.nptel.ac.in/courses/108/105/108105132/ https://archive.nptel.ac.in/courses/108/106/108106177/

PBL Course Elements

L: Lecture (3 Hrs.)	R: Project (1 Hr.), 2 Faculty Members		
	Tutorial	Practical	Presentation
Lecture delivery	Project identification	Simulation/ Laboratory Work/ Workshops	Presentation (Progress and Final Presentations)
Group discussion	Project Analysis	Data Collection	Evaluation
Question answer Sessions/ Brainstorming Sessions	Analytical thinking and self-learning	Testing	Project Milestone Reviews, Feedback, Project reformation (If required)
Guest Speakers (Industry Experts)	Case Study/ Field Survey Report	Prototyping	Poster Presentation/ Video Presentation: Students present their results in a 2 to 5 minutes video

Assessment and Evaluation for Project Activity

Sl. No	Evaluation for	Allotted Marks
1	Project Planning and Proposal	5
2	Contribution in Progress Presentations and Question Answer Sessions	4
3	Involvement in the project work and Team Work	3
4	Execution and Implementation	10
5	Final Presentations	5
6	Project Quality, Innovation and Creativity	3
Total		30

1. Project Planning and Proposal (5 Marks)

- Clarity and feasibility of the project plan
- Research and background understanding
- Defined objectives and methodology

2. Contribution in Progress Presentation and Question Answer Sessions (4 Marks)

- Individual contribution to the presentation
- Effectiveness in answering questions and handling feedback

3. Involvement in the Project Work and Team Work (3 Marks)

- Active participation and individual contribution
- Teamwork and collaboration

4. Execution and Implementation (10 Marks)

- Adherence to the project timeline and milestones
- Application of theoretical knowledge and problem-solving
- Final Result

5. Final Presentation (5 Marks)

- Quality and clarity of the overall presentation
- Individual contribution to the presentation
- Effectiveness in answering questions

6. Project Quality, Innovation, and Creativity (3 Marks)

- Overall quality and technical excellence of the project
- Innovation and originality in the project
- Creativity in solutions and approaches

SEMESTER S4
RENEWABLE ENERGY SOURCES

Course Code	PEEET412	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	NIL	Course Type	Theory

Course Objectives:

1. To understand energy scenario, energy sources and their utilization
2. To explore society's present needs and future energy demands
3. To study the principles of renewable energy conversion systems
4. To be exposed to energy conservation methods

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	<p>Introduction: Principles of renewable energy; energy and sustainable development, fundamentals and social implications. Worldwide renewable energy availability, renewable energy availability in India, types of renewable energy.</p> <p>Wind Energy: Properties of wind, availability of wind energy in India, wind velocity and power from wind (numerical problems); major problems associated with wind power, Basic components of wind energy conversion system (WECS); Classification of WECS- Horizontal axis- single, double and multi-blade system. Vertical axis - Savonius and Darrieus types.</p>	9

2	<p>Solar Energy: Fundamentals; Solar Radiation; Estimation of solar radiation on horizontal and inclined surfaces; Solar radiation Measurements - Pyrheliometers, Pyranometer, Sunshine Recorder. Solar Thermal systems: concentrating and non-concentrating collectors - Flat plate collectors; Solar tower electric power plant. Photovoltaic system for electric power generation – Classification of PV system - Principle of Solar cell, advantages, disadvantages and applications of solar photovoltaic system.</p>	9
3	<p>Biomass Energy: Introduction; Principle of biomass energy generation - Biofuels; Biomass Resources; Biomass conversion technologies-fixed dome type biogas plant; Urban waste to energy conversion; Biomass gasification (Downdraft).</p> <p>Tidal Power: Tides and waves as energy suppliers and their mechanics; fundamental characteristics of tidal power, classification of tidal power plants - harnessing tidal energy, advantages and limitations.</p>	9
4	<p>Ocean Thermal Energy Conversion: Principle of working, classification, OTEC power stations in the world, environmental impacts associated with OTEC.</p> <p>Introduction to geothermal energy</p> <p>Green Energy: Introduction, Fuel cells: Classification of fuel cells – Hydrogen energy; Operating principles, Zero-energy Concepts. Benefits of hydrogen energy, hydrogen production technologies (electrolysis method only), hydrogen energy storage, applications of hydrogen energy, problem associated with hydrogen energy.</p>	9

