

COEP Technological University Pune
(A Unitary Public University of Govt. of Maharashtra)

School of Engineering and Technology

Curriculum Structure of Third Year

Electrical Engineering

(F.Y. Structure Effective from: A.Y. 2025-26)

T. Y. B. Tech. in Electrical Engineering
Semester -V

Sr. No.	Course Code	Course Title	L	T	P	S	Cr	Category
01	PCC-10	Digital Signal Processing	3	0	0	1	3	PCC
02	PCC-11	Synchronous Machines	3	0	2	1	4	PCC
03	PCC-12	Power System Analysis	3	0	2	1	4	PCC
04	PEC-01	Program Specific ElectiveI	3	0	0	1	3	PEC
05	OE-03	Open Elective – III	2	0	0	1	2	OE
06	OJT-01	Internship	--	--	--	--	1	OJT
07	VSEC-01	Project Stage I	--	--	4	--	2	VSEC
08	MDM-02	Multidisciplinary Minor – II	4	0	0	1	4	MD M
Total			18	00	08	06	23	

Semester -VI

Sr. No.	Course Code	Course Title	L	T	P	S	Cr	Category
01	PCC-13	Power Electronics	3	0	2	1	4	PCC
02	PCC-14	Control Systems	3	0	2	1	4	PCC
03	PCC-15	Power System Operation and Control	3	0	0	1	3	PCC
04	PCC-16	Digital Protection and Switchgears	3	0	2	1	4	PCC
05	PEC-02	Program Specific Elective II	3	0	0	1	3	PEC
06	VSEC-02	Project Stage II	0	0	4	--	2	VSEC
07	MDM-03	Multidisciplinary Minor –III	4	0	0	1	4	MD M
Total			19	00	10	06	24	

Exit option to qualify for B. Voc. :

- Internship of 8 weeks

Program Elective Courses (PECs)

PEC/Sem	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
	Sustainable Mobility	Electrical Machines	Power Systems	Control Systems	Renewable Energy Systems	Electric Mobility
PEC - 1/V	Energy Storage Systems	Electrical Machine Design	Utilization of Electrical Energy	Mathematical Modelling of Dynamic Systems	Energy Economics	Foundation and BMS
PEC - 2/VI	Motor Control for Electric Mobility	Analysis of Electric Machinery	High Voltage Engineering	Motor Control for Electric Mobility	Distributed Generation	
PEC - 3/VII	Converters for Electric Vehicles	Condition Monitoring of Electrical Machines	Smart Grid Technologies	Intelligent Control	Solar and Wind Energy Systems	EV Charger
PEC - 4/VII	Machine Learning and Artificial Intelligence for Electric Vehicles	Machine Learning and Artificial Intelligence	Applications of Machine Learning and Artificial Intelligence in Power Systems	Machine Learning and Artificial Intelligence	Applications of Machine Learning and Artificial Intelligence in Renewable Energy	
PEC - 5/VIII	Deep Learning	Power Quality				
PEC - 6/VIII	MOOC Courses offered by NPTEL/SWAYAM					
PEC - 7/VIII	MOOC Courses offered by NPTEL/SWAYAM					

Additional Credits for Exits

After Completion of Third Year

- Eight Weeks Internship

Open Electives

Sr. No.	Course Code	Course Title	L	T	P	S	Cr	Category
01	OE – I	Electrical Machines and Drives	2	0	0	1	2	OE
02	OE – II	Principles of Electronic Communication	2	0	0	1	2	OE
03	OE - III	Sensors and Actuators	2	0	0	1	2	OE
Total			6	0	0	3	6	

T. Y. B. Tech. in Electrical Engineering

Evaluation Scheme -Semester-V

Sr. No.	Course Type	Course Code	Course Name	L	T	P	S	C r	Evaluation Scheme (Weightages in %)				
									Theory			Laboratory	
									MSE	TA	ESE	ISE	ESE
01	PCC	<td>	Digital Signal Processing	3	0	0	1	3	30	20	50	50	50
02	PCC	<td>	Synchronous Machines	3	0	2	1	4	30	20	50	50	50
03	PCC	<td>	Power System Analysis	3	0	2	1	4	30	20	50	50	50
04	PCC	<td>	Program Specific Elective I	3	0	0	1	3	30	20	50	50	50
05	VEC	<td>	Open Elective-III	2	0	0	1	2	30	20	50	50	50
06	OE	<td>	Internship	--	--	--	--	1	--	--	--	CIE 100	
07	VSEC	<td>	Project Stage I	--	--	4	--	2	--	--	--	CIE 100	
08	MDM	<td>	Energy Resources, Economics and Environment	4	0	0	1	4	30	20	50	--	--
Total				18	00	08	05	23					

[PCC 10] Digital Signal Processing

Teaching Scheme

Lectures: 3 Hrs./week

Self-study: 1 hr/week

Examination Scheme

Mid Sem Evaluation-30 Marks

TA-20 Marks

End Sem Evaluation- 50 Marks

Course Outcomes:

After successful completion of this course students will be able to:

1. solve engineering problems in the area of signal processing.
2. implement FFT algorithms for computing the DFT
3. design FIR and IIR filters.
4. use DSP processor to solve real time application

Unit 1

[7Hrs]

Discrete time signals and systems

Importance of DSP, Discrete time signals, classification of discrete time signals and systems, mathematical operations on discrete time signal, response of LTI discrete system, discrete of linear convolution, circular convolution, correlation, crosscorrelation, autocorrelation Z transform, fourier series and fourier transform.

Unit 2

[7Hrs]

Discrete Fourier Transform (DFT)

The DFT and its properties; Inverse DFT, Linear filtering methods based on DFT - Use of DFT in linear filtering, filtering of long data sequences, Efficient computation of DFT algorithms-Radix2 (DIT and DIF), Radix4, Split radix algorithms. Linear filtering approach to computation of DFT-Goertzel algorithm, Chirp z transform, Fast Fourier Transform (FFT)

Unit 3

[6Hrs]

Digital Filters:

Linear phase FIR filter, characteristic response, location of zeros, Design of FIR filter Windowing, Frequency sampling, Design of IIR filters from Analog filters-Impulse in variance, Bilinear transformation, Matched z-transform.

Unit 4

[6Hrs]

Digital Filter Structures:

FIR filters - Direct form, Cascade form, Frequency sampling, Lattice IIR filter - Direct form I, Direct form II cascade form parallel form Lattice and Lattice loader

Unit 5

[7Hrs]

Multirate Digital Signal Processing: Decimation by a factor D, Interpolation by a factor I, Sampling rate conversion by a rational factor I/D

Unit 6

[7 Hrs]

DSP Processors:

TMS C6xxx, Features, Architecture and Applications. Harvard Architecture, pipelining, Multiplier-Accumulator (MAC) Hardware. Architectures of Fixed- and Floating-point DSP processors. Addressing modes, functional modes. Memory architecture, on-chip peripherals of a DSP processor.

Text Books:

- J. G. Proakis and D. G. Manolakis, Digital Signal Processing - Principles, algorithms and Applications, PHI, 2000.
- 2. S. K. Mitra, Digital Signal Processing – A computer Based Approach, MGH, 2010, 4th Edition.
- 3. A. NagoorKeni, Digital Signal Processing, MGH India Pvt. Ltd.

Reference Books:

- Hwei Hsu, "Signals and Systems", 3rd edition, Schaum's series, McGraw Hill, 2013.
- Alan V. Oppenheim, Ronald W. Schaffer, "Discrete-Time Signal Processing, 3rd edition, Prentice Hall, 2010.
- B. P. Lathi, "Linear Systems and Signals", 2nd edition, Oxford University Press, 2006.
- S. Salivahanan, "Digital Signal Processing", 2nd edition, McGraw Hill, 2011.

e Learning Resources:

1. Prof. Alan V. Oppenheim, MIT online lecture series on Signals and Systems
<https://ocw.mit.edu/resources/res-6-007-signals-and-systems-spring-2011/index.htm>
2. Prof. Alan V. Oppenheim, MIT online lecture series on Digital Signal Processing
<https://ocw.mit.edu/resources/res-6-008-digital-signal-processing-spring-2011/>
3. Prof. S. C. Datta Roy, IIT Delhi, online lecture series on Digital Signal Processing
<https://nptel.ac.in/courses/117/102/117102060/>

[PCC 11] Synchronous Machines

Teaching Scheme

Lectures: 3 Hrs./week

Self-study: 1 hr/week

Laboratory: 2 Hrs/week

Examination Scheme

Mid Sem Evaluation-30 Marks

TA-20 Marks

End Sem Evaluation- 50 Marks

Course Outcomes:

After successful completion of this course students will be able to:

1. compare the constructional features of conventional and modern synchronous machines.
2. select and design armature winding for synchronous machine.
3. analyse the steady state characteristics of synchronous generator
4. analyse the steady state characteristics of synchronous motor
compute various performance parameters of BLDC, SRM

Unit 1

[8Hrs]

Basic concepts in rotating machines

Revision of electromechanical energy conversion principles, AC machines classification, construction,

basic principles of operation, MMF of concentrated windings, Magnetic fields in rotating machines, rotating MMF waves in ac machines, generated voltage, torque in no salient pole machines, MMF in linear machines and magnetic saturation, Operation of ac machines, MMF of concentrated and distributed windings, ac machine windings, winding connections, winding factors, modified emf equation, harmonic causes and their suppression.

Unit 2

[6Hrs]

Synchronous Generator

Construction, types, circuit model, effects of saliency, determination of synchronous reactance, phasor diagram, power angle characteristics, parallel operation and load sharing, synchronizing process.

Unit 3

[7 Hrs]

Synchronous Motor

Synchronous motor, representation, phasor diagram, characteristics curves, torque-speed curves, under and over excitation operation, losses and efficiency, applications

Unit 4

[7 Hrs]

Permanent Magnet Synchronous Machines

Permanent magnet synchronous motors, operation, rotor types, equivalent circuit, sine wave motors, air gap flux density, phasor diagram, permanent magnet materials, emf and torque equation, starting, rotor position sensing, speed control, cogging torque, maximum torque, losses and efficiency.

Unit 5

[7 Hrs]

Brushless DC motors

Operation of three phase brushless DC motor, construction, rotor types, windings, magnetic circuit analysis, emf and torque equation, emf waveform, torque and emf constants, speed-torque characteristics, losses and efficiency

Unit 6

[7 Hrs]

Switched Reluctance Motor

Introduction to Switched Reluctance Motor, Construction, Poles, phases, windings, static torque equation, energy conversion loop, effects of saturation, Dynamic torque production, Control, shaft position sensing, torque-speed characteristics.

Text Books:

- D. P. Kothari and I. J. Nagrath, "Electric Machines", Tata McGraw Hill Publication, (4th edition reprint 2012).
- A. E. Fitzgerald, C. Kingsley, S. D. Umans, "Electrical Machinery", Tata McGraw Hill, 2002, (6th edition).
- Miller, T. J. E., "Brushless Permanent Magnet and Reluctance Motor Drives", Oxford Science Publications, 1989.
- P. S. Bimbhra, "Electrical Machinery", Khanna Publishers, 7th edition, 2011.

