Department of Electrical and Electronics Engineering
Birla Institute of Technology, Mesra, Ranchi - 835215 (India)

Institute Vision

To become a Globally Recognized Academic Institution in consonance with the social, economic and ecological environment, striving continuously for excellence in education, research and technological service to the National needs.

Institute Mission

- To educate students at Undergraduate, Post Graduate, Doctoral and Post-Doctoral levels to perform challenging engineering and managerial jobs in industry.
- To provide excellent research and development facilities to take up Ph.D. programmes and research projects.
- To develop effective teaching and learning skills and state of art research potential of the faculty.
- To build national capabilities in technology, education and research in emerging areas.
- To provide excellent technological services to satisfy the requirements of the industry and overall academic needs of society.

Department Vision

To become an internationally recognized centre of excellence in academics, research and technological services in the area of Electrical and Electronics Engineering and related inter-disciplinary fields.

Department Mission

- Imparting strong fundamental concepts to students and motivate them to find innovative solutions to engineering problems independently
- Developing engineers with managerial attributes capable of applying latest technology with responsibility
- Creation of congenial atmosphere and excellent research facilities for undertaking quality research by faculty and students
- To strive for more internationally recognized publication of research papers, books and to obtain patent and copyrights
- To provide excellent technological services to industry

Program Educational Objectives (PEO)

PEO 1: To acquire in-depth knowledge of complex Electrical Engineering problems especially in Power Systems to impart ability to discriminate, evaluate, analyze critically and synthesize knowledge pertaining to state of art and innovative research.

PEO 2: To solve complex power system problems with commensurate research methodologies as well as modern tools to evaluate a broad spectrum of feasible optimal solutions keeping in view socio- cultural and environmental factors.

PEO 3: To posses wisdom regarding group dynamics to efficaciously utilize opportunities for positive contribution to collaborative multidisciplinary engineering research and rational analysis to manage projects economically.

PEO 4: To communicate with engineering community and society at large adhering to relevant safety regulations as well as quality standards.

PEO 5: To inculcate the ability for life-long learning to acquire professional and intellectual integrity, ethics of scholarship and to reflect on individual action for corrective measures to prepare for leading edge position in industry, academia and research institutes.

Program Outcomes (PO)

PO1: An ability to independently carry out research /investigation and development work to solve practical problems.

PO2: An ability to write and present a substantial technical report/document.

PO3: Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.

PO4: Recognise the need for continuous learning and will prepare one-self to create, select and apply appropriate techniques and modern engineering and IT tools to solve complex power system problems.

PO5: Demonstrate knowledge of engineering and management principles and apply to manage projects efficiently and economically with intellectual integrity and ethics for sustainable development of society.

PO6: Possess knowledge and understanding to recognize opportunities and contribute to collaborative-multidisciplinary research, demonstrate a capacity for teamwork, decision-making based on open-mindedness and rational analysis in order to achieve common goals.

Graduate Attributes (GAs)

GA 1: Scholarship of Knowledge

Acquire in-depth knowledge of specific discipline or professional area, including wider and global perspective, with an ability to discriminate, evaluate, analyse and synthesise existing and new knowledge, and integration of the same for enhancement of knowledge.

GA 2: Critical Thinking

Analyse complex engineering problems critically, apply independent judgement for synthesising information to make intellectual and/or creative advances for conducting research in a wider theoretical, practical and policy context.

GA 3: Problem Solving

Think laterally and originally, conceptualise and solve engineering problems, evaluate a wide range of potential solutions for those problems and arrive at feasible, optimal solutions after considering public health and safety, cultural, societal and environmental factors in the core areas of expertise.

GA 4: Research Skill

Extract information pertinent to unfamiliar problems through literature survey and experiments, apply appropriate research methodologies, techniques and tools, design, conduct experiments, analyse and interpret data, demonstrate higher order skill and view things in a broader perspective, contribute individually/in group(s) to the development of scientific/technological knowledge in one or more domains of engineering.

GA 5: Usage of modern tools

Create, select, learn and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling, to complex engineering activities with an understanding of the limitations.

GA 6: Collaborative and Multidisciplinary work

Possess knowledge and understanding of group dynamics, recognise opportunities and contribute positively to collaborative-multidisciplinary scientific research, demonstrate a capacity for self-management and teamwork, decision-making based on open-mindedness, objectivity and rational analysis in order to achieve common goals and further the learning of themselves as well as others.

GA 7: Project Management and Finance

Demonstrate knowledge and understanding of engineering and management principles and apply the same to one‘s own work, as a member and leader in a team, manage projects efficiently in respective disciplines and multidisciplinary environments after consideration of economical and financial factors.

GA 8: Communication

Communicate with the engineering community, and with society at large, regarding complex engineering activities confidently and effectively, such as, being able to comprehend and write effective reports and design documentation by adhering to appropriate standards, make effective presentations, and give and receive clear instructions.

GA 9: Life-long Learning

Recognise the need for, and have the preparation and ability to engage in life-long learning independently, with a high level of enthusiasm and commitment to improve knowledge and competence continuously.

GA 10: Ethical Practices and Social Responsibility

Acquire professional and intellectual integrity, professional code of conduct, ethics of research and scholarship, consideration of the impact of research outcomes on professional practices and an understanding of responsibility to contribute to the community for sustainable development of society.

GA 11: Independent and Reflective Learning

Observe and examine critically the outcomes of one‘s actions and make corrective measures subsequently, and learn from mistakes without depending on external feedback.

1^{st} Semester

Program Core

COURSE INFORMATION SHEET

Course code: EE501
Course title: Advanced Digital Signal Processing
Pre-requisite(s): Basics of signals and systems, transform methods, Filter theory.
Credits: 3

L	T	P
3	0	0

Class schedule per week: 3 Lectures
Class: M.Tech
Semester / Level: I/05
Branch: Electrical Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1.	enumeratethe basic concepts of signals and systems and their interconnections in a simple and easy-to-understand manner by employingdifferent mathematical operations like folding, shifting, scaling, convolutions, Z-transform etc;
2.	determine transfer function, impulse response and comment on various properties like linearity, causality, stability of a system;
3.	predict time and frequency response of discrete-time systems using various techniques like Z-transform, Hilbert transform, DFT, FFT;
4.	designdigital IIR and FIR filters using filter approximation theory, frequency transformation techniques, window techniques and finally construct different realisation structures;
5.	apply DSP processor in processing of 1D and 2D signals.

Course Outcomes:
At the end of the course, a student should be able to:

CO1	state sampling theorem and reproduce a discrete-time signal from an analog signal; acquire knowledge of multi rate digital signal processing, STFT and wavelets;
CO2	classify systems based on linearity, causality, shift-variance, stability criteria and represent transfer function of the selected system;
CO3	evaluate system response of a system using Z-transform, convolution methods, frequency transformation technique, DFT, DIF-FFT or DIT-FFT algorithm, window techniques;
CO4	designFIR and IIR filters used as electronic filter, digital filter, mechanical filter, distributed element filter, waveguide filter, crystal filter, optical filter, acoustic filter, etc.;
CO5	construct (structure) and recommend environment-friendly filter for real- time applications.

SYLLABUS

EE501 Advanced Digital Signal Processing

Module I

Introduction: Overview of discrete time signal and systems, Types of discrete time systems, Analysis of discrete-time linear time invariant systems, Multirate signal processing: Decimation by factor D, I sampling rate conversion by a rational factor I/D. Z-transform, Properties of Z-transform, Inverse of Z-transform, Chrip Z-ransform, Zury's test for stability, Digital filter structures: Direct form I & II, Cascade, Parallel and Ladder realizations.

(8L)

Module II

Frequency domain analysis: Discrete Fourier transform (DFT), Inverse DFT, Inter relationship with z-transform and Hilbert-transforms, Discrete Hilbert transform, FFT algorithms- Decimation in time and decimation in frequency. Spectral analysis using DFT, Short term DFT.

(8L)

Module III

Filter function approximation, transforms and IIR filter design: Review of approximation of ideal analog filter response. Butterworth, Chebyshev type I & II, IIR filter designs based on impulse invariant and Bilinear transformation.

(8L)

Module IV

Design of FIR Filters: Characteristic of FIR filters with linear phase, Symmetric and antisymmetric FIR filters, design of linear phase FIR filters using windows and frequency sampling methods, comparison of FIR and IIR filters.

(8L)

Module V

DSP Processor and applications: Introduction to DSP processor, Types of architectures, DSP support tools, code composer studio, compiler, assembler and linker, Introduction TMS320 C6x architecture, functional units, fetch and execute packets, pipe lining, registers, Linear and circular addressing modes. DSP applications in the area of biomedical signal, speech, and image.

(8L)

Books Recommended:

Text Book

1. John G. Proakis, Dimitris G. Mamalakis, Digital Signal Processing, Principles, Algorithms and Applications.
2. Alan V. Oppenheim Ronald W. Schafer, Digital Signal Processing, PHI, India.

Reference Book

1. Antonious, Digital Filter Design, Mc-Graw-Hill International Editions.
2. S. Salivahanan C Gnanapriya, Digital Signal Processing, Tata McGraw Hill Education Private Limited.
3. A. NagoorKani, Digital Signal Processing, McGraw Hill Education Private Limited.

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements):

1. Visualize different signal processing techniques in real time.
2. Application of real time implementation of digital filter.

POs met through Gaps in the Syllabus:PO5 & PO6

Topics beyond syllabus/Advanced topics/Design:

Adaptive signal processing, Image processing.

POs met through Topics beyond syllabus/Advanced topics/Design: PO5 & PO6

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment

Assessment Tools	**% Contribution during CO Assessment**
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	**% Distribution**
3 quizzes	30 (3×10)
Assignment(s)	10
Seminar before a committee	10

Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training

CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	-	-	-
CO2	3	2	1	2	-	1
CO3	3	1	2	3	-	1
CO4	2	2	2	3	2	2
CO5	2	2	3	1	3	3

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD6
CO2	CD1, CD6,CD7
CO3	CD1, CD2, CD3,CD6,CD7
CO4	CD1, CD3,CD6,CD7
CO5	CD1,CD2,CD3,CD4,CD5,CD7

COURSE INFORMATION SHEET

Course code: EE503
Course title: Modern Control Theory
Pre-requisite(s): B.E./B.Tech. in ECE/EEE with basic courses on Control Theory
Co- requisite(s): Linear Algebra

Credits: 3	L	T	P
	3	0	0

Class schedule per week: 03
Class: M.Tech.
Semester / Level: I/05
Branch: Electrical Engineering
Name of Teacher:
Course Objectives:
This course enables the students to:

1.	state basic concepts of state variables, state diagrams, controllability, observability;
2.	extend comprehensive knowledge of mathematical modelling of physical system;
3.	illustrate basics of transformations and decompositions for controllability and observability tests;
4.	enhance skills with application of different control strategy for designing a control problem;
5.	design controller for any type of linear plants.

Course Outcomes:
At the end of the course, a student should be able to:

CO1	demonstrate an understanding of the building blocks of basic and modern control systems by creating mathematical models of physical systems in input-output or transfer function form;
CO2	organize state representations to satisfy design requirements using transformations and decompositions;
CO3	examine state space equations for time domain analysis;
CO4	assess a system for its stability, controllability, and observability properties leading to design of controller and observer in a feedback control system;
CO5	aspire for pursuing a carrier in control, recognize the need to learn, to engage and to adapt in a world of constantly changing technology and play role of team leader or supporter of team.

SYLLABUS

EE503 Modern Control Theory

Module I

Background and Preview, Modelling, Highlights of Classical Control Theory; Block diagram, Transfer functions, State Variables and State Space description of dynamic systems, State diagrams, Differential equations to state diagrams, State diagrams to Transfer function, State diagrams to state and output equations, State equations from system's linear graph.

(8L)

Module II

Fundamentals of Matrix Algebra, Vectors and Linear Spaces, Simultaneous Linear Equations, Eigenvalues and Eigenvectors, Functions of Square Matrices, Similarity Transformations, CCF, OCF, DCF and JCF forms, Decomposition of Transfer Functions, The Caley-Hamilton Theorem and it's applications.

(8L)

Module III

Analysis of Continuous and Discrete-Time Linear State Equations, Local linearization of non-linear models, State Transition Matrix, Significance, Properties and Evaluation of STM, Stability analysis using direct method of Lyapunov.

(8L)

Module IV

Controllability and Observability concept for linear Systems, Relationship among Controllability, Observability and Transfer Functions, Invariant theorems on Controllability and Observability.

(8L)

Module V

Design of Linear Feedback Control Systems, pole placement design through state feedback, Design of servo systems, State observers, Design of Regulator Systems with observers, Design of control systems with Observers, Quadratic Optimal Regulator Systems.

(8L)

Books Recommended:

Text Book

1. Modern Control Theory by Brogan, Pearson, 3rd edition. (**T1)**
2. Systems and Control by Zak, 1st edition, Oxford University Press. **(T2)**
3. Modern Control System Theory by M. Gopal, New Age International(P) Ltd., 2nd edition. (**T3**)
4. Automatic Control Systems by F. Golnaraghi and B.C.Kuo, Wiley Student Edition, 9th edition. (**T4**)
5. Modern Control Engineering by K. Ogata, Pearson, 5th edition (**T5)**

Reference Book

1. Digital Control & State Variable Methods – M. Gopal, Tata McGraw Hill Education. (**R1**)
2. Linear Systems by Thomas Kailath, Prentice-Hall Inc.,1980. (**R2**)

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements):

POs met through Gaps in the Syllabus:PO5 & PO6

Topics beyond syllabus/Advanced topics/Design:

Design optimization for industrial projects, Fractional order controller.

POs met through Topics beyond syllabus/Advanced topics/Design: PO5 & PO6

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment

Assessment Tools	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 quizzes	30 (3×10)
Assignment(s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment

3. Student Feedback on Faculty
4. Student Feedback on Course

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOME AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	-	1	3	-	-
CO2	3	-	1	3	-	1
CO3	3	1	2	3	-	1
CO4	3	2	2	3	2	2
CO5	3	3	3	3	3	3

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD6
CO2	CD1, CD6,CD7
CO3	CD1, CD2, CD3,CD6,CD7
CO4	CD1, CD3,CD6,CD7
CO5	CD1,CD2,CD3,CD4,CD5,CD7

COURSE INFORMATION SHEET

Course code: EE509
Course title: Advanced Power System Analysis
Pre-requisite(s): B.E./B.Tech. in ECE/EEE
Co- requisite(s):
Credits: 3 L T P
3 0 0

Class schedule per week: 03
Class: M.Tech.
Semester / Level: I/05
Branch: Electrical Engineering
Name of Teacher:
Course Objectives:
This course enables the students:

1.	to define single-phase modeling of power system components;
2.	to describe steady state operation of large-scale power systems and to solve the power flow problems using efficient numerical methods suitable for computer simulation like N-R,FDLF, Continuation Load Flow, Series Load Flow;
3.	to analyze power systems under abnormal conditions (short circuit) utilizing bus impedance matrix for short circuit analysis;
4.	to analyze power system security in different outage events by contingency analysis and assess the state estimation;
5.	to extend the knowledge for solving harmonic load flow analysis stating the causes for harmonic content and modeling component in harmonic domain.