Course Assessment Method

(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microp project	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
<ul style="list-style-type: none"> • 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks <p>(8x3 =24marks)</p>	<ul style="list-style-type: none"> • Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. <p>(4x9 = 36 marks)</p>	60

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Describe the environmental aspects of renewable energy resources in comparison with various conventional energy systems, their prospects and limitations.	K1
CO2	Understand the concepts of wind energy.	K1
CO3	Describe the use of solar energy and the various components used in the energy production with respect to applications like-heating, cooling, desalination, power generation.	K2
CO4	Understand the concept of biomass energy resources and conversion principles of tidal energy.	K2
CO5	Acquire the basic knowledge of ocean thermal energy conversion. Understand the principle of green energy and hydrogen energy.	K1

Note: *K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3										2
CO2	3	3										2
CO3	3	3										2
CO4	3	3										2
CO5	3	3										2

Note: 1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation

Text Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Non-conventional energy sources	G. D. Rai	Khanna	4 th edition 2023
2	Renewable energy systems	Thomas E. Kissell, David M. Buchla, Thomas L. Floyd,	Pearson	2017
3	Non-Conventional Energy Resources	Sawhney G. S.	PHI Learning	2012
4	Renewable energy systems	Thomas E. Kissell, David M. Buchla, Thomas L. Floyd,	Pearson	Pearson 2017

SEMESTER S4
ECONOMICS FOR ENGINEERS
(Common to All Branches)

Course Code	UCHUT346	CIE Marks	50
Teaching Hours/Week (L: T:P: R)	2:0:0:0	ESE Marks	50
Credits	2	Exam Hours	2 Hrs. 30 Mins.
Prerequisites (if any)	None	Course Type	Theory

Course Objectives:

1. Understanding of finance and costing for engineering operation, budgetary planning and control
2. Provide fundamental concept of micro and macroeconomics related to engineering industry
3. Deliver the basic concepts of Value Engineering.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Basic Economics Concepts - Basic economic problems – Production Possibility Curve – Utility – Law of diminishing marginal utility – Law of Demand - Law of supply – Elasticity - measurement of elasticity and its applications – Equilibrium- Changes in demand and supply and its effects Production function - Law of variable proportion – Economies of Scale – Internal and External Economies – Cobb-Douglas Production Function	6

2	Cost concepts – Social cost, private cost – Explicit and implicit cost – Sunk cost - Opportunity cost - short run cost curves - Revenue concepts Firms and their objectives – Types of firms – Markets - Perfect Competition – Monopoly - Monopolistic Competition - Oligopoly (features and equilibrium of a firm)	6
3	Monetary System – Money – Functions - Central Banking –Inflation - Causes and Effects – Measures to Control Inflation - Monetary and Fiscal policies – Deflation Taxation – Direct and Indirect taxes (merits and demerits) - GST National income – Concepts - Circular Flow – Methods of Estimation and Difficulties - Stock Market – Functions- Problems faced by the Indian stock market-Demat Account and Trading Account – Stock market Indicators- SENSEX and NIFTY	6
4	Value Analysis and value Engineering - Cost Value, Exchange Value, Use Value, Esteem Value - Aims, Advantages and Application areas of Value Engineering - Value Engineering Procedure - Break-even Analysis - Cost-Benefit Analysis - Capital Budgeting - Process planning	6

Course Assessment Method
(CIE: 50 marks, ESE: 50 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Case Study/Microp project	Internal Examination-1 (Written)	Internal Examination - 2 (Written)	Total
10	15	12.5	12.5	50