Reference Books:

- Nasser Syed, "Electrical Machines and Transformers", A New York, Macmillan, 1984.
- P. C. Sen., "Principles of Electric Machines and Power Electronics", 2nd Edition, John Wiley and Sons Inc., 1997.
- Bhag S. Guru and Huseyin R. Hizirouglu, "Electric Machinery and Transformers", 3rd Indian Edition, Oxford University press, Reprint 2014.
- M. G. Say, "Alternating Current Machines", Fifth edition, Low price edition, ELBS, Reprinted 1994
- J. R. Handershot and T.J. E. Miller, "Design of Brushless permanent magnet machines", Book masters Inc. 2010.
- Duane C. Hansalman, "Brushless permanent magnet motor design", second edition, Magna Physics publication, 2006
- K. Venkataratnam, "Special Electrical Machines", Universities press, 2009

e Learning Resources:

- <https://nptel.ac.in/courses/108105017>; NPTEL: Electrical Engineering, Electrical Machines–I and Electrical Machines -II. Dr. D. Kashta, IIT Kharagpur.
- <https://nptel.ac.in/courses/108/105/108105131/> Prof. Tapas Kumar Bhattacharya

e-Book/Notes:

- M. V. Deshpande, “Electrical Machines”, PHI Learning Pvt. Ltd. New Delhi, 2011.
- NPTEL web course by Prof. P. Sasidhara Rao, G. Sridhara Rao and Krishna Vasudevan, IIT Madras, <https://nptel.ac.in/courses/108/106/108106072/>

Synchronous Machines Laboratory**Laboratory: 2 Hrs/week****Examination Scheme:**

CIE: 50 Marks

ESE : 50 Marks

Course Outcomes:

After successful completion of this course students will be able to:

1. analyze the construction of synchronous machines.
2. test the synchronous machine to determine its parameters.
3. evaluate steady state performance of synchronous machine.
4. determine the steady state performance of PMSM, SRM, BLDC.

The laboratory should consist of minimum eight experiments based on the following topics:

List of Experiments:

1. Perform O.C. and S.C. test on Alternator: Determination of parameters and regulation of synchronous machine by the EMF method.
2. Perform direct loading test on three phase alternator and determine its performance.
3. Estimate “V” and inverse V” curves of synchronous motor at no load and constant load.
4. Determine the power and load angle curve of synchronous machine.
5. Perform a load test on permanent magnet synchronous motor.
6. Perform a load test on line start permanent magnet synchronous motor.
7. Perform a load test on a BLDC motor.
8. Perform a load test on synchronous reluctance motor.
9. Perform an experiment to control the speed of a brushless DC motor.
10. To study the flux distribution and saturation of Synchronous machine at various loads using FEM package

[PCC 12] Power System Analysis**Teaching Scheme**

Lectures: 3 Hrs./week

Self-study: 1 hr/week

Laboratory: 2 Hrs/week

Examination Scheme

Mid Sem Evaluation-30 Marks

TA-20 Marks

End Sem Evaluation- 50 Marks

Course Outcomes:

After successful completion of this course students will demonstrate the ability to:

1. familiarize with the various components of the power system, its structure, evolution and national level scenario
2. evaluate the performance of various transmission line models
3. develop the mathematical model for power system components like generators, transformers etc.
4. compute power flow for the given power system network
5. analyse faults on power system
6. analyse the stability of single/multi machine systems

Unit 1**[8 Hrs]****Introduction and Basic Concepts of Power Systems**

Structure of power systems, Power system scenario in India, concept of regional and National GRID, overview of conventional and non-conventional power generation. Distribution system, impact of EV and DGs, concept of smart and micro grid, Complex power: concept of real, reactive power and their effects on power system operation, per unit system.

Unit 2

[7 Hrs]

Models and Performance of Transmission Line:

Transmission line parameters: Resistance, inductance and capacitance of single phase and three phase line, concept of GMR and GMD, Skin effect, Proximity Effect. Transmission line models -short, medium and long lines, voltage and current waves, surge impedance loading of Transmission Line, Phenomenon of Corona, complex power flow through transmission lines, power transmission capability, Ferranti effect, Tuned power lines, methods of voltage control.

Unit 3

[8 Hrs]

Modeling of Power System Components

Synchronous generators: generator model, steady state characteristics, power transformer: Three phase power transformer and its modelling, network model formulation, synchronous machine transients, determination of transient constants, DC component of stator currents.

Unit 4

[7 Hrs]

Power Flow Analysis

Power flow equations and solution techniques. Formation of bus admittance matrix, Gauss-Seidel method, Newton-Raphson method, decoupled and fast decoupled methods, comparison of power flow methods, power flow simulation software.

Unit 5

[6 Hrs]

Symmetrical and Unsymmetrical Fault Analysis

Internal voltages of loaded machines under transient conditions, selection of circuit breakers, Symmetrical components of unsymmetrical phasors, effect of the transformation on power, sequence impedances and sequence networks of power system, single Line to Ground (LG) faults, Line-to-Line (LL) faults, Double Line to Ground (LLG) faults and open conductor faults.

Unit 6

[6 Hrs]

Power System Stability

Steady-state and transient stability concepts, rotor dynamics and swing equation, equal area criterion, step by step solution of swing curve, multi-machine stability, factors affecting transient stability.

Textbooks:

1. Grainger John J and W D Stevenson Jr., "Power system analysis", Mc-Graw Hill.. D. Glover and M. Sarma, "Power System Analysis and Design", (3rd edition), Brooks/ Cole Publishing, 2002.
2. Hadi Sadat, "Power system analysis", McGraw Hill International, 3rd Edition, 2010.
3. J. Nagrath, D. P. Kothari, "Modern Power System Analysis", 4th Edition, Tata McGraw Hill Publishing Co. Ltd., 2011.

Reference Books:

1. O. I. Elgerd, "Electrical energy systems theory: An introduction" Tata McGraw Hill, edition 1999
2. A. R. Bergen and Vijay Vittal, "Power system analysis", (2nd edition), Pearson Education Asia, 2001.

E Resources:

- https://onlinecourses.nptel.ac.in/noc19_ee62/preview

Power System Analysis Laboratory

Teaching Scheme:

Practical: 2 Hrs/week

Examination Scheme:

CIE: 50 Marks

ESE: 50 Marks

Course Outcomes:

After successful completion of this course students will be able to:

1. model power system components for steady state studies.
2. analyze the reactive power requirement of lines and VAR compensation.
3. use MATLAB and ATP/PSCAD for power system studies.
4. analyze the symmetrical and unsymmetrical faults.
5. compute the Y-Bus matrix, perform load flow and interpret the results.

List of Experiments:

Group I: Students will perform an experiment

1. To validate Ferranti effect on an unloaded transmission line.
2. To determine A, B, C, D constants of a given transmission line.
3. To determine the effect of surge impedance loading of a transmission line.
4. To study the Effect of VAR compensation on receiving end voltage profile of distribution line.
5. To determine suitability of cable for AC transmission.
6. To determine the insulator string efficiency.
7. Visit to HV/EHV substation, power generating station.

Group II (minimum four using MATLAB/ PSCAD):

1. Simulation of typical power system- familiarization with generator, line and load models.
2. Formulation of Y-bus matrix using computer program.
3. Computer aided solution of power flow problem by Gauss Siedel/ Newton-Raphson method.
4. To plot the swing curve.
5. Determination of steady state power limit of transmission line.
6. Simulation and analysis for a symmetrical three phase fault by simulation.
7. Simulation and analysis of unsymmetrical faults - LL, LG and LLG.

[OE 3] Sensors and Actuators

Teaching Scheme

Lectures: 2 Hrs./week

Self-study: 1 hr/week

Examination Scheme

Mid Sem Evaluation-30 Marks

TA-20 Marks

End Sem Evaluation- 50 Marks

Course Outcomes:

After successful completion of this course students will be able to:

1. select and specify a sensor actuator system for an application
2. implement a sensor and actuator system for discrete and continuous processes
3. identify the lacunas in the existing sensors selection and suggest improvements
4. troubleshoot the given sensors and actuators systems and commission it in a stipulated time
5. develop a proto-type for effective implementation of automation at level zero

Unit I

[6 Hrs]

Overview of discrete and continuous processes

Characteristics, requirements, specifications, used cases, and cost considerations, block schematic of control loop, various parameters to assess performance

Unit II

[6 Hrs]

Overview of sensors and Transducers

Case studies based on selection, specifications, installation, commissioning, and troubleshooting of various sensors used for measurement of temperature, pressure, level, and flow

Unit III

[8 Hrs]

Overview of sensors and Transducers

Case studies based on selection, specifications, installation, commissioning, and troubleshooting of various sensors used for measurement of displacement, velocity, and acceleration

Unit IV

[8 Hrs]

Implementation case studies

Case studies based on various applications in the area of construction, refrigeration, automotive, and traffic control system

Unit V

[8 Hrs]

Actuators

Working, designing, selecting, and troubleshooting of pneumatic, hydraulic, and electrical actuators. Case studies comprising of application of actuator knowledge in real life situations and in chosen plants.

Unit VI

[6 Hrs]

Case studies

Based on various applications and interfacing of sensors in chosen fields, actuators, safety aspects, maintenance and trouble shooting of sensor actuator systems

[INTERNSHIP II] Internship

Examination Scheme

CIE- 50 Marks

ESE- 50 Marks

S r N o	Items	Type of Internship to be undertaken
1	Nature of Internship	Industry / R and D labs / Govt Depts/ Education institutes (HEI within 100 NIRF rank) Some of the indicative areas as per Internship Policy are : a) Education institutes / R and D labs/ Incubation centre / Start-up b) Reputed industries c) Economy & Banking Financial Services and Insurance Area d) Logistics, Automotive & Capital Goods Area e) Information Technology/Information Technology enabled Services & Electronics Area f) Handcraft, Art, Design & Music Area g) Healthcare & Life Science Area h) Sports, Wellness and Physical Education Area i) Digitisation & Emerging Technologies j) Humanitarian, Public Policy and Legal Service Area k) Food processing industries l) Sustainable development Area m) Environment Area n) Pharmaceutical and textile Industries
2	End Semester Evaluation process	Individual students shall submit a report followed by viva voce by the department panel. Reporting and evaluation format as per template provided by the Nodal Officer, COEP Tech

Internship involves minimum 4 weeks of practical work in the field, technical report writing, and exposure to industry best practices. It aims to bridge the gap between theoretical knowledge and real-world

application, fostering professional and personal development. Key elements often include a mini-project, mentorship, and evaluation through viva and term work. Internships emphasize applying technical knowledge to practical situations, fostering an understanding of engineer's responsibilities and ethics.

Key Components of an Internship Syllabus:

1. Practical Work and Project:

Students engage in real-world engineering tasks, often involving a small-scale project aligned with their field of study.

2. Technical Report Writing:

Internships require students to document their experiences, findings, and contributions through comprehensive reports.

3. Industry Exposure:

Internships provide valuable experience in various materials, processes, and quality control aspects within the industry.

4. Mentorship and Guidance:

A faculty mentor from the college and an industry expert act as guides, providing support and feedback throughout the internship.

5. Evaluation:

The internship is evaluated through a viva and a term work component, assessed by both faculty and industry mentors.

6. Internship Diary/Workbook:

Students maintain a detailed diary/workbook to record observations, impressions, and information gathered during the internship.

7. Attendance and Evaluation:

Regular attendance is crucial, and the internship is formally evaluated by the industry supervisor, with a signed and stamped evaluation sheet submitted to the institute.

