Course of Study
T. Y. B. Tech. (Electrical Engineering)
(With effective from Academic Year 2020-21)

Department of Electrical Engineering,
SGGS Institute of Engineering and Technology, Vishnupuri,
Nanded-431606 (MS), India
(An Autonomous Institute of Government of Maharashtra)

Program Outcomes (POs)

Engineering Graduates will be able to:

1. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.
2. Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Educational Objectives (PEOs)

Engineering Graduates will be able to:

1. Excel in growing careers involving design, development of electrical / electronic systems by working in the diversified sectors of the industry, government organizations, public sector and multinational corporations and/or pursue higher education at various reputed institutes.
2. Make considerable progress in their chosen domain of interest and will build up additional technical expertise to remain globally competitive.
3. Be able to demonstrate inter-personal skills, professional and personal leadership and growth with commitment to ethical and social responsibilities.

Program Specific Outcomes (PSOs)

1. Specify, design, plan and implement new electrical systems and modification of existing systems in the field of Electrical Engineering.
2. Test, operate, supervise and maintain different Electrical and Electronics equipment's and integrated systems.
3. Analyze and select appropriate techniques for optimum operation of Power System, Electrical machines, Power electronics and Industrial drives system.

Correlation between the PEOs and the POs

PO/PSO ➡ ⬇ PEO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
PEO1	✓	✓				✓	✓						✓		✓
PEO2		✓	✓	✓		✓		✓	✓		✓	✓	✓	✓	
PEO3				✓	✓	✓	✓			✓	✓	✓		✓	✓

SGGS Institute of Engineering and Technology, Vishnupuri, Nanded
Department of Electrical Engineering
T. Y. B. Tech.
Curriculum Structure of T. Y. B.Tech.
(With effective from Academic Year 2020-21)

Semester- I						
Course Code	**Name of the Course**	**L**	**T**	**P**	**Credits**	
					Th	**Pr**
PCC-EE301	Power System Engineering	03	-	02	03	01
PCC-EE302	Feedback Control System	03	-	02	03	01
PCC-EE303	Microprocessor and Microcontroller	03	01	02	04	01
PCC-EE304	Digital Signal Processing	03	-	02	03	01
PEC-EE3**	Elective-I	03	-	-	03	--
PRJ-EE308	Mini Project and Seminar-I	-	-	04	-	02
Sub Total		**15**	**01**	**12**	**22**	
Semester-II						
Course Code	**Name of the Course**	**L**	**T**	**P**	**Credits**	
					Th	**Pr**
PCC-EE309	Power System Analysis and Stability	03	-	02	03	01
PCC-EE310	Control System Design	03	-	02	03	01
PCC-EE311	Power Electronics	03	-	02	03	01
PCC-EE312	Power Plant Engineering	03	-	-	03	--
PEC-EE3**	Elective-II	03	-	-	03	--
PRJ-EE316	Mini Project and Seminar-II	-	-	04	-	02
Sub Total		**15**	**0**	**10**	**20**	

L—No of Lecture Hours/Week**, T**—No. of Tutorial Hours/Week**, P**—No. of Practical Hours/Week

Elective- I	
PEC-EE305	Basic of Photovoltaic System
PEC-EE306	Renewable Energy Technologies
PEC-EE307	Electrical Installation and Design
Elective- II	
PEC-EE313	Energy Audit and Conservation
PEC-EE314	Electrical Machine Analysis
PEC-EE315	Utilization of Energy and Management

Attendance Criteria: Students have to maintain 75% attendance in all the registered courses in a semester to be eligible for appearing examinations

PCC-EE301 Power System Engineering

Teaching scheme:			Examination scheme:
Lectures	3	hrs/week	Theory
Tutorials	--	hrs/week	In Semester Evaluation : 20 Marks
Practical's	2	hrs/week	Mid Semester Examination: 30 marks
Credits	4		End Semester Examination : 50 marks

Course Objectives:

1.	To introduce students to the basic structure and requirements of an electric power supply system
2.	To develop an understanding of components in a power system and to understand the basic principles involved in these components.
3.	To explore analysis and design principles for the complete power system

Course Outcomes: On successful completion of this course students will be able to

PCC-EE301.1	Understand the concepts of power systems
PCC-EE301.2	Understand the various power system components
PCC-EE301.3	Estimate the parameters of transmission line, understand its operation, role and select the model for various studies.
PCC-EE301.4	Build model and analyse various power system components like, generator, transformers, and load.
PCC-EE301.5	Apply knowledge in evaluating performance of power system

Course Articulation Matrix: Mapping of Course outcome and Program outcome

PO/PSO → ↓ CO	PO1	PO2	PO3	PO4	PO 5	PO 6	PO 7	PO 8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
PCC-EE301.1	3	1	1	-	2	-	-	-	1	-	-	1	3	3	1
PCC-EE301.2	3	1	1	-	2	-	-	-	1	1	-	1	3	3	1
PCC-EE301.3	3	2	3	2	3	-	-	-	1	3	-	2	2	2	2
PCC-EE301.4	2	2	3	3	3	-	-	-	3	3	-	3	2	2	3
PCC-EE301.5	3	3	3	3	3	-	-	3	3	3	-	3	2	1	3

Syllabus:

Unit 1	**Fundamentals of Power Systems: (6 Hours)**
	Evolution of Power Systems and Present-Day Scenario. Structure of a power system: Bulk Power Grids and Micro-grids. Generation: Conventional and Renewable Energy Sources. Distributed Energy Resources. Energy Storage. Transmission and Distribution Systems: Line diagrams, transmission and distribution voltage levels and topologies (meshed and radial systems), Synchronous Grids and Asynchronous (DC) interconnections. Review of Three-phase systems. Analysis of simple three-phase circuits. Power Transfer in AC circuits and Reactive Power.
Unit 2	**Electrical Design of Overhead Transmission Lines: (8 Hours)**
	Resistance, Inductance: Definition, Inductance due to internal flux of two wire single phase line of composite conductor line, Concept of GMD, Inductance of three phase line with equal & unequal spacing, vertical spacing. Capacitance: Concept of electric field, Potential difference between two points in space, Effect of

	earth's surface on electric field, Computation of capacitance of single phase, three phase transmission lines with & without symmetrical spacing for solid & composite conductors. Concept of GMR and GMD, Skin effect, Proximity Effect, Ferranti effect.
Unit 3	**Transmission line modelling and performance: (6 Hours)**
	Performance of Transmission Lines: Classification of lines such as short, medium, long lines Voltages and currents at sending end and receiving end of the lines, effect of load p.f. on regulation and efficiency, Determination of generalized ABCD constants in them, , Surge Impedance Loading. Series and Shunt Compensation of transmission lines.
Unit 4	**Modeling of Power System Components (8 Hours)**
	Power Transformers: Three-phase connections and Phase-shifts. Three-winding transformers, autotransformers, Neutral Grounding transformers. Tap-Changing in transformers. Transformer Parameters. Single phase equivalent of three-phase transformers. Synchronous Machines: Steady-state performance characteristics. Operation when connected to infinite bus. Real and Reactive Power Capability Curve of generators. Typical waveform under balanced terminal short circuit conditions – steady state, transient and sub-transient equivalent circuits. Loads: Types, Voltage and Frequency Dependence of Loads. Per-unit System and per-unit calculations
Unit 5	**Mechanical design of overhead transmission line: (7 Hours)**
	Main components of overhead line, conductor materials, line supports, Insulators: Type of insulators, potential distribution over suspension insulator string, string efficiency, methods of improving string efficiency. Corona: Phenomenon of corona, factors affecting corona, advantages and disadvantages of corona, methods of reducing corona. Sag: Sag in overhead line, calculation of sag, Effects of wind & ice coating on transmission line.
Unit 6	**Distribution System: (6 Hours)**
	Classification of distribution, AC and DC distribution system, overhead versus underground system, connection scheme of distribution system, Requirements of Distribution System, Design Consideration in Distribution Systems, Numerical Problems
Text/ Reference Books:	
1.	Grainger John J and W D Stevenson Jr,"Power system analysis" Mc-Graw Hill.
2.	I. J. Nagrath, D. P. Kothari, "Modern Power System Analysis" (3rd Edition), Tata McGraw Hill Publishing Co. Ltd.
3.	C.L. Wadhwa, "Electrical Power Systems", 6th Edition, New Age International, Latest Edition
4.	O. I. Elgerd, "Electrical energy systems theory: An introduction" Tata McGraw Hill, edition 1999.
5.	A. R. Bergen and Vijay Vittal, "Power system analysis", (2nd edition), Pearson Education Asia, 2001.
6.	Hadi Sadat, "Power system analysis", McGraw Hill International, 1999
7.	V.K.Mehta, Rohit Mehta "Principles of Power System", Fourth Edition , S.Chand Publications, Latest Edition
Term work:	
	The laboratory consists of minimum EIGHT experiments from following list. 1. Visit to HV/EHV substation, power generating station. 2. Study of transmission line inductance. 3. Study of transmission line capacitance. 4. Study of different components of power system. (e.g. different types of line conductors, insulators, pole structure) 5. Study of regulation and transmission efficiency for short, medium and long transmission lines. 6. Study and Determination of ABCD parameters of short, medium and long transmission lines. 7. Study of corona effect for transmission lines. 8. Study of different effects of power system. (e.g. skin effect, Ferranti effect, proximity effect, surge impedance loading)

	9. Simulation of the effect of line parameters on performance of transmission line. . 10Simulation of typical power system- familiarization with generator, line and load models.

The computational work is to be carried preferably by using software tools like **MATLAB, Mi-Power, ETAP, Scilab or any open source software.**

Independent Learning Experiences:

• https://swayam.gov.in

NPTEL Equivalent Course : "Power System Engineering " by Prof. Debapriya Das, IIT Kharagpur

PCC-EE302 Feedback Control System

Teaching scheme:		**Examination scheme:**
Lectures	3hrs/week	Theory In Semester Evaluation : 20 Marks Mid Semester Examination: 30 marks End Semester Examination : 50 marks
Tutorials	-	
Practicals	2hrs/week	
Credits	4	

Course Objectives:

1. Introduction to concepts of modelling of physical systems.
2. Introduction to time domain and frequency domain modelling.
3. Analyse the system response and stability in time domain and frequency domain.