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
<ul style="list-style-type: none"> • Minimum 1 and Maximum 2 Questions from each module. • Total of 6 Questions, each carrying 3 marks <p>(6x3 =18marks)</p>	<ul style="list-style-type: none"> • 2 questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 2 sub divisions. • Each question carries 8 marks. <p>(4x8 = 32 marks)</p>	50

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Understand the fundamentals of various economic issues using laws and learn the concepts of demand, supply, elasticity and production function.	K2
CO2	Develop decision making capability by applying concepts relating to costs and revenue, and acquire knowledge regarding the functioning of firms in different market situations.	K3
CO3	Outline the macroeconomic principles of monetary and fiscal systems, national income and stock market.	K2
CO4	Make use of the possibilities of value analysis and engineering, and solve simple business problems using break even analysis, cost benefit analysis and capital budgeting techniques.	K3

Note: *K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	-	-	-	1	-	-	-	-	1	-
CO2	-	-	-	-	-	1	1	-	-	-	1	-
CO3	-	-	-	-	1	-	-	-	-	-	2	-
CO4	-	-	-	-	1	1	-	-	-	-	2	-

Text Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Managerial Economics	Geetika, Piyali Ghosh and Chodhury	Tata McGraw Hill,	2015
2	Engineering Economy	H. G. Thuesen, W. J. Fabrycky	PHI	1966
3	Engineering Economics	R. Paneerselvam	PHI	2012

Reference Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Engineering Economy	Leland Blank P.E, Anthony Tarquin P. E.	Mc Graw Hill	7 TH Edition
2	Indian Financial System	Khan M. Y.	Tata McGraw Hill	2011
3	Engineering Economics and analysis	Donald G. Newman, Jerome P. Lavelle	Engg. Press, Texas	2002
4	Contemporary Engineering Economics	Chan S. Park	Prentice Hall of India Ltd	2001

SEMESTER S4
DC MACHINES & TRANSFORMERS LAB

Course Code	PCEEL407	CIE Marks	50
Teaching Hours/Week (L: T:P: R)	0:0:3:0	ESE Marks	50
Credits	2	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	PCEET303	Course Type	Lab

Course Objectives:

1. Provide practical experience in operation and testing of DC machines and transformers

Expt. No.	Experiments
PART A – DC MACHINES	
1	<p>Open circuit characteristics of DC shunt generator (CO1)</p> <p>Objectives:</p> <ol style="list-style-type: none"> Predetermine the OCC at different speeds Determine the critical field resistance Determine the maximum voltage built up with given shunt field resistance Determine the critical speed for a given shunt field resistance
2	<p>Load test on DC shunt generator (CO1)</p> <p>Objectives:</p> <p>Determine the external and internal characteristics</p>
3	<p>Brake test on DC shunt motor (CO2)</p> <p>Objectives:</p> <p>Plot the following characteristics</p> <ol style="list-style-type: none"> Performance characteristics Electrical characteristics Mechanical characteristics

4	<p>Brake test on DC series motor (CO2)</p> <p>Objectives:</p> <p>Plot the following characteristics</p> <ol style="list-style-type: none"> Performance characteristics Electrical characteristics Mechanical characteristics
5	<p>Load test on DC compound generator (CO1)</p> <p>Objectives:</p> <ol style="list-style-type: none"> Plot the load characteristics when cumulatively compounded Plot the load characteristics when differentially compounded
6	<p>Swinburne's test on a DC shunt machine (CO3)</p> <p>Objectives:</p> <ol style="list-style-type: none"> Predetermine the efficiency while DC machine is acting as generator and motor Plot the efficiency curves while DC machine is acting as generator and motor
7	<p>Hopkinson's test on a pair of DC machines (CO3)</p> <p>Objectives:</p> <p>Determine the efficiency the DC machine while working as a motor and generator under various load conditions</p>
8	<p>Retardation test on a DC machine (CO3)</p> <p>Objectives:</p> <ol style="list-style-type: none"> Separate the hysteresis, eddy current, friction and windage losses Find the moment of inertia of the rotating system
9	<p>Separation of losses in a DC shunt motor (CO3)</p> <p>Objectives:</p> <p>Separate the hysteresis, eddy current, friction and windage losses by conducting no-load tests at different excitations.</p>
PART B - TRANSFORMERS	
10	<p>OC and SC tests on single-phase transformer (CO4)</p> <p>Objectives:</p> <ol style="list-style-type: none"> Predetermine the voltage regulation and efficiency at different loads and power factors. Determine the equivalent circuit referred to LV side and HV side Plot the voltage regulation vs power factor curves at full-load and half full-load. Plot the efficiency curve at unity p.f. and 0.5 p.f. Determine the power factor at which the voltage regulation is zero Determine the load at which maximum efficiency occurs and the maximum