Course Outcomes:
After completion of the course, the learners will be able to:

CO1	draw the impedance and reactance diagram and can explain different components modeling for load flow, short circuit, contingency analysis and harmonic analysis of power system;
CO2	solve load flow problems by different methods;
CO3	Identify and analyze the different abnormal (fault) conditions in power system utilizing efficient computer algorithm;
CO4	explain different factors affecting the power system security for single and multiple contingencies;
CO5	explain different numerical methods for state estimation of power system.

SYLLABUS

EE509 Advanced Power System Analysis

Module I

Introduction: Modeling of power system component, Basic single-phase modelling, Generation, Transmission line, Transformers, Shunt elements.

(8L)

Module II

Load Flow Analysis: Introduction, Nature of load flow equations, Newton Raphson method: Formulation for load buses and voltage controlled buses in rectangular and polar co-ordinates, Computational steps and flow chart, Computational Aspects of Large Scale System - Introduction, Sparsity oriented technique for reducing storage requirements, Factorization.

(8L)

Module III

Decoupled Load Flow: Formulation, Fast decoupled load flow method, Continuation load flow technique, Series load flow technique. Harmonic Analysis - Power Quality, Sources, Effects of Harmonics, Harmonic load flowanalysis, Suppression of Harmonics.

(8L)

Module IV

Short Circuit Analysis: Introduction, Bus impedance matrix and its building algorithm through modifications, Fault calculation uses Zbus and its computational steps. Symmetrical and Unsymmetrical faults.

(8L)

Module V

Contingency Analysis: Introduction to power system security, Factors affecting power system security, Analysis of single contingencies, Linear sensitivity factors, Analysis of multiple contingencies, Contingency ranking. State Estimation: Introduction, weighted least square technique, Statistics, Errors and estimates.

(8L)

Text Books:

1. Power System Analysis - John J. Grainger, William D. Stevenson, Jr.
2. Power System Analysis - L. P. Singh

Reference Books:

1. Electric Energy Systems Theory - An Introduction, O.L. Elgerd.
2. Computer Modelling of Electrical Power Systems - J. Arrillaga, N.R. Watson
3. Power System harmonic Analysis, J. Arrillage, B.C. Smith, et al.

Course Evaluation:
Individual assignment, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements):

POs met through Gaps in the Syllabus:
Topics beyond syllabus/Advanced topics/Design:

POs met through Topics beyond syllabus/Advanced topics/Design:

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment

Assessment Tools	**% Contribution during CO Assessment**
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 quizzes	30 (3×10)
Assignment(s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Tutorials/Assignments
CD3	Seminars
CD4	Industrial visits/in-plant training
CD5	Self- learning such as use of NPTEL materials and internets
CD6	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	3	2
CO2	3	3	3	3	2	2
CO3	3	3	3	2	3	2
CO4	3	3	3	2	2	3
CO5	3	3	2	2	2	3

< 34% = 1, 34-66% = 2, > 66% = 3

Mapping Between Course Outcomes and Course Delivery Method

Course Outcome	Course Delivery Method
CO1	CD1, CD2, CD3,CD5
CO2	CD1, CD2, CD3,CD5
CO3	CD1, CD2, CD3,CD5
CO4	CD1, CD2, CD3,CD5
CO5	CD1, CD2, CD3,CD5

COURSE INFORMATION SHEET
Program Elective-I

Course code: EE511
Course title: Optimization in Engineering Design
Pre-requisite(s):B.E./B.Tech. in ECE/EEE
Co- requisite(s) :
Credits: 3 L T P
3 0 0

Class schedule per week: 03
Class: M.Tech.
Semester / Level: I/05
Branch: Electrical Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1.	conceptualize the optimizations in engineering design and model the problem mathematically;
2.	understand various optimization methods and algorithms for solving optimization problems;
3.	develop substantial interest in research, for applying optimization techniques in problems of engineering and technology;
4.	analyze and apply mathematical results and numerical techniques for optimization of engineering problems, while being able to demonstrate solutions through computer
5.	formulate the optimization criteria for real time applications.

Course Outcomes:
At the end of the course, a student should be able to:

CO1	have a basic understanding of traditional and non-traditional optimization algorithms;
CO2	formulate engineering design problems as mathematical optimization problems;
CO3	use mathematical software for the solution of engineering problems;
CO4	differentiate the various optimization concepts and equivalently apply them to engineering problems;
CO5	evaluate pros and cons for different optimization techniques.

SYLLABUS

EE511 Optimization in Engineering Design

Module I

One-dimensional search and multivariable optimization algorithm: Optimality Criteria, Bracketing methods: Exhaustive search methods, Region – Elimination methods; Interval halving method, Fibonacci search method, Golden section search method, Point-estimation method; Successive quadratic estimation method. Optimality criteria, Unidirectional search, Direct search methods: Simplex search method, Hooke-Jeeves pattern search method

(8L)

Module II

Gradient-based methods: Newton-Raphson method, Bisection method, Secant method, Cauchy's (Steepest descent) method and Newton's method.

(8L)

Module III

Linear Programming: Graphical method, Simplex Method, revised simplex method, Duality in Linear Programming (LP), Sensitivity analysis, other algorithms for solving LP problems, Transformation, assignment and other applications.

(8L)

Module IV

Constrained Optimization Algorithm: Characteristics of a constrained problem. Direct methods: The complex method, Cutting plane method, Indirect method: Transformation Technique, Basic approach in the penalty function method, Interior penalty function method, convex method.

(8L)

Module V

Advanced Optimization Techniques: Genetic Algorithm, Working principles, GAs for constrained optimization, Other GA operators, advanced GAs, Differences between GAs and traditional methods. Simulated annealing method, working principles. Particle swarm optimization method, working principles.

(8L)

Books recommended:

Reference Book:

1. Optimization for Engineering Design - Kalyanmoy Deb.
2. Optimization Theory and Applications - S.S. Rao.
3. Analytical Decision Making in Engineering Design – Siddal.
4. Linear Programming – G. Had

Course Evaluation:
Individual assignment, Theory (Quiz and End semester) examinations

<u>Gaps in the syllabus (to meet Industry/Profession requirements)</u> :
Validation of optimization based design for industrial projects.
<u>POs met through Gaps in the Syllabus:</u>PO6

<u>Topics beyond syllabus/Advanced topics/Design:</u>
Genetic Algorithm based machine design.

<u>POs met through Topics beyond syllabus/Advanced topics/Design</u>: PO6

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

<u>Direct Assessment</u>

Assessment Tools	**% Contribution during CO Assessment**
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	**% Distribution**
3 quizzes	30 (3×10)
Assignment(s)	10
Seminar before a committee	10

Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Continuous Internal Assessment					
Semester End Examination					

<u>Indirect Assessment</u>

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

<u>MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES</u>

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	-	1	3	-	-
CO2	3	-	1	3	-	1
CO3	3	1	2	3	-	1
CO4	3	2	2	3	2	2
CO5	3	3	3	3	3	3

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD6
CO2	CD1, CD6,CD7
CO3	CD1, CD2, CD3,CD6,CD7
CO4	CD1, CD3,CD6,CD7
CO5	CD1,CD2,CD3,CD4,CD5,CD7

COURSE INFORMATION SHEET

Course code: EE 531

Course title: EHV AC Power Transmission

Pre-requisite(s): Knowledge of basic power system and control system courses.
Co- requisite(s): B.E./B.Tech. in ECE/EEE with basic courses on Power System

Credits: 3 **L T P**
3 0 0

Class schedule per week: 3 Classes per week
Class: M.Tech.
Semester / Level: I/05
Branch: Electrical Engineering
Name of Teacher:
Course Objectives
This course enables the students to:

1.	provide the concept of calculation of line resistance, inductance, capacitance and ground return parameters for N-conductor bundle;
2.	make the students understand the field of point charge ,line charge and then surface voltage gradient for bundle conductor;
3.	expose the students about the calculation process of electrostatic and electromagnetic field for bundle conductor and their effects;
4.	provide the core concept of HVDC system and the working principles of converters, harmonic generation and filtration.

Course Outcomes
After the completion of this course, students will be able to:

CO1	understand the mathematical equations and process of calculation involved to determine the basic parameters for EHV and HVDC line;
CO2	understand the core concept involving with the different alternative designing procedurals to mitigate the different problems for EHV and HVDC line;
CO3	analyze the performance of a conventional EHV A.C. transmission system and evaluate the need of for improvement;
CO4	formulate the mathematical equations for different factors that causes the operational limitations for EHV and HVDC line;
CO5	comprehend the importance of the course and the need for more learning considering the vastness of the subjects and advancements in the particular field.

SYLLABUS

EE581 EHV AC Power Transmission

Module I

Maxwell's coefficients, Sequence inductance and capacitance, Charge Matrix, Effect of Ground wire.

(8L)

Module II

Surface Voltage-gradient on bundled conductors, Mangoldt's formula, Gradient factors & their use, Ground level electrostatic field of EHV lines.

(8L)

Module III

Power frequency over-voltage control, Series and shunt compensation, Generalised Constants of Compensated line, Static Var Compensators (SVC/SVS). Switching over-voltages in EHV Systems.

(8L)

ModuleIV

Six-pulse Bridge Circuit: waveforms and relevant equations, Twelve-pulse converter, Advantages of higher pulse number, Bipolar to monopolar operation, Converter performance with phase control, Commutation and effect of reactance.

(8L)

ModuleV

Introduction to HVDC Transmission system, Economical advantages, Technical advantages, Critical distance, Submarine transmission.Inverter, Equivalent circuit of HVDC system, Schematic diagram, Reactive power consideration in HVDC system, Harmonics, Filters in HVDC system.

(8L)

Text Books:

1. Extra High Voltage AC Transmission Engineering (2nd Ed.) by R.D. Begamudre, Wiley Eastern Ltd.
2. HVDC Power Transmission Systems by K. Padiyar, Wiley Eastern Ltd.

Reference Books:

1. EHV AC and HVDC Transmission

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements):

POs met through Gaps in the Syllabus: **PO5 & PO6**

Topics beyond syllabus/Advanced topics/Design:

POs met through Topics beyond syllabus/Advanced topics/Design: **PO5 & PO6**

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment

Assessment Tools	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 quizzes	30 (3×10)
Assignment(s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD	Course Delivery methods
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes And Program Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	3	-	1
CO2	3	3	2	2	1	1
CO3	3	3	2	2	1	1

CO4	3	3	2	2	1	1
CO5	3	3	2	2	1	1

< 34% = 1, 34-66% = 2, > 66% = 3

Mapping Between Course Outcomes and Course Delivery Method

Course Outcomes	**Course Delivery Method**
CO1	CD1,CD6
CO2	CD1, CD6,CD7
CO3	CD1, CD2, CD3,CD6,CD7
CO4	CD1, CD3,CD6,CD7
CO5	CD1,CD2,CD3,CD4,CD5,CD7

COURSE INFORMATION SHEET

Course code: EE 533
Course title: Modern Power System Planning
Pre-requisite(s): Knowledge of basic power system and control system courses.
Co- requisite(s): B.E./B.Tech. in ECE/EEE with basic courses on Power System
Credits: 3 L T P
3 0 0
Class schedule per week: 3 Classes per week
Class: M.Tech.
Semester / Level: I/05
Branch: Electrical Engineering
Name of Teacher:

Course Objectives
This course enables the students to:

1.	understand the need of power system planning;
2.	describe load forecasting models for short-term and long-term power system planning;
3.	describe the methodologies to solve power system generation system and network expansion planning;
4.	understand the maintenance scheduling processes for obtaining quality power;
5.	understand the research trend towards smart grid planning and integration of distributed generation planning.

Course Outcomes
After the completion of this course, students will be able to:

CO1	acquire the knowledge of basic planning aspects;
CO2	understand the load forecasting models and apply for long and short term load forecasting;
CO3	analyze the techniques for generation system and network expansion planning;
CO4	analyze the maintenance scheduling processes;

CO5	formulate concepts for smart grid planning , micro grid planning, integration of distributed generation.

SYLLABUS
EE533 Modern Power System Planning

Module I

Introduction: Hierarchy of modern power system planning, Brief description about short term and long term planning.Load Forecasting: Classification and characteristics of loads, Forecasting methodology (extrapolation and correlation), Energy forecasting, Peak demand forecasting, Non-weather sensitive forecast (NWSF), Weather-sensitive forecast (WSF), Total forecast, Annual and monthly peak demand forecast.

(8L)

Module II

Power System Probabilistic Production Simulation: Fundamentals of production simulation, Cumulant method in probabilistic production simulation, Equivalent energy function method, Simulation of hydroelectric generating units and pump-storage units.

(8L)

Module III

Maintenance Scheduling of Generating Units in a Power System: Introduction, Levelized reserve method, Levelized risk method, Maintenance scheduling using soft computing techniques.

(8L)

Module IV

Generation Expansion Planning: Fundamental economic analysis, Generation planning optimized according to generating unit categories (WASP), Generation planning optimized according to power plants (JASP), Network Planning: Introduction, Heuristic methods of network planning, Network planning by mathematical optimization, Fast static security contingency analysis, Probabilistic load flow calculation.

(8L)

Module V

Planning of Smart Grid: Introduction, optimal placement of PMUs, planning of microgrid, planning of distributed generation

(8L)

Books Recommended:

1. Modern Power System Planning, X, Wang and J.R. McDonald, McGraw-Hill Book Company.
2. Power System Planning, R.L. Sullivan, McGraw-Hill International Book Company

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements):
Design of real-time industrial projects.
POs met through Gaps in the Syllabus:**PO5 & PO6**

Topics beyond syllabus/Advanced topics/Design:
Design optimization for industrial projects, Fractional order controller
POs met through Topics beyond syllabus/Advanced topics/Design: **PO5 & PO6**

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment

Assessment Tools	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 quizzes	30 (3×10)
Assignment(s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD	Course Delivery methods
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	3	-	1
CO2	3	3	2	2	1	1

CO3	3	3	2	2	1	1
CO4	3	3	2	2	1	1
CO5	3	3	2	2	1	1

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD6
CO2	CD1, CD6,CD7
CO3	CD1, CD2, CD3,CD6,CD7
CO4	CD1, CD3,CD6,CD7
CO5	CD1,CD2,CD3,CD4,CD5,CD7

COURSE INFORMATION SHEET

Course code: EE 535
Course title: HVDC and FACTS
Pre-requisite(s):
Co- requisite(s): B.E./B.Tech. in ECE/EEE with basic courses on Power System
Credits: 3 L T P
3 0 0
Class schedule per week: 3 Classes per week
Class: M.Tech.
Semester / Level: I/05
Branch: Electrical Engineering
Name of Teacher:

Course Objectives
This course enables the students to:

1.	identify the significance of HVDC System and its components;
2.	understanding the AC/DC conversion, interpretation of harmonics in HVDC system;
3.	judge the efficacy of different controllers and protective mechanism in HVDC system;
4.	judge the significance of reactive power compensation and requirement of FACTS;
5.	analyze different types of FACTS and their need in emerging power system and investigate their performance when installed in a given transmission system.