Course Outcomes: On successful completion of this course students will be able to

1. Exhibit the capability to represent the mathematical model of physical systems using linear differential equations; Laplace transform and use block diagram algebra, Mason's gain formula to simplify complicated control systems.
2. To determine time response of first, second and higher order systems to standard test signals and to specify control system performance in terms of time and frequency domain specifications.
3. Construct Hurwitz determinant, Routh array, root-locus, polar plot, Bode plot and Nyquist plot for single variable feedback control systems and investigate system stability.
4. Realize lead, lad and lag lead compensators using electrical, electronic and mechanical components.
5. Validate the concepts of time domain, frequency domain and stability analysis using MATLAB.
6. Gain **some** practical experience in control engineering which might become a future research point for them. **(Some is not specific and measurable)**

Course Articulation Matrix: Mapping of Course outcome and Program outcome

PO/PSO → ↓ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
PCC-EE302.1	3	2	-	2	-	-	-	-	1	1	-	-	3	1	2
PCC-EE302.2	3	2	2	3	1	-	-	-	1	1	-	-	3	1	1
PCC-EE302.3	2	2	2	3	1	-	-	-	1	1	-	-	2	2	2
PCC-EE302.4	1	1	2	-	-	-	-	-	1	1	-	-	3	1	1
PCC-EE302.5	1	2	-	-	3	-	-	-	2	2	-	1	3	2	2
PCC-EE303.6	1	2	2	2	3	-	-	-	2	2	-	3	1	2	2

Syllabus:	
Unit 1	**Introduction to control systems** **(04 Hours)** Definition, history, elements of control systems, examples of control systems, open- loop (non-feedback) and closed loop (feedback) control systems, effect of feedback on overall gain, parameter variations, external disturbances or noise and control over system dynamics, regenerative feedback, linear versus nonlinear control systems, time- invariant versus time-varying systems, SISO and MIMO systems
Unit 2	**Mathematical modelling of dynamic systems** **(10 Hours)** Introduction, canonical form of feedback, control systems, transfers function and impulse response, differential equations and transfer functions of physical systems such as mechanical, electrical, electromechanical, thermal, pneumatic and liquid-level systems, analogous systems, force-voltage, force-current, torque-voltage and torque- current analogies, loading effects in interconnected systems, systems with transportation lags, linearization of nonlinear mathematical models, block diagram representation of control system, rules and reduction techniques, signal flow graph: elements, definition, properties, masons gain formula, application of gain formula to block diagrams
Unit 3	**Time- domain analysis of control systems** **(08 Hours)** Standard test signals, transient response, steady state error and error constants, dynamic error series, time response of first and second order systems and transient response specifications, dominant poles of transfer function, basic control actions and response of control systems, effects of integral and derivative control action on system performance, higher order systems
Unit 4	**Stability of linear control systems** **(04 Hours)** Concept of stability, BIBO stability: condition, zero input and asymptotic stability, Hurwitz stability criterion, Routh-Hurwitz criterion in detail, relative stability analysis, effect of adding poles and zeros to transfer functions on stability
Unit 5	**The Root–Locus technique** **(04 Hours)** Introductions, basic properties of the root loci, general rules for constructing root loci, Root Locus analysis of control systems
Unit 6	**Frequency domain analysis** **(12 Hours)** Frequency response of closed loop systems, frequency domain specifications of the prototype second order system, correlation between time and frequency response, effect of adding a pole and a zero to the forward path transfer function, polar plots, Bode plots, phase and gain margin, stability analysis with Bode plot, Nyquist stability criterion: mathematical preliminaries, stability and relative stability analysis
Unit 7	**Compensators** **(03 Hours)** Introduction, different types of compensators, Realization of lead, lag and lag lead compensators (Electrical, Electronic and Mechanical type), their transfer functions and frequency responses
Text/Reference Books:	
1.	K. Ogata, “Modern Control Engineering”, Fourth Edition Pearson education India, 2002.
2.	B. C. Kuo, “Automatic control systems”, Seventh Edition, Prentice –Hall of India, 2000.
3.	Norman S. Nise, “Control systems Engineering”, Third Edition, John Wiley and Sons. Inc, Singapore, 2001.
4.	R. C. Dorf and R. H. Bishop, “Modern Control systems”, Eighth Edition, Addison Wesley, 1999.
5.	I. J. Nagrath and M. Gopal, “Control systems Engineering”, Third Edition, New age International Publishers, India, 2001.

Term work:

It will consist of at least eight experiments/assignments/programs from the following list:

1.	Determination of transfer function of an armature controlled d. c. motor.
2.	Determination of transfer functions of D. C. generator.
3.	Effect of feedback on D. C. generator.
4.	Transient response of second order system.
5.	Study of D. C. positional servo system.
6.	Study of A. C. servo voltage stabilizer.
7.	Study the performance of an open and closed loop control system using electronic amplifiers using OPAMPs.
8.	Study the performance of a second order system (Use any OPAMP based electronic system such as an active second order Butterworth filter).
9.	Study the performance of any first order and second order system
	Experiments based on software (programs)
1.	Introduction to MATLAB, MATLAB's simulink and control systems toolbox (with some examples) or any other control system related software package.
2.	Compare and plot the unit-step responses of the unity-feedback closed loop systems with the given forward path transfer function. Assume zero initial conditions. Use any computer simulation program.
3.	Study of effect of damping factor on system performance by obtaining unit step response and unit impulse response for a prototype standard second order system. Consider five different values for x = 0.1, 0.3, 0.5, 0.7 and 1.0. Also study the effect of varying undammed natural frequency by taking three different values. Comment on the simulations obtained.
4.	Write a program that will compute the step response characteristics of a second order system i.e. Percent overshoot, rise time, peak time and settling time. Generalize it for accepting different values of undammed natural frequency and damping factor.
5.	Study and plot the unit step responses of addition of a pole and a zero to the forward path transfer function for a unity feedback system. Plot the responses for four different values of poles and zeros. Comment on the simulations obtained.
6.	Study and plot the unit step responses of addition of a pole and a zero to the closed loop transfer function. Plot the responses for four different values of poles and zeros. Comment on the simulations obtained.
7.	Program for compensator design using Bode plot.
8.	Program for compensator design using Root Locus analysis.
9.	Plot and comment on various properties of any three systems (problems) using • Routh-Hurwitz criterion • Root locus technique • Bode plots • Nyquist plots Use any software package.

PCC- EE303 Microprocessor and Microcontroller			
Teaching Scheme :		**Examination Scheme:**	
Lectures	3 Hrs./ Week	Theory: Mid Term:30 Marks Continuous Evaluation : 20 Marks End Sem. Exam :50 Marks	
Tutorials	1 Hrs/Week		
Practical	2 Hrs./Week		
Credits	5		

Prerequisites Courses:	
1	Analog and Digital Circuits
Course Objective:	
1	To teach the students to familiarize with microprocessor and microcontroller architecture and functioning.
2	To train the students to program the microprocessor and microcontrollers for any application.
Course Outcomes: Students' will be able to:	
1.	To describe basics of 8085, 8051 and its instruction set.
2.	To understand historical development of microcontrollers and to know different 8, 16, 32 bit microcontrollers.
3.	To solve assembly language programs based on the instruction set of 8085 and 8051.
4.	To get insight of 8051 based hardware system and so to study ADC, keyboard etc.
5.	To execute assembly language programs based on the instruction set of 8051
6.	To develop 8085, 8051 based instrumentation system.

Course Articulation Matrix: Mapping of Course outcome and Program outcome

PO/PSO → ↓ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
PCC-EE303.1	3	1	-	-	-	-	-	-	-	-	-	2	3	2	3
PCC-EE303.2	3	1	-	-	-	-	-	-	-	-	-	1	3	2	2
PCC-EE303.3	2	2	3	2	3	-	-	-	-	-	-	-	3	2	3
PCC-EE303.4	2	2	3	2	3	-	-	-	-	-	-	-	3	2	1
PCC-EE303.5	1	3	3	3	2	-	-	-	3	1	2	3	3	3	3
PCC-EE303.6	1	3	3	3	2	3	3	-	3	2	3	2	2	2	3

Syllabus :	
Unit 1	**Introduction to 8085**
	Architecture and operation, pin out diagram. Assembly language programming for 8085 microprocessor, instruction classification, instruction set study in details, addressing modes, writing assembly language programs, stacks subroutines, instruction set timing diagrams, a minimum configuration for 8085, interrupt structure of 8085, internal interrupt circuit, hardware and software interrupts.
Unit 2	**Interfacing memories to 8085**
	Interfacing memories EPROM and RAM with 8085 with exhaustive and partial decoding techniques.
Unit 3	**Peripheral devices used in 8085 systems**
	Following structure programmable peripheral devices are to be studied in details as regards block diagram, software for their interfacing with 8085: 8255, 8253, 8279, ADC.
Unit 4	**Introduction to microcontrollers and Programming 8051**
	8051 Architecture, pin out diagram, 8051 oscillator and clock, Program counter and Data