	efficiency.
11	<p>Load test on single-phase transformer (CO4)</p> <p>Objectives:</p> <p>Determine the voltage regulation and efficiency at different loads and at unity power factor.</p>
12	<p>Separation of losses in a single-phase transformer (CO4)</p> <p>Objectives:</p> <ol style="list-style-type: none"> Separate the hysteresis and eddy current losses using voltage and frequency control. Plot losses Vs frequency curves at normal voltage and different frequencies Plot losses Vs frequency curves at different frequencies keeping V/f constant
13	<p>Sumpner's test (CO4)</p> <p>Objectives:</p> <ol style="list-style-type: none"> Predetermine the voltage regulation and efficiency at different loads (full-load and half full-load) and power factors (unity, 0.8 lag and lead) Determine the equivalent circuit referred to LV side and HV side
14	<p>Parallel operation of two dissimilar single-phase transformers (CO4)</p> <p>Objectives:</p> <ol style="list-style-type: none"> Determine the load sharing while two dissimilar transformers are operating in parallel Verify the load sharing by using the impedances of the two transformers
15	<p>OC and SC tests on 3-phase transformer (CO5)</p> <p>Objectives:</p> <ol style="list-style-type: none"> Predetermine the voltage regulation and efficiency at different loads (full-load and half full-load) and power factors (unity, 0.8 lag and lead) Determine the per phase equivalent circuit
16	<p>Scott Connections (CO4)</p> <p>Objectives:</p> <p>Convert 3-phase AC supply into 2-phase AC by means of Scott connection and to conduct the load test for finding the performance</p>
<p>NOTE: A minimum of TWELVE experiments are mandatory out of the sixteen listed</p>	

Course Assessment Method
(CIE: 50 marks, ESE: 50 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Preparation/Pre-Lab Work experiments, Viva and Timely completion of Lab Reports / Record (Continuous Assessment)	Internal Examination	Total
5	25	20	50

End Semester Examination Marks (ESE):

Procedure/ Preparatory work/Design/ Algorithm	Conduct of experiment/ Execution of work/ troubleshooting/ Programming	Result with valid inference/ Quality of Output	Viva voce	Record	Total
10	15	10	10	5	50

- ***Submission of Record:*** *Students shall be allowed for the end semester examination only upon submitting the duly certified record.*
- ***Endorsement by External Examiner:*** *The external examiner shall endorse the record*

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Analyze the performance of DC generators by conducting load/no-load tests	K3
CO2	Sketch the performance characteristics of DC shunt and series motors	K3
CO3	Investigate the losses and efficiency in DC machines by conducting no-load tests	K3
CO4	Examine the performance of individual and parallel connected single-phase transformers by conducting load/no-load tests	K3
CO5	Determine the voltage regulation and efficiency of 3-phase transformer by conducting no-load tests.	K3

Note: *K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO- PO Mapping (Mapping of Course Outcomes with Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2		2					3	2		3
CO2	3	2		2					3	2		3
CO3	3	2		2					3	2		3
CO4	3	2		2					3	2		3
CO5	3	2		2					3	2		3

1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation

Reference Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Electrical Machinery	P.S. Bimbhra	Khanna Publishers	7th edition 2021
2	Electric Machines	D P Kothari & I J Nagrath	Tata McGraw Hill	5th edition 2017

Continuous Assessment (25 Marks)

1. Preparation and Pre-Lab Work (7 Marks)

- Pre-Lab Assignments: Assessment of pre-lab assignments or quizzes that test understanding of the upcoming experiment.
- Understanding of Theory: Evaluation based on students' preparation and understanding of the theoretical background related to the experiments.