Course Outcomes
After the completion of this course, students will be able to:

CO1	state the significance of HVDC systems over EHVAC systems and identify appropriate HVDC link and converter;
CO2	explain different converters for AC to DC & DC to AC conversion and to interpret

	the effect of harmonics in HVDC system and filtering;
CO3	evaluate the function and efficacy of different controllers and analyze the different faults in HVDC systems with required protective mechanism;
CO4	analyze the performance of a conventional A.C. transmission system and evaluate the need of for improvement;
CO5	investigate different series, shunt FACTS controllers and compute the performance when installed in a given transmission system.

SYLLABUS

EE535 HVDC and FACTS

Module I

Introduction to HVDC Transmission: Comparison with EHV AC power transmission, HVDC system configuration and classification: Monopolar links, Bipolar links, Homopolar links, Back-to-back connection, Multi-terminal HVDC System, HVDC systems elements: Converter transformers, D.C. smoothing reactors, Thyristor valves, Earth electrodes & Earth return, etc. HVDC-AC interactions: SCR, Problems with low ESCR system, Solutions to problems associated with weak system.

(8L)

Module II

Principles of AC/DC Conversion with Harmonic Analysis and Filtering: Steady state characteristics of converters, Combined characteristics of rectifier and inverter, Converter connections, Reactive power requirements, Characteristic and non-characteristic harmonics, Harmful effects of harmonics, Harmonic filters and detuning, Cost considerations of filters.

(8L)

Module III

Protection and System Control in HVDC:Response to D.C. and A.C. system faults, D.C. line fault, A.C. system fault, Converter fault, Protection issues in HVDC, D.C. Circuit Breakers, Basic mechanism of HVDC system control, Power reversal, Power control, Constant ignition angle, constant current, constant extinction angle control, High level controllers. Converter mal-operations - misfire, arc through, commutation failure, Frequency Control of A.C. system, Stabilisation & damping of A.C. networks.

(8L)

Module IV

FACTS Concept: Fundamentals of A.C. power transmission, Introduction to FACTS: Need for FACTS in emerging power systems, Definitions, Types of FACTS, Co-ordination of FACTS with HVDC, Static VAr Compensator (SVC) – Functional description and structures

, Control components and Models , Concepts of voltage control, Controls and Applications, MATLAB Implementation.

(8L)

Module V

Static Shunt and Series Compensation – Principles of shunt compensation : Variable Impedance type & switching converter type , Static synchronous compensator (STATCOM) configuration, Characteristics, Principles of static series compensation using GCSC, TCSC and TSSC – applications, Static Synchronous Series Compensator (SSSC). (8L)

Books recommended:

TEXT BOOK

6. Padiyar, K.R., 'HVDC transmission systems', Wiley Eastern Ltd., 2010.
7. Kimbark, E.W., 'Direct Current Transmission-vol.1', Wiley Inter science, New York, 1971.
8. Hingorani,L.Gyugyi, 'Concepts and Technology of Flexible AC Transmission System', IEEE Press New York, 2000 ISBN –078033 4588.
9. Padiyar K.R., 'FACTS controllers for Transmission and Distribution systems' New Age International Publishers, 1st Edition, 2007.

REFERENCE BOOK

1. Song, Y.H. and Allan T. Johns, 'Flexible AC Transmission Systems (FACTS)', Institution of Electrical Engineers Press, London, 1999.
2. Vijay K. Sood, 'HVDC and FACTS Controllers', Kluwer Academic Publishers, New York, 2004.
3. Arrilaga, J., 'High Voltage Direct Current Transmission', 2nd Edition, Institution of Engineering and Technology, London, 1998.
4. Enrique Acha, Claudio R.Fuerte-Esqivel, Hugo Ambriz-Perez, Cesar Angeles-Camacho 'FACTS –Modeling and simulation in Power Networks' John Wiley & Sons, 2002.
5. Mohan Mathur R. and Rajiv K.Varma , 'Thyristor - based FACTS controllers for Electrical transmission systems', IEEE press, Wiley Inter science , 2002.
6. Kamakshaiah, S and Kamaraju, V, 'HVDC Transmission', 1st Edition, Tata McGraw Hill Education (India), Newdelhi 2011.

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements):

Design of real-time industrial projects.
POs met through Gaps in the Syllabus:**PO5 & PO6**

Topics beyond syllabus/Advanced topics/Design:

POs met through Topics beyond syllabus/Advanced topics/Design: **PO5 & PO6**

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment

Assessment Tools	**% Contribution during CO Assessment**
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	**% Distribution**
3 quizzes	30 (3×10)
Assignment(s)	10
Seminar before a committee	10

Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	2	3	-	1
CO2	3	3	2	2	1	1
CO3	3	3	2	2	1	1
CO4	3	3	2	2	1	1
CO5	3	3	2	2	1	1

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	**Course Delivery Method**
CO1	CD1,CD6
CO2	CD1, CD6,CD7
CO3	CD1, CD2, CD3,CD6,CD7

CO4	CD1, CD3,CD6,CD7
CO5	CD1,CD2,CD3,CD4,CD5,CD7

COURSE INFORMATION SHEET

Course code: EE537
Course title: Substation Design and Automation
Pre-requisite(s):
Co- requisite(s):
Credits: 3 L T P
3 0 0
Class schedule per week: 3
Class: M.Tech.
Semester / Level: I/05
Branch: EEE
Name of Teacher:

Course Objectives
This course enables the students to:

1.	understand the overall idea of Sub-station design and automation;
2.	outline the development of Sub-Station and work on its protection issues;
3.	understand the importance and effectiveness of grounding system;
4.	outline the testing and maintenance mechanism of various sub-stations.

Course Outcomes
After the completion of this course, students will be able to:

CO1	outline the significance of Sub-station design and automation;
CO2	apply the basic knowledge of sub-station development in practical scenario;
CO3	develop the protection aspects in various sub-stations;
CO4	outline the significance of grounding system in various sub-stations;
CO5	assess different types of testing and maintenance in sub-stations.

SYLLABUS
EE537 Substation Design and Automation

Module I

Introduction to Sub-Station Design: Principle of Sub-station design, Types of Sub-station, Bus bar systems and layout, Selection of Sub-station site, Benefits of Substation Automation system, Substation Automation with IEC 61850 Standard.
(8L)

Module II

Sub-Station Design Development: Design of Sub-station grounding system, Design of Bus bars, Insulators, Sub-station equipment, Insulation Coordination and surge Arresters, Power Cables, Auxiliary supplies and battery systems. (8L)

Module III

Automation and Protection in Sub-station: Protection schemes, Electromagnetic pulse (EMP) protection in sub-station, Control and automation in Sub-station, Power line carrier Communication and Tele-control of Sub-stations.

(8L)

Module IV

Earthing Design and Calculation of Sub-station: Factors influencing the choice of earthed and unearthed systems, system earthing & equipment earthing connections to earth, selection of an earthing conductor and connection of an electrode, voltage gradient around earth electrodes, connections to earth electrodes — earthing and protective Conductors, Earthing Arrangement for Protective Purposes, Earthing Arrangement for Functional Purposes, Equipotential Bonding Conductors, Typical Schematic of Earthing And Protective Conductors, Earthing In Power Stations and Substations, Earthing Associated with Overhead Power Lines, Calculation of Earth Fault Currents, Measurement of Earth Resistivity, Measurement of Earth Electrode Resistance, Measurement of Earth Loop Impedance.

(8L)

Module V

SF6 Gas Insulated Sub-station: SF6 Gas Insulated Sub-station (GIS) and Gas insulated cables, Reactive power management, Testing and maintenance of Sub-station equipment.

(8L)

Text Books:

1. Substation Structure Design Guide by Leon Kempner Jr., American Society of Civil Engineers, Technology & Engineering.
2. Electric Power Substations Engineering by John D. McDonald, CRC Press.

Reference Books:

3. Electrical Transmission and Substation Structures by Marlon W. Vogt, American Society of Civil Engineers, Technology & Engineering.

Course Evaluation:
Individual assignment, Theory (Quiz and End semester) examinations

<u>Gaps in the syllabus (to meet Industry/Profession requirements)</u>:
Design of real-time industrial projects.
POs met through Gaps in the Syllabus:

<u>Topics beyond syllabus/Advanced topics/Design:</u>

POs met through Topics beyond syllabus/Advanced topics/Design:

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

<u>Direct Assessment</u>

Assessment Tools	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 quizzes	30 (3×10)
Assignment(s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	3	-	1
CO2	3	3	2	2	1	1
CO3	3	3	2	2	1	1
CO4	3	3	2	2	1	1
CO5	3	3	2	2	1	1

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD6
CO2	CD1, CD6,CD7
CO3	CD1, CD2, CD3,CD6,CD7
CO4	CD1, CD3,CD6,CD7
CO5	CD1,CD2,CD3,CD4,CD5,CD7

COURSE INFORMATION SHEET

Course code: EE 539
Course title: Power System Dynamics
Pre-requisite(s): Knowledge of basic power system and control system courses.
Co- requisite(s):
Credits: 3 L T P
3 0 0

Class schedule per week: 3 Classes per week
Class: M. Tech.
Semester / Level: I/05
Branch: EE
Name of Teacher:

Course Objectives
This course enables the students to:

1.	know the basic classification of power system stability;
2.	understand the concept of dynamic model of synchronous machine excitation system;
3.	investigate the concept of excitation system and load modelling;
4.	examine the concept of small signal stability and transient stability.

Course Outcomes

At the end of the course, a student should be able to:

CO1	differentiate between different states and stability;
CO2	describe the dynamic model of single and multi-synchronous machine system;
CO3	describe the modelling of excitation system of a synchronous machine;
CO4	explain the static and dynamic load modelling;
CO5	examine the small signal stability of single and multi-machine system and evaluate the transient stability of an electrical system.

SYLLABUS

EE539Power System Dynamics

Module I

Introduction to Power System Stability problem: Stability classification - Small signal & Transient stability, Rotor angle & Voltage stability, Hierachy of controls in a Power System.

(8L)

Module II

Synchronous Machine Modelling: Basic equations, dqo transformation, equations of motion.

(8L)

Module III

Excitation System: Requirements of excitation system, Elements of excitation system, Types of excitation system, Modelling of excitation system.

(8L)

Module IV

Power System Loads: Static load models, Dynamic load models.

(8L)

Module V

Small Signal (Steady State) Stability: Linearization, State matrix, modal analysis technique. Transient Stability Studies: Network performance equations, Methods of enhancement of transient stability, MATLAB Implementation.

(8L)

Text Books:

1.Power System Stability and Control, P. Kundur.

Reference Books:

2. Electric Energy System Theory – O.I. Elgerd
3. Power System Dynamics – K.R.Padiyar

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements):

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:

POs met through Topics beyond syllabus/Advanced topics/Design:

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment

Assessment Tools	**% Contribution during CO Assessment**
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	**% Distribution**
3 quizzes	30 (3×10)
Assignment(s)	10
Seminar before a committee	10

Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO 5**	**PO6**
CO1	3	3	2	3	-	1
CO2	3	3	2	2	1	1
CO3	3	3	2	2	1	1
CO4	3	3	2	2	1	1
CO5	3	3	2	2	1	1

< 34% = 1, 34-66% = 2, > 66% = 3

Mapping Between Course Outcomes and Course Delivery Method

Course Outcomes	**Course Delivery Method**
CO1	CD1,CD6
CO2	CD1, CD6,CD7
CO3	CD1, CD2, CD3,CD6,CD7

CO4	CD1, CD3,CD6,CD7
CO5	CD1,CD2,CD3,CD4,CD5,CD7

COURSE INFORMATION SHEET
(Open Electives)

Course code: EE585
Course title: Hybrid Electric Vehicles
Pre-requisite(s): Electrical Machines, Power Electronics and Electrical Drives
Co- requisite(s): Induction Motor, BLDC Motor, Battery, Power Converters
Credits: 3 L T P
3 0 0
Class schedule per week: 03
Class: M. Tech
Semester / Level: I/05
Branch: EEE
Name of Teacher:

Course Objectives
This course enables the students to:

1.	understand basic working principle of power converter controlled traction drive;
2.	apply power converters in order to provide proper power modulation;
3.	analyze transient performance of power converters for meeting traction load requirement;
4.	evaluate cost of design of HEV;
5.	design a suitable power converter for HEV.

Course Outcomes
At the end of the course, a student should be able to:

CO1	describe fundamental working principle of power converter controlled traction drive;
CO2	apply power converters in conjunction with IC engine for obtaining dynamic requirement of traction drive;
CO3	analyze mutual effect of power converter and IC engine for obtaining optimal performance of HEV;
CO4	evaluate cost effectiveness and optimize performance parameters;
CO5	design an HEV for a particular application with help of interdisciplinary team work.

SYLLABUS
EE585 Hybrid Electric Vehicles

Module I

Introduction: Hybrid and Electric Vehicles (HEV): History Overview and Modern Applications, Ground vehicles with mechanical powertrain and reasons for HEV development, HEV configurations and ground vehicle applications, Advantages and challenges in HEV design

(8L)

Module II

Power Flow and Power Management Strategies in HEV: Mechanical power: generation, storage and transmission to the wheels, Vehicle motion and the dynamic equations for the vehicle., Vehicle power plant and transmission characteristics and vehicle performance including braking performance., Fuel economy characteristics of internal combustion engine, Basic architecture of hybrid drive train and analysis series drive train., Analysis of parallel, series parallel and complex drive trains and power flow in each case., Drive cycle implications and fuel efficiency estimations.

(8L)

Module III

Hybrid Electric Vehicle: Concept of Hybrid Electric Drive Trains, Architectures of Hybrid Electric Drive Trains, Series Hybrid Electric Drive Trains, Parallel Hybrid Electric Drive Trains, Torque-Coupling Parallel Hybrid Electric Drive Trains, Speed-Coupling Parallel Hybrid Electric Drive Trains, Torque-Coupling and Speed-Coupling Parallel Hybrid Electric Drive Trains. (8L)

Module IV

Electric Vehicles: Traction Motor Characteristics, Tractive Effort and Transmission Requirement, Vehicle Performance, Tractive Effort in Normal Driving, Energy Consumption. (8L)

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Module V

Design of Hybrid Electric Vehicles: Design of Series Hybrid Electric Vehicle, Design of Parallel Hybrid Electric Vehicle, Design of Electric Vehicle, Impact on Environment.