8. Application of Knowledge to practical problems.

[VSEC 01] Project Stage I

Examination Scheme

CIE- 50 Marks

ESE- 50 Marks

Course Outcomes:

After successful completion of this course students will be able to:

1. identify and define an engineering problem based on societal, industrial, or technological needs.
2. conduct an effective literature review and identify research gaps to justify the scope and direction of the project.
3. formulate a structured project plan, team work with time estimation, and task distribution.
4. analyze the feasibility of their proposed solution, considering technical, financial, and sustainability aspects.
5. demonstrate the ability to document and communicate their work effectively through written reports and oral presentations.

The B.Tech project work spans **three consecutive semesters (V, VI, and VII)** to provide students sufficient time to explore, develop, and refine innovative engineering solutions. The project stage I is initiation and planning.

A structured approach using relevant project management tools are to be used for tracking the project work.

1. **Topic Selection:** Choose a feasible project within the domain, addressing a real-world problem, industry need, or research challenge.

2. **Literature Survey:** Conduct in-depth reviews of academic journals, patents, technical papers, and existing systems to identify gaps and opportunities.
3. **Project Planning:** Define objectives, scope, deliverables, and develop a timeline with clear milestones.
4. **Preliminary Design and Methodology:** Formulate the solution approach and outline initial design plans or system architecture.
5. **Deliverables:** Submission of a detailed project synopsis, literature survey documentation, and initial design, along with a presentation.

Sr No	Items	Description of activity
1	Scope (TRL-2)	Research Problem Identification, Literature, objective, methodology and Architecture / Plan of work
2	Student project group	Four students maximum per project. The student group remained the same till the completion of the three stages of the project. No change in topic/ group / guide is allowed in subsequent stages of projects. In case of eventuality, alternate guide may be allotted.
3	Problem statement identification	It is mandatory for faculty members to float projects with carefully selected problem statements well in advance. The project should be floated and allotted within a week after the 5 th semester registration process is over. Since the project will run for one and half years, it is required by the department to float topics for the choice of students. The project topic should be in line with National Mission / Atmanirbharbharat/ Industry requirements/ Funding body requirements / socially relevant project / Sustainable Development Goals (SDGs)
4	Project topic selection	The student group shall choose a project topic amongst the available topics given by the department based on the previous semester CGPA.
5	Self-Study material for the student	The department should recommend relevant online / offline self-study materials on IPR, technical paper writing, plagiarism, safety, NDA, Regulatory standards, for example- BIS, etc.
6	End Semester Evaluation process	The end semester evaluation shall be based on project power point presentation and well-structured project report. The evaluation shall be done by the panel of at least three members including one of them is project guide.

[MDM II] Energy Resources, Economics and Environment

Teaching Scheme

Lectures: 4 Hrs./week

Self-study: 1 hr/week

Examination Scheme

Mid Sem Evaluation-30 Marks

TA-20 Marks

End Sem Evaluation- 50 Marks

Course Outcomes:

After successful completion of this course, students will demonstrate the ability to

1. Analyse the availability of energy resources and assess methods for quantifying resource depletion and scarcity.

2. Apply basic concepts of economics to energy systems and their impacts.
3. Utilize tools and techniques for project economics from both individual/company and macro-decision-making perspectives.
4. Understand fundamental concepts of welfare economics and environmental economics relevant to energy systems analysis.
5. Evaluate the environmental impacts of energy systems and their associated economic implications.

Unit 1

[7 Hrs]

Energy Flow Diagram, Global Trends in Energy Use, India and World- Disaggregation by supply, end use, Energy and Environment, the Kaya Identity, Emission Factor

Energy and Quality of Life, Energy Inequality, Energy Security, Introduction to Country Energy Balance assignment

Unit 2

[8 Hrs]

Energy Economics - Simple Payback Period, Time Value of Money- discount rate, Criteria for Assessing Energy Projects –(Net Present Value (NPV), Benefit/Cost Ratio (B/C), Inflation, Internal Rate of Return (IRR)

Unit 3

[8 Hrs]

Resources and Reserves Growth Rates in Consumption, Estimates of Duration of Fossil Fuels, McKelvey Diagram, Peak oil, Hubbert's model

Unit 4

[8 Hrs]

Materials used in renewable energy (Kuznet's Curve, Betting on the planet, Simon's Change), Non Renewable Energy Economics (Hotelling's Rule)

Unit 5

[8 Hrs]

Preferences and Utility, Utility and Social Choice Public and private goods / bads, Demand curves ,Externalities Financing Energy – Debt/ Equity- Sources of funds, innovative financing models Input Output Analysis Primary Energy Analysis, Net Energy Analysis, Examples, Energy Cost of Energy, Life Cycle Analysis of Bioenergy, Net Energy Examples, Energy Policy, Energy Policy Examples, Practice problems solution.

This course is based on Swayam Portal Course by Dr. Rangan Banerjee

<https://archive.nptel.ac.in/courses/109/101/109101171/>

Text Books:

Dr. Rangan Banerjee, "Energy Resources, Economics and Environment"

<https://drive.google.com/file/d/1Ndn32ykytW2JV2eLHtR1KrqpHzGwTqBM/view>

T. Y. B. Tech. in Electrical Engineering

Evaluation Scheme -Semester-V

S r. N o.	Cours e Type	Course Code	Course Name	L	T	P	S	Cr	Evaluation Scheme (Weightages in %)				
									Theory		Laboratory		
									MS E	T A	ESE	ISE	ESE
1	PCC	<tbd>	Power Electronics	3	0	2	1	4	30	20	50	50	50
2	PCC	<tbd>	Control Systems	3	0	2	1	4	30	20	50	50	50
3	PCC	<tbd>	Power System Operation and Control	3	0	0	1	3	30	20	50	--	--

4	PCC	<td>	Digital Protection and Switchgear	3	0	2	1	4	30	20	50	50	50
5	PEC	<td>	Program Specific Elective II	3	0	0	1	3	30	20	50	--	--
6	VSEC	<td>	(Project Stage II)	0	0	4	--	2	--	--	--	CIE-100	
7	MDM	<td>	Multidisciplinary Minor –III :Energy Audit and Management	4	0	0	1	4	30	20	50	--	--
			TOTAL	19	00	10	06	24					

[PCC 13] Power Electronics

Teaching Sche

Lectures: 3 Hrs./week

Self-study: 1 hr/week

Laboratory: 2 Hrs/week

Course Outcomes:

After successful completion of this course students will be able to

1. understand the structure, characteristics, and protection of various power electronics devices and circuits
2. analyse the single phase and three phase AC-DC and AC-AC converters.
3. analyse various DC-AC converters.
4. design different control strategies for various DC-AC converters.
5. describe the performance characteristics of various DC-DC converters.
6. identify and design driver circuits and magnetics in various power electronics converters

Unit 1

[7 Hrs]

Power Devices and their properties:

Structure, static and switching Characteristics, Trigger requirements, Ratings, protection and snubber circuit and application of Power diode, SCR, IGBT, Power MOSFET, WBG devices and comparison: GaN, SiC devices, IPM.

Unit 2

[8 Hrs]

DC-DC Converter:

MOSFET based choppers: Buck, Boost, Buck-Boost converters, their working, Duty cycle equation, output waveforms, Performance analysis, continuous and discontinuous conduction mode, Voltage Mode Control, Current mode control, Modeling of VM in CCM, Power loss and efficiency calculation.

Unit 3

[8 Hrs]

Modern Power Converters:

Hard switched and soft switched converters, ZVS and ZCS Converter, LLC Converter, Phase Shifted full bridge converter, Bidirectional DC to DC converter, Fly back SMPS, Introduction to EMI/EMC: Basic concepts, sources of EMI, and types of coupling mechanisms. EMC Standards and Regulations: CISPR, MIL-STD, FCC

Unit 4

[8 Hrs]

AC-DC Converter:

Principle of phase controlled converter, Uncontrolled, semi-controlled and fully controlled converters in single-phase and three-phase configurations. Performance parameters and input-output waveforms for R, R-L loads, harmonic analysis. Improved power quality AC-DC converters (introduction to PFC), Single phase and three phase unity power factor converters.

Unit 5

[8 Hrs]

DC-AC Converter:

PWM Inverters: single phase and three phase circuits, principle of operation, performance parameters.
Multilevel Inverters: Cascaded H bridge, neutral point clamped. Sinusoidal PWM, Space vector PWM.
Algorithm for PWM generation for power converters

Unit 6

[8 Hrs]

Driver Circuit and Magnetic Design for PE Converters:

Driver circuit design, ac and dc voltage and current sensing circuits, Heat sink design and selection

Text Books:

1. Ned Mohan, Siddharth Raju, "Simulations and Laboratory Implementations", Wiley, 2nd Edition, December 19, 2022.
2. P. C. Sen, "Power Electronics", Tata McGraw hill Publication, 2nd edition, 2017.
3. M. H. Rashid, "Power Electronics", PHI publication, 3rd edition, 2004.
4. L. Umanand, Power Electronics: Essentials and Applications, Wiley India Pvt. Ltd., 1st Edition, 2009.

Reference Books:

1. Robert W. Erickson and Dragan Maksimović, Fundamentals of Power Electronics, Springer, 2nd Edition, 2001.
2. Keith H. Sueker, "Power Electronic Design: A Practitioner's Guide", Elsevier Publication.
3. Kumar L. Ashok, "Power Electronics with MATLAB", Cambridge University Press.
4. B W Williams, "Power Electronics: Devices, Drivers, Applications and Passive Components", Mac-Millan Publication.
5. Issa Bataresh, Ahmad Harb, "Power Electronics circuit design and analysis", second edition

e-resources:

<https://archive.nptel.ac.in/courses/108/102/108102145/>

Power Electronics Laboratory

Teaching Scheme

Practical: 2 Hrs/week

Examination Scheme:

CIE: 50 Marks

ESE: 50 Marks

Course Outcomes:

After successful completion of this course students will be able to

1. Evaluate the V-I characteristics for different power semiconductor devices.
2. Demonstrate the operation and control techniques of power converters.
3. Analyze the waveforms exhibited at the input and output ports of the converters.
4. Simulate and analyze different converters with their control strategies

List of Experiments:

The laboratory should consist of minimum eight experiments based on the following topics:

1. To evaluate SCR Characteristics, their Turn-on methods.
2. To evaluate IGBT/MOSFET Characteristics, its loss calculations and measurement of Rds-on and parasitic capacitances including miller capacitor.
3. To evaluate the performance of Single-phase full bridge diode Rectifiers with R and RL load.
4. To evaluate the performance of Single-phase full bridge-controlled Rectifiers with R and RL load.
5. To evaluate the open loop performance of DC-DC buck converter.
6. To evaluate the open loop performance of DC-DC boost converter.
7. To evaluate the open loop performance of DC-DC Flyback back Converter
8. To evaluate the performance of LLC converter.
9. To evaluate the performance of three phase Inverter using different PWM technique.
10. To evaluate the performance of PWM rectifier.