2. Conduct of Experiments (7 Marks)

- Procedure and Execution: Adherence to correct procedures, accurate execution of experiments, and following safety protocols.
- Skill Proficiency: Proficiency in handling equipment, accuracy in observations, and troubleshooting skills during the experiments.
- Teamwork: Collaboration and participation in group experiments.

3. Lab Reports and Record Keeping (6 Marks)

- Quality of Reports: Clarity, completeness and accuracy of lab reports. Proper documentation of experiments, data analysis and conclusions.
- Timely Submission: Adhering to deadlines for submitting lab reports/rough record and maintaining a well-organized fair record.

4. Viva Voce (5 Marks)

- Oral Examination: Ability to explain the experiment, results and underlying principles during a viva voce session.

Final Marks Averaging: The final marks for preparation, conduct of experiments, viva, and record are the average of all the specified experiments in the syllabus.

Evaluation Pattern for End Semester Examination (50 Marks)

1. Procedure/Preliminary Work/Design/Algorithm (10 Marks)

- Procedure Understanding and Description: Clarity in explaining the procedure and understanding each step involved.
- Preliminary Work and Planning: Thoroughness in planning and organizing materials/equipment.
- Algorithm Development: Correctness and efficiency of the algorithm related to the experiment.
- Creativity and logic in algorithm or experimental design.

2. Conduct of Experiment/Execution of Work/Programming (15 Marks)

- Setup and Execution: Proper setup and accurate execution of the experiment or programming task.

3. Result with Valid Inference/Quality of Output (10 Marks)

- Accuracy of Results: Precision and correctness of the obtained results.
- Analysis and Interpretation: Validity of inferences drawn from the experiment or quality of program output.

4. Viva Voce (10 Marks)

- Ability to explain the experiment, procedure results and answer related questions
- Proficiency in answering questions related to theoretical and practical aspects of the subject.

5. Record (5 Marks)

- Completeness, clarity, and accuracy of the lab record submitted

SEMESTER S4
POWER ELECTRONICS AND DRIVES LAB

Course Code	PCEEL408	CIE Marks	50
Teaching Hours/Week (L: T:P: R)	0:0:3:0	ESE Marks	50
Credits	2	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	PCEET403	Course Type	Lab

Course Objectives:

1. To motivate students to design and implement power electronic converters having high efficiency, small size, high reliability and low cost
2. To enable the students to select suitable power devices and passive components
3. To compare simulation results and hardware results and do iterative design

Expt. No.	Experiments
	<p>Suggestions: Students are encouraged to do the simulations associated with the experiments before the corresponding lab session so that more emphasis can be given to the hardware part in the lab (Simulations can be done off-lab) and the simulation results need to be correlated with the hardware results. For experiments where the effects of device parasitics cannot be neglected and circuit-level simulations are needed, SPICE based simulation software such as LTSpiceTM, OrCADTM, PSpiceTM, ProteusTM etc. may be used. In other cases, software like MATLAB SimulinkTM, SciLabTM, SEQUELTM, PSIMTM, PLECSTM etc. may be used if required.</p>
	<p>Preliminary work-1 (Mandatory)</p> <p>(a) Testing and Troubleshooting- Power diodes, SCR, Power Transistors, MOSFETS, IGBTs, OP-Amps, MOSFET drivers etc – Use of Multimeter, DSO, and Data sheets</p> <p>(b) Simulation of any Power Electronic circuit using a SPICE based software such as LTSpice, ORCAD, PSpice, and Proteus</p>