	pointer, A and B CPU registers, flags and PSW, internal memory, stack and stack pointer, SFRS, internal ROM, I/P and O/P ports. Assembly language programming for 8051 microcontroller, instruction classification, instruction set Arithmetic and Logical operations, jump and call instructions etc., writing assembly language programming based on instruction set, stacks and subroutines.
Unit 5	**Timers in 8051 and Serial data transmission**
	Interrupts of 8051, counters and timers, timer modes, timer/counter programming. Introduction to serial data transmission methods.
Unit 6	**Interfacing peripherals to 8051 and Design of 8051 based systems**
	8051 microcontroller interfacing with: keyboard and display, A/D and D/A chips. Design of dedicated systems using 8051 for temperature indication OR/AND control, flow indication, OR/AND control, stepper motor control, embedded control systems, Smart transmitters.
Text/ Reference Book:	
1.	K. L. Short, "Microprocessor and programming logic", Second Edition, Prentice- Hall India Pvt. Ltd.
2.	R. S. Gaonkar, "Microprocessor Architecture, Programming and application with 8085/8085A", Fourth Edition, Willey Eastern Ltd.
3.	B. Ram, "Fundamentals of microprocessor and Microcomputer", Dhanpat Rai and Sons, Eighth Edition, New Delhi.
4.	Ayala K. J., "8051 Microcontroller: Architecture, Programming and applications" Second Edition, Penram international.
5.	Muhammad Ali Mazidi, Janice G. Mazidi and Rolin D. McKinlay, "The Microcontroller and Embedded Systems", Second Edition, Pearson, 2012.
Reference Books:	
1.	B. Ram, "Advanced Microprocessor and Interfacing" Tata McGraw-Hill Publishing Company Ltd., First Edition, New Delhi.
2.	Ajit Pal, "Microprocessor Principles and Applications", Tata Mc-Graw Hill, First Edition New Delhi.
3.	U. V. Kulkarni and T. R. Sontakke, "The 8085A Basics: Programming and Interfacing", Sadusudha Prakashan, First Edition, Nanded.
4.	Intel Mcs, "8085 users manual", Intel Corporation.
5.	Myke Predko, "Programming and customizing the 8051 Microcontroller", Tata McGraw-Hill, First Edition, New Delhi.
6.	N.G. Palan, "8031 Microcontroller – Architecture, Programming and Hardware Design", Technova publishing House.
Term Work: It will consist of a record of at least eight of the following experiments based on the Prescribed syllabus.	
1.	Study of Dyralog 8085 kit.
2.	Writing simple programs based on 8085 Instruction set.
3.	Write a program to find largest number from a series of numbers.
4.	Write a program to transfer a block of data.
5.	Write a program for arranging numbers in ascending / descending order.
6.	To study interfacing of 8255 with LEDs, 7-Segment display.
7.	To study interfacing of 8255 with Keyboard, ADC.
8.	To study 8051 Simulator.
9.	To write simple programs using 8051 simulator like- a. Finding largest/smallest number. b. arranging numbers in ascending / descending order. c. Arithmetic of 16-bit numbers.

10.	Interfacing of stepper motor with microcontroller.
11.	Mini project based on 8051.
Note: The computational work is to be carried preferably by using software tools likeMATLAB, Scilab.	
Practical Examination:	
The examination will be of three hours duration and will consist of an experiment based on term-work and followed by an oral based on above syllabus.	

PCC-EE304 Digital Signal Processing

Teaching Scheme :		**Examination Scheme:**
Lectures	3 Hrs/ Week	Theory: Mid Term:30 Marks Continuous Evaluation : 20 Marks End Sem. Exam :50 Marks
Tutorials	--	
Practical	2 Hrs/Week	
Credits (Th)	4	

Prerequisites Courses:	
1	Signals and Systems

Course Objective:	
1	To provide better understanding of discrete-time signals with representation in time and frequency domain.
2	To provide knowledge for analysis and design of linear and time-invariant (LTI) systems using mathematical tools like Fourier Transform and z-transform.
3	To provide knowledge for efficient realization of digital systems (FIR and IIRfilters) using hardware and software.

Course Outcomes: Students' will be able to:	
1	to understand benefits and limitations of processing signals digitally and properties of discrete-time LTI systems.
2	Represent and analyze the discrete-time signals and LTI systems in the frequency domain using Discrete-Time Fourier Transform (DTFT), z-transform and Discrete Fourier transform (DFT) tools.
3	Implement DFT efficiently using Fast Fourier Transform (FFT) algorithms and use in practical applications.
4	Design an FIR or IIR filter for the specifications given in frequency domain.
5	To realize digital system whose coefficients are known using hardware or software.
6	To propose and design a digital system for simple real application.

Course Articulation Matrix: Mapping of Course outcome and Program outcome

PO/PSO → ↓ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
PCC-EE304.1	3	1	-	-	-	-	-	-	-	-	-	-	3	2	3
PCC-EE304.2	3	2	-	2		-	-	-	-	-	-	-	2	2	2
PCC-EE304.3	2	2	1	-	2	-	-	-	-	-	-	-	3	2	3
PCC-EE304.4	3	3	3	-	1	-	-	-	-	-	-	-	2	2	3
PCC-EE304.5	2	2	2	-	1	-	-	-	-	-	-	-	2	3	3
PCC-EE304.6	2	3	3	1	2	-	-	-	-	-	-	1	2	3	3

Syllabus:	
Unit 1	**Introduction**
	Discrete-time signals and systems, time-domain characterization of discrete-time LTI systems, sampling theorem, benefits and limitations of processingsignal digitally. Correlation of signals. The Z-transform: inverse Z-transform andZ-transform properties for one-sided and two-sided z-transforms. Discrete-Time Fourier Transform (DTFT) and its properties.
Unit 2	**LTI Discrete-Time Systems in Transform Domain**
	The frequency response, the transfer function, types of transfer functions, Allpass transfer function, minimum-phase and maximum-phase transfer functions,inverse systems.
Unit 3	**Discrete Fourier Transform**
	Discrete Fourier Transform (DFT) and its properties. Computation of DFT (FFTalgorithms), Decimation-In-Time (DIT), Decimation-In-Frequency (DIF) andradix-n algorithms of FFT.
Unit 4	**Digital filter structures**
	Digital filter structures: block diagram representation, equivalent structures,basic FIR structures, basic IIR structures, All pass filters, IIR tapped cascadedlattice structures, FIR cascaded lattice structures.
Unit 5	**Digital Filter Design**
	IIR Filter Design: Analog Filter Approximations – Butterworth and Chebyshev approximations. Frequency Transformations: low-pass to low-pass, low-pass to high-pass, low-pass to band-pass and low-pass to band-stop transformations. Analog to Digital Transformations: Impulse Invariant Technique and Bilinear Transformation Technique. FIR Filter Design: windowing technique, frequency sampling technique, and computer aided design.
Unit 6	**Digital Signal Processor**
	Harvard architecture and modified Harvard architecture. Introduction to fixed-point and floating-point DSP processors, architectural features, computationalunits, bus architecture and memory architecture, data addressing, addressgeneration unit, pipelining, on-chip peripherals.
Text/Reference Books:	
1.	A. V. Oppenheim, R. W. Schafer, "Discrete-Time Signal Processing", Prentice-Hallof India, 2001
2.	J. G. Proakis, D. G. Manolakis, "Digital Signal Processing – Principles, Algorithmsand Applications", Prentice Hall of India, 2002.
3.	S. K. Mitra, "Digital signal processing- A computer based approach", TataMcGraw Hill, 2002.
4.	E. C. Ifeachor, B. W. Jarvis, "Digital Signal Processing- A Practical Approach",Second Edition, Pearson Education, New Delhi, 2002.
5.	Johnny R Johnson, "Introduction to Digital Signal Processing", Prentice-Hallof India, 2011
6.	Sen M Kuo and Bob H. Lee, "Real-Time Digital Signal Processing: Implementation Applications and Experiments with the TMS 320C55X" John Wiley and Sons, New York
Term work:	
Term work shall consist of six to eight assignments/tutorials/practical based on above syllabus. Some suggested experiments are given in the following list. Teacher of the course can assign other experiments based on the syllabus. Students are supposed to write the programs (at least eight) on general-purpose computer using any development environment (C/C++/Matlab) or on any DSP processor and development environment.	
1.	Digital signal generation.
2.	Simple operations on signals.
3.	Linear and Circular Convolutions.
4.	Discrete time Fourier transform (DTFT) and its properties.
5.	Discrete Fourier Transform (DFT) – Direct computation, DIT algorithm, DIF algorithm.
6.	Linear and Circular Convolutions using DFT.

7.	FIR filters design and software realization using (i) Rectangular Window (ii) Generalized Hamming Window (iii) Bartlet Window and (Iv) Kaiser Window.
8.	Frequency Sampling Design of FIR Filter.
7.	IIR filter design and software realization using Butterworth Filter Approximation with(i) Impulse Invariance Method and (ii) Bilinear Transformation Method.
8.	IIR filter design and software realization usingChebyshev Approximation with(i) Impulse Invariance Method and (ii) Bilinear Transformation Method.

Equivalent SWAYAM/NPTEL Course:

Title: Discrete-Time Signal Processing
Faculty: Prof. Mrityunjay Chakraborty, IIT Kharagpur
Duration: 8 Weeks

NOTE: In SWAYAM/NPTEL it is offered in even semester

ELECTIVES –I

PEC-EE305 Basics of Photovoltaic Systems		
Teaching scheme:		**Examination scheme:**
Lectures	3 hrs/week	Theory In Semester Evaluation : 20 Marks Mid Semester Examination: 30 marks End Semester Examination : 50 marks
Tutorials	--	
Practical's		
Credits	3	

Course Objectives:	
1.	To introduce students with basics of PV systems
2.	To develop an understanding of PV cells and their characteristics, basic components of PV systems
3.	To make students understand the energy from sun and its estimation
4.	To teach students battery characteristics, combination, selection and interfacing with PV
5.	To explain design and analysis of MPPT , Charge controllers and their algorithms

Course Outcomes: On successful completion of this course students will be able to	
1.	Understand different characteristics of PV cells, their series-parallel combination and protection.
2.	Calculate incident energy from the sun.
3.	Determine battery rating and PV sizing as per the load.
4.	Understand MPPT and its algorithm
5.	Perform PV Battery interface
6.	Understand the application of PV Systems and its Life cycle costing.