Perform Any two

1. To perform MATLAB/PSIM Simulation of Unity power factor Converter.

2. To perform MATLAB/PSIM Modeling and analysis of DC-DC converter.
3. To perform MATLAB/PSIM Simulation of Multilevel inverter or various PWM strategies.
4. Introduction to LTSPICE circuit simulator

[PCC 13] Control Systems

Teaching Scheme

Lectures: 3 Hrs./week

Self-study: 1 hr/week

Laboratory: 2 Hrs/week

Examination Scheme

Mid Sem Evaluation-30 Marks

TA-20 Marks

End Sem Evaluation-50 Marks

Course Outcomes:

After successful completion of this course students will be able to

1. identify components of control systems.
2. represent the system using transfer function and state space approach.
3. analyze the system performance in both the time and frequency domain.
4. check the stability of the system using time and frequency domain techniques.

apply state feedback control to the given system.

Unit 1

[6 Hrs]

Introduction to Control System:

Introduction to control system block diagram, Open loop control and closed loop control, Components of control system, explanation with the help liquid level control system, Significance of actuators and sensors, Types of actuators, Types of sensors, Use of relays, switches and contactors for simple and sequential control system.

Unit2

[6 Hrs]

Control System Representation:

Mathematical representation of simple mechanical, electrical, thermal, hydraulic system. Block diagram representation and reduction, Signal flow graph, Transfer function of these systems, Pole zero concepts.

Unit3

[8 Hrs]

Time Domain Analysis:

Time response of first order, second order systems. Analysis of steady state error, Type of system and steady state error, Time response specifications, Effect of parameter variation on open loop and closed loop system response, sensitivity, Effect of feedback on system response, stability and disturbance.

Unit4

[6 Hrs]

Stability:

Concept of stability, Effect of pole zero location on stability, Routh- Hurwitz criterion. Root Locus method for analysis of gain margin, phase margin and stability.

Unit5

[6 Hrs]

Control System Analysis in Frequency Domain:

Concept of frequency domain behaviour, Bode Plot for analyzing system in frequency domain. Frequency domain performance specifications, Correlation between time domain and frequency domain specification, Nyquist Analysis.

Unit6

[8 Hrs]

State Space Approach

Representation of system in state space, Converting transfer function model into state space model. Non uniqueness of state space model, Canonical representation, Eigen values, Solution of state equations, Concept of State feedback control, controllability, Observability.

Text Books:

1. Nagrath and M. Gopal, "Control System Engineering", New Age International Publisher, 8th edition, 2009.
2. Norman S. Nice, "Control System Engineering", Wiley, 8th edition, 2008.

Reference Books:

1. Smarajit Ghosh, "Control Systems Theory and Applications", Pearson Education, 2nd Edition, 2007.
2. Katsuhiko Ogata, "Modern Control Engineering", Prentice Hall, 5th Edition, 2010.

e-resources:

NPTEL Course Control Engineering. Prof. M. Gopal (IIT Delhi)

Control System Engineering Laboratory

Teaching Scheme
Practical: 2 Hrs/week

Examination Scheme:
CIE: 50 Marks
ESE: 50 Marks

Course Outcomes:

After successful completion of this course students will be able to

1. analyse the step response of first order and second order system experimentally and by simulation in MATLAB
2. simulate the system to check the stability of system using time domain and frequency domain approaches.
3. simulate the system to evaluate state feedback gain matrix.
4. demonstrate an industrial application (like Bottle filling/Pick and Place control) using PLC

List of Experiments:

The laboratory should consist of minimum eight experiments based on the following topics:

Group I: Students will perform an experiment

1. to study input-output characteristics of various control system components such as potentiometer, relay, stepper motor etc
2. to find time response specifications of electrical system/hydraulic system/pneumatic system/thermal system etc
3. to find transfer function of DC motor.
4. to obtain root locus of DC Motor/ Spring mass damper system

Group II: minimum four simulation experiments using MATLAB/Simulink

1. to plot and analyse the step response of first order and second order system.
2. to study the effect of damping factor zeta on time response performance specifications of first order and second order system.
3. to obtain root locus for a given system and study effect of addition of zero and pole on root locus.
4. to obtain Bode plot and to find the gain margin and phase margin for various systems.
5. to obtain state space representation from transfer function and transfer function to state space.
6. to find Eigen values, and check controllability, observability of the system.
7. to find out feedback gain matrix of state space model of the system.

To study an industrial application (like Bottle filling/Pick and Place control) using PLC.

[PCC 15] Power System Operation and Control

Teaching Scheme
Lectures: 3 Hrs./week
Self-study: 1 hr/week

Examination Scheme
Mid Sem Evaluation-30 Marks
TA-20 Marks
End Sem Evaluation- 50 Marks

Course Outcomes:

After successful completion of this course students will be able to

1. analyze different control strategies for real and reactive power scheduling using control devices.
2. solve problems of economic dispatch, unit commitment using engineering and economic aspects

3. solve power system problems for frequency and voltage control.
4. familiarize with demand side management and electricity markets
5. analyze security aspects of power systems
6. understand various power quality issues and concept of micro-grid.

Unit 1

[6 Hrs]

Introduction:

General characteristics of modern power systems, evolution, structure, power system control, operating states of a power system and control strategies, Power System stability Problem, Generator capability curve, AC Transmission.

Unit 2

[7 Hrs]

Economic operation of power systems:

Economic dispatch, I/O characteristics, incremental fuel cost curves, economic dispatch without and with transmission losses, penalty factor and participation factor, B-coefficient loss formula, solution of economic dispatch problem using direct method and λ -iteration method, hydro-thermal economic dispatch, co-ordination equations without and with losses, unit commitment using priority list method and dynamic programming, role of load dispatch centres.

Unit 3

[8 Hrs]

Voltage and reactive power control:

Need for reactive power control in transmission and distribution systems, control methods in EHV lines, FACTS controllers, HVDC converter, Reactive Power compensation devices: shunt reactors and capacitors, series capacitors, synchronous condensers, tap changing transformers, static VAR systems, voltage profile under variable loading and renewable energy integration, effect of generator excitation adjustment for post disturbance stabilization, voltage collapse, voltage stability and load shedding, Distribution system voltage regulation, Pre fault and post fault power flows.

Unit 4

[8 Hrs]

Load frequency control:

Turbine and governor dynamics, load dynamics, need for automatic generation control (AGC), generation control loops and load frequency control (LFC), LFC for single area case, LFC for 2-area case, flat frequency control, tie-line control and tie line bias control, AGC with economic dispatch.

Unit 5

[6 Hrs]

Power system security:

Introduction, system state classification in relation to security, security and contingency analysis, state estimation and bad data detection, energy control centres, SCADA systems applications in power networks, wide area monitoring systems (WAMS), PMU, data storage for control, advanced distribution management systems (ADMS).

Unit 6

[6 Hrs]

Power System Economics and Recent Developments:

Fundamentals of electricity markets, Market structure and operating mechanisms, Electricity Markets Pricing, Transmission and distribution network pricing, Demand Side management, Introduction to Power Quality, Integration of renewable energy sources, Concept of micro-grid.

Textbooks:

1. Kundur P. and Balu N. J., "Power System Stability and Control", EPRI Series, McGraw-Hill International Book Company, 1998
2. Nagrath I. J. and Kothari D. P., "Power System Engineering", 2nd Ed., Tata Mc-Graw Hill Publishing Company, 2008
3. C L Wadhwa, "Electrical Power Systems", Sixth Ed., New Age International Publishers, 2010
4. Wood A. J., Wollenberg B. F. and Sheblé G. B., "Power Generation, Operation and Control", 3rd Ed., John Wiley and Sons, Inc, 2014

Reference Books:

1. Grainger J. J. and Stevenson W. D., "Power System Analysis", Tata McGraw-Hill Publishing Company Limited, 2008
2. Roger C Dugan and Mark F. McGranahan., "Electrical Power Systems Quality", 2nd Ed., Tata McGraw-Hill Publishing Company Limited., 2010
3. Elgerd O. I., "Electric Energy Systems Theory – An Introduction", 2nd Ed., Tata McGraw-Hill Publishing Company Limited., 2008
4. M. Shahidehpour, H. Yamin, and L. Zuyi, "Market Operations in Electric Power Systems". New York: Wiley, 2002.
5. D. S. Kirschen and G. Strbac, "Fundamentals of power system economics", John Wiley and Sons, 2004

e-resources:

NPTEL Course

Power System Operation and Control Dr. A. Chakrabarti (IIT Kharagpur)

<https://archive.nptel.ac.in/courses/108/104/108104052/>

[PCC 16] Digital Protection and Switchgear**Teaching Scheme**

Lectures: 3 Hrs./week

Self-study: 1 hr/week

Laboratory: 2 Hrs/week

Examination Scheme

Mid Sem Evaluation-30 Marks

TA-20 Marks

End Sem Evaluation- 50 Marks

Course Outcomes:

After successful completion of this course the students will be able to:

1. identify appropriate L.T. and H.T. switchgear for particular application
2. select the different components of protection system such as CT, PT, relays etc.
3. design protection schemes for transformer, generator, transmission lines, bus bar, motors etc.
4. estimate the phasors using different algorithms and design the numerical protection system

Unit 1**[06 Hrs]****Circuit Breakers**

Circuit Breakers: arc voltage, arc interruption, resistance switching, interruption of capacitive and inductive current, circuit breaker ratings, classification of C.Bs- air break, air blast, vacuum, minimum oil and bulk oil CB, SF₆ C.B. L.T. switchgear: MCB, MCCB, HRC fuse-construction and application, Circuit breaker selection.

Unit 2**[07 Hrs]****Fundamentals of Power System Protection and Over Current Protection**

Need of protection, protection principles, protection paradigms-apparatus protection and system protection, desirable attributes of protection. Introduction to C.T., equivalent circuit, C.T. saturation and offset current, V.T. equivalent circuit, Ferro-resonance, Review of calculation of fault currents, fuse protection, over current protection, PSM and TMS setting, phase relay coordination, earth fault protection using over current relays, introduction to directional over-current relays.

Unit 3**[07 Hrs]****Numerical Protection**

Numerical relaying fundamentals, sampling theorem, anti-aliasing filters, least square method for estimation of phasors, Fourier algorithms, Fourier analysis and discrete Fourier transform, estimation of phasors from discrete Fourier transform, Applications for implantation of various numerical relays. Fundamentals of PMU and WAMS.

Unit 4**[06 Hrs]**

Transmission System Protection

Introduction to distance relaying, zones of protection, effect of fault arc resistance, directional properties, setting and coordination of distance relays, pilot protection with distance relays, realization of distance relays using numerical relaying algorithms, Basics of load encroachment and power swing.

Unit 5

[07 Hrs]

Protection of Transformer, Generator, Motors

Percentage differential protection, magnetic inrush current phenomenon, percentage differential relay with harmonic restraint, restricted earth fault protection, incipient faults, Buchholz relay, protection against over fluxing. Generator protection: Stator phase and ground fault protection, protection against unbalanced loading, loss of excitation, loss of prime mover and over speeding, protection of large motors

Unit 6

[06 Hrs]

Bus bar protection, Lightning Protection:

Bus bar protection: Different bus bar arrangements, differential protection of bus bar, high impedance differential relay. Lightning and switching over voltages, need and types of lightning arresters, insulation coordination.