	<p>Preliminary work -2 (Mandatory)</p> <p>(a) PCB routing using any standard PCB layout software such as ORCAD, Proteus, KiCAD, Altium, Eagle etc. ensuring good PCB routing practices</p> <p>(b) Soldering and desoldering Practice – Through-Hole/SMD (It is recommended to select any one of the experiments for the PCB practice)</p>
1	<p>Static VI characteristics of Power Devices</p> <p>Aim: To simulate the static VI characteristics of (a) Power Diode (b) SCR (b) MOSFET (c) IGBT using any suitable simulation software and compare with datasheet values</p>
2	<p>High frequency diode - Measurement of power loss and reverse recovery time</p> <p>Aim: To measure the power losses & reverse recovery time of a high frequency diode, compare with theoretical estimate and to compare with a schottky diode of similar ratings (Hardware/Simulation).</p>
3	<p>Single-Phase half-wave-controlled rectifier feeding R/RL load</p> <p>Aim: To simulate and set up a half-wave-controlled rectifier with line synchronized R and RC firing circuits and plot relevant waveforms such as voltage waveform across the load and thyristor, gate voltage and gate current for different firing angles. The need for line synchronization to be emphasized. (Any suitable simulation software may be used for the simulation)</p>
4	<p>Single-Phase half-controlled(semi-converter)/fully-controlled rectifier feeding R/RL loads</p> <p>Aim: To simulate and set up any type of line synchronized Triggering circuit such as UJT firing, Ramp firing, Digital firing etc. for single-phase half-controlled/full controlled rectifier feeding R and RL loads and observe relevant waveforms. The need for line synchronization to be emphasized (Any suitable simulation software may be used for the simulation).</p>
5	<p>Effect of source inductance in single-phase controlled rectifier feeding highly inductive loads</p> <p>Aim: To set up a single-phase full controlled rectifier with source inductance, for highly inductive loads, observe relevant waveforms and calculate the source power factor, line current THD and the average voltage lost due to the effect of source inductance (Simulation may be used to get more insights).</p>
6	<p>Single-Phase half-controlled/fully-controlled Rectifier fed PMDC/Separately excited DC motor drive</p> <p>Aim: To simulate and set up a single-phase half-controlled/full controlled rectifier feeding a PMDC/SEDC motor (additional inductor may be included in the armature circuit to get continuous conduction) and observe relevant waveforms (Any suitable simulation</p>

	software may be used for the simulation)
7	<p>AC Voltage controller feeding R/RL loads</p> <p>Aim: To set up a single-phase AC voltage controller using TRIAC/SCR and to observe relevant waveforms such as voltage waveforms across the load (R/RL Load) & TRIAC/SCR, gate voltage, gate current etc. for different firing angles (Simulation may be used to get more insights).</p>
8	<p>Isolated Gate Driver Circuit for Single-phase half-Bridge IGBT/MOSFET Inverter</p> <p>Aim: (a) To identify the gate current and voltage requirement to drive the MOSFET/IGBT in a half-bridge configuration for a certain switching frequency with galvanic isolation, to select suitable industry-standard IGBT/MOSFET driver ICs and to test the driver circuit both for floating and ground-referenced configurations, and to observe relevant waveforms (b) To simulate and set up a circuit for dead-time generation for use with the half- bridge inverter</p>
9	<p>Gate drive using Bootstrap technique</p> <p>Aim: To identify the gate current and voltage requirement to drive the MOSFET/IGBT with boot-strap technique for a certain switching frequency, understand the merits & pertinent limitations of the bootstrapping circuit and to explore dead-time and shutdown/over current protection options</p>
10	<p>Single-phase half-bridge/full-bridge IGBT/MOSFET inverter feeding RL load</p> <p>Aim: To simulate and set up a single-phase half-bridge inverter with L/LC filter for square wave and sine-triangle PWM, observe relevant waveforms and obtain THD (Any suitable simulation software may be used for the simulation)</p>
11	<p>Inductor design and Fabrication</p> <p>Aim: To design and fabricate an inductor to be used in a high frequency switching application and measure the inductance value using time constant measurement/LCR meter</p> <p>Note: The inductor may be designed taking into account the requirement in expt #12</p>
12	<p>Design and set-up a buck/ boost /buck-boost converter</p> <p><i>(Mandatory Experiment)</i></p> <p>Aim: (a) Design, simulate and set up a buck/boost/buck-boost converter (continuous conduction mode) and observe relevant waveforms (b) Compare the measured quantities such as capacitor voltage ripple and inductor current ripple with the designed values (c) Calculate power loss in power devices and select heat sink (and snubbers) needed if any (d) Overall efficiency computation and measurement of temperature of the heatsink and passive components (e) Explore performance improvement opportunities</p>