Course Articulation Matrix: Mapping of Course outcome and Program outcome

PO/PSO → ↓ CO	PO1	PO2	PO 3	PO4	PO 5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
PEC-EE 311A.1	1	2	1	1	2	-	-	-	-	-	-	1	1	-	-
PEC-EE 311A.2	2	1	1	1	1	2	-	-	-	-	-	2	-	1	-
PEC-EE 311A.3	2	1	3	3	3	2	-	-	-	-	2	-	2	2	-
PEC-EE 311A.4	1	2	1	2	2	-	-	-	-	-	-	-	-	-	-
PEC-EE 311A.5	2	3	3	3	3	-	-	-	-	-	2	-	1	2	-
PEC-EE 311A.6	1	1	3	3	2	2	-	-	-	-	-	3	-	-	-

Syllabus:	
Unit 1	**Photo Voltaic Cells:** **(6 Hours)** Historical Perspective of PV cells, Cell efficiency, data sheet study, effect of temperature on PV cells and related calculation, form factor, fill factor, model of PV cell, PV cell characteristics and equivalent circuits, Short circuit, open circuit and peak power parameters…
Unit 2	**Series Parallel Interconnection and Protecting circuit of PV cells** **(6 Hours)**

	Identical cells in series, Load Line, Non identical cells in series, Protecting Cells in series, interconnecting cells in series, Identical cells in parallel, Non identical cells in parallel, Protecting Cells in parallel, interconnecting cells in parallel…..
Unit 3	**Energy from Sun and Incident Energy estimation (6 Hours)** Insolation and Irradiance, Insolation variation with time of day, Earth centric view point and declination, solar geometry, insolation on a horizontal flat plate collector, Energy on a horizontal flat plate collector, sunrise and sunset angles, Energy on a tilted flat plate collector, atmospheric effects, energy with atmospheric effects, Clearness index and air mass…
Unit 4	**Battery characteristics and PV Sizing (8 Hours)** Sizing PV for applications without batteries, Introduction to batteries, Battery capacity, C-rating, efficiency, energy and power densities, battery comparison and selection, other energy storage methods, PV system design related to -load profile, days of autonomy, battery sizing PV array sizing.
Unit 5	**Maximum Power Point Tracking and Algorithms (MPPT) (8 Hours)** MPPT Concept, input impedance of boost converter, input impedance of buck converter, input impedance of buck-boost converter, PV module, impedance control methods, reference cell voltage scaling method, reference cell current scaling method, sampling method, power slope methods, Hill climbing method, Practical point for housekeeping power supply, gate drivers, MPPT for non-resistive loads…
Unit 6	**PV-Battery Interface and Applications of PV systems (6 Hours)** Direct PV battery connections, charge controller, battery charger understanding current control, battery charger slope compensation, batteries in series charge equalization, batteries in paralle. Applications of PV systems in Water pumps and Grid Connection Principles… Life Cycle Costing…
Text/ Reference Books:	
1.	Chetan Singh Solanki, Solar Photovoltaics Fundamentals, Technologies and Applications, PHI Learning , Third Edition, April 2015.
2.	Chenming H. and White, R. M., Solar Cells from B to Advanced Systems, McGraw Hill Book Co, 1983
3.	Ruschenbach , HS, Solar Cell Array Design Hand Varmostrand, Reinhold, NY, 1980
4.	Proceedings of IEEE Photovoltaics Specialists Conferences, Solar Energy Journal
5.	S. P. Sukhatme, J. K. Nayak Solar Energy- Principles of Thermal Collection and Storage (3rd edition), Tata McGraw-Hill Publication.
6.	Mullic and G.N.Tiwari, "Renewable Energy Applications", Pearson Publications.
7.	Website :powermin.nic.in, www.mnre.gov.in
Term work: (Performance in Term Work will be added to In-Semester Evaluation) It will consist of a record of the following experiments based on the prescribed syllabus. (Any 8) Any of the following software's can be used MATLAB, ETAP, NgSpice, gschem , octave etc	
1.	To study the PV cell Sub circuit.
2.	To study the PV cell characteristics and its equivalent circuit
3.	Simulation of Cells in Series
4.	Simulation of Cells in Parallel
5.	Design and Simulation of Boost Converter
6.	Design and Simulation of Buck Converter
7.	Design and Simulation of Buck-Boost Converter
8.	Simulation of PV and DC-DC converter interface
9.	Simulation of MPPT
10.	Simulation of Battery Charger Current Control Method

PEC- EE306 Renewable Energy Technologies			
Teaching Scheme :		**Examination Scheme:**	
Lectures	3Hrs/ Week	Theory: Mid Term:30 Marks Continuous Evaluation : 20 Marks End Sem. Exam :50 Marks	
Tutorials	--		
Practical	--		
Credits	3		

Prerequisites Courses:	
1	Engineering Physics , Environmental Science, Engineering Chemistry
Course Objective:	
1	To develop fundamental understanding about Solar Thermal and Solar Photovoltaic systems.
2	To provide knowledge about development of Wind Power plant and various operational as well as performance parameter/characteristics
3	To explain the contribution of Biomass Energy System in power generation
4	To teach Integration and Economics of Renewable Energy System.
Course Outcomes: Students' will be able to:	
1	Explain theory of sources like solar, wind and also experiments of same
2	Analyse operating conditions like stand alone and grid connected of renewable sources
3	Reproduce different Storage Systems, concept of Integration and Economics of Renewable Energy System
4	Summarizing forthcoming renewable technologies
5	Design the solar tracking system for roof top application
6	Simulate and implement solar charge controller in practical applications

Course Articulation Matrix: Mapping of Course outcome and Program outcome

PO/PSO → ↓ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
PEC-EE305B.1	3	1	3	1	-	1	2	1	-	-	-	3	2	3	2
PEC-EE305B.2	3	1	2	1	-	2	2	1	-	-	-	2	3	2	2
PEC-EE305B.3	3	1	3	1	-	1	2	1	-	-	-	3	3	2	2
PEC-EE305B.4	3	1	2	1	-	1	1	1	-	-	-	2	3	2	1
PEC-EE305B.5	3	2	3	2	1	2	2	1	-	-	-	2	2	2	3
PEC-EE305B.6	3	2	3	2	1	2	2	1	-	-	-	2	2	3	3

Syllabus :	
Unit 1	**Introduction to Renewable Energy Sources: (06 Hours)** Energy sources: classification of energy sources, introduction to renewable energy, Renewable energy trends, and key factors affecting renewable energy supply, advantages and disadvantages of RES and their uses, national and international policies on RES
Unit 2	**Solar Energy: (08 Hours)** Solar Photovoltaic: Technologies-Amorphous, monocrystalline, polycrystalline; V-I characteristics of a PV cell, PV module, array, Maximum Power Point Tracking (MPPT) algorithms. solar thermal conversion: basics, solar concentrator and tracking system, flat plate collectors-liquid and air type, theory of flat plate collectors, selective coatings, advanced collectors: ETC, solar Pond
Unit 3	**Wind Energy: : (08 Hours)**

	Power available in wind, wind turbine power & torque characteristics, types of rotors, characteristics of wind rotor, local effects, wind shear, turbulence & acceleration effects, measurement of wind, wind speed statistics, energy estimation of wind regimes, capacity factor, aerodynamics of wind turbines, airfoil, lift & drag characteristics, power coefficient & tip speed ratio characteristics, electrical generator machines in wind energy systems.
Unit 4	**Biomass Energy: : (06 Hours)** Overview of biomass as energy source, biomass as a fuel, physicochemical and thermal characteristics of biomass as fuel, biochemical conversion of biomass for energy production, liquid biofuel, energy plantation- overview on energy plantation, basis of selecting the plants for energy plantation, waste land utilization through energy plantation
Unit 5	**Forthcoming renewable technologies: (06 Hours)** Geothermal Energy Generation, ocean-thermal energy generation, tidal energy generation, magneto hydro dynamic power generation- working, layout, different components, advantages, limitations.
Unit 6	**Storage Technologies: (06 Hours)** Introduction, need for storage for RES, basic thermodynamic and electrochemical Principles, classification, traditional energy storage system- battery, fuel cell, principle of operation, types, applications for power generation.
Text Books:	
1.	Gary-L. Johnson Wind Energy Systems Tata Mc-Graw-Hill Book Company.
2.	Boyle, Godfrey. 2004. Renewable Energy (2nd edition). Oxford University Press, 450 pages (ISBN: 0-19-926178-4).
Reference Books:	
1.	S. P. Sukhatme, J. K. Nayak Solar Energy- Principles of Thermal Collection and Storage (3rd edition), Tata McGraw-Hill Publication.
2.	Paul Gipe Wind Power, Renewable Energy for Home, Farm, and Business.
3.	Mullic and G.N.Tiwari, “Renewable Energy Applications”, Pearson Publications.
4.	Website :powermin.nic.in, www.mnre.gov.in

PEC- EE307 Electrical Installation and Design

Teaching Scheme :		**Examination Scheme:**
Lectures	3Hrs/ Week	Theory: Mid Term:30 Marks Continuous Evaluation : 20 Marks End Sem. Exam :50 Marks
Tutorials	--	
Practical	--	
Credits (Th)	3	

Prerequisites Courses:	
1	Electrical Measurement, Electrical machines
2	Power System

Course Objective:	
1	Study of essentials of electrical installation.
2	Study of wiring system and their estimation.
3	To study various aspects of illumination.
4	To study estimation and costing of H.T and L.T conductors for installation.
5	All Indian Electricity Rules.