Text Books:

1. Fundamentals of power system protection by Y.G. Paithankar, S.R. Bhide., Prentice Hall, India, second edition, 2010.
2. **Reference Books:**
 1. Computer relaying for power systems by A.G. Phadke, J.S.Thorp-research studies press ltd. England John Wiley and sons Inc. New York.
 2. Protection of power systems by Blackburn

e-resources:

1. A Web Course on Digital protection of power system by Prof. Dr. S. A. Soman, IIT Bombay.

Digital Protection and Switchgear Laboratory

Teaching Scheme

Practical: 2 Hrs/week

Examination Scheme:

CIE: 50 Marks

ESE: 50 Marks

Course Outcomes:

After successful completion of this course students will be able to

1. understand and simulate the magnetizing current waveform of a single-phase transformer using SIMULINK and practical setup.
2. analyse the transient behaviour of a synchronous machine under sudden short-circuit conditions.
3. examine the working of numerical protection relays such as over-current and earth fault relays.
4. interpret standard impulse voltage waveforms using MATLAB.
5. analyse the restriking voltage waveform using MATLAB and understand its impact on circuit breakers.
6. evaluate the operation of negative phase sequence protection through numerical relay studies.

List of Experiments:

The laboratory should consist of minimum eight experiments based on the following topics:

1. (a) To study magnetizing current waveform of a single phase transformer using SIMULINK.
(b) To study magnetizing current waveform of a single phase Transformer
2. To study transient by applying sudden short circuit to the synchronous machine
3. To study numerical over-current relay
4. To study micro controller based under/over voltage relay
5. To simulate the generation of standard impulse voltage using MATLAB
6. To simulate the generation of Restriking Voltage Waveform using MATLAB
7. To study numerical earth fault and negative phase sequence relay.
8. To simulate the pilot protection scheme for long transmission lines using communication channels.

[MDM III] Energy Audit and Management

Teaching Scheme

Lectures: 4 Hrs./week

Self-study: 1 hr/week

Examination Scheme

Mid Sem Evaluation-30 Marks

TA-20 Marks

End Sem Evaluation- 50 Marks

Course Outcomes:

After successful completion of this course the students will be able to:

1. formulate energy related problems in the broad areas like electrical and mechanical installations, electrical machines, power systems.
2. plan energy management strategies.
3. Provide energy conservation solutions through energy audit
4. understand the energy billing and financial aspect in energy audit.

Unit 1

[06 Hrs]

Energy Scenario

Energy sources-Primary and Secondary, Commercial and Non-commercial, Renewable and Non-Renewable; Energy scenario in India (sector wise consumption, energy needs and integrated energy policy) and Global scenario, Energy Security, Energy and GDP, Energy Intensity on purchasing power parity, Electricity pricing in India, Energy conservation and its importance

Unit 2

[06 Hrs]

Energy Conservation Policies

Salient Features of the Energy Conservation Act, 2001 and, The Energy Conservation (Amendment) Act, 2022, Schemes of BEE under the Energy Conservation Act-2001, Electricity Act, 2003, Integrated Energy Policy, National Action Plan on Climate Change (NPACC)

Unit 3

[08 Hrs]

Energy Audit and Management

Energy Audit Definition, Need for Energy Audit, Types of Energy Audit and Approach, Understanding Energy Costs, Benchmarking, Energy Performance, Matching Energy Usage to Requirement, Maximizing System Efficiencies, Optimizing Input Energy Requirements, Fuel and Energy Substitution, Instruments and Metering For Energy Audit, Bureau of Energy Efficiency (the manner and intervals of time for conduct of energy audit) Regulations, 2008; Components of Materials and Energy Balance, Basic Principles of Material and Energy Balance, Classification of Processes.

Unit 4

[06 Hrs]

Energy Monitoring

Assessing Energy Profile and Establishing Baseline, Energy Policy and Planning Implementation, Evaluating Energy Performance, Recognize Achievements; What is Monitoring and Targeting, Key Elements of Monitoring and Targeting, Data and Information Sources, Data and Information Analysis, Energy Management Information System (EMIS); Project Development Cycle (PDC), Project Planning Techniques, Implementation Plan for Top Management, Planning Budget

Unit 5

[06 Hrs]

Financial and Project Management

Investment Need, Appraisal and Criteria, Financial Analysis Techniques; Simple payback period, ROI, Cash Flow, Sensitivity and Risk Analysis, Time value of money ,Net present value, IRR, Breakeven analysis, Energy Performance Contracting and Role of ESCOs, Developing a Typical ESCO Contract, Municipal Energy Efficiency Project through Performance Contracting

Unit 6

[06 Hrs]

Global Environmental Issues

Acid Rain, Ozone Layer Depletion, Global Warming and Climatic Change ,International Agreements:

United Nations Framework Convention on Climate Change (UNFCCC), The Intergovernmental Panel on Climate Change (IPCC), Conference of Parties (COP), The Kyoto Protocol, Sustainable Development

Text Books:

1. Guidebooks for National Certification Examination for Energy Manager/Energy Auditors Book General Aspects (available online)
2. Guidebooks for National Certification Examination for Energy Manager/Energy Auditors Book2, Thermal Utilities (available online)
3. Guide books for National Certification Examination for Energy Manager / Energy Auditors Book-3, Electrical Utilities (available online)
4. Guide books for National Certification Examination for Energy Manager Energy Auditors Book- (Available online)

Reference Books:

1. S.C. Tripathy, "Utilization of Electrical Energy", Tata McGraw Hill
2. Success stories of Energy Conservation by BEE, New Delhi (www.bee-india.org).

Project Stage- II

Sr No	Items	Description of activity
1	Scope (TRL-3)	Continuation of Project-I, Planning, fabrication and development of hardware / software and execution; relevant standards.
2	Self-Study material for the student	The department shall recommend relevant online / offline self-study materials on Incubation, Innovation (online / offline)
3	End Semester Evaluation process	The end semester evaluation shall be based on project work in power point presentation and a project report. The evaluation shall be done by the panel of faculty members, at least three members including one of them is project guide.

[PEC-I] Energy Storage Systems

Teaching Scheme

Lectures: 3 Hrs./week
Self-study: 1 hr/week

Examination Scheme:

Mid Sem Evaluation-30 Marks
TA-20 Marks
End Sem Evaluation- 50 Marks

Course Outcomes:

After successful completion of this course, students will be able to:

1. classify energy storage technologies
2. analyze the performance of various Electrical Energy Storage Systems.
3. select the appropriate energy storage system for an application
4. design the battery pack for an application
5. evaluate techno-economic, social and environmental performance with Performance Indicators

Unit 1

[5 Hrs]

Energy storage systems overview

Scope of energy storage, needs and opportunities in energy storage, comparison of time scale of storages and applications, Energy storage in the power and transportation sectors. Importance of energy storage systems in electric vehicles, Current storage business

Unit 2

[5 Hrs]

Mechanical Storage System:

Heat pumps, hot water storage tank, CAE , Pumped hydro storage, flywheel energy storage, thermal batteries, application of phase change materials for heat storage-organic and inorganic materials, efficiencies, and economic evaluation of thermal energy storage systems.

Unit 3**[5 Hrs]****Chemical Storage System:**

Concept of chemical storage of hydrogen etc, application of chemical energy storage system, advantages and limitations of chemical energy storage, challenges, and future prospects of chemical storage systems. Operational principle of a fuel cell, types of fuel cells, hybrid fuel cell-battery systems

Unit 4**[6 Hrs]****Electrical storage systems**

Working principle of supercapacitor, types of supercapacitors, cycling and performance characteristics, difference between battery and supercapacitors, hybrid fuel cell-supercapacitor systems, Superconducting magnetic energy storage(SMES), concepts, applications of SME, advantages and limitations of electromagnetic energy storage systems, and future prospects of electrical storage systems.

Unit 5**[11 Hrs]****Electro Chemical Storage System:**

Working principle of battery, primary and secondary (flow) batteries, comparison of supercapacitor and battery, battery performance evaluation methods, major battery chemistries and their voltages- Li-ion battery and Metal hydride battery vs lead-acid battery.

Unit 6**[10Hrs]****Battery Design:**

Battery design for transportation, smart battery, Mechanical Design and Packaging of Battery Packs for Electric Vehicles, Charging and discharging mechanism, monitoring and testing of batteries, Thermal management of battery systems, State of Charge and State of Health Estimation Over the Battery Lifespan, Recycling of Batteries, Current chemistry of batteries.

Text books:

- Frank S. Barnes and Jonah G. Levine, Large Energy Storage Systems Handbook (Mechanical and Aerospace Engineering Series), CRC press (2011)
- Ralph Zito, Energy storage: A new approach, Wiley (2010)
- A. G. Ter-Gazarian, Energy Storage for Power Systems, Institution of Engineering and Technology, 2011.

Reference Books:

- Pistoia, Gianfranco, and Boryann Liaw. Behaviour of Lithium-Ion Batteries in Electric Vehicles: Battery Health, Performance, Safety, and Cost. Springer International Publishing AG, 2018.
- Robert A. Huggins, Energy storage, Springer Science and Business Media (2010)

e-learning resources:

<https://batteryuniversity.com>

NPTEL course on Electric Vehicles and Renewable Energy, By Prof. Ashok Jhunjhunwala, Prof. Kaushal Jha, Prof. L Kannan, Prof. Prabhjot Kaur by IIT Madras

[PEC-I] Electrical Machine Design**Teaching Scheme:**

Lectures: 3 Hrs/week

Self-study: 1 hr/week

Examination Scheme:

Mid Sem Evaluation-30 Marks

TA-20 Marks

End Sem Evaluation- 50 Marks

Course Outcomes:

After successful completion of this course the students will be able to:

1. select proper commercial materials, their properties and selection criteria, IS standards used in electrical machine design.
2. design commercial transformers and induction motors as per specifications.
3. apply computer-aided optimization techniques for the design of electrical machines
4. design electrical machines using finite element-based software.
5. analyze electrical machines using finite element-based software

Unit 1

[06 Hrs]

Introduction of Electric Machines:

Transformers and three phase induction motors - types, specifications, constructional features, conducting, magnetic and insulating materials, heating and cooling in electrical machines, magnetic circuit calculations.

Unit 2

[07 Hrs]

Transformer Design:

Magnetic circuit specific electric and magnetic loading selection, output equation, core and yoke sections, main dimensions design, core loss from design data, winding design, calculations of magnetizing current, winding resistances and leakage reactance's, losses, performance, temperature rise, cooling methods, radiators, tank wall dimensions.

Unit 3

[06 Hrs]

Induction Motor Design (Part I):

Output equation, specific electrical and magnetic loading, main dimensions, selection of slots, stator design, stator turns per phase, selection of air gap, unbalanced magnetic pull estimation, harmonic minimization, squirrel cage and wound rotor design, Calculation of magnetic circuit, MMF calculations, stator teeth, stator core, effect of saturation, magnetizing current, no load current and its core loss component, leakage fluxes and reactance calculations, performance calculations - losses, efficiency.

Unit 4

[07 Hrs]

FEA based Motor Design :

Induction Motor, BLDC and PMSM Motor, Back emf and torque estimation, Parameter Estimation, Loss Calculations, Design Optimization, Performance and field studies.

Unit 5

[06 Hrs]

Fundamentals of Fluid Mechanics and Heat Transfer:

Governing equations (Navier-Stokes, continuity, energy equations), boundary conditions, and physical principles of fluid flow and heat transfer, Numerical Methods in CFD: Discretization techniques (Finite Difference, Finite Volume, Finite Element), mesh generation, stability, and convergence criteria.