	(Any suitable simulation software may be used for the simulation)
13	<p>Speed control of Permanent Magnet/Separately-Excited DC motor using chopper drive</p> <p>Aim: To simulate and set up a One-quadrant/Two-quadrant DC chopper to control the speed of a PMDC/SEDC motor for operation in continuous conduction and observe relevant waveforms (Any suitable simulation software may be used for the simulation)</p>
14	<p>Three-phase IGBT/MOSFET inverter feeding RL Load</p> <p>Aim: To simulate and set up (Demo is sufficient) a three-phase inverter for (a) sine-triangle PWM (b) third-harmonic (or triple-n harmonic) injection PWM and observe relevant waveforms & THD. Influence of various parameters such as switching frequency, amplitude & frequency modulation indices, dead-time etc. on the performance may be studied (Any suitable simulation software may be used for the simulation).</p>
15	<p>Stator Voltage control of Three-Phase Induction Motor</p> <p>Aim: To set up (Demo is sufficient) a three-phase induction motor drive using stator voltage control and observe relevant waveforms & THD (Simulation may be used to get more insights).</p>
16	<p>Single phase unidirectional/bidirectional interface – boost PWM rectifier Aim:</p> <p>To set up (Demo is sufficient) a single-phase PWM rectifier with near unity power, observe relevant waveforms and obtain the line current THD/PF (Simulation may be used to get more insights).</p>
17	<p>V/F control of Three-Phase Induction Motor</p> <p>Aim: To simulate and set up (Demo is sufficient) a three-phase induction motor drive using V/F control and observe relevant waveforms & THD for different speeds of operation (Any suitable simulation software may be used for the simulation).</p>

Course Assessment Method
(CIE: 50 marks, ESE: 50 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Preparation/Pre-Lab Work experiments, Viva and Timely completion of Lab Reports / Record (Continuous Assessment)	Internal Examination	Total
5	25	20	50

End Semester Examination Marks (ESE):

Procedure/ Preparatory work/Design/ Algorithm	Conduct of experiment/ Execution of work/ troubleshooting/ Programming	Result with valid inference/ Quality of Output	Viva voce	Record	Total
10	15	10	10	5	50

- **Submission of Record:** Students shall be allowed for the end semester examination only upon submitting the duly certified record.
- **Endorsement by External Examiner:** The external examiner shall endorse the record

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Understand the operation of modern power semiconductor devices, its characteristics and Design & Select suitable gate driver circuits & heatsinks	K5
CO2	Understand the features of phase-controlled rectifiers, AC voltage Controllers & Switching Regulators and Analyse the operation	K4
CO3	Understand the features of different types of switch mode DC-AC Inverters and Analyse the operation	K3
CO4	Understand the need for improved efficiency, improved reliability, improved load & source waveforms and improved utility interface	K3
CO5	Understand the features of adjustable speed drives and Analyse the basic drive schemes for DC motors and Induction Motors	K4

Note: *K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO- PO Mapping (Mapping of Course Outcomes with Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3									
CO2	3	1	3									
CO3	3	1	3									
CO4	3	1	3									
CO5	3	1	3									