Course Outcomes: Students' will be able to:	
1	Design the electrical wiring systems for residential, commercial and industrial consumers, representing the systems with standard symbols and drawings, SLD
2	Substation arrangement studies
3	Find out specifications of cables, insulators for various voltage ratings.
4	Acquainted with different methods of measuring resistances.
5	Start his/her own consultancy and business opportunities in electrical installation
6	Design and representing the electrical systems with standard symbols and drawings, SLD

Course Articulation Matrix: Mapping of Course outcome and Program outcome

PO/PSO → ↓ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
PEC-EE305C.1	3	1	3	1	-	1	2	1	-	-	-	3	2	3	2
PEC-EE305C.2	3	2	2	1	-	2	2	1	-	-	-	2	3	2	2
PEC-EE305C.3	2	1	3	1	-	1	2	2	-	-	-	3	2	1	1
PEC-EE305C.4	3	1	2	1	-	1	1	1	-	-	-	2	3	2	1
PEC-EE305C.5	2	1	3	2	1	2	2	1	-	-	-	2	2	1	3
PEC-EE305C.6	2	2	3	2	1	2	2	2	-	-	-	2	2	2	2

Syllabus :	
Unit 1	**Electrical Drawing:** **(06 Hours)** Principles, Symbols, Single Line Diagrams (SLD), Introduction to common Electrical Components, such as contactor, switches, relays, timers, cables, lugs, connectors, MCCB, ELCB, panel meters etc. Different Tools Used: Screwdriver, Pliers of various types, wrench, and blowlamp, Precaution for using tools
Unit 2	**Wiring System**: **(06 Hours)** Selection of types of wiring, Methods of wiring (Cleat, Casing capping, Metal sheathed and Conduit) Calculation and Estimation of power rating of different AC and DC machines. Electrical system design for a typical midsize housing complex, mechanical workshop, auditorium and IT industry, Estimation for a light and fan system, Process of tendering and Construction and Design of MCC and PCC for a typical industry

Unit 3	Complete arrangement of substation (Single and double bus bar), key diagrams for typical substations. Various type's pole structure, Insulators, cables and their types. Review of Insulated Wires: Types: Rubber covered taped and compounded or VIR, Lead alloy sheathed, Tough rubber sheathed, Weather proof, Flexible wire splicing, Termination (Twist splicing, Married joint, Tap joint, Pig tail joint) **(06 Hours)**
Unit 4	**Illumination:** Radiant Energy, Terms and Definitions, Laws of Illumination, Polar Curves, Photometry, Methods of Lighting calculations, Consideration points for planning a lighting installation ,Design consideration of good lighting scheme, Luminous Efficacy, Electrical Lamps, Design of Interior and Exterior Lighting Systems, Illumination Levels for Various Purposes, Light Fittings, Factory Lighting, Flood Lighting, Street Lighting, Energy ,Conservation in Lightin **(06 Hours)**
Unit 5	**Measurement of earth resistance & Testing**: **(08 Hours)** Measurement of Earth Resistance ,Two Point Methods, Three Point method, Fall of potential method, Direct measurement of Earth resistance, Testing of Installations, **Estimating & Conductor size calculations for internal wiring H.T & L.T Overhead Lines and Underground cables:** Estimating, Price catalogue, Schedule of rates & Estimating data, Determination of conductor size, Current carrying capacity, Voltage drop, Minimum permissible size, Conductor size calculation for internal domestic wiring, Underground cable, Overhead lines with A.C.S.R
Unit 6	Estimates for L.T Distributors & Street Light Feeders,Estimates for 11 kV Feeders, All Indian Electricity Ruleslike 1956,2003,2005, National Tariff Policies **(06 Hours)**
Text Books:	
1.	K.B. Raina & S.K. Bhattacharaya – Electrical Design Estimating & Costing, New age international publishers (1991), 1st Edition.
2.	S. L.Uppal and G.C. Garg – Electrical Wiring, Estimation & Costing, Khanna Publication (2008).
Reference Books:	
1.	J. B. Gupta, "Utilization of Electric Power and Electric Traction", 2002,S. K. Kataria and Sons.
2.	Pratab H., "Art and Science of Utilization of Electrical Energy", Second Edition, DhanpatRai and Sons, New Delhi.
3.	Surjeet Singh, "Electrical Estimating and Costing" Dhanpat Rai and Company (P) Ltd, Reprint 2008.

PRJ-EE308 Mini Project and Seminar-I

Credit (2)

The project work is intended to develop skill of electrical hardware assembly, electronics PCB design and assembly for small gadgets amongst the students. This skill may become useful during their final year project.

The students should undertake an electrical/electronic based hardware project and they have to submit report on the same. The project should include design and development of a small gadget useful in day-to-day life, in consultation with the faculty advisor.

SEMESTER-VI

PCC-EE309 Power System Analysis and Stability

Teaching scheme:			**Examination scheme:**
Lectures	3	hrs/week	Theory In Semester Evaluation : 20 Marks Mid Semester Examination: 30 marks End Semester Examination : 50 marks
Tutorials	-	hrs/week	
Practical's	2	hrs/week	
Credits	4		

Course Objectives:

1	To understand the need of load flow and short circuit analysis
2	To impart knowledge of Load flow Analysis, Short circuit studies and power system stability
3	To develop skills for performing stability studies

Course Outcomes: At the end of this course, students will demonstrate the ability to

PCC-EE307.1	Use numerical methods to analyse a power system in steady state
PCC-EE307.2	Understand methods to control the voltage, frequency and power flow.
PCC-EE307.3	Understand the monitoring and control of a power system.
PCC-EE307.4	Produce report of load flow analysis and stability analysis of practical power system network in software.
PCC-EE307.5	Understand the basics of power system economics.

Course Articulation Matrix: Mapping of Course outcome and Program outcome

PO/PSO → ↓ CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
PCC-EE307.1	**3**	**3**	**2**	**2**	**3**	**-**	**-**	**-**	**-**	**-**	**-**	**3**	**3**	**3**	**3**
PCC-EE307.2	**3**	**3**	**2**	**3**	**3**	**2**	**--**	**-**	**-**	**-**	**-**	**3**	**3**	**2**	**3**
PCC-EE307.3	**2**	**3**	**3**	**3**	**3**	**2**	**2**	**2**	**2**	**-**	**-**	**3**	**2**	**3**	**3**
PCC-EE307.4	**3**	**3**	**3**	**3**	**3**	**2**	**2**	**2**	**2**	**-**	**-**	**3**	**3**	**3**	**3**
PCC-EE307.5	**2**	**2**	**2**	**3**	**1**	**2**	**2**	**1**	**-**	**2**	**3**	**3**	**3**	**3**	**2**

Syllabus:

UNIT 1	**Power Flow Analysis: (06 Hours)** Loop Equations and Node Equations, Bus admittance and bus impedance matrix, network solution using matrix algebra, per unit system, single line diagram. Load Flow Studies: Load flow problem Bus classification, Nodal admittance matrix, Network model formulation and development of load flow equations. Iterative methods of solution a) Gauss Sidel method b) Newton Raphson method c) Fast decoupled method.
UNIT 2	**Symmetrical and Unsymmetrical Fault Analysis: (08 Hours)** Transient in RL series circuits, short circuit of synchronous machines, Short Circuit of a loaded synchronous machine, The bus impedance matrix in fault calculations, selection of circuit breaker, Symmetrical Components of Unsymmetrical Phasors, sequence Networks, Unsymmetrical faults on unloaded alternator and three phase power system with a) line to ground b) line to line c) double line to ground d) one conductor open fault e) Two conductor open fault, Simplified models of synchronous machines for transient analysis.

UNIT 3	**Power System Stability:** **(08 Hours)** Introduction to Power system stability problem, Rotor dynamics, m/c representation, Swing equation, power angle equation for two m/c system, Steady state stability and transient state stability, equal area criterion for stability and its application. Numerical solution of swing equation, factors affecting transient stability, methods for improving stability of Power system.
UNIT 4	**Control of Frequency and Voltage :** **(07 Hours)** Turbines and Speed-Governors, Frequency dependence of loads, Droop Control and Power Sharing. Automatic Generation Control. Generation and absorption of reactive power by various components Of a Power System. Excitation System Control in synchronous generators, Automatic Voltage Regulators. Shunt Compensators, Static VAR compensators and STATCOMs. Tap Changing Transformers.
UNIT 5	**Monitoring and Control :** **(06 Hours)** Overview of Energy Control Centre Functions: SCADA systems. Phasor Measurement Units and Wide-Area Measurement Systems. State-estimation. System Security Assessment. Normal, Alert, Emergency, Extremis states of a Power System. Contingency Analysis. Preventive Control and Emergency Control.
UNIT 6	**Power System Economics and Management :** **(07 Hours)** Basic Pricing Principles: Generator Cost Curves, Utility Functions, Power Exchanges, Spot Pricing. Electricity Market Models (Vertically Integrated, Purchasing Agency, Whole-sale competition, Retail Competition), Demand Side-management, Transmission and Distributions charges, Ancillary Services. Regulatory framework
Text/ Reference Books:	
1.	Grainger John J and W D Stevenson Jr,"Power system analysis" Mc-Graw Hill.
2.	I. J. Nagrath, D. P. Kothari, "Modern Power System Analysis" (3rd Edition), Tata McGraw Hill Publishing Co. Ltd.
3.	C.L. Wadhwa, "Electrical Power Systems", 6th Edition, New Age International, Latest Edition
4.	O. I. Elgerd, "Electrical energy systems theory: An introduction" Tata McGraw Hill, edition 1999.
5.	A. R. Bergen and Vijay Vittal, "Power system analysis", (2nd edition), Pearson Education Asia, 2001.
6.	Hadi Sadat, "Power system analysis", McGraw Hill International, 1999
7.	V.K.Mehta, Rohit Mehta "Principles of Power System", Fourth Edition , S.Chand Publications, Latest Edition
8.	B. M. Weedy, B. J. Cory, N. Jenkins, J. Ekanayake and G. Strbac, "Electric Power Systems", Wiley, 2012.
Term work:	
	The laboratory consists of following experiment list. 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 Siedal/ Newton-Raphson method. 4. Simulation and analysis for a symmetrical three phase fault by simulation. 5. Simulation and analysis of unsymmetrical fault - LL, LG and LLG. 6. Problems on stability using Equal area criteria, Swing equations Critical Clearing angle, Critical Clearing time. 7. Visit to load dispatch centre is suggested
	The computational work is to be carried preferably by using software tools like **MATLAB, Mi-Power, ETAP, Scilab or any open source software.**
	Independent Learning Experiences: NPTEL Equivalent Course : "Power System Analysis" by Prof. Debapriya Das, IIT Kharagpur • https://swayam.gov.in

PCC-EE310 Control System Design

Teaching scheme:		**Examination scheme:**
Lectures	3hrs/week	Theory In Semester Evaluation : 20 Marks Mid Semester Examination: 30 marks End Semester Examination : 50 marks
Tutorials	--	
Practicals	2hrs/week	
Credits	4	

Course Objectives:

1. Modeling of Physical systems using state space technique.
2. Analysis and Design of control system using state space technique.
3. Provide the knowledge of various nonlinearities observed in real world.
4. Design a control system using lead – lag compensator, P, PI and PID controllers.
5. Provide the knowledge of absolute and relative stability.

Course Outcomes: On successful completion of this course students will be able to

1. Apply the concepts of state space modeling, analysis and design.
2. Understand the various nonlinearities and their behaviour observed in real world.
3. Analyse the nonlinear system with describing function method and phase plane method and Lyapunov theory.
4. Apply Ziegler-Nichol PID tuning methods and determine PID controller settings, analyse the response and stability of system with different controllers.
5. Design series compensators to meet desired time domain and frequency domain specifications and evaluate the performance of compensated and uncompensated systems in time and frequency domain.
6. Validate the performance of systems without and with controllers through simulation using MATLAB.

Course Articulation Matrix: Mapping of Course outcome and Program outcome

PO/PSO → ↓ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
PCC-EE308.1	2	3	3	3	1	-	-	-	1	1	-	-	3	2	2
PCC- EE308.2	1	1	-	-	-	-	-	-	1	1	-	-	2	3	2
PCC- EE308.3	2	2	-	3	-	-	-	-	1	1	-	-	2	3	2
PCC- EE308.4	1	1	3	3	-	-	-	-	1	1	-	-	2	2	3
PCC- EE308.5	1	2	3	3	1	-	-	-	1	1	-	-	2	3	3
PCC-EE308.6	1	2	1	3	3	-	-	-	2	2	-	-	2	3	3

Syllabus:	
Unit 1	**State Space Representation of LTI systems: (10 Hours)** Terminology of state space representation: Concept of state, state variable, state vector, state space and state model, state space representation using physical, phase and canonical variables, determination of transfer function from state model, similarity transformation for diagonalization of plant matrix, solution of homogeneous state equation, state transition matrix its properties and computation using Laplace transform, Caley Hamilton, similarity transformation and infinite series method, solution of non homogeneous state equation
Unit 2	**State Space Analysis and Design: (06 Hours)** Concept of Controllability and Observability, investigation of controllability using Kalman and Gilbert test, design for pole placement using state feedback regulator, concept of state observer, types of state observer, design of full order state observer
Unit 3	**Non-linear control systems: (04 Hours)** Behavior of nonlinear systems, common physical nonlinearities, Concept of describing function, phase plane analysis, singular points
Unit 4	**Fundamentals of Lyapunov Theory: (06 Hours)** Equilibrium points, concept of stability, linearization and local stability, Lyapunov's Direct method: positive definite functions and Lyapunov functions, equilibrium point theorems, stability analysis of LTI systems using Lyapunov's direct method, Krasovski's method, Variable gradient method for stability of nonlinear systems.
Unit 5	**PID controllers: (06 Hours)** Introduction to Proportional (P), Integral (I) & Derivative (D) controller, individual effect on overall system performance, P, PI, PD & PID control and effect on overall system performance, Tuning of PID controllers using Ziegler-Nichol methods
Unit 6	**Compensator Design using Root Locus and Bode Plot: (12 Hours)** Review of compensators, Compensator design using root locus: design of lead, lag and lag-lead compensators using root locus approach for meeting desired time domain specifications, Compensator Design using Bode Plot: Reshaping Bode plot, design of lead, lag and lag-lead compensators using Bode plot approach for meeting desired frequency domain specifications
Text/Reference Books:	
1.	Norman Nise, "Control system Engineering", 3rd edition, 2000, John Wiley
2.	I. J. Nagrath and M. Gopal, "Control system engineering", Wiley Eastern Ltd, 3rd edition, 2000
3.	J. E. Slotine and W. Li, "Applied Nonlinear Control", Prentice Hall International, 1991.
4.	Benjamin C. Kuo, "Automatic Control system", Prentice Hall of India Pvt Ltd.
5.	John J. D'Azzo, C. H. Houpis, Linear control system analysis and design (conventional and modern), McGraw Hill International Fourth edition.
6.	Katsuhiko Ogata, Modern Control Engineering, Prentice Hall of India Pvt Ltd.
7.	
Term work: It will consist of a record of the following experiments based on the prescribed syllabus.	
1.	Introduction to MATLAB and Control system Design toolbox.
2.	Solution of Ordinary differential equation using MATLAB.
3.	Modeling of Physical Systems using MATLAB.
4.	Modeling of Physical Systems using Simulink.
5.	Conversion of given transfer function to State Space forms and vice versa.
6.	Determine Controllability and Observability of a system.
7.	Design and tuning PID controller using MATLAB/Simulink.
8.	Design of controller in state space Domain.

PCC-EE311 Power Electronics

Teaching scheme:			**Examination scheme:**
Lectures	3	hrs/week	Theory In Semester Evaluation : 20 Marks Mid Semester Examination: 30 marks End Semester Examination : 50 marks
Tutorials	--	hrs/week	
Practical's	2	hrs/week	
Credits	4		

Course Objectives:

1. Study different power electronic devices
2. To extend simple power electronic converters to realize rectifiers and inverters.
3. To develop and quantify common performance objectives for power electronic circuits such as efficiency, power factor, etc.
4. To analyze and design DC/DC converter (chopper) circuits.
5. To analyze and evaluate the operation of cycloconverters and voltage controllers.
6. To outline operating principles of application of power electronic circuits as motor drives, UPS systems, etc.

Course Outcomes: On successful completion of this course students will be able to

1. To understand the basic principle, characteristics and applications of power electronic and switching devices.
2. Analytical study of different types of Power Converter systems.
3. Solve the numerical problems on semiconductor switches, rectifier, converter, inverter, choppers and cycloconverter, circuits.
4. Simulate DC-DC converters
5. Simulate and Design DC-AC Inverters
6. Apply PWM technique

Course Articulation Matrix: Mapping of Course outcome and Program outcome

PO/PSO → ↓ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
PCC-EE309.1	3	2	2	1	1	-	-	-	-	-	-	-	3	3	2
PCC-EE309.2	3	1	2	2	-	1	-	-	-	-	-	-	3	3	2
PCC-EE309.3	3	1	2	-	-	-	-	-	-	-	-	-	3	3	2
PCC-EE309.4	3	2	3	1	1	-	-	-	-	-	-	-	3	3	2
PCC-EE309.5	3	2	3	1	1	-	-	-	-	-	-	-	2	3	3
PCC-EE309.6	3	1	1	1	-	-	-	-	-	-	-	-	2	2	3

Syllabus:

Unit 1	**Power Semiconductor Devices** **(06 Hours)** Modern power semiconductor devices and their characteristics, gate drive specifications, ratings, applications, turn ON and turn OFF methods, design of gate triggering circuits using UJT and thyristor protection circuits.

Unit 2	**Phase controlled rectifiers** **(06 Hours)** Single phase rectifiers: Half wave, center tapped, bridge (half controlled and fully controlled) with R and RL load. Three phase rectifiers: half wave, bridge with R and RL load effect of source inductance, dual converters, power factor improvement methods
Unit 3	**DC chopper** **(08 Hours)** Basic chopper, continuous and discontinuous current conduction, TRC, CLC methods, classification of choppers, step-up chopper, switching mode regulators.
Unit 4	**AC voltage controller & cycloconverters** **(06 Hours)** AC voltage controller: types of ac voltage controllers, single-phase and three phase ac voltage controllers with R and RL load, transformer tap changers, single phase to single phase cycloconverters, three phase to single phase cycloconverters, three phase to three phase cycloconverters with circulating and non-circulating mode.
Unit 5	**Inverters** **(08 Hours)** Single phase inverters: series, parallel and bridge configurations with R load, PWM inverters. Three phase inverters: 120° and 180° conduction with R and load RL, voltage control and harmonics reduction.
Unit 6	**Application in power electronics** **(06 Hours)** UPS and SMPS, basic characteristics of DC motors, operating modes, DC motor control using different rectifiers, induction motor drives, performance characteristics, stator voltage control, rotor voltage control, frequency control, voltage and frequency control.
Text/Reference Books:	
1.	P. S. Bhimra “Power Electronics”, , Khanna Publishers (2010).
2.	M.H. Rashid “Power Electronics, Circuits, Devices and Applications”, Pearson Education Inc., 3rd Edition .
3.	M. D. Singh and K. B. Khanchandani, Power Electronics, Tata McGraw-Hill Publishing Company Limited, New Delhi (India), 1998.
4.	P.C. Sen, “Power Electronics”,Tata McGraw-Hill Publications India
5.	Mohan, Undeland& Robins “Power Electronics, Converter Applications and Design”, , John Wiley and sons (Asia) Pvt. Ltd
6.	“G. K. Dubey and Others Thyristorised Power Controller”, Wiley Eastern Ltd
7.	B.K. Bose, “Modern Power Electronics and A.C. Drives”, Prentice Hall of India Pvt. Ltd. Publication
8.	B. W. Williams, “Power Electronics”, John Willey .
Term work:	It will consist of a record of at least six to eight experiments based on the following list
1.	UJT Characteristics.
2.	SCR Characteristics.
3.	TRIAC Characteristics.
4.	Power Control using SCR.
5.	Power Control using TRIAC.
6.	Single Phase Half Wave Controlled Rectifier.
7.	Single Phase Full wave Controlled Rectifier.
8.	Single Phase Inverter using Transistor/ MOSFET/SCR.
9.	Basic Step-Down Chopper.
10.	Basic Step-Up Chopper.
11.	Study of D.C. Motor control using controlled Rectifiers.
12.	Study of D.C. Motor control using chopper.
13.	Study of A.C. Motor control using Inverter.
Note: The above set of computational work is to be carried preferably using software like	

PEC- EE312 Power Plant Engineering			
Teaching Scheme :		**Examination Scheme:**	
Lectures	3 Hrs/ Week	Theory: Mid Term:30 Marks Continuous Evaluation : 20 Marks End Sem. Exam :50 Marks	
Tutorials	--		
Practical	--		
Credits (Th)	3		

Prerequisites Courses:	
1	Power System Engineering,
2	Electrical machines
Course Objective:	
1	To develop fundamental understanding about various energy sources
2	To provide knowledge about working of steam power plant, Hydro power plant , nuclear power plant and diesel power plant
3	To teach Economics of combined working power plants
Course Outcomes: Students' will be able to:	
1	Classify different sources of energy and analyse economics of power plant
2	Explain the working of various power plant
3	Reproduce Economics of combined working power plants
4	Understand mechanical and chemical aspect related to power plant engineering
5	Analyse different components of power plants

Course Articulation Matrix: Mapping of Course outcome and Program outcome

PO/PSO → ↓ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
PCC-EE310.1	2	1	3	1	-	1	2	1	-	-	-	3	1	1	2
PCC-EE310.2	3	1	2	1	-	2	2	1	-	-	-	2	2	2	2
PCC-EE310.3	2	1	3	1	-	1	2	1	-	-	-	3	2	2	2
PCC-EE310.4	3	1	2	1	-	1	1	1	-	-	-	2	2	2	1
PCC-EE310.5	2	2	3	2	1	2	2	1	-	-	-	2	2	2	2

Syllabus :	
Unit 1	**Sources of Energy and Economics of Power Plant (06 Hours)** Sources of energy , Fuels ,Types of fuels, Solid fuels, Liquid fuels, Gaseous fuels, Calorific value of fuels, Types of coal, Coal selection, Requirements of fuel ,HydelPotential energy, Nuclear energy – Comparison of Sources of power – Non conventional sources of energy Solar energy, Wind energy, Tidal power and Bio gas. Types of loads. Economic load sharing, Economics in plant selection, Economic of power generation , Choice of power station , Energy rates
Unit 2	**Steam Power Plant (08 Hours)** Thermal Station: Introduction, selection of sites, Layout of Steam power Plant, Fuel and ash handling, Combustion for burning coal, Mechanical stackers, Pulverizes, Electrostatic Precipitators, Draughts-Different types, Surface condensers - Types of cooling towers, Steam turbines, Steam engines: Advantages of steam turbines over steam engines, Boilers: Types of boilers, Principles of steam power plant design, Factors affecting steam plant design ,Thermal

	power plants environmental control, simple numerical examples.
Unit 3	**Hydro Electric Power Plant** **(06 Hours)** Lay out of Hydroelectric power plant: Elements of Hydroelectric power plan, Classification of Hydroelectric power plant, Advantages of Hydroelectric power plant, Mini and Micro hydro power plants, Types of Dams, Pen stock, Draft tube, Surge tank, Hydraulic turbines, Classifications, Turbine governing, Cavitation's, Safety measures in Hydro power stations, Control room functions, Switch gear, Site selection, Comparison of Hydroelectric power plant and steam power plant.
Unit 4	**Nuclear Power Plant** **(08 Hours)** Review of atomic physics (atomic number, mass number, isotopes, atomic mass, unit rate of radioactivity, mass equivalent number, binding energy and mass defects), Nuclear power plant layout, Elements of Nuclear power plant, Types of reactors ,Pressurized water reactor, Boiling water reactor, Waste disposal and safety, Advantages of Nuclear power plant, Comparison of Nuclear power plant and steam power plant, Site selection and Commissioning procedures, simple numerical, India's nuclear power program.
Unit 5	**Diesel Engine & Gas Turbine Power Plant** **(06 Hours)** Types of diesel engine power plants, Layout and components, Diesel engine power plant auxiliaries, Engine starting methods, Advantages of Diesel engine power plant, Application of Diesel engine power plant , Site selection. Gas turbine power plant ,Classification, Elements of simple gas turbine power plant, Layout, Open and Closed cycles, Reheating,Regeneration and Inter cooling – Combined cycles - Applications and advantages of Gas turbine plant, simple numerical examples.
Unit 6	**Combined working of power plants:** **(06 Hours)** Economics of combined working power plants, base load and peak load stations, pumped storage plants, inter- connections of power stations. Tariff: Fixed cost, running cost and their interrelation for all types of conventional power plants, depreciable cost, different types of tariffs, numerical example based on above, effect of deregulation on pricing.
Text Books:	
1.	P.K. Nag, "Power Plant Engineering", Third Edition, Tata McGraw – Hill, 2007
2.	G.R. Nagpal "Power Plant Engineering", Khanna Publishers.
Reference Book:	
1.	Arora S.C and Domkundwar ,"A Course in Power plant Engineering's, DhanpatRai, 2001.
2.	El-Wakil M.M, "Power Plant Technology", Tata McGraw-Hill
3.	Rai G.D, "Introduction to Power Plant Technology", Khanna Publishers.

ELECTIVES -II

PEC- EE313 Energy Audit and Conservation		
Teaching Scheme :		**Examination Scheme:**
Lectures	3 Hrs/ Week	Theory: Mid Term:30 Marks Continuous Evaluation : 20 Marks End Sem. Exam :50 Marks
Tutorials	--	
Practical	--	
Credits	3	

Prerequisites Courses:	
1	Generation, transmission and distribution of Electric Power Switchgear and Protection
Course Objective:	
1	To explain the current energy scenario and need of energy conservation.
2	To demonstrate the advantages of energy audit.
3	To demonstrate importance of energy management.
4	To identify importance of energy efficiency in electrical utility.
Course Outcomes: Students' will be able to:	
1	To implement conservation of energy techniques in electrical system.
2	Evaluate the technical economic feasibility of the energy audit technique.
3	To understand various kinds of tariffs in electrical utility.
4	Explain captive power generation.
5	Apply financial management in electrical conservation.
6	Analyse captive power generation and co-generation.

Course Articulation Matrix: Mapping of Course outcome and Program outcome

PO/PSO → ↓ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
PEC-EE311A.1	3	2	3	2	-	1	2	1	-	-	-	3	3	3	3
PEC-EE311A.2	3	1	2	1	3	2	2	1	-	-	-	2	3	3	2
PEC-EE311A.3	3	2	3	1	-	1	2	1	-	-	-	3	3	3	3
PEC-EE311A.4	2	1	2	1	-	1	1	1	-	-	-	2	3	3	2
PEC-EE311A.5	3	2	3	2	1	2	2	1	-	-	-	2	3	3	2
PEC-EE311A.6	3	1	3	2	-	1	2	1	-	-	-	3	3	3	2

Syllabus :	
Unit 1	**Energy scenario: (06 Hours)** Energy scenario: Introduction, energy problems, energy use trends in developing countries, prospects of changes in energy supply, strategies for sustainable development, finite fossil reserve, Energy and environment, Need for renewable and energy efficiency, Energy conservation principles, Energy conservation in industries, generation, transmission and distribution, household, commercial sectors, transport, agriculture.
Unit 2	**Energy Audit: (06 Hours)** Energy flow diagram, strategy of energy audit, comparison with standards, considerations in implementing energy with conservations programmes, instruments for energy audit, energy audit of illumination system, energy audit of electrical system, energy audit of heating ventilation and air conditioning systems, energy audit of compressed air system, energy audit of building, distribution and utilization system, economic analysis. Energy conservation Act 2003, energy audit of an industry .

Unit 3	**Energy Management and Integrated Resource Planning:** **(06 Hours)** Definition and Objectives of Energy management, Energy management strategy, Key elements, Responsibilities and duties of Energy Manager, Energy efficiency Programs, Energy Monitoring System, Importance of SCADA, Analysis techniques, Cumulative sum of differences (CUSUM).
Unit 4	**Energy efficiency in electrical utility:** **(06 Hours)** Electrical billing, power factor management, distribution and transformer losses, losses due to unbalance and due to harmonics, Demand Side Management, Demand-Response, Role of tariff in DSM and in Energy management, TOU tariff, Power factor tariff, Energy conservation in lighting system, HVAC system, Electrical Motors, Pump and pumping System.
Unit 5	**Financial Analysis and Management:** **(06 Hours)** Investment need, Financial analysis techniques, Calculation of Simple Pay-back period, return on investment, cash flows, risk and sensitivity analysis, Time value of money, Net Present value, Breakeven analysis, Cost optimization, Cost and Price of Energy services, Cost of Energy generated through Distributed Generation.
Unit 6	**Captive Power Generation**: **(06 Hours)** Types of captive power plants, financing of captive power plants, captive power plants in India, energy banking, energy wheeling, Carbon credits Cogeneration- Cogeneration technologies, industries suitable for cogeneration, allocation of costs. Sale of electricity to utility, impact of pricing of cogeneration, electric power plant reject heat, agricultural uses of waste heat, Potential of cogeneration in India, energy audit of renewable or hybrid industry/plant.

Text/ Reference Books:

1. B. R. Gupta, "Generation of Electrical Energy" S.Chand Publication.
2. S. Rao & Dr. B. B. Parulekar, "Energy Technology: Non-conventional,Renewable and Conventional" Khanna Publishers.
3. Frank Kreith and George Burmeister, "Energy Management &Conservation", Amazon Publishers.
4. Beggs and Clive, "Energy Management Supply and Conservation", Wall Mart Publishers
5. K.Bhattacharya, MHJ Bollen, J .E.Dalder, "Operation of Restructured Power System", Kluwer Academic Publications.
6.S. C. Tripathy, "Utilization of Electrical Energy", Tata Mc Graw Hill.
7. Energy Conservation Act 2001.
8. Bureau of Energy Efficiency India web-site http://www.bee-india.com.

Term Work:

Students have to submit audit report on following topics :

1. Computing efficiency of DC motor/Induction Motor/Transformer.
2. Draw the energy flow diagram for an industry/shop floor division and prepare energy audit report.
3. Study of various energy efficient equipment like LED lighting devices, Energy Efficient motors, Electronics ballast etc.
4. Study of Variable frequency drive based IM speed control for energy conservation.
5. Industry visit with an aim of

(i) Studying various energy management systems prevailing in a particular industry/Organization

(ii) Identifying the various energy conservation methods useful in a particular industry

6. Studying the various energy conservation methods useful in power generation, transmission and distribution
7. Study of APFC panel or Estimating the requirement of capacitance for power factor improvement.