Unit 6

[08 Hrs]

Thermal Modeling and Simulation FEA Software packages:

Modeling conduction, convection, radiation heat transfer; coupling thermal and fluid flow simulations; validation and applications in engineering problems.

Text Books:

- A. K. Sawhney – “A Course in Electrical Machine Design”, 10th Edition, - Dhanpat Rai and sons New Delhi, 2013.
- M. G. Say –The Performance and Design of A.C. Machines, 3rd Edition, CBS Publishers and distributors, Delhi, Reprint 2002.
- S. K. Sen, “Principles of Electrical Machine Design with computer programmes”, Oxford and IBH Company Pvt. Ltd. New Delhi, 2006.

Reference Books:

- A. Shanmugasundaram, G. Gangadharan, R. Palani, -Electrical Machine Design Data Book, 3rd Edition, 3rd Reprint, John Wiley Eastern Ltd., New Delhi, 1988.
- K. M. Vishnu Murthy, “Computer Aided Design of Electrical Machines”, B.S. Publications, 2008.

- Electrical machines and equipment design exercise examples/ Tutorials using Ansoft's Maxwell 2D machine design package.

e-learning resources

NPTEL Course

Design of Electrical Machines, Prof. Tapas Kumar Bhattacharya (IIT Kharagpur),

[PEC-I] Utilization of Electrical Energy

Teaching Scheme

Lectures: 3 Hrs./week

Self-study: 1 hr/week

Examination Scheme:

Mid Sem Evaluation-30 Marks

TA-20 Marks

End Sem Evaluation- 50 Marks

Course Outcomes:

After successful completion of this course the students will be able to:

1. investigate the various essential requirements and acquire the ability to design a safe and cost-effective electric traction system
2. compare the suitability of different motor drives to be used for a specific purpose
3. analyze the operation of various electric appliances used
3. select appropriate techniques for designing indoor and outdoor lighting schemes
4. apply appropriate techniques, tools and resources in designing/developing electrolytic and electrometallurgical processes
5. design smart electrical heating and welding systems through the use of modern Electrical Engineering and IT tools

Unit 1

[7 Hrs]

Illumination

Nature of light, visibility spectrum curve of relative sensitivity of human eye and wave length of light, Definition: Luminous flux, solid angle, luminous intensity, illumination, luminous efficiency, depreciation factor, coefficient of utilization, space to height ratio, reflection factor, glare, shadow, lux, Laws of illumination, Different type of lamps, construction and working of incandescent and discharge lamps – their characteristics, fittings required for filament lamp, mercury vapour lamp, fluorescent lamp, metal halide lamp, neon lamp, Main requirements of proper lighting; absence of glare, contrast and shadow, General ideas about street lighting, flood lighting, monument lighting and decorative lighting, light characteristics etc.

Unit 2

[6 Hrs]

Electric Heating

Advantages of electrical heating, Heating methods: Resistance heating – direct and indirect resistance heating, electric ovens, their temperature range, properties of resistance heating elements, domestic water heaters and other heating appliances and thermostat control circuit, Induction heating; principle of core type and coreless induction furnace, Electric arc heating; direct and indirect arc heating, construction, working and applications of arc furnace

Unit 3

[7Hrs]

Electric Welding and Electrolysis

Advantages of electric welding, Welding method, Principles of resistance welding, types, Principle of arc production, electric arc welding, characteristics of arc; carbon arc, metal arc, hydrogen arc welding method of and their applications.

Arc furnaces transformer and welding transformers. Review of electrolytic principles, laws of electrolysis, electroplating, anodizing-electro-cleaning, extraction of refinery metals, power supply for electrolytic process, current and energy efficiency.

Unit-4

[7 Hrs]

Electric Traction

Special features of Traction motors, selection of Traction Motor, Different system of ni traction and their Advantages and disadvantages, Mechanics of train movement: simplified speed time curves for different services, average and schedule speed, tractive effort, specific energy consumption, factors affecting specific energy consumption, acceleration and braking retardation, adhesive weight and coefficient of adhesion

Unit 5

[7 Hrs]

Electric Drives and Elevators

Electric drives : Concept, factors governing selection of electric drives(motor), Types of electrical drives : Individual and Group drive, Applications, Mechanical features of drives: Types and applications various types of enclosures, Transmission of Mechanical Power: Direct and Indirect drive (Belt, Rope, Chain, Gear), Vertical drives and its applications, Bearing: Types and applications, Size and Rating of motor : (Simple numerical on this topic), Load Cycles : Concept with graphical representation, Load equalization, Elevators: Function, Application, types, safety and precautions, case study of latest Elevator, Factors on which shape and size of car depends.

Unit 6

[6 Hrs]

Refrigeration and Air conditioning

Electrical Circuits used in Refrigeration and Air Conditioning and Water Coolers: Principle of air conditioning, vapor pressure, refrigeration cycle, eco-friendly Refrigerants, VRF, Centralized air conditioning system, design of AC system for a small room

Text Books:

1. Art and Science of Utilisation of Electrical Energy” by H.Pratab, Dhanpat Rai and Co.
2. “Utilization of electrical energy” by E. O. Taylor.

Reference Books:

1. Gupta, J.B., Utilization of Elect. Energy ,Katariya and sons, New Delhi. •
Garg, G.C., Utilization of Elect. Power and Elect. Traction
2. Hancock N N, Electric Power Utilisation, Wheeler Pub.

e-learning resources:

<https://opac.library.iitb.ac.in/cgi-bin/koha/opac-detail.pl?biblionumber=140160>

[PEC-I] Mathematical Modelling of Dynamic Systems

Teaching Scheme:

Lectures: 3 Hrs/week
Self-study: 1 hr/week

Examination Scheme:

Mid Sem Evaluation-30 Marks TA-
20 Marks
End Sem Evaluation- 50 Marks

Course Outcomes:

After successful completion of this course the students will be able to

1. develop mathematical models of various engineering and physical systems using classical and energy approaches.
2. demonstrate linearization techniques.
3. analyze the models for various practical systems.
4. validate the mathematical models of practical systems using software.

Unit 1

[6 Hrs]

Introduction to Modelling: This unit covers the concept of models and their various types. It introduces simulation and various simulation tools. The unit discusses the state space approach, transfer function approach, and methods such as linearization, Lagrangian, and Hamiltonian methods for modelling. Additionally, it includes modelling using first principles.

Unit 2

[6 Hrs]

Mathematical Modelling of Physical Systems: Focuses on modelling mechanical and electrical systems, including analogous systems. It covers system representation using the nodal method, and modelling mechanical components like gear trains, chain drivers, and levers. [6 Hrs]

Unit 3

Mathematical Modelling of Mechanical Systems: Introduces the basics of heat transfer and mathematical modelling of thermal, pneumatic, and hydraulic systems. The unit also involves analysis of these systems for various types of inputs.

Unit 4

[6 Hrs]

Mathematical Modelling of Electrical Systems: Covers fundamentals of electrical system modelling, including mathematical models of RLC circuits. It also focuses on modelling different electrical machines such as DC machines, AC machines, and permanent magnet motors, along with system analysis for various inputs.

Unit 5

[4 Hrs]

Mathematical Model of Various Systems: Includes mathematical models of advanced systems such as quadruple and quadrotor systems, magnetic levitation, and simple and inverted pendulum. Faculty may also introduce other significant systems.

Unit 6

[4 Hrs]

Bond Graphs Modelling: Introduces bond graph theory and explains the generation of system equations. The unit covers methods of drawing bond graph models for both mechanical and electrical systems.

Text books:

1. K. Ogata, "System Dynamics", Pearson Prentice-Hall, 4th Edition, 2004.
2. M. Gopal, "Modern Control Systems Theory", 2nd Edition, John Wiley, 1993
3. E.O. Doebelin, "System Modeling and Response", John Wiley and Sons, 1980.

Reference books:

1. Desai and Lalwani, "Identification Techniques", Tata McGraw Hill, 1977.
2. Goldstain, "Classical Mechanics"

e-resource:

NPTEL, Modelling and Simulations of Dynamic system by Prof P.M. Phatak, IIT Roorkee

[PEC-I] Energy Economics

Teaching Scheme:

Lectures: 3 Hrs/week
Self-study: 1 hr/week

Examination Scheme:

Mid Sem Evaluation-30 Marks
TA-20 Marks
End Sem Evaluation-50 Marks

Unit 1

[6 Hrs]

Energy Economics

Origin and Definitions of Energy Economics, Link between Economics and Energy, Energy Resources and Energy Commodities; Properties of Energy Resources and Energy Commodities, concept of Energy conservation and Energy efficiency. Basics of engineering economics, Role of engineering economics in the decision making process, Economic decisions versus design decisions, discount rate and economic equivalence, present-worth analysis, annual equivalent- worth analysis, rate-of-return analysis, depreciation, and taxation, developing project cash flows, social cost benefit analysis, Origins of renewable energy project risks, sensitivity analysis, break-even analysis, expected value decisions.

Unit 2

[6 Hrs]

Demand and Supply of energy

Demand for Energy as a Derived Demand, National Energy consumption, Economic Growth and World Energy Consumption, Demand substitution and energy use Classification of Energy supplies: renewable and non-renewable, Fossil fuels (coal, oil, natural gas), Renewable energy (Hydro, Marine, wind, solar, Geothermal, bio), Nuclear power, Trend and patterns of energy production.

Unit 3

[8 Hrs]

Energy Modelling

Review of various energy sector models, energy demand analysis and forecasting, energy supply assessment and evaluation, energy demand – supply balancing, energy modelling in the context of climate change

Unit 4

[8 Hrs]

Energy Prices and Markets

Global and National scenario Trend and Patterns of Energy Consumption and the Energy Crisis (since 1970 the Oil shocks and other events), Basic pricing principles, short run versus long run marginal cost pricing, peak load, seasonal, sectoral pricing of electricity, pricing of natural gas and petroleum products, green power markets Energy Pricing and Taxation: Production Cost versus Return on Investment, Models of Pricing, Market Failures, Peak and Off-peak Pricing, Subsidies, The role of regulatory bodies like MERC, Energy Finance: Banks, International organisations, Green Finance initiatives

Unit 5

[6 Hrs]

Techno-economic Evaluation of Renewable Energy Technologies:

Technology dissemination models, volume and learning effects on costs of renewable energy systems, dynamics of fuel substitution by renewable energy systems and quantification of benefits, fiscal, financial and other incentives for promotion of renewable energy systems and their effect on financial viability, case studies on financial feasibility evaluation of renewable energy devices and systems. Renewable energy economy policy

Unit 6

[5 Hrs]

Sustainable Development and Energy Policy

Concept of Sustainable Development and SDGs, Energy Security: India's initiatives, Energy and Climate Change, Energy Efficiency and carbon emissions: Global and National trends, Energy Policy The Economics of Climate Change, Climate Change Background, Overview of GHG Emissions, Economic Approach to Control the Greenhouse Effect, Options to Cope with Global Warming, Generic Options, National Policy Options, Emissions Trading System (ETS)

Text Books:

1. Bhattacharyya, S C. (2011), Concepts, Issues, Markets and Governance, Springer Kandpal T.C. & Garg, H.P. (2003), Financial Evaluation of Renewable Energy Technologies, Macmillan India Park
2. C. S., Kim, G., & Choi, S. (2007). Engineering Economics. Pearson Prentice Hall, New Jersey.
3. Thuesen, G. J., & Fabrycky, W. J., (2002). Engineering economy. Prentice Hall of India.