(8L)

Books recommended:

Text Book

1. Modern Electric, Hybrid Electric and Fuel Cell Vehicles. Mehrdad Ehsani, CRC Press
2. Modern Electric Vehicle Technology, C.C. Chan and K.T. Chau, Oxford University Press

Reference Book

1. R.Krishnan, 'Electric motor drives' , Prentice hall of India,2002
2. T.J.E. Miller, 'Brushless magnet and Reluctance motor drives',

<u>Gaps in the syllabus (to meet Industry/Profession requirements):</u>

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design
Assignments: Regenerative Braking, Self Driven HEV

POs met through Topics beyond syllabus/Advanced topics/Design: PO5

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment

Assessment Tools	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 quizzes	30 (3×10)
Assignment(s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Tutorials/Assignments
CD3	Seminars
CD4	Mini projects/Projects
CD5	Laboratory experiments/teaching aids
CD6	Industrial/guest lectures
CD7	Industrial visits/in-plant training
CD8	Self- learning such as use of NPTEL materials and internets
CD9	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO 5	PO6
CO1	3	3	2	2	2	1
CO2	3	3	3	2	2	1
CO3	3	3	3	3	2	2
CO4	3	3	3	3	3	2
CO5	3	3	3	3	2	3

< 34% = L, 34-66% = M, > 66% = H

<u>Mapping Between Course Outcomes and Course Delivery Method</u>

Course Outcomes	Course Delivery Method
CO1	CD1,CD6
CO2	CD1, CD6,CD7
CO3	CD1, CD2, CD3,CD6,CD7
CO4	CD1, CD3,CD6,CD7
CO5	CD1,CD2,CD3,CD4,CD5,CD7

COURSE INFORMATION SHEET

Course code: EE587
Course title: Electromechanical Energy Conversion
Pre-requisite(s):
Credits: 3 L T P
3 0 0
Class schedule per week: 03
Class: M.Tech.
Semester / Level: I/05
Branch: Electrical Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1.	to explore the basic principles of transformer, dc and ac machines and analyze comprehensively their steady –state behaviors;
2.	to examine characteristic of static and dynamic dc and ac machines;
3.	a technique to draw armature winding of dc machine;
4.	magnetic circuit of transformer in order to evaluate their performance;
5.	to design and recommend low cost and high-performance machines which finds applications in modern industries, homes and offices.

Course Outcomes:
At the end of the course, a student should be able to:

CO1	state and explain working principle, constructions as well as steady- state behaviour of an ac static and dc machines;
CO2	interpret the different transformer and dc machines;
CO3	identify, formulate and solve problems related to power transformer and dc machines;
CO4	specify, interpret data, design an electrical machine and make a judgment about the best design in all respect;
CO5	students able to test, validate and design electrical machine.

SYLLABUS

EE587 Electromechanical Energy Conversion

Module I

Basic Concepts of Electromechanical Energy Conversion: Electromagnetic induction, Classification and description of electrical machines, Rotor, Stator and field excitation. Generator and motor action, EMF and torque equations, Classification and description of electrical machines, Leakage flux, Losses and efficiency, Rating, Electrical and mechanical degrees.

(8L)

Module II

Transformers: Construction**,** Principle of operation, Ideal and physical transformer, emf equation, transformation ratio, Phasor diagram. Equivalent circuit, Losses and efficiency, Autotransformer, 3-phase transformer, Three-phase transformer connections.

(8L)

Module III

Introduction to D.C. Machines: Principle of operation, Armature winding- Lap and wave, Simplex and duplex, Method of excitation, emf and torque equations, commutation.

DC Generators: Magnetization characteristics, Critical resistance and critical speed, Process of building up of voltage.

D.C. Motors: Basic equation for voltage, Power, Torque and speed, Operating characteristics- Torque-current, and Speed-current and Torque-speed characteristics. Starters, Speed control methods.

(8L)

Module IV

Synchronous Machines: Principle of operation, Excitation system, Effect of winding factor on EMF, Circuit model, Phasor diagram, O.C. and S.C. tests, Short-circuit ratio, Determination of voltage regulation by synchronous impedance, MMF and zero power factor methods. Two reaction theory, Power-angle characteristic of synchronous generators, synchronizing power and torque, Synchronizing methods.

(8L)

Module V

3-phase Induction Motor: Principle of operation, Slip and rotor frequency, Comparison with transformer, Equivalent circuit model, Torque and power output, Losses and efficiency, Torque-slip characteristics, Effect of rotor resistance, starting torque and maximum torque, Starting and speed control methods.

1-phase Induction Motor: Introduction, Double revolving field theory, Equivalent circuit model Capacitor Motor, Torque-speed characteristic.

(8L)

Books recommended:

Text Book

1. I. J. Nagrath, D.P. Kothari, Electric Machines, 4th Edition, TMH, New Delhi, 2014.
2. P. S. Bimbhra, Electrical Machines, Khanna Publishers, New Delhi, 7th Edition 2014.

Reference Books:

1. A.E. Fitzgerald, Charles Kinsley, Stephen D. Umansd; Electric Machinery, McGraw Hill Education (India) Pvt. Ltd, Noida, Indian 6th Edition 2003.
2. E.H. Langsdorf; Theory of Alternating Current Machinery, McGraw-Hill,New York 1955.
3. M.G. Say, "Alternating Current Machines", Pitman Publishing Ltd. 1976.

Course Evaluation:
Individual assignment, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements):

1. Cost Evaluation of Electrical drive in electrical machines based on reliability.
2. Application of artificial intelligence in Electrical Machines.
3. Study of impact of Electrical Machine on society and environment

POs met through Gaps in the Syllabus: PO6

Topics beyond syllabus/Advanced topics/Design:

1. Reliability analysis in Electrical Machine topologies
2. Application of adaptive algorithms in Electrical Machine based systems.

POs met through Topics beyond syllabus/Advanced topics/Design: PO6

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment

Assessment Tools	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 quizzes	30 (3×10)
Assignment(s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	2	2	1
CO2	3	3	3	3	2	2
CO3	3	3	3	3	3	2
CO4	3	3	3	3	3	3
CO5	3	3	3	3	3	3

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD6
CO2	CD1, CD6,CD7
CO3	CD1, CD2, CD3,CD6,CD7
CO4	CD1, CD3,CD6,CD7
CO5	CD1,CD2,CD3,CD4,CD5,CD7

COURSE INFORMATION SHEET

Course code: EE589
Course title: Power Semiconductor Devices
Pre-requisite(s): Basic Electronics

Credits: 3	L	T	P
	3	0	0

Class schedule per week: 03
Class: B.Tech.
Semester / Level: I/05
Branch: Electrical Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1.	identify different type of modern semiconductor based switching devices and their operating characteristics;
2.	explain working principle of semiconductor devices such as Thyristors and PMOSFET;
3.	analyze protection circuit and firing circuit;
4.	evaluate performance parameters of a semiconductor device;
5.	plan and Design complex power electronics based systems.

Course Outcomes:
At the end of the course, a student should be able to:

CO1	list different types of semiconductor devices and remember their operating characteristics. Explain working principle of different semiconductor devices;
CO2	classify different types of power converters. Show suitability of a power converter for a particular application. Solve power management related problems with application of power electronics based topologies;
CO3	outline shortcomings of each class of power devices and solve them using proper circuits such as firing circuit and protection circuit;
CO4	estimate the cost and long term impact of power electronics technology on a large scale project of socio-economic importance;
CO5	modify existing power electronics based installations. Design new power converter topologies and Plan to develop a power processing unit for a particular requirement in industrial plants as well as domestic applications. Lead or support a team of skilled professionals.

SYLLABUS

EE589 Power Semiconductor Devices

Module I

Introduction: Power switching devices overview – Attributes of an ideal switch, application requirements, circuit symbols; Power handling capability – (SOA); Device selection strategy

– On-state and switching losses – EMI due to switching – Power diodes – Types, forward and reverse characteristics, switching characteristics – rating.

(8L)

Module II

Current Controlled Devices: BJT's – Construction, static characteristics, switching characteristics; Negative temperature coefficient and second breakdown; – Thyristors – Physical and electrical principle underlying operating mode, Two transistor analogy – concept of latching; Gate and switching characteristics; converter grade and inverter grade and other types; series and parallel operation; comparison of BJT and Thyristor – steady state and dynamic models of BJT &Thyristor- Basics of GTO, MCT, FCT, RCT.

(8L)

Module III

Voltage Controlled Devices: Power MOSFETs and IGBTs – Principle of voltage-controlled devices, construction, types, static and switching characteristics, steady state and dynamic models of MOSFET and IGBTs – and IGCT. New semiconductor materials for devices – Intelligent power modules- Integrated gate commutated thyristor (IGCT) – Comparison of all power devices.

(8L)

Module IV

Firing and Protection Circuits: Necessity of isolation, pulse transformer, optocoupler – Gate drives circuit: SCR, MOSFET, IGBTs and base driving for power BJT. – Over voltage, over current and gate protections; Design of snubbers.

(8L)

Module V

Thermal Protection: Heat transfer – conduction, convection and radiation; Cooling – liquid cooling, vapour – phase cooling; Guidance for hear sink selection – Thermal resistance and impedance -Electrical analogy of thermal components, heat sink types and design – Mounting types- switching loss calculation for power device.

(8L)

Books Recommended:

Text Books:

1. M.H. Rashid,"Power Electronics: Circuits, Device and Applications",2nd Edn, PHI, New Jersey, 1993.
2. Mohan, Underland, Robbins; Power Electronics Converters, Applications and Design, 3rd Edn., 2003, John Wiley & Sons Pte. Ltd.
3. M. D. Singh, K. B. Khanchandani, "Power Electronics", 2nd Edn., Tata McGraw-Hill, 2007.

Reference Books:

1. R. Krishnan, "Electric Motor Drives: Modeling, Analysis and Control", 1st Edn., Prentice Hall,2001.
2. B. K. Bose, "Modern Power Electronics & AC Drives" , 1st Edn., Prentice Hall, 2001
3. L. Umanand, "Power Electronics: Essentials & Applications", 1st Edn. Wiley India Private Limited, 2009.
4. Jeremy Rifkin, "Third Industrial Revolution: How Lateral Power Is Transforming Energy, the Economy, and the World", 1st Edn., St. Martin's, Press, 2011.

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :

1. Cost Evaluation of Power Electronics based installation based on reliability
2. Study of impact of power electronics on society and environment

POs met through Gaps in the Syllabus: PO6

Topics beyond syllabus/Advanced topics/Design:

1. Reliability analysis in power electronics topologies
2. Application of power electronics in the field of Renewable Energy.

POs met through Topics beyond syllabus/Advanced topics/Design: PO6

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment

Assessment Tools	**% Contribution during CO Assessment**
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	**% Distribution**
3 quizzes	30 (3×10)
Assignment(s)	10
Seminar before a committee	10

Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars

CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	2	2	1
CO2	3	3	2	2	1	1
CO3	3	3	3	2	1	1
CO4	3	3	3	3	2	1
CO5	3	3	3	3	3	2

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD6
CO2	CD1, CD6,CD7
CO3	CD1, CD2, CD3,CD6,CD7
CO4	CD1, CD3,CD6,CD7
CO5	CD1,CD2,CD3,CD4,CD5,CD7

COURSE INFORMATION SHEET

Course code: EE595
Course title: Smart Grid
Pre-requisite(s): Power system courses, power electronics

Co- requisite(s): Credits: 3 L T P
3 0 0
Class schedule per week: 03
Class: M. Tech
Semester / Level: I/05
Branch: EEE
Name of Teacher:

Course Objectives:
The course objectives are:

1.	introduction to grid operation, necessity of making grid more smart, and basic components of today's grid;
2.	to extend knowledge on different design challenges with grid interfacing systems for Renewable Energy Sources;
3.	to illustrate the basics of the working principle of PMU and its application;
4.	to educate the students about communication protocol and its application in smart grid;
5.	to make the students understood about different demand response programmes.

Course Outcomes:
After the completion of this course, students will be able to:

CO1	demonstrate steps about building blocks of the smart grid;
CO2	organise the steps involved in working principles of PMU and WAMS through PMUs;
CO3	analysis the challenges involved with grid interactive converters connected with RES;
CO4	understand the design concept involved with demand response Programmes, communication standards, cyber security etc;
CO5	aspire and confident for taking up challenge to adopt new technology needed for monitoring, control and operation of power system.

SYLLABUS

EE595 Smart Grid

Module I

Introduction: Basics about Power Grid operation, Concept of Smart Grid, necessity for pushing smart grid concept, operation and control architecture, Basic components.

(8L)

Module II

Smart Grid and Generation: Renewable energy generation, Solar, Wind, Hydroelectric, Biomass, fuel cell, challenges with RE generation, uncertainty and risk estimation, concept of Converter design for grid tied RE sources.

(8L)

Module III

Smart Grid and transmission system: Introduction, Wide area monitoring system, Phasor measurement units (PMUs) smart meters, multi-agent system technology, phasor measurement techniques: introduction, phasor estimation of nominal frequency signals, phasor updation using non-recursive and recursive updates, phasor estimation at off-nominal frequency input, hierarchy of phasor measurement systems, communication options for PMUs, functional requirements of PMUs and phasor data concentrators (PDCs).

(8L)

Module IV

Smart Grid and Communication system: Introduction, communication requirement, list of the standards, architecture of the communication system, wired and wireless communication, security and safety.

(8L)

Module V

Smart Grid and Demand Response: Introduction, demand response, Types of demand Response Programmes, Aggregator concept, Advanced metering infrastructure, Smart home and building automation standards. Basic concept of Big data analysis.

(8L)

Books recommended:

Text Book:

1.Smart Grid Standards : Specifications, Requirements, and Technologies by by Takuro Sato, Daniel M. Kammen, , Bin Duan, , Martin Macuha, , Zhenyu Zhou, , Jun Wu, , Muhammad Tariq, , and Solomon A. Asfaw **PUBLISHER** John Wiley & Sons, Incorporated.

2.A.G. Phadke J.S. Thorp, “Synchronized Phasor Measurements and their Applications”, springer 2008.

3.James Momoh**, “**SMART GRID: Fundamentals of Design and Analysis”, IEEE (Power engineering series) – Wiley- Blackwell, April 2012.

4.Janaka Ekanayake, KithsiriLiyanage, JianzhongWu, Akihiko Yokoyama, Nick Jenkins “Smart Grid Technology and Applications”, Wiley, New- Delhi, August 2015.

Course Evaluation:

Individual assignments, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements):

1. Design of real-time industrial projects.
2. POs met through Gaps in the Syllabus:**PO5 & PO6**

Topics beyond syllabus/Advanced topics/Design:

POs met through Topics beyond syllabus/Advanced topics/Design: **PO5 & PO6**

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment

Assessment Tools	**% Contribution during CO Assessment**
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	**% Distribution**
3 quizzes	30 (3×10)
Assignment(s)	10
Seminar before a committee	10

Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Tutorials/Assignments
CD3	Seminars
CD4	Mini projects/Projects
CD5	Laboratory experiments/teaching aids
CD6	Industrial/guest lectures
CD7	Industrial visits/in-plant training
CD8	Self- learning such as use of NPTEL materials and internets
CD9	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	1	3	3	2	2
CO2	3	3	3	2	1	2
CO3	2	3	2	3	2	3
CO4	3	2	3	3	3	3
CO5	3	2	3	2	2	1

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD6
CO2	CD1, CD6,CD7
CO3	CD1, CD2, CD3,CD6,CD7
CO4	CD1, CD3,CD6,CD7
CO5	CD1,CD2,CD3,CD4,CD5,CD7

COURSE INFORMATION SHEET

Course code: EE 597
Course title: Reliability Engineering
Pre-requisite(s): Engineering Mathematics, Probability Theory
Co- requisite(s):

Credits: 3	**L**	**T**	**P**
	3	**0**	**0**

Class schedule per week: 3
Class: M.Tech.
Semester / Level: I/05
Branch:
Name of Teacher:

Course Objectives

This course enables the students to:

1.	define probability theory and relate the concept of reliability of systems;
2.	understand general reliability mathematics applicable to all systems;
3.	understand Markov chains, and application of Markov models in reliability analysis of systems;
4.	evaluate reliability of systems using Markov models and available reliability parameters of systems;
5.	use frequency and duration technique for various reliability analysis problems.