1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation

Text Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Power Electronics- Essentials and Applications	L. Umanand	John Wiley	2009
2	Power Electronic Systems- Theory and Design	Jai P Agrawal	Pearson	2006
3	Power Electronics- Converters, Applications and Design, 3e (Indian Adaptation)	Ned Mohan, Undeland, Robbins	Wiley India	2022
4	Power electronics: principles and applications	Joseph Vithayathil	Tata McGraw Hill	2010
5	Power Electronics	D.W. Hart	McGraw Hill	2010

Reference Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Elements of Power Electronics	Philip T Krein	Oxford	2017
2	Power Electronics- Devices, Circuits and Applications	Muhammad H. Rashid,	Pearson	2014
3	Power Electronics	Cyril W Lander	McGrawHill	1993
4	Power Electronics- A first course: Simulations and Laboratory Implementations	Ned Mohan, Siddharth Raju	Wiley	2023
5	Power Electronics Step by Step- Design, Modeling, Simulation and Control	Weidong Xiao	McGrawHill	2021

Video Links (NPTEL, SWAYAM...)	
Module No.	Link ID
1	Lecture Series on Power Electronics by Prof. G. Bhuvaneswari , IIT Delhi https://www.youtube.com/watch?v=Z2CORFayCv0&list=PLp6ek2hDcoND7i5-DAD9mPmYF1Wg6ROdO&index=3
2	NPTEL Lecture Series on Power Electronics by Prof. L. Umanand , IISc Bangalore https://www.youtube.com/watch?v=eLIdqiPMjBs&list=PLgMDNELGJ1CaXa4sX6QSrkhu-yP_Wu2EN&index=26
3	NPTEL Lecture Series by Prof. Shabari Nath , IIT Guwahati https://www.youtube.com/watch?v=S_UXW2UzAi8&list=PLwdnzlV3ogoWVgA9fHBV36L_bxWZlpa7X&index=7

Continuous Assessment (25 Marks)

1. Preparation and Pre-Lab Work (7 Marks)

- Pre-Lab Assignments: Assessment of pre-lab assignments or quizzes that test understanding of the upcoming experiment.
- Understanding of Theory: Evaluation based on students' preparation and understanding of the theoretical background related to the experiments.

2. Conduct of Experiments (7 Marks)

- Procedure and Execution: Adherence to correct procedures, accurate execution of experiments, and following safety protocols.
- Skill Proficiency: Proficiency in handling equipment, accuracy in observations, and troubleshooting skills during the experiments.
- Teamwork: Collaboration and participation in group experiments.

3. Lab Reports and Record Keeping (6 Marks)

- Quality of Reports: Clarity, completeness and accuracy of lab reports. Proper documentation of experiments, data analysis and conclusions.
- Timely Submission: Adhering to deadlines for submitting lab reports/rough record and maintaining a well-organized fair record.

4. Viva Voce (5 Marks)

- Oral Examination: Ability to explain the experiment, results and underlying principles during a viva voce session.

Final Marks Averaging: The final marks for preparation, conduct of experiments, viva, and record are the average of all the specified experiments in the syllabus.

Evaluation Pattern for End Semester Examination (50 Marks)

1. Procedure/Preliminary Work/Design/Algorithm (10 Marks)

- Procedure Understanding and Description: Clarity in explaining the procedure and understanding each step involved.
- Preliminary Work and Planning: Thoroughness in planning and organizing materials/equipment.
- Algorithm Development: Correctness and efficiency of the algorithm related to the experiment.
- Creativity and logic in algorithm or experimental design.

2. Conduct of Experiment/Execution of Work/Programming (15 Marks)

- Setup and Execution: Proper setup and accurate execution of the experiment or programming task.

3. Result with Valid Inference/Quality of Output (10 Marks)

- Accuracy of Results: Precision and correctness of the obtained results.
- Analysis and Interpretation: Validity of inferences drawn from the experiment or quality of program output.

4. Viva Voce (10 Marks)

- Ability to explain the experiment, procedure results and answer related questions
- Proficiency in answering questions related to theoretical and practical aspects of the subject.

5. Record (5 Marks)

- Completeness, clarity, and accuracy of the lab record submitted