Reference books:

1. Belli, P., Anderson, J., Barnum, H., Dixon, J., & Tan, J. P. (1998). Handbook on economic analysis of investment operations. The World Bank, Washington,
2. DC. Dahl, C. (2015). International Energy Markets: Understanding Pricing, Policies, & Profits.
3. PennWell Books. Desai, V. (1997). Guidelines for the economic analysis of projects. Asian Development Bank.
4. Gittinger, J. P. (1973), Economic Analysis of Agricultural Project, The Johns Hopkins University Press. Jebaraj, S., & Inian, S. (2006). A review of energy models. Renewable and Sustainable Energy Reviews, 10(4), 281-311.
5. Kaplan, S. (1983). Energy economics: quantitative methods for energy and environmental decisions. McGraw-Hill College.

e-resource:

https://s3.ap-south-1.amazonaws.com/aipnpc.org/downloads/T_5052_ENERGY_EFFICIENCY_IN_ELECTRICAL_UTILITIES_BOOK_03.pdf

[PEC-II] Motor Control for Electric Mobility

Teaching Scheme:

Lectures: 3 Hrs/week

Self-study: 1 hr/week

Examination Scheme:

Mid Sem Evaluation-30 Marks

TA-20 Marks

End Sem Evaluation-50 Marks

Course Outcomes:

After successful completion of this course the students will be able to

1. describe the architecture of electric vehicles and the role of motor control systems in electric mobility applications.
2. compare different types of electric motors (DC, BLDC, Induction, PMSM) based on their characteristics and suitability for electric vehicle applications.
3. analyze various motor control strategies such as scalar control, vector control, and field-oriented control (FOC).
4. implement motor drive systems using simulation tools and/or hardware platforms
5. evaluate the performance of electric drive systems under different loading and operating conditions

Unit 1

[6 Hrs]

Fundamentals of Electric Mobility and Motors

Introduction to Electric Mobility: Trends, types of EVs (BEV, HEV, PHEV), Overview of EV Powertrain, Need for Efficient Motor Control in EVs, Review of Electric Machines: DC Machines, AC Machines, Motor Characteristics: Torque-speed curves, efficiency

Unit 2

[6 Hrs]

DC and BLDC Motor Control

Brushed DC Motor: Operation, control methods (voltage control, PWM), BLDC Motor: Construction, operation, commutation techniques, Open-loop vs. Closed-loop Control of BLDC, BLDC applications in electric mobility.

Unit 3

[5 Hrs]

AC Motor Control – Induction Motors (IM)

Construction, working, and characteristics of Induction Motors, Control Techniques: Scalar control (V/f), Vector control (introduction), Slip, torque, and efficiency in IM, Pros and cons of IM for EV applications.

Unit 4

[5 Hrs]

Permanent Magnet Synchronous Motor (PMSM) Control

PMSM vs BLDC: Similarities and differences, Field-Oriented Control (FOC): Theory and implementation, Sensor-based vs. Sensorless Control, Applications in EVs, e-bikes, drones

Unit 5

[6 Hrs]

Motor Drives and Power Electronics Interface

Overview of Motor Drives (DC-DC, DC-AC converters), Inverters: Topologies and operation PWM techniques: Sine PWM, SVPWM, Regenerative braking and energy recovery.

Unit 6

[6 Hrs]

Integration, Applications, and Case Studies

Motor selection criteria for EV applications, Integration of motor, drive, and controller Case studies on LMVs, HMVs, Reliability, thermal design, and efficiency mapping.

Text Books:

1. Dr. P. S. Bimbhra, Generalized Theory of Electrical Machines, Fifth edition, Khanna publishers
2. P.C.Krause, Oleg Wasynczuk, Scott D. Sudhoff, Analysis of Electrical Machinery and Drive systems, 3rd Edition, 2013 Wiley, IEEE Press.
3. Electric Motor Drives: Modeling, Analysis, and Control , R. Krishnan ,Pearson Education, 2001, ISBN: 9780130910149
4. Modern Electric Vehicle Technology , C. C. Chan, K. T. Chau ,Oxford University Press ,2001,ISBN: 9780198504160
5. Electric Machines and Drives: A First Course , Ned Mohan ,Wiley , 2011 , ISBN: 9781118074817
6. Electric Drives for Electric Vehicles ,K.T. Chau , IET (The Institution of Engineering and Technology), 2015 ,ISBN: 9781849198208

Reference books

Power Electronics: Converters, Applications, and Design ,Ned Mohan, Tore M. Undeland, William P. Robbins ,Wiley , 2003 (3rd Edition), ISBN: 9780471226932

e-resource

NPTEL Course Electrical Machines - II (Dynamic modeling of machines) Prof. G. Sridhara Rao, IIT Madras

(PEC-III) Analysis of Electric Machinery**Teaching Scheme:**

Lectures: 3 Hrs/week

Self-study: 1 hr/week

Examination Scheme:

Mid Sem Evaluation-30 Marks

TA-20 Marks

End Sem Evaluation-50 Marks

Course Outcomes:

After successful completion of this course the students will be able to:

- 1.analyze electromechanical devices and machines
- 2.use reference frame theory to study and analyze the behavior of induction and synchronous machines
- 3.calculate the machine inductances for use in machine analysis
- 4.model the electrical machine from the terminal junction with transmission systems

Unit 1

[4 Hrs]

MODELING CONCEPTS

Basic Two-pole machine representation of commutator machines 3- phase - phase synchronous machine without damper bars and 3 phase induction machine Kron primitive machine voltage, current and torque equations. Real time model of a two-phase induction machine transformation to obtain constant matrices. Three phases to two phase transformation power invariances.

Unit 2

[6 Hrs]

REFERENCE FRAME THEORY and PM AC MACHINE:

Introduction–Background–Equations of Transformation stationary circuit variables transformed to the Arbitrary Reference Frame, – Commonly Used Reference Frames Balanced Steady -State Phasor Relationships, Balanced Steady-State Voltage Equations PM AC Machine: Voltage and Torque equations in Machine Variables and Rotor Reference Frame Variables

Unit 3

[6 Hrs]

DC Machines Modelling:

Mathematical model of a separately excited DC motor, Steady state and transient analyses Transfer function of a separately excited DC machine, Mathematical model of a DC series motor, shunt motor-linearization techniques for small perturbations.

Unit 4

[6 Hrs]

Dynamic Analysis of Synchronous Machine:

Synchronous machine inductances, voltage equations in the rotor's dq0 reference frame, electromagnetic torque-current in terms of linkages, Dynamic performance of synchronous machine, three-phase fault, comparison of actual and approximate transient torque characteristics, Equal area criteria, simulation of three phase synchronous machine, Dynamic performance during a sudden change in input torque, Torque vs. rotor angle characteristics

Unit 5**[5 Hrs]****Modeling of Three Phase Symmetrical Induction:**

Generalized model in an arbitrary reference frame, Electromagnetic torque– Derivation of commonly used induction machine models, Stator reference frame model, Rotor reference frame model, Synchronously rotating frame model, Equations in flux linkages, per unit model- Dynamic Simulation, Small signal equations of induction machine, derivation of dq flux linkage model.

Unit 6**[5 Hrs]****Modelling of Reluctance Machines**

Introduction to Reluctance Machines, Magnetic Circuit and Inductance Modeling , Dynamic Modeling, Torque Production and Characteristics, Reluctance Machines Models, Applications and Recent Developments.

Text Books:

1. P. C. Krause, "Analysis of Electric Machinery", McGraw Hill, 3rd edition, New York, 1987.
 1. Chee Mun Ong, "Dynamic simulation of Electrical Machinery using Matlab/Simulink" Prentice Hall PTR, 1st edition, 1997.
 2. P. Vas, "Vector Control of A.C. Machines", Clarendon Press, 1st edition, Oxford 1990.
- Reference Books:
3. J.M. D. Murphy and F.G. Turnbull, "Power Electronic Control of AC motors", Pergamum Press, 1st edition, 1988.
 4. W. Leonhard, "Control of Electrical Drives", Springer Verlag, 3rd edition, 1985.

[PEC-IV] High Voltage Engineering**Teaching Scheme;**

Lectures: 3 Hrs./week

Self-study: 1 hr/week

Examination Scheme:

Mid Sem Evaluation-30 Marks

TA-20 Marks

End Sem Evaluation-50 Marks

Course Outcomes (COs):

After successful completion of this course the students will be able to:

1. propose the proper insulating medium / system; based on the insulation strength of the material for applying to high voltage systems.
2. measure the high voltages and currents.
3. design the high voltage laboratory and the equipment installations in it.
4. carry out HV tests on various equipments e. g. Cables, CBs, Insulators etc, using relevant testing IS and be able to give analysis of the test results

Unit 1**[05 Hrs]****Breakdown in Gases:**

Breakdown in Uniform gap, non-uniform gaps, Townsend's theory, Streamer mechanism, Corona discharge

Unit 2**[04 Hrs]**

Breakdown in liquid and solid Insulating materials: Breakdown in pure and commercial liquids, Solid dielectrics and composite dielectrics, intrinsic breakdown, electromechanical breakdown and thermal breakdown, Partial discharge, applications of insulating materials.

Unit 3

[04 Hrs]

Generation of High Voltages:

Generation of high voltages, generation of high alternating voltages, generation of impulse voltages, generation of impulse currents, tripping and control of impulse generators.

Unit 4

[04 Hrs]

Measurements of High Voltages and Currents:

Peak voltage, impulse voltage and high direct current measurement method, cathode ray oscillographs for impulse voltage and current measurement, measurement of dielectric constant and loss factor, partial discharge measurements

Unit 5

[03 Hrs]

Design, Planning and Layout of H. V. Laboratories:

High voltage laboratory layout, indoor and outdoor laboratories, testing facility requirements, High Voltage laboratories all over the world

Unit 6

[04 Hrs]

High Voltage Testing of Electrical Apparatus:

Various standards for HV Testing of electrical apparatus, IS, ANSI, IEC standards, Testing of insulators and bushings, testing of isolators and circuit breakers, testing of cables, power transformers and some high voltage equipment.

Text Books:

1. High Voltage Engineering by M. S. Naidu, V. Kamaraju, Tata McGraw Hill Publication Co. Ltd New Delhi, 2013, ISBN-978-1-25-906289-6
2. High Voltage Engineering by C. L. Wadhwa, New Age International Publishers Ltd.
3. High Voltage Engineering by Prof. D. V. Razevig Translated from Russian by Dr. M. P. Chourasia Khanna Publishers, New Delhi 67

Reference Book:

1. High Voltage Engineering Fundamentals by E. Kuffel, W. S. Zaengl, J. Kuffel Newnes Publication, ISBN-0-7506-3634-3
2. High Voltage and Electrical Insulation Engineering by Ravindra Arora, Wolfgang Mosch New Age International Publishers Ltd. Wiley Eastern Ltd., ISBN-978-0-470- 60961-3
3. Various IS standards for HV Laboratory Techniques and Testing

e-resources:

NPTEL Course on High Voltage Engineering
Prof. Subba Reddy B, IIT Madras

(PEC-V) Distributed Generation

Teaching Scheme:

Lectures: 3 Hrs/week

Self-study: 1 hr/week

Examination Scheme:

Mid Sem Evaluation-30 Marks

TA-20 Marks

End Sem Evaluation-50 Marks

Course Outcomes (COs):

After successful completion of this course the students will be able to:

1. explain the principles, classification, and benefits of distributed generation technologies.
2. analyze various renewable energy technologies such as solar PV, wind, and biomass for DG applications.
3. understand power electronic converters and storage systems used in DG.
4. assess the performance of DG integration on power quality, protection, and reliability.
5. evaluate technical, regulatory, and economic issues related to DG systems.
6. interpret emerging trends such as microgrids, IoT, and peer-to-peer energy trading.