08. Evaluating the energy conservation opportunity through various methods like simple payback period IRR and NPV.

09. Determine depreciation cost of a given energy conservation project/equipment.

10. Study of various measuring instruments used for energy audit: Lux meter, Power analyzer, flue gas analyzer.

11. Identifying the energy conservation opportunities in a lab, department or institute.

12. Internship

PEC- EE314 Electrical Machine Analysis

Teaching Scheme :		**Examination Scheme:**
Lectures	3Hrs/ Week	Theory: Mid Term:30 Marks
Tutorials	--	Continuous Evaluation : 20 Marks
Practical	--	End Sem. Exam :50 Marks
Credits (Th)	3	

Prerequisites Courses:

1	Electromagnetism
2	Electrical Machines

Course Objective:

1	Introduction to basic concepts of magnetically coupled circuits
2	Study of various principles of electromechanical energy conversion
3	To understand the concept of space vector on d-axis and q-axis variables
4	Study of Clarke and Park’s Transformations
5	Study of various models of induction and synchronous machines

Course Outcomes: Students’ will be able to:

1	Understand the limitations of conventional models of electrical machines
2	Determine the torque produced in electrical machines using the concept of co energy
3	Determine the performance of machines using reference frame theory
4	Select strategies to control the torque for a given application
5	Apply Clarke and Park’s Transformations for analysis of synchronous machines
6	Evaluate the performance of induction machine

Course Articulation Matrix: Mapping of Course outcome and Program outcome

PO/PSO → ↓ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
PEC-EE 311B.1	3	2	3	2	-	1	2	1	-	-	-	3	3	3	3
PEC-EE 311B.2	3	2	2	2	3	2	2	1	-	-	-	2	3	3	2
PEC-EE 311B.3	3	2	3	2	2	1	2	1	-	-	-	3	3	3	3
PEC-EE 311B.4	3	2	2	2	2	1	1	1	-	-	-	2	3	3	2
PEC-EE 311B.5	3	2	3	2	2	2	2	1	-	-	-	2	3	3	2
PEC-EE 311B.6	3	2	3	2	3	1	2	1	-	-	-	3	3	3	2

Syllabus:

Unit 1	**Magnetically coupled circuits:** **(06 Hours)** Review of basic concepts, magnetizing inductance, Modelling linear and nonlinear magnetic circuits.
Unit 2	**Electromechanical energy conversion:** **(08 Hours)** Principles of energy flow, concept of field energy and co-energy, Derivation of torque

	expression for various machines using the principles of energy flow and the principle of co energy, Inductance matrices of induction and synchronous machines
Unit 3	**Theory of DC machines : (08 Hours)** Review of the DC machine, mathematical model of commutator, State-space model of a DC machine, reduced order model & transfer function of the DC machine, Reference Frame Theory-Concept of space vector, components of space vector, direct and quadrature axis variables.
Unit 4	**Transformation: : (06 Hours)** Types of transformation, condition for power invariance, zero-sequence component, Expression for power with various types of transformation, Transformations between reference frames, Clarke and Park's Transformations, Variables observed from various frames, Simulation studies
Unit 5	**Theory of symmetrical Induction Machines: (06 Hours)** Voltage and torque in machine variables, Derivation of dq0 model for a symmetrical induction machine, Voltage and torque equation in arbitrary reference frame variables, Analysis of steady state operation, State-space model of induction machine in'd-q' variables, Simulation studies
Unit 6	**Theory of synchronous machines: (06 Hours)** Equations in arbitrary reference frame, Park's transformation, Derivation of dq0 model for a salient pole synchronous machine with damper windings, Torque expression of a salient pole synchronous machine with damper windings and identification of various components
Text Books:	
1.	E. Fitzgerald, Charles Kingsley, Stephen D. Umans: Electric Machinery, TMH, 5th Ed
2.	A. K. Sawhney, "A Course in Electrical Machine Design", DhanpatRai and Sons, Delhi
3.	Say.M.G. "Performance & Design of Alternating Current Machine" (English LanguageBook Society), CBS Publisher (2002)
Reference Books:	
1.	Rik De Doncker, Duco W. J. Pulle, André Veltman: Advanced Electrical Drives: Analysis, Modeling, Control Springer, 2011.
2.	Paul C. Krause, Oleg Wasynczuk, Scott D. Sudhoff: "Analysis of Electric Machinery & Drive systems"-IEEE Press, 2002
3.	K.M. Vishnu Murthy, B.S. "Computer Aided Design of Electrical Machines" Publications, 2008
4.	Rama Krishnan: Electric motor drives: Modeling, analysis, and control, Prentice Hall, 2001.

PEC- EE315 Utilization of Energy and Management			
Teaching Scheme :		**Examination Scheme:**	
Lectures	3Hrs/ Week	Theory: Mid Term:30 Marks Continuous Evaluation : 20 Marks End Sem. Exam :50 Marks	
Tutorials	--		
Practical	--		
Credits (Th)	3		

Prerequisites Courses:	
1	Power System Engineering, Electrical Machine
Course Objective:	
1	To give an overview of various areas of application of Electrical Energy.
2	Study of Speed-time curves and mechanics of train movement.
3	Study of various methods of Control of traction motors.
4	Study of various electrical motors and DG start up assessment
Course Outcomes: Students' will be able to:	
1	Understand selection of electrical motors according to load
2	Understand basic principles of electric heating and welding
3	Evaluate speed time curves for traction
4	Understanding and planning of Energy Audit
5	Analysis of DG system start up process
6	Do Energy Audit of commercial organization

Course Articulation Matrix: Mapping of Course outcome and Program outcome

PO/PSO → ↓ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
PEC-EE 311C.1	2	2	3	2	-	1	2	1	-	-	-	3	2	2	3
PEC-EE 311C.2	2	2	2	2	3	2	2	1	-	-	-	2	2	3	2
PEC-EE 311C.3	2	2	3	2	2	1	2	1	-	-	-	3	2	2	3
PEC-EE 311C.4	2	2	2	2	2	1	1	1	-	-	-	2	2	3	2
PEC-EE 311C.5	2	2	3	2	2	2	2	1	-	-	-	2	2	3	3
PEC-EE 311C.6	3	3	3	3	3	3	2	2	-	-	-	3	2	3	3

Syllabus:	
Unit 1	**Industrial application of Electrical Motors: (06 Hours)** Selection of motor for particular application, heating and cooling curves, load equalization, capitalization of losses.
Unit 2	**Heating and Welding: (06 Hours)** Classification, design of resistance ovens, dielectric heating, arc furnaces, electric welding and its control
Unit 3	**Speed-time curves and mechanics of train movement: (06 Hours)** Introduction to electric traction, traction systems, track electrification systems, ST curves, mechanics of train movement, coefficient of adhesion, specific energy consumption.
Unit 4	**Control of traction motors: (08 Hours)** Series-parallel control, drum controller, multiple unit control, regenerative braking, systems of current collection and train lighting, negative booster, traction sub-station.
Unit 5	**General aspects of Energy Audit and Energy Management (EAM): (06 Hours)** Energy scenario, basics of energy and its various forms EM&A, Energy monitoring and targeting, and electrical systems.

Unit 6	**Efficiency and performance assessment: (06 Hours)** Electrical motors, lighting system, DG set system, energy efficient technologies in electrical systems, application of non-conventional and renewable energy resources
Text Books:	
1.	J. B. Gupta"Utilization of Electrical Power and Electric Traction", , 8th edition 2006
2.	H. Partab"Art and Science of Utilization of Electrical Energy", , 2nd Edition, 2005.
3.	"Bureau of Energy Efficiency, Energy manager training" – ebook1- Chapter 1,2,3,8; ebook3-Chapter 1,2,8,9,10; ebook4- Chapter 5,10,12
Reference Books:	
1.	Visit to a local industry for the study of electrical energy utilization. A comprehensive report to be submitted.
2.	Prepare the energy audit report for the industry visited.
3.	Prepare a model of renewable energy source and submit a report on the same.

PRJ- EE316 Mini Project and Seminar-II

Credit (2)

The project work is intended to develop skill of electrical hardware assembly, electronics PCB design and assembly for small gadgets amongst the students. This skill may become useful during their final year project.

The students should undertake an electrical/electronic based hardware project and they have to submit report on the same. The project should include design and development of a small gadget useful in day-to-day life, in consultation with the faculty advisor.

List of Equivalent Subjects from SWAYAM/NPTEL for Credit Transfer:

Third Year B.Tech

Sr. No.	Institute Course		Details of course from SWAYAM/NPTEL
		SEMESTER-I	
1.	PCC-EE301	Power System Engineering	Power System Analysis Prof. Debapriya Das, IIT Kharagpur
			Power System Engineering Prof. Debapriya Das, IIT Kharagpur
2.	PCC-EE302	Feedback Control System	Control System, Dr. Shankar Raman, IIT Madras
			Control Engineering, Prof. R. Pasumarthy, IIT Madras
3.	PCC-EE303	Microprocessor and Microcontroller	Microprocessor and Microcontroller Prof. Santanu Chattopadhyay, IIT Kharagpur
4.	PCC-EE304	Digital Signal Processing	Discrete-Time Signal Processing Prof. MrityunjayChakraborty, IIT Kharagpur
5.	PEC-EE305	Elective-II : Basic of Photovoltaic (PV) System	Design of photovoltaic systems Prof. L Umanand, IISc Bangalore
6.	PEC-EE306	Elective-II : Renewable Energy Technologies	
7.	PEC-EE307	Elective-II : Electrical Installation and Design	
		SEMESTER-II	
1.	PCC-EE309	Power System Analysis and Stability	Power System Analysis Prof. Debapriya Das, IIT Kharagpur
			Power System Engineering Prof. Debapriya Das, IIT Kharagpur
2.	PCC-EE310	Control System Design	Control System, Dr. Shankar Raman, IIT Madras
			Control Engineering, Prof. R. Pasumarthy, IIT Madras
3.	PCC-EE311	Power Electronics	Power Electronics Prof. G. Bhuvaneshwari, IIT Delhi
4.	PCC-EE312	Power Plant Engineering	Steam Power Engineering Prof. Vinayak N Kulkarni, IIT Guwahati
5.	PEC-EE313	Elective-III : – Energy Audit and Conservation	
6.	PEC-EE314	Elective-III : Electrical Machine Analysis	
7.	PEC-EE315	Elective-III : Utilization of Energy and Management	