Course Outcomes

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

1.	understand the general reliability concept and mathematics;
2.	identify events or causes responsible for unreliability of systems through failures;
3.	evaluate the associated system risk and thus finding solutions for minimizing the risks to an acceptable level;
4.	apply engineering knowledge and design techniques to prevent or to reduce the likelihood or frequency of failures for different systems;
5.	apply methods for estimating the reliability of new designs, and for analyzing reliability data.

SYLLABUS

EE597 Reliability Engineering

Module I

Introduction: Types of systems, Qualitative and quantitative assessment, Reliability definitions and concepts, Reliability indices and criteria, Reliability evaluation techniques, Reliability improvements, Reliability economics, Reliability monitoring and growth, Basic probability theory**,** Probability concepts, Permutations and combinations, Application in probability evaluation, Practical engineering concepts, Venn diagrams, Rules for combining probabilities, Probability distributions.

(8L)

Reliability Mathematics: The general reliability function, The exponential distribution, Mean time to failure and repair, series and parallel systems, Markov processes, System reliability using network and state space method.

(8L)

Module III

Network Modeling and Evaluation of Simple and Complex Systems: Service quality criterion, Conditional probability approach, Two-plant single load and two load systems. The probability array for two interconnected systems, Loss of load approach, Interconnection benefits.

(8L)

Module IV

Discrete Markov Chains and Continuous Markov Processes: Introduction toDiscrete Markov chain, Stochastic transitional probability matrix by Discrete Markov chain, Time dependent probability evaluation by Discrete Markov chain, Limiting state probability evaluation, Absorbing states, Application of discrete Markov techniques, Introduction to Continuous Markov process, General modeling concepts, State space diagrams, Stochastic transitional probability matrix by Continuous Markov process , Evaluating limiting state probabilities by Continuous Markov process, Reliability evaluation in repairable systems, Application of techniques to complex systems.

(8L)

Module V

Frequency and Duration Techniques: Frequency and duration concepts, Application to multi-state problems: Two component repairable system, State probabilities, Frequency of encountering individual states, Mean duration of individual states, Cycle time between individual states , Frequency of encountering cumulated states, Recursive evaluation of cumulative frequency, Mean duration of cumulated states, Frequency balance approach, Two stage repair and installation process :One component system-no spare available, one spare available, two spares available, one spare available, Limiting number of spares, Application of the techniques.

(8L)

Text Books:

1. Roy Billinton, Ronald N. Allan, “Reliability Evaluation of Engineering Systems Concepts and Techniques”, 2nd Edition, Springer Science + Business Media New York 1992.

2. Hoang Pham, “Handbook of Reliability Engineering”, Springer 2003.

3. Alessandro Birolini, “Reliability Engineering: Theory and Practice”, Springer 1999.

Reference Books:

1. Donald W. Benbow, “The Certified Reliability Engineer Handbook”, 2009.

Course Evaluation:
Individual assignment, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements):
POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:
POs met through Topics beyond syllabus/Advanced topics/Design:

Direct Assessment

Assessment Tools	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 quizzes	30 (3×10)
Assignment(s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes And Program Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	3	-	1
CO2	3	3	2	2	1	1
CO3	3	3	2	2	1	1
CO4	3	3	2	2	1	1
CO5	3	3	2	2	1	1

< 34% = 1, 34-66% = 2, > 66% = 3

Mapping Between Course Outcomes And Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1,CD6
CO2	CD1, CD6,CD7
CO3	CD1, CD2, CD3,CD6,CD7
CO4	CD1, CD3,CD6,CD7
CO5	CD1,CD2,CD3,CD4,CD5,CD7

COURSE INFORMATION SHEET
(Programme Core)

Course code: EE502
Course title: Advanced Digital Signal Processing Laboratory
Pre-requisite(s): Basics of signals and systems, transform methods, Filter theory.
Credits: 2

L	T	P
0	0	4

Class schedule per week: 4
Class: M.Tech.
Semester / Level: I/05
Branch: Electrical Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1.	enumerate the basic concepts of signals and systems and their interconnections in a simple and easy-to-understand manner through different mathematical operations like folding, shifting, scaling, convolutions, etc. using MATLAB; also gain Knowledge of TMS kit, digital image filter;
2.	construct different realization structures;
3.	determine transfer function and predict frequency response of discrete-time systems by applying various techniques like Z-transform, DFT and FFT using MATLAB;
4.	evaluate cost of filters in terms of memory space complexity, algorithm complexity and economic values;
5.	design and compose digital IIR and FIR filters using filter approximation theory, for optimal cost.

Course Outcomes:
At the end of the course, a student should be able to:

CO1	convert analog signal into digital signals and vice-versa, generation of different signals and basic knowledge of TMS kit;
CO2	compute frequency response of the systems using frequency transformation technique, DFT, DIF-FFT or DIT-FFT algorithm, window techniques and visualization using MATLAB;
CO3	design FIR and IIR filters;
CO4	evaluate performance of filter with time variant signals;
CO5	recommend environment-friendly filter for different real- time applications such as optical filter design, acoustic filter design etc.

LIST OF EXPERIMENTS
EE502 Advanced Digital Signal Processing Laboratory

1. **Name: Introduction to MATLAB.**
   Aim: An introduction to MATLAB.

2. **Name: Generation and representation of different types of signal.**
   Aim: To perform generation of different signals in MATLAB.

3. **Name: The Z-Transform and Inverse Z-Transform.**
   Aim: To write a program to find z-transform of given signal.

4. **Name: The Cross-correlation, Auto-correlation between two sequences. Also, Circular convolution between two periodic sequence.**
   Aim: To perform cross-correlation, auto-correlation and circular convolution of two sequence.

5. **Name:- Discrete Fourier transform and Inverse- Discrete Fourier transform**
   Aim: To write an MATLAB program to find discrete Fourier transform and Inverse-discrete Fourier transform.

6. **Name: DFT by DIT-FFT and DIF-FFT method.**
   Aim: To perform DFT by DIT-FFT and DIF-FFT methods in MATLAB.

7. **Name: The low pass, high-pass, band-pass and band-stop filter using Butterworth approximation.**
   Aim: To write a MATLAB program for low pass, high pass and band pass filter using Butterworth approximation.

8. **Name: Familiarization with TMS-320C6713 DSP starter Kit.**
   Aim: To perform a descriptive and practical study for hardware of TMS- 320C6713 DSP starter Kit.

9. **Name: Correlation of two discrete time signal**
   Aim: To write a MATLAB program to perform correlation of two discrete time signal.

10. **Name: Linear convolution of two sequence using circular matrix method.**
    Aim: To write a MATLAB program to perform Linear convolution of two sequence using circular matrix method.

11. **Name: The Radix-2 DIT FFT algorithm.**
    Aim: To perform Radix-2 DIT FFT algorithm of 8-point sequence in MATLAB.

12. **Name: Image Processing.**
    Aim: 1.To write a program to remove Salt & paper type noise from a given image
    2. To change the colour of specific part of given image
    3. Write a program to remove Gaussian noise from given image

Books Recommended:

1. Digital signal processing and applications with C6713 and C6416 DSK by RulphChassaing, wiley publication.

2. Real-Time digital signal processing based on the TMS320C6000 by Nasser Kehtarnavaz, ELSEVIER publication

3. DSP applications using C and the TMS320c6x DSK by RulphChassaing, Wiley Publication.

Reference Books:

1. Antonious,Digital Filter Design,Mc-Graw-Hill International Editions.
2. WavelateTransform,S.Rao.
3. WavelateAnalysis:“The scalable structure of Information”Springer2008–Howard L.Resinkoff, Raymond O.Wells

Course Evaluation:
Group project evaluation, Progressive and End semester evaluations

Gaps in the syllabus (to meet Industry/Profession requirements) :

1. Visualize different signal processing techniques in real time.
2. Application of real time implementation of digital filter.

POs met through Gaps in the Syllabus:PO5 & PO6

Topics beyond syllabus/Advanced topics/Design:
Adaptive signal processing, Image processing.

POs met through Topics beyond syllabus/Advanced topics/Design: PO5 & PO6

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment

Assessment Tools	**% Contribution during CO Assessment**
Progressive Evaluation	60
End Semester Evaluation	40

Progressive Evaluation	**% Distribution**
Day to day performance & Lab files	30
Quiz (zes)	10
Viva	20
End Semester Evaluation	**% Distribution**
Examination Experiment Performance	30
Quiz	10

Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Progressive Evaluation					
End Semester Evaluation					

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	-	-	-
CO2	3	2	1	2	-	1
CO3	3	1	2	3	-	1
CO4	2	2	2	3	2	2
CO5	2	2	3	1	3	3

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD6
CO2	CD1, CD6,CD7
CO3	CD1, CD2, CD3,CD6,CD7
CO4	CD1, CD3,CD6,CD7
CO5	CD1,CD2,CD3,CD4,CD5,CD7

COURSE INFORMATION SHEET

Course code: EE506
Course title: Advanced Power Electronics Laboratory
Pre-requisite(s): Basics of signals and systems, transform methods, Filter theory.

Credits: 2	L	T	P
	0	0	4

Class schedule per week: 4 Lab session
Class: M.Tech.
Semester / Level: I/05
Branch: Electrical Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1.	identify semiconductor switches and carryout experimentation to reproduce the I-V characteristics;
2.	explain the operation of triggering circuits, commutation circuits for the semiconductor switches and different energy conversion topologies through experimentation;
3.	choose a suitable and proper switching device for a required power electronics based design;
4.	calculate the performance parameters of energy conversion topologies through experimental and analytical approach;
5.	design simple and efficient power converters under laboratory conditions. Support a team as team member or play the role of team leader to implement projects in group.

Course Outcomes:
At the end of the course, a student should be able to:

CO1	identify different types of semiconductor based switching devices available in market;
CO2	observe different characteristics of semiconductor based switching devices;
CO3	demonstrate and draw the waveforms of the circuit variables through and across the switches and load in different energy conversion topologies, though experimentation;
CO4	experiment with conventional power converters;
CO5	design assigned circuit topology for given specification and fabricate the circuitry of any of the power converter. Evaluate the performance of the power electronics circuitry available in the laboratory and the fabricated one.

LIST OF EXPERIMENTS
EE506 Advanced Power Electronics Laboratory

1. Name: Develop a mathematical model of IGBT and do an experiment in order to obtain its Transfer and Output characteristics.

Aim:
(i) To develop mathematical model.
(ii) To simulate the mathematical model.

(iii) To obtain saturation, cut off and active region of a IGBT.
(iv) To measure minimum gate voltage required for turning on IGBT

2. Name: Develop a mathematical model of Power MOSFET based step up chopper with R and RL load and perform an experiment on the chopper for drawing curve between boost factor and efficiency.

Aim :
(i) To develop mathematical model.
(ii) To simulate the mathematical model.
(iii) To find relative error between calculated and observed output load voltage of Step up Chopper with change in duty cycle.
(iv) To draw curve between boost factor and efficiency for different switching frequency

3. Name: Develop a mathematical model of impulse commutated chopper and do test on its power circuit to study method of commutation and draw corresponding waveforms.

Aim :
(i) To develop mathematical model.
(ii) To simulate the mathematical model.
(iii) To validate the condition for impulse commutation.
(iv) To draw waveform across capacitor and load voltage.
(v) To obtain relation between duty cycle and output average load voltage.

4. Name: Develop a mathematical model of resonant pulse thyristor chopper circuit and execute an experiment on the chopper to study the method of commutation and draw corresponding waveforms.

Aim :
(i) To develop mathematical model.
(ii) To simulate the mathematical model.
(iii) To validate the condition for resonant commutation.
(iv) To draw waveform across capacitor and load voltage.
(v) To obtain relation between duty cycle and output average load voltage.

5. Name: Develop mathematical equations of commutating current in different methods of commutation (Class A, B, C) and perform an experiment to observe the device voltage and load current.

Aim:
(i) To develop mathematical model.
(ii) To simulate the mathematical model.
(iii) To observe load voltage waveform under natural commutation.
(iv) To observe load voltage waveform under forced commutation.

6. Name: Study of single phase rectifier inverter module with multiple PWM.

Aim :
(i) To obtain mathematical expression of Fourier analysis of load voltage waveform
(ii) To simulate a single phase inverter for R and RL load.
(iii) To obtain relation between modulation index and output RMS voltage.
(iv) To develop algorithm for frequency control of line voltage of inverter output.

7. Name: Develop a mathematical model of single phase modified series inverter and do an experiment to find the performance of the inverter.

Aim :

(i) To develop a mathematical model.

(ii) To simulate the mathematical model.

(iii) To differentiate between basic series inverter and modified series inverter.

(iv) To obtain load voltage waveform for line frequencies below resonance and above resonance.

8. Name: Develop a simulation model on PSIM software for three phase VSI based motor speed controller

Aim :

(i) Introduction to simulation using PSIM

(ii) To calculate of RMS output voltage and THD using PSIM

(iii) To obtain speed and torque characteristics of three phase VSI controlled induction motor

9. Name: Minor Project: Mathematical modeling and simulation of a converter

Aim:

(i) Mathematical modeling of a power converter

(ii) Simulation of a power converter

10. Name: Minor Project: Hardware based project in group.

Aim :

(i) Design of a power converter based on basic knowledge of power electronics

(ii) Development of skills to function effectively as individual as well as a team member or as leader of team.

(iii) Application of interdisciplinary skills.

(iv) To think innovative ideas for possible engineering based solution for various social problems.

Text Books:

1. M.H. Rashid,"Power Electronics: Circuits, Device and Applications",2nd Ed.n, PHI, New Jersey, 1993.
2. Mohan, Underland, Robbins; Power Electronics Converters, Applications and Design, 3rd Edn., 2003, John Wiley & Sons Pte. Ltd.
3. M. D. Singh, K. B. Khanchandani, "Power Electronics", 2nd Edn., Tata McGraw-Hill, 2007.

Reference Books:

1. R. Krishnan, "Electric Motor Drives: Modeling, Analysis and Control ", 1st Edn., Prentice Hall,2001.

2. B. K. Bose, "Modern Power Electronics & AC Drives" , 1st Edn., Prentice Hall, 2001.

3. L. Umanand, “Power Electronics: Essentials & Applications”, 1st Edn. Wiley India Private Limited, 2009. 4. Jeremy Rifkin, “Third Industrial Revolution: How Lateral Power Is Transforming Energy, the Economy, and the World”, 1st Edn., St. Martin’s, Press, 2011.
4. Sabyasachi Sengupta and et. all, "NPTEL Power Electronics Notes", [Online]. Available at www.nptel.iitm.ac.in

Course Evaluation:

Group project evaluation, Progressive and End semester evaluations

Gaps in the syllabus (to meet Industry/Profession requirements) :

1. Electrical drives based design
2. Adaptive controller design for power converter.

POs met through Gaps in the Syllabus:PO6

Topics beyond syllabus/Advanced topics/Design:
Fuzzy controller based simulation of DC motor.

POs met through Topics beyond syllabus/Advanced topics/Design: PO6

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment

Assessment Tools	**% Contribution during CO Assessment**
Progressive Evaluation	60
End Semester Evaluation	40

Progressive Evaluation	**% Distribution**
Day to day performance & Lab files	30
Quiz (zes)	10
Viva	20
End Semester Evaluation	**% Distribution**
Examination Experiment Performance	30
Quiz	10

Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Progressive Evaluation					
End Semester Evaluation					

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	1	1	1
CO2	3	2	2	2	1	1
CO3	3	3	3	3	2	1
CO4	3	3	3	3	2	2
CO5	3	3	3	3	3	2

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD6
CO2	CD1, CD6,CD7
CO3	CD1, CD2, CD3,CD6,CD7
CO4	CD1, CD3,CD6,CD7
CO5	CD1,CD2,CD3,CD4,CD5,CD7

COURSE INFORMATION SHEET

Course code: EE 508
Course title: Control and Power Electronics Lab
Pre-requisite(s): B.E./B.Tech. in ECE/EEE
Co- requisite(s): Credits: 2 L T P
4 0 0
Class schedule per week: 4
Class: M.Tech.
Semester / Level: I/05
Branch: Electrical Engineering
Name of Teacher:

Course objectives:

This course enables the students to:

1.	impart basic concept of various control system components of converter and inverter operation;
2.	provide skills for application of appropriate tools in order to solve various technical problems;
3.	encourage students to undertake technical projects of multi disciplinary nature;
4.	evaluate performance parameters of closed loop converters for optimal design;
5.	provide knowledge current state of art in the field of power electronics and control system in order to motivate students to take up research activities.

Course Outcomes:

At the end of the course, a student should be able to:

CO1	explain basic operating principle of various control system components, converters and inverters;
CO2	analyze the performance parameter of various controllers, converters in the application of control of electric drives;
CO3	select appropriate tools for design and up gradation work to solve complex engineering problem;
CO4	undertake design projects involving inter disciplinary nature in the domain of control system and power electronics;
CO5	provide capability to work in a team consisting of members from different areas of expertise and pursue research in order to find new innovative solution for various social and economic problems using technical rationale.

LIST OF EXPERIMENTS

EE508 Control and Power Electronics Lab

Control System Experiments

1. To study and implementation of ON-OFF temperature controller.
2. To obtain the step response of first and second order RLC series circuit and determine the value of R and L for a given value of C through time response specification.
3. To study the characteristics of synchros, potentiometers and servomotors.
4. Determine the characteristics of LOW PASS and HIGH PASS filters by experimental sine sweep and Lissajous figures draw on CRO.
5. Controller design for stabilization of inverted pendulum.

Power Electronics Experiments

1. Perform an experiment on a single phase fully controlled SCR rectifier and find its voltage ripple.

2. Conduct an experiment on a synchronous motor in order to draw it V-Curve.
3. Do a suitable test on a given IGBT to draw its output and transfer characteristics.
4. Execute test on a resonant pulse SCR chopper in order to study its performance.
5. Execute an experiment on a two identical DC machine to find out itsover all efficiency.

Text Books:

1. M.H. Rashid,"Power Electronics: Circuits, Device and Applications",2nd Ed.n, PHI, New Jersey, 1993.
2. Mohan, Underland, Robbins; Power Electronics Converters, Applications and Design, 3rd Edn., 2003, John Wiley & Sons Pte. Ltd.
3. M. D. Singh, K. B. Khanchandani, "Power Electronics", 2ndEdn., Tata McGraw-Hill, 2007.
4. M. Gopal, "Control Systems Principles & Design", 2nd Edition, TMH. (T2)

Reference Books:

1. R. Krishnan, "Electric Motor Drives: Modeling, Analysis and Control", 1st Edn., Prentice Hall,2001.
2. B. K. Bose, "Modern Power Electronics & AC Drives" , 1st Edn., Prentice Hall, 2001.
3. L. Umanand, "Power Electronics: Essentials & Applications", 1stEdn. Wiley India Private Limited, 2009.
4. M. Gopal, "Digital Control & State Variable Method", TMH, 2015.
5. P.S. Bimbra,Modern Power Elctronics , Khanna Publications New Delho,2015

Course Evaluation:

<u>Gaps in the syllabus (to meet Industry/Profession requirements)</u>:
POs met through Gaps in the Syllabus:

<u>Topics beyond syllabus/Advanced topics/Design:</u>
POs met through Topics beyond syllabus/Advanced topics/Design:

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure
<u>Direct Assessment</u>

Assessment Tools	**% Contribution during CO Assessment**
Progressive Evaluation	60
End Semester Evaluation	40

Progressive Evaluation	**% Distribution**
Day to day performance & Lab files	30
Quiz (zes)	10
Viva	20
End Semester Evaluation	**% Distribution**
Examination Experiment Performance	30

Quiz	10

Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Progressive Evaluation					
End Semester Evaluation					

Indirect Assessment
1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	3	3
CO2	3	3	3	3	3	3
CO3	3	3	3	3	3	3
CO4	3	3	3	3	3	3
CO5	3	3	-	3	2	3

< 34% = 1, 34-66% = 2, > 66% = 3

2nd Semester

Program Core

COURSE INFORMATION SHEET

Course code: EE567
Course title: Smart Grid Technology
Pre-requisite(s): Power system courses, power electronics.
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 3
Class: M. Tech
Semester / Level: II

Branch: EEE
Name of Teacher:

Course Objectives: This course enables the students to:

1	To provide knowledge on fundamentals about renewable energy sources and challenges for grid interfacing systems.
2	To discriminate the working principle of PMU and its application.
3	To educate the students about communication protocol and its application in smart grid.
4	To make the students understood about different demand response programmes.

Course Outcomes: After the completion of this course, a student will be able to:

CO1	Interpret the fundamental elements of the smart grid.
CO2	Analysis the challenges involved with grid interactive converters connected with RES.
CO3	Demonstrate the DSP application to the function of PMUs and its application in WAMS and the function of PMUs.
CO4	Relate the importance of cyber security in smart grid.
CO5	Apply the design concept involved with demand response Programmes.

Syllabus

Module-1: Introduction
Basics about Power Grid operation, Concept of Smart Grid, necessity for pushing smart grid concept, operation and control architecture, Basic components, IEEE Standards on Distribution sources integration, Synchrophasor, Cyber Security.
[8L]

Module 2: Smart Grid and Generation
Renewable energy generation, Solar, Wind, Hydroelectric, Biomass, fuel cell, challenges with RE generation, uncertainty and risk estimation, concept of Converter design for grid tied RE sources.
[8L]

Module 3: Smart Grid and transmission system
Introduction, Wide area monitoring system, Phasor measurement units (PMUs) smart meters, multi-agent system technology, phasor measurement techniques: introduction, phasor estimation of nominal frequency signals, phasor updation using non-recursive and recursive updates, phasor estimation at off-nominal frequency input, hierarchy of phasor measurement systems, communication options for PMUs, functional requirements of PMUs and phasor data concentrators (PDCs).
[8L]

Module 4: Smart Grid and Communication system
Introduction, communication requirement, list of the standards, architecture of the communication system, wired and wireless communication, security and safety. [8L]

Module 5: Smart Grid and Demand Response: Introduction, demand response, Types of demand Response Programmes, Aggregator concept, Advanced metering infrastructure, Smart home and building automation standards. Basic concept of Big data analysis. [8L]

Text Books:

1. Smart Grid Standards : Specifications, Requirements, and Technologies by by Takuro Sato, Daniel M. Kammen, Bin Duan, Martin Macuha, Zhenyu Zhou, Jun Wu, Muhammad Tariq, and Solomon A. Asfaw publisher John Wiley & Sons, Incorporated

2. A.G. Phadke, J.S. Thorp, "Synchronized Phasor Measurements and their Applications", Springer 2008
3. James Momoh, "SMART GRID: Fundamentals of Design and Analysis", IEEE (Power engineering series) – Wiley- Blackwell, April 2012
4. Janaka Ekanayake, Kithsiri Liyanage, JianzhongWu, Akihiko Yokoyama, Nick Jenkins "Smart Grid Technology and Applications", Wiley, New- Delhi, August 2015

Course Evaluation: Individual assignment, Seminar before a committee, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements):

POs met through Gaps in the Syllabus:
Topics beyond syllabus/Advanced topics/Design:

POs met through Topics beyond syllabus/Advanced topics/Design:

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure
Direct Assessment

Assessment Tools	**% Contribution during CO Assessment**
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	**% Distribution**
3 quizzes	30 (3×10)
Assignment(s)	10
Seminar before a committee	10

Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment
1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD	**Course Delivery methods**
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Tutorials/Assignments
CD3	Seminars
CD4	Industrial visits/in-plant training
CD5	Self- learning such as use of NPTEL materials and internets
CD6	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**

CO1	2	2	2	3	3	2
CO2	3	2	3	3	2	3
CO3	3	2	3	3	3	3
CO4	2	2	1	2	2	2
CO5	3	2	3	3	3	3

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Mapping Between COs and Course Delivery (CD) methods	
Course Outcome	**Course Delivery Method**
CO1	CD1, CD2, CD3,CD5
CO2	CD1, CD2, CD3,CD5
CO3	CD1, CD2, CD3,CD5
CO4	CD1, CD2, CD3,CD5
CO5	CD1, CD2, CD3,CD5

COURSE INFORMATION SHEET

Course code: EE565
Course title: Power System Operation and Control
Pre-requisite(s): Power system, Control system.
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 3
Class: M. Tech
Semester / Level: II
Branch: EEE
Name of Teacher:

Course Objectives: This course enables the students to:

1	To analyse different states in power system and transition between the states following the dynamic changes happened in power system.
2	To evaluate the nature of frequency change in Isolated and integrated system and thereby the control strategy for Generator.
3	To investigate different methods for economic operation of the power plant by fuel saving and scheduling of thermal and hydel units.
4	To provide the introductory concept on power system deregulation and its effect on power system operation.

Course outcome: At the end of the course, a student should be able to:

CO1	To apply different operating condition and methods and technologies involved in control action according to different operating states of power system.
CO2	To design the primary and secondary controllers for automatic generation control.
CO3	To evaluate the economic generation scheduling in case of thermal units and combination of hydro-thermal units using different solution techniques.
CO4	To execute the frequency controller in multi-area system.
CO5	To identify the responsibilities of different agencies in power system operation and control in India and the charges in operation and control in deregulated environment.

Syllabus

Module - 1

Introduction - Operating States, Preventive and Emergency control, Indian Electricity Grid Code, Co-ordination between different agencies in India, Power System Restructuring: Introduction, Regulation vs. Deregulation, Competitive Market for Generation, Advantages of Deregulation, Electric supply industry structure under deregulation in India. Restructuring Models

[8L]

Module - 2

Load Frequency Control - Introduction, Types of speed governing system and modelling, Mechanical, Electro-hydraulic, Digital electro-hydraulic governing system, Turbine modelling, Generator-load modelling, Steady-state and dynamic response of ALFC loop, the secondary ALFC loop, Integral control.

[8L]

Module -3

Multi-control-Area System - Introduction, Pool operation, Two-area system, Modelling the tie line, Static and dynamic response of two area system, Tie-line bias control, State space representation of two-area system, Generation allocation, Modern implementation of AGC scheme

[8L]

Module - 4

Optimum Operating Strategies- Introduction, Generation mix, Characteristic of steam and Hydro-electric units, Optimum economic dispatch- neglecting Loss and with transmission loss, Computational steps, Derivation of loss formula, Short-term Hydro-thermal scheduling, Reactive power scheduling.
Excitation System- Introduction, elements of an excitation system, Types of excitation system

[8L]

Module - 5

Unit Commitment - Introduction, Constraints in unit commitment, Thermal unit constraints, Hydro-constraints, Unit commitment solution method - Priority list method, Dynamic programming solution, Genetic Algorithm.

[8L]

Text Books:

1. Electric Energy Systems Theory- An Introduction - Olle I. Elgerd, TMH, Edition 1983.
2. Power Generation Operation and Control - A.J. Wood, B.F. Wollenberg, John Wiley 7 Sons, 2nd Edition

Reference Books:

1. Power System Restructuring and Deregulation- Trading, Performance and Information Technology- Loi Lei Lai (Editor), Wiley
2. Power System Stability and Control - P. Kundur, TMH
3. Indian Electricity Grid Code -Central Electricity Regulatory Commission www.cercind.gov.in/2010/ORDER/February2010/IEGC_Review_Proposal.pdf
4. Power System Analysis – John J. Grainger & W.D. Stevenson, TMH, Edition 1994.

Course Evaluation: Individual assignment, Seminar before a committee, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements):

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:

POs met through Topics beyond syllabus/Advanced topics/Design:

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment

Assessment Tools	**% Contribution during CO Assessment**
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	**% Distribution**
3 quizzes	30 (3×10)
Assignment(s)	10
Seminar before a committee	10

Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD	**Course Delivery methods**
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Tutorials/Assignments
CD3	Seminars
CD4	Industrial visits/in-plant training
CD5	Self- learning such as use of NPTEL materials and internets
CD6	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	2	2	3	3	2
CO2	3	2	3	3	2	3
CO3	3	2	3	3	3	3
CO4	2	2	1	2	2	2
CO5	3	2	3	3	3	3

$< 34\% = 1$, $34\text{-}66\% = 2$, $> 66\% = 3$

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Mapping Between COs and Course Delivery (CD) methods	
Course Outcome	**Course Delivery Method**
CO1	CD1, CD2, CD3,CD5
CO2	CD1, CD2, CD3,CD5

CO3	CD1, CD2, CD3,CD5
CO4	CD1, CD2, CD3,CD5
CO5	CD1, CD2, CD3,CD5

COURSE INFORMATION SHEET

Course code: EE563
Course title: Advanced Power System Protection
Pre-requisite(s): Basic knowledge on short circuit analysis, digital system and signal processing.
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 3
Class: M. Tech
Semester / Level: II
Branch: EEE
Name of Teacher:

Course Objectives: This course enables the students to:

1	Grasp and apply the principles and algorithms of computer relaying in power system
2	Analyse, Compare and imbibe the efficacy of computer relaying for protection of power equipment with flexibility as well as adaptability
3	Design and implement wide area monitoring and protection system for enhancing situational awareness
4	Have adequate skills to integrate appropriate protection measures for power equipment and system as a whole
5	Have commensurate technological up gradation related to state-of-the-art in power system protection

Course Outcomes: At the end of the course, a student should be able to:

CO1	Comprehend the evolution of computer relaying and analyze its potent applications in a synthetic way
CO2	Apply the concepts of computer relaying for wide area monitoring and protection
CO3	Design and implement concepts of computer relaying for power equipments
CO4	Compare and contrast the unique advantages of phasor measurement unit over conventional protection
CO5	Skilfully design emerging advanced power system integrity protection schemes\

Syllabus

Module 1: Introduction
Evolution of Power System Relaying from electromagnetic to static to computer relaying; Relay operating principles for electromagnetic, static and computer relaying; Expected benefits of computer relaying, Computer relay architecture, Substation computer hierarchy [8L]

Module 2: Mathematical basis for protective relaying algorithms
Use of Fourier transforms and Discrete Fourier transform for relaying purposes, Mann-Morrison technique, Three sample algorithm, Differential Equation based Algorithms [8L]

Module 3: Computer Relaying for Protection of transformers, rotating machines and transmission lines

Introduction, Power transformer protection algorithms, Generator protection algorithms, Motor protection algorithms, Distance protection of transmission lines, 3 zone protection [8L]

Module 4: Wide area measurement based relaying using synchronized phasor measurements

Introduction to Phasor measurement units (PMUs), Phasor Estimation of Nominal Frequency Signals, Formulas for updating phasors, Frequency Estimation of Wide area measurement systems (WAMS), WAMS architecture, WAMS based adaptive protection concepts. [8L]

Module 5: System Integrity Protection Schemes (SIPS)

Architecture of SIPS, Design and Implementation of SIPS for Generator as well as transmission line protection, Performance Evaluation of SIPS, Enhancement of Situational Awareness for Smart Grids Using SIPS [8L]

TEXT BOOKS:

4. Digital Power System Protection, S. R. Bhide, PHI Publications, 2014
5. Power System Relaying, Stanley H. Horowitz, A.G. Phadke, 3rd edition, Willey Publications, 2008
6. T.S.M. Rao, "Digital Relay / Numerical relays ", Tata McGraw Hill, New Delhi, 2005
7. Bhavesh Bhalaja, R.P Maheshwari, Nilesh G.Chothani "Protection & Switchgear", Oxford Publisher, 2011

REFERENCE BOOKS:

1. Computer Relaying for Power Systems, A.G. Phadke, James S. Thorp, 2nd edition, Willey Publications, 2009
2. Y.G. Paithankar and S.R Bhide, "Fundamentals of Power System Protection", Prentice Hall of India, 2003

Course Evaluation: Individual assignment, Seminar before a committee, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements):

POs met through Gaps in the Syllabus:
Topics beyond syllabus/Advanced topics/Design:

POs met through Topics beyond syllabus/Advanced topics/Design:

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure
<u>Direct Assessment</u>

Assessment Tools	**% Contribution during CO Assessment**
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	**% Distribution**
3 quizzes	30 (3×10)
Assignment(s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD	Course Delivery methods
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Tutorials/Assignments
CD3	Seminars
CD4	Industrial visits/in-plant training
CD5	Self- learning such as use of NPTEL materials and internets
CD6	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	2	3	3	2
CO2	3	2	3	3	2	3
CO3	3	2	3	3	3	3
CO4	2	2	3	2	2	2
CO5	3	2	3	3	3	3

$< 34\% = 1$, $34\text{-}66\% = 2$, $> 66\% = 3$

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Mapping Between COs and Course Delivery (CD) methods	
Course Outcome	**Course Delivery Method**
CO1	CD1, CD2, CD3,CD5
CO2	CD1, CD2, CD3,CD5
CO3	CD1, CD2, CD3,CD5
CO4	CD1, CD2, CD3,CD5
CO5	CD1, CD2, CD3,CD5

COURSE INFORMATION SHEET
(Program Elective 2)

Course code: EE 591
Course title: Power System Deregulation
Pre-requisite(s): Knowledge of basic power system courses.

Co- requisite(s):
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 3
Class: M.E
Semester / Level: II
Branch: EE
Name of Teacher:

Course Objective: This course enables the students to:

1	Define power system restructuring and distinguish between regulation and deregulation of electric supply industry.
2	Explain and relate different power system restructuring models.
3	Identify and analyse the different electricity trading mechanism.
4	Analyse and demonstrate different types of congestion management

Course Outcomes: At the end of the course, a student should be able to

CO1	Explain the regulation and deregulation of electric supply industry.
CO2	Explain different power system restructuring models.
CO3	Explain competitive wholesale electricity markets.
CO4	Demonstrate pricing of transmission services.
CO5	Analyse inter-zonal and intra-zonal congestion management

Syllabus

Module- 1
Power System Restructuring: introduction, Regulation vs. Deregulation, Competitive Market for Generation, The Advantages of Competitive Generation, Electric Supply Industry Structure under Deregulation in India.

[8L]

Module- 2
Restructuring Models: Introduction, Monopoly, Single Purchasing Agent Model, Wholesale Competition Model, Pool Model, Bilateral, Different Independent System Operator Model.

[8L]

Module- 3
International Experiences: Introduction, North American Deregulation Process: California State, Canada, England and Wales, China.

[8L]

Module- 4
Competitive Wholesale Electricity Markets: Introduction, Bidding, Market Clearing and Pricing, Central Auction, Unit Commitment Based Auction Model, Market Power and Mitigation.

[8L]

Module- 5
Transmission Pricing: Introduction, cost components of Transmission system, pricing of transmission services, location based marginal costing. Congestion Management: Introduction, Different ways of congestion management, impact on marginal price, congestion pricing, Inter-zonal and intra zonal congestion management.

[8L]

Text Books

1. Power System Deregulation by Loi Lei Lai
2. Course material on "Operation and Management in Restructured Environment"-Edited by Dr. S.N. Singh, IIT, Kanpur

Reference Book

1. Understanding Electric Utilities and Deregulation by L. Philipson, N.L. Willis.

Course Evaluation: Individual assignment, Seminar before a committee, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements):

POs met through Gaps in the Syllabus:
Topics beyond syllabus/Advanced topics/Design:

POs met through Topics beyond syllabus/Advanced topics/Design:

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure
Direct Assessment

Assessment Tools	**% Contribution during CO Assessment**
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	**% Distribution**
3 quizzes	30 (3×10)
Assignment(s)	10
Seminar before a committee	10

Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods:

CD	**Course Delivery methods**
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Tutorials/Assignments
CD3	Seminars
CD4	Industrial visits/in-plant training
CD5	Self- learning such as use of NPTEL materials and internets
CD6	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	Program Outcomes					
	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	3	2	2	3	2	1
CO 2	3	2	3	3	2	2
CO 3	3	2	3	3	3	2
CO 4	2	2	2	2	3	1
CO 5	2	2	2	2	3	1

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Mapping Between COs and Course Delivery (CD) methods	
Course Outcome	**Course Delivery Method**
CO1	CD1, CD2, CD3,CD5
CO2	CD1, CD2, CD3,CD5
CO3	CD1, CD2, CD3,CD5
CO4	CD1, CD2, CD3,CD5
CO5	CD1, CD2, CD3,CD5

COURSE INFORMATION SHEET

Course code: EE583
Course title: Renewable Sources of Electrical Energy and Grid Integration
Pre-requisite(s): Power Electronics and Power System
Co- requisite(s):
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 03
Class: M.Tech
Semester / Level: II/05
Branch: EEE
Name of Teacher:

Course Objectives: This course enables the students to:

1	Understand about different sources of energy
2	Analyse maximum generation from SPV, and its integration with Grid
3	Develop a model about wind generation, wind generators and control.
4	Carry out design work on different other issues like battery management, reactive power, harmonic mitigation.
5	Evaluate cost and efficiency of grid integrated system.

Course Outcomes: At the end of the course, a student should be able to

CO1	Articulate the basic operation of different renewable sources and storage method of electrical

	energy
CO2	Develop the mathematical modeling of SPV with controllers and design the controllers.
CO3	Explain mathematical modeling of Wind turbine system and devise the controllers.
CO4	Carry out the designing power converters and controllers in grid interactive mode.
CO5	Apply themselves for solving different issues like reactive power, harmonic, etc.

Syllabus

Module I: Drivers of Renewable sources of electrical energy

Decarburization, Energy security, Expanding energy access ,Present status of RE generation and future projections, Wind energy, Solar energy, RE grid integration challenges, Non-controllable variability, Partial unpredictability, Locational dependency [4L]

Module II: Basics of solar PV

Solar PV systems: Fundamentals of solar cell, semiconductors as basis for solar cells materials and properties, P-N junction, sources of losses and prevention, I-V and P-V characteristics, Array design [4L]

Module III: Power converters and control for PV

Characteristics and circuit models, Topologies, principles of operation. Maximum power tracking algorithms and Buck-Boost Converter, single- and three-phase inverters for PV , PLL technique for grid interfacing, Harmonic analysis, power quality and filter design, Current injection control at unity power factor, reactive power control and smart inverters, interconnection standards such as IEEE 1547 , Steady-state and dynamic models of PV systems and implementation in simulation tools [15L]

Module IV: Wind Energy: Power converters and control for wind generators

Overview of wind turbine systems and configurations, Detailed analysis of doubly fed induction generator and PMSM based wind generators ,Dynamic modeling of wind generators, Field oriented control of rotor side and grid side power converters , Control methods for maximum power extraction, active and reactive power control [12L]

Module V: Basics of other renewable sources

Biomass Energy System: Biomass – various resources, energy contents, technological advancements, Hydro energy: Feasibility of small, mini and micro hydel plants scheme, Tidal and wave energy, Fuel Cell, Energy storage: Battery – types, equivalent circuit, performance characteristics, battery design, charging and charge regulators. Battery management, Ultra Capacitors.

[10L]

Text Books:

1. Renewable energy technologies - R. Ramesh, Narosa Publication.
2. Energy Technology – S. Rao, Parulkar 3. Non-conventional Energy Systems – Mittal, Wheelers Publication.

Reference Books:

1. Wind and solar systems by Mukund Patel, CRC Press.
2. Solar Photovoltaics for terrestrials, Tapan Bhattacharya.
3. Wind Energy Technology – Njenkins, John Wiley & Sons
4. Solar & Wind energy Technologies – McNeils, Frenkel, Desai, Wiley Eastern.
5. Solar Energy – S.P. Sukhatme, Tata McGraw Hill.
6. Solar Energy – S. Bandopadhay, Universal Publishing. 7. Guide book for National Certification Examination for EM/EA – Book 1

Course Evaluation: Individual assignment, Seminar before a committee, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements): Different Standards and technical guidelines of RES operation and integration.
POs met through Gaps in the Syllabus: Part of PO5.
Topics beyond syllabus/Advanced topics/Design: Guidelines, MATLAB simulation
POs met through Topics beyond syllabus/Advanced topics/Design: Part of PO4 and PO5.
Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

<u>Direct Assessment</u>

Assessment Tools	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 quizzes	30 (3×10)
Assignment(s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

<u>Indirect Assessment</u>
1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD	Course Delivery methods
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Tutorials/Assignments
CD3	Seminars
CD4	Industrial visits/in-plant training
CD5	Self- learning such as use of NPTEL materials and internets
CD6	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	3	2
CO2	3	3	3	3	2	2
CO3	3	3	3	2	3	2
CO4	3	3	3	2	2	3
CO5	3	3	2	2	2	3

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Mapping Between COs and Course Delivery (CD) methods

Course Outcome	Course Delivery Method
CO1	CD1, CD2, CD3,CD5
CO2	CD1, CD2, CD3,CD5
CO3	CD1, CD2, CD3,CD5
CO4	CD1, CD2, CD3,CD5
CO5	CD1, CD2, CD3,CD5

COURSE INFORMATION SHEET

Course code: EE573
Course title: Embedded System and Applications
Pre-requisite(s):
Co- requisite(s):
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 03
Class: M.Tech
Semester / Level: II
Branch: EEE
Name of Teacher:

Course Objectives: This course enables the students to:

1	Comprehend the basic functions, structure, concept and definition of embedded systems
2	Interpret ATMEGA8 microcontroller, FPGA & CPLD, TMS320C6713 processors in the development of embedded systems.
3	Correlate different serial interfacing protocols (SPI, TWI, I2C, USART).
4	Interface different peripherals (ADC, DAC, LCD, motors).
5	Evaluate design cost of any given embedded system application.

Course Outcomes: At the end of the course, a student should be able to:

CO1	Visualize the basic elements and functions of ATMEGA8 and FPGA/CPLD in building an embedded system.
CO2	Work with modern hardware/software tools (Xilinx project navigator for synthesis of VHDL codes) for building prototypes of embedded systems.
CO3	Interface various sensors, ADC, DAC, LCD, stepper motors with FPGA/CPLD and ATMEGA8.
CO4	Employ various bus protocols like SPI, TWI, I2C for interfacing peripherals.
CO5	Apply design methodologies for embedded systems, while appreciating the considerations for embedded systems design: specification, technological choice, development process, technical, economic, environmental and manufacturing constraints, reliability, security and safety, power and performance.

Syllabus

Module 1
Introduction & Basic Concepts of Computer Architecture:

Embedded Systems Overview Processor technology- General purpose processors (Software), Single purpose processors (Hardware), Application- Specific processors; IC Technology- Full-custom/VLSI, Semicustom ASIC (Gate Array and standard cell), PLD, etc. Concepts, Memory, Input/ Output, DMA, Parallel and Distributed computers, Embedded Computer Architecture, etc. [8L]

Module 2
Embedded Processors & Systems:
Atmel AVR ATMEGA 8 Micro-controller: Introduction, Major features, Architecture, Application and programming. Timers/Counters, ADC, USART, SPI, TWI, Vectored Interrupts. [8L]

Module 3
IIIFPGA:
Xilinx XC3S400 FPGA Architecture, XC9572 CPLD Architecture, VHDL Programming (VHDL Synthesis) [8L]

Module 4
DSP-Based Controllers:
Texas Instrument's TMS320C6713 DSP processor: Introduction, Major features, Architecture, Application and programming. [8L]

Module 5
Peripherals and Interfacing:
Adding Peripherals and Interfacing- Serial Peripherals and Interfacing- Serial Peripheral Interface (SPI), Inter Integrated Circuit (I2C), Adding a Real-Time Clock with I2C, Adding a Small Display with I2C; Serial Ports - UARTs, RS-232C & RS-422, Infrared Communication, USB, Networks- RS-485, Controller Area Network (CAN), Ethernet, Analog Sensors - Interfacing External ADC, Temperature Sensor, Light Sensor, Accelerometer, Pressure Sensors, Magnetic - Field Sensor, DAC, PWM; Embedded System Applications - Motor Control, and Switching Big Loads. [8L]

Text Books:

1. Catsoulis, John, "Designing Embedded Hardware", First/Second Edition, Shroff Publishers & Distributors Pvt. Ltd., New Delhi, India.
2. Vahid, Frank and Givargis, Tony, "Embedded System Design - A Unified hardware/Software Introduction", John Wiley & Sons, (Asia) Pvt Ltd., Replika Press Pvt., Delhi - 110040.
3. Douglas Perry, "VHDL Programming by Example", TMH publication
4. J. Bhaskar, "A VHDL Primer", Pearson Education
5. Mazidi & Mazidi, "AVR Microcontrollers & Embedded Systems using Assembly & C Pearson Education
6. Rulph Chassaing, "Digital Signal Processing and Applications with C6713 and C6416 DSK", John Wiley and Sons publication

Reference books:

1. Stuart R. Ball, "Embedded Microprocessor Systems, Real World Design", Second Edition, Newnes publication.
2. Nasser Kehtarnavaz, "Real Time Digital Signal Processing based on the TMS320C6000", Elsevier publication.

Course Evaluation: Individual assignment, Seminar before a committee, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements): Practical implementation of microcontroller based system design.

POs met through Gaps in the Syllabus: PO5

Topics beyond syllabus/Advanced topics/Design:

Assignments: Hardware design of closed loop Temperature control using AVR microcontroller

POs met through Topics beyond syllabus/Advanced topics/Design: PO5

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment

Assessment Tools	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 quizzes	30 (3×10)
Assignment(s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery methods:

CD	Course Delivery methods
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Tutorials/Assignments
CD3	Seminars
CD4	Mini projects/Projects
CD5	Laboratory experiments/teaching aids
CD6	Industrial/guest lectures
CD7	Industrial visits/in-plant training
CD8	Self- learning such as use of NPTEL materials and internets
CD9	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	3	3	3	2	2	2
CO 2	3	3	3	3	2	2
CO 3	3	3	3	3	2	2
CO 4	3	3	3	3	3	2
CO 5	3	3	3	3	3	3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD6
CO2	CD1, CD6,CD7
CO3	CD1, CD2, CD3,CD6,CD7
CO4	CD1, CD3,CD6,CD7
CO5	CD1,CD2,CD3,CD4,CD5,CD7

COURSE INFORMATION SHEET

Course code: EE 593
Course title: High Voltage Engineering
Pre-requisite(s): Fundamental of Electrical and Electronics Engineering, Electromagnetic Field, Electrical Measurement, Electrical Insulating Material
Co- requisite(s):
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 03
Class: M.Tech
Semester / Level: II
Branch: EEE
Name of Teacher:

Course Objectives: This course enables the students:

1	To educate students about electric field stress
2	To give an exposure about different types of electrical insulation
3	To give information about conduction and breakdown in different types of electrical insulation
4	To impart knowledge about the methods of generation and measurement of high voltage and current for testing
5	To train the students for design of high voltage laboratory

Course Outcomes: At the end of the course, a student should be able to:

CO1	Gain skilful knowledge of controlling the electrical stress in electrical systems and proper use of electrical insulating media.
CO2	Perform experiments on generation and measurement of high voltage and current
CO3	Identify possible reasons for failure of electrical insulation
CO4	Explore remedial measure for failure of electrical insulation.
CO5	Design circuits for generation of high voltage and current, electrical insulation system and set up high voltage lab

Syllabus

MODULE – I

Introduction: Electric Field Stresses, Gas/Vacuum as Insulator, Liquid Breakdown, Solid Breakdown, Estimation and Control of Electric Stress [3L]

MODULE – II

Conduction and Breakdown in Gases: Gases as Insulating Media, Ionization Processes, Townsend's Current Growth Equation, Townsend's Criterion for Breakdown, Breakdown in Electronegative Gases, Time Lags for Breakdown, Streamer Theory of Breakdown in Gases, Paschen's Law, Breakdown in Non-Uniform Fields and Corona Discharges, Post-Breakdown Phenomena and Applications, Vacuum Insulation. [6L]

MODULE – III

Conduction and Breakdown in Liquid: Liquids as Insulators, Pure Liquids and Commercial Liquids, Conduction and Breakdown in Pure and Commercial Liquids. [6L]

Conduction and Breakdown Solid Dielectrics: Introduction, Intrinsic Breakdown, Electromechanical and Thermal Breakdown, Breakdown of Solid Dielectrics in Practice, Breakdown in Composite Dielectrics. [6L]

MODULE – IV

Generation High Voltage and Currents: Generation of High dc voltages, Generation of High alternating voltages, Generation of impulse voltages, Generation of impulse currents, Tripping and control of impulse generators. [8L]

Measurement of High Voltage and Currents: Measurement of High direct current voltages, Measurement of High ac and impulse voltages, Measurement of High impulse currents. [8L]

MODULE – V

Design, Planning and Layout of High Voltage Laboratories: Introduction, Test Facilities provided in high voltage laboratories, Activities and studies in high voltage laboratories, Classification of high voltage laboratories, Size and Rating of large size high voltage laboratories, Grounding of impulse testing laboratories [3L]

Text Book:

1. High Voltage Engineering, MS Naidu and V. Kamaraju, 4th edition, TMH New Delhi.
2. High Voltage Engineering Fundamentals, E. Kuffel and W S Zaengl, Pergamon Press, Oxford.

Reference Book:

1. High Voltage Engineering, C L Wadhwa, 2nd edition, New Age International (P) Limited, Publishers, New Delhi**.**
2. Electrical Breakdown of Gases, 2nd edition, JM, Meek and JD, Crages, John Wiley, New York.

Course Evaluation: Individual assignment, Seminar before a committee, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements): HVDC and HVAC Power Transmission, Insulation Coordination

POs met through Gaps in the Syllabus: PO1, PO6

Topics beyond syllabus/Advanced topics/Design: Insulation simulation and design using software, Lightning

POs met through Topics beyond syllabus/Advanced topics/Design: PO4

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment

Assessment Tools	**% Contribution during CO Assessment**

Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	**% Distribution**
3 quizzes	30 (3×10)
Assignment(s)	10
Seminar before a committee	10

Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD	**Course Delivery methods**
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Tutorials/Assignments
CD3	Seminars
CD4	Industrial visits/in-plant training
CD5	Self- learning such as use of NPTEL materials and internets
CD6	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

Course outcomes	**Programme Outcomes**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	1	1	3	2	3	3
CO 2	1	3	2	2	2	2
CO 3	1	2	3	3	2	3
CO 4	1	2	3	2	2	2
CO 5	2	2	3	2	3	3

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Mapping Between COs and Course Delivery (CD) methods	
Course Outcome	**Course Delivery Method**
CO1	CD1, CD2, CD3, CD4, CD5
CO2	CD1,CD2, CD4, CD5
CO3	CD1, CD2,CD5
CO4	CD1,CD5,CD6
CO5	CD1, CD5, CD6

COURSE INFORMATION SHEET

Course code: EE577
Course title: Control of Electric Drives
Pre-requisite(s): Power electronics and Machine
Co- requisite(s):
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 03
Class: M.Tech
Semester / Level: II/05
Branch: EEE
Name of Teacher:

Course Objectives: This course enables the students to:

1	Understand different types of electrical drives system.
2	Explanation of working principle of power converters and relate them with different types of drives system
3	Analysis of closed loop control of electrical drives based on power converters.
4	Differentiation between different control strategy of electrical drives in terms of dynamic parameters of system and overall efficiency.
5	Performance evaluation, planning and design procedure for a complex power electronics based drives system.

Course Outcomes: After the completion of this course, students will be able to:

CO1	List different types of electrical drives.
CO2	Associate different types of power converters with different type's electrical drives. Show suitability of a power converter for a particular application. Solve power management related problems with application of power electronics based topologies.
CO3	Outline shortcomings of each class of conventional drives control strategy and solve them using proper modifications. Identify potential area for power electronics applications.
CO4	Estimate the cost and long-term impact of power electronics-based drives technology on a large-scale project of socio-economic importance.
CO5	Modify existing power electronics-based installations. Design new power converter topologies and Plan to develop a power processing unit for a particular requirement in industrial plants as well as domestic applications. Lead or support a team of skilled professionals.

Syllabus

Module1:
Introduction to Electrical Drives:
Drive concepts, different machines & load characteristics, equilibrium and steady state stability, four quadrant operations, referred inertia and load torque for different coupling mechanism, thermal selection of machines

[8L]

Module 2:
DC Motor drives:
Operating limits using armature voltage control and field control techniques, dynamic model (armature voltage control only) of machine and converters (continuous conduction only), open loop dynamic performance, closed loop control using single (speed) and two loops (speed, current), implementation of four quadrant operation. Modelling and control of separately excited dc machine in field weakening region and discontinuous converter conduction mode, design of close loop speed controller for separately excited dc motors.

[8L]

Module 3:
Induction motor drives:
Review of scalar control methods (voltage, constant V/f & frequency) of three phase symmetrical Induction machines, speed control using current controlled VSI drives, close loop speed control with constant v/f control strategy, effects of harmonics and power factor [8L]

Module 4:
Vector control of Induction machines & Speed control of wound rotor induction machine:
Review of vector control, Implementation of direct & indirect vector control schemes, methods of flux estimation, effect of machine parameter variation on vector control performance, speed sensorless control, Direct Torque Control. Static rotor resistance control, static Scherbius Drive using line commutated converter cascade & Cyclo-converter, close loop speed control using slip power recovery, vector control of wound rotor induction machine using Cyclo-converter, introduction to Variable Speed Constant Frequency (VSCF) generation. **[8L]**

Module 5:
Control of synchronous machine:
Wound field synchronous machine: Constant volts/Hz control, scalar self-control (commutator less control), vector control. Control of permanent magnet synchronous machine: Brushless DC machine, surface permanent magnet machine. [8L]

Text Books (T):

1. Fundamental of Electrical Drives: G K Dubey
2. Electric Motor Drives, modelling analysis and control: R Krishnan

Reference Books (R):

1. Modern Power Electronics & Drives: B K Bose

Course Evaluation: Individual assignment, Seminar before a committee, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements):
Practical implementation of microcontroller based electric drive design.

POs met through Gaps in the Syllabus: PO5

Topics beyond syllabus/Advanced topics/Design
Assignments: Hardware design of closed loop Temperature control using AVR microcontroller

POs met through Topics beyond syllabus/Advanced topics/Design: PO5

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment

Assessment Tools	**% Contribution during CO Assessment**
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	**% Distribution**
3 quizzes	30 (3×10)
Assignment(s)	10
Seminar before a committee	10

Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Tutorials/Assignments
CD3	Seminars
CD4	Mini projects/Projects
CD5	Laboratory experiments/teaching aids
CD6	Industrial/guest lectures
CD7	Industrial visits/in-plant training
CD8	Self- learning such as use of NPTEL materials and internets
CD9	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO 1	3	3	2	2	2	1
CO 2	3	3	3	3	2	2
CO 3	3	3	3	3	3	2
CO 4	3	3	3	3	3	3
CO 5	3	3	3	3	3	3

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD6
CO2	CD1, CD6,CD7
CO3	CD1, CD2, CD3,CD6,CD7
CO4	CD1, CD3,CD6,CD7

CO5	CD1,CD2,CD3,CD4,CD5,CD7

COURSE INFORMATION SHEET

Course code: EE571
Course title: Soft Computing Techniques in Electrical Engineering
Pre-requisite(s): Basics of signals and systems, Digital Signal Processing, Filter theory.
Credits: L: 3 T: 1 P: 0 C: 3
Class schedule per week: 4 lectures week
Class :M.Tech
Semester/level: II
Branch: Electrical Engineering
Name of Teacher:

Course Objectives: This course enables the students to:

1	Understand the basic of Soft Computing Techniques.
2	Acquainted with the solving methodology of soft computing technique in power systems operation and control.
3	Analysis of ANN based systems for function approximation in application to load forecasting.
4	Evaluate fuzzy based systems for load frequency control in power systems.
5	Design of different problems of optimization in power systems and power electronics.

Course Outcomes: At the end of the course, a student should be able to:

CO1	Identify the soft computing techniques and their roles in building intelligent machines.
CO2	Recognize an appropriate soft computing methodology for an engineering problem.
CO3	Apply fuzzy logic and reasoning to handle uncertainty while solving engineering problems.
CO4	Analysis of neural network and genetic algorithms to combinatorial optimization problems.
CO5	Classify neural networks to pattern classification and regression problems and evaluated its imparts while being able to demonstrate solutions through computer programs.

Syllabus

Module - 1
Introduction to Soft Computing: Introduction, Definition of Soft Computing Techniques, Importance of Soft Computing, Main Components of Soft Computing: Fuzzy Logic, Artificial Neural Networks, Introduction to Evolutionary Algorithms, Hybrid Intelligent Systems, Single and multi-objective optimization.

[8L]

Module –2
Artificial Neural Network and Applications: Introduction, Artificial Neuron Structure, ANN Learning; Back-Propagation Learning, Properties of Neural Networks, Unsupervised learnings, Hopfield networks, Application of GN Models to Electrical Machine Modeling, Short Term Electrical Load Forecasting Using Generalized Neuron Model, Aircraft Landing Control System Using GN Model.

[8L]

Module - 3
Introduction to Fuzzy Logic and Genetic Algorithm: Introduction, Uncertainty and Information, Types of Uncertainty, Introduction of Fuzzy Logic, Fuzzy Set, Operations on Fuzzy Sets, Fuzzy Intersection, Fuzzy Union, Fuzzy Complement, Fuzzy Concentration, Fuzzy Dilation, Fuzzy Intensification, α-Cuts,

Characteristics of Fuzzy Sets, Demorgan's Law, Fuzzy Cartesian Product, Various Shapes of Fuzzy Membership Functions, Methods of Defining of Membership Functions, Fuzzy Relation, Defuzzification Methods.Introduction to Genetic Algorithm, Crossover, Mutation, Survival of Fittest, Population Size, Evaluation of Fitness Function.

[8L]

Module-4

Applications of Fuzzy Rule Based System: Introduction, System's Modeling and Simulation Using Fuzzy Logic Approach, Selection of Variables, Normalization Range and Number of Linguistic Values, Selection of Shape of Membership Functions for Each Linguistic Value, Selection of Fuzzy Union and intersection Operators, Selection of Defuzzification Method, Steady State D.C. Machine Model, Transient Model of D.C. Machine, Fuzzy Control System, Power System Stabilizer Using Fuzzy Logic.

[8L]

Module-5

Applications of Soft Computing Techniques to Electrical Engineering: Applications of Artificial Neural Network, Genetic Algorithms, Fuzzy and Hybrid Systems for Power System Applications: voltage control, voltage stability, Economic load dispatch, Unit commitment, Condition monitoring. Applications of Soft Computing Techniques for Power Electronics and Control Applications.

[8L]

Text Books:

1Neural Networks: A Comprehensive Foundation – Siman Haykin, IEEE, Press, MacMillan, N.Y. 1994.

2. S. Rajasekaran, G. A. Vijayalakshmi