Unit 1

[4 Hrs]

Introduction to Distributed Generation

Concept and need for distributed energy generation, Centralized vs. decentralized generation Classification of DG technologies: renewable and non-renewable, Benefits: reliability, resilience, efficiency, environmental technical challenges in integration

Unit 2

[8 Hrs]

Renewable Energy Technologies for DG

Solar PV Systems: Operating principles, I-V and P-V curves, MPPT techniques, PV configurations: standalone, grid-connected, hybrid Design aspects and performance modeling

Wind Energy Systems: Wind turbine types, power curves, site selection Wind generators: Squirrel cage, DFIG, PMSG Grid integration aspects. Other DG Sources: Biomass, small hydro, fuel cells, diesel generators, Working principles and applications.

Unit 3

[6 Hrs]

Power Electronics and Energy Storage for DG

Overview of power converters: DC-DC, DC-AC, AC-DC, Voltage source and current source inverters Control of inverters: frequency, voltage, and reactive power Energy storage technologies: batteries, supercapacitors Hybrid energy systems and energy management strategies.

Unit 4

[6 Hrs]

Grid Integration, Power Quality, and Protection

Operating modes: grid-connected, islanded, Synchronization techniques Standards and codes: IEEE 1547, IEC 61727, CEA regulations, Power quality issues: harmonics, flicker, voltage sags, Protection: anti-islanding, fault detection, coordination.

Unit 5

[6 Hrs]

Technical and Economic Evaluation of DG

Impact of DG on voltage profile, losses, and system reliability, Reactive power capabilities and VAR support, Economic analysis: CAPEX, OPEX, LCOE, payback period, Tariff mechanisms: net metering, TOD, feed-in tariffs.

Unit 6

[6 Hrs]

Policy, Regulation, and Emerging Trends:

National and international DG policies and regulatory frameworks, Renewable purchase obligations (RPOs), incentives, Smart grid and microgrid concepts, Emerging technologies: IoT, blockchain, AI in DG systems, Peer-to-peer energy trading and virtual power plants

Textbooks

1. G. M. Masters, Renewable and Efficient Electric Power Systems, 3rd Edition, Wiley, 2021.
2. M. H. J. Bollen and F. Hassan, Integration of Distributed Generation in the Power System, Wiley-IEEE Press, 2011.

Reference Books

1. John Twedell and Tony Weir, Renewable Energy Resources, 4th Edition, Routledge, 2021.
2. Mukund R. Patel and Omar Faruque, Wind and Solar Power Systems: Design, Analysis, and Operation, 3rd Edition, CRC Press, 2021.
3. IEEE Std 1547-2018, Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces.
4. M. C. Chandorkar, Distributed Generation and Microgrid, Oxford University Press, 2020.

e-resources

NPTEL Course

Distributed Generation and Renewable Energy Integration, Prof. Ashish Pathak, NIT Delhi

Exit option to qualify for B. Voc. :

- Internship of 8 weeks

Final Year B. Tech. in Electrical Engineering

Semester -VII

Sr. No.	Course Code	Course Title	L	T	P	S	Cr	Category
01	PCC-17	Electric Drives	3	0	0	1	3	PCC
02	PCC-14	Control System Design	3	0	2	1	4	PCC
03	PEC-03	Program Specific Elective III	3	0	0	1	3	PEC
05	RM	Research Methodology	2	0	0	1	2	RM
06	OJT-02	Internship	-	-	-	--	1	OJT
07	VSEC- 03	(Project Stage III)	0	0	4	--	5	VSEC
08	MDM- 04	Multidisciplinary Minor –IV Multidisciplinary Project	3	0	0	1	3	MD M
Total			14	00	06	05	21	

Semester –VIII

Sr. No.	Course Code	Course Title	L	T	P	S	Cr	Category
01	OJT-03	Internship	-	-	-	--	3	OJT
01	PEC-04	Program Specific Elective - MOOC-I	3	0	0	--	3	
01	PEC-05	Program Specific Elective - MOOC-II	3	0	0	--	3	PEC
02	PEC-06	Program Specific Elective - MOOC- III	3	0	0	--	3	PEC
Total			06	00	00	00	12	

Additional Credits for Exits

After Completion of Second Year

Sr. No.	Course Code	Course Title	L	T	P	Cr	Category
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01	VSEC- 02	Electrical Design Software	1	0	4	3	VSEC
02	VSEC- 03	PLC for Industrial Automation	1	0	4	3	VSEC
		Total	02	00	08	06	

INTERNSHIP-III (after semester VI, summer internship)

Sr. No.	Items	Type of Internship to be undertaken
1	Nature of Internship	Industry / R and D labs / Education institutes (HEI less than 100 NIRF rank) This should be decided by the nature of Project-I selected by the group of students in the 5th semester. A project guide should assist in grooming the student group in relevant areas to enhance their knowledge and skills.
2	End Semester Evaluation process	Individual student / Group of students shall submit a report followed by viva voce by the department level faculty members on the project report prepared by them. A template for report writing and evaluation format will be provided by the Nodal Officer, COEP Tech.

INTERNSHIP-IV, (semester VIII)

Sr No	Items	Type of Internship to be undertaken
1	Nature of Internship	Industry / R and D labs / Education institutes (less than 100 NIRF) / International Internship / Replacement
2	Scope of internship	a) The project student group can pursue innovation (TRL > 4) on carry forward ideas / Proof of concept derived from Project -III for scaling up the model/ prototyping/ product development / Start-up. OR b) Students can pursue international internship abroad / Preplacement / Internship in Industry / Education institutes (less than 100 NIRF) / R and D labs
2	End Semester Evaluation process	Students shall submit Internship report followed by voce viva, power point presentation by the department level faculty members. A template for report writing will be provided by the Nodal Officer, COEP Tech.

[VSEC] Course Title: Electrical Design Software

Duration: 16 weeks – 8 Hrs/Day	Level: Undergraduate Professional Certificate Prerequisites: S.Y. (ELECTRICAL) Basic knowledge of electrical engineering and circuit theory
Course Outcomes: After successful completion of this course the students will be able to: 1. Develop proficiency in using industry-standard electrical design softwares for schematic drafting, simulation, and system analysis. 2. Understand and apply electrical engineering principles to design and analyze real-world electrical systems including power distribution, control panels, and automation circuits. 3. Interpret and generate technical documentation 4. Simulate and analyze power system behavior under various conditions using tools like ETAP or PSCAD, including load flow, short circuit, and protection coordination. 5. Design and execute a capstone project that demonstrates integration of software tools to solve practical electrical engineering problems in industrial or utility applications.	
Unit 1	
Introduction to Electrical Design and CAD Tools • Overview of Electrical Design Workflow • Types of Electrical Design (Power Systems, Control Systems, etc.) • Introduction to CAD in Electrical Engineering • Software Overview: AutoCAD Electrical, ETAP, MATLAB Simulink, EPLAN, PSCAD, etc.	
Unit 2	
AutoCAD Electrical • Basics of AutoCAD Interface • Creating and Editing Electrical Schematics • Working with Symbols, Components, and Wires • PLC I/O Drawings • Generating Reports and Bill of Materials (BOM) • Project and Panel Layouts	
Unit 3	
ETAP (Electrical Transient Analyzer Program) • ETAP Interface and One-Line Diagrams • Load Flow Analysis • Short Circuit Analysis • Motor Starting Analysis • Protection Coordination • Arc Flash Analysis • Case Studies	
Unit 4	

MATLAB & Simulink for Electrical Systems	
• Basics of MATLAB for Electrical Engineers • Simulink Environment Overview • Modeling of Electrical Circuits and Systems • Power Electronics Simulation • Control Systems Design • Real-Time Simulation Concepts	
Unit 5	
EPLAN Electric P8	
• Project Setup and Data Management • Wiring and Device Configuration • Creating Panel Layouts • PLC Configuration • Integration with Manufacturing	
Unit 6	
Industry Applications and Mini-Project	
• Industrial Electrical Design Practices • Standards and Compliance (IEC, IEEE, NEC) • Documentation and Quality Assurance • Mini-Project using one or more software tools (Example: Substation design, Control panel layout, Renewable energy system modeling)	
e-resources:	
• https://www.advanceelectricaldesign.com • solidedge.siemens.com	

Multidisciplinary Minors

Title: Energy Sustainability and Management

Semester	Course Code	Course Title	L	T	P	S	Cr
IV	MD M-01	Clean and Green Energy Technology	3	0	0	1	3
V	MD M-02	Energy Resources, Economics and Environment	4	0	0	1	4
VI	MD M-03	Energy Audit and Management	4	0	0	1	4
VII	MD M-04	Multidisciplinary Project	3	0	0	1	3
Total			14	0	0	4	14

MOOCs Identified – NPTEL- PEC-05, 06

Sr. No	Course Name	Weeks	Level	NOC URL
1	DC Microgrid and Control System	12	UG	https://onlinecourses.nptel.ac.in/noc20_ee84/preview
2	Electrical Distribution System Analysis	12	UG	https://onlinecourses.nptel.ac.in/noc19_ee61/preview
3	Electrical Equipment And Machines: Finite Element Analysis	12	UG	https://onlinecourses.nptel.ac.in/noc20_ee81/preview
4	Control And Tuning Methods In Switched Mode Power Converters	12	UG	https://archive.nptel.ac.in/courses/108/105/108105180/
5	Power System Dynamics, Control And Monitoring	12	UG	https://onlinecourses.nptel.ac.in/noc21_ee16/preview
6	Design And Simulation of DC-DC Converters Using Open-Source Tools	12	UG	https://archive.nptel.ac.in/noc/courses/noc16/SEM1/noc16-ec07/
7	Industrial Automation And Control	12	UG	https://archive.nptel.ac.in/courses/108/105/108105062/
8	High Power Multilevel Converters - Analysis, Design And Operational Issues	12	UG	https://archive.nptel.ac.in/courses/108/102/108102157/
9	Data Analytics using Python	12	UG	https://nptel.ac.in/noc/courses/noc20/SEM1/noc20-cs46/
10	Linear Dynamical Systems	12	UG	https://onlinecourses.nptel.ac.in/noc20_ee47/preview
11	Linear System Theory	12	UG	https://archive.nptel.ac.in/courses/108/106/108106150/
12	Deep Learning	12	UG	https://nptel.ac.in/noc/courses/noc19/SEM2/noc19-cs54
13	Embedded System Design with ARM	12	UG	https://nptel.ac.in/noc/courses/noc20/SEM1/noc20-cs15/
14	Electrical Equipment and Machines: Finite Element Analysis	12	UG	https://onlinecourses.nptel.ac.in/noc24_ee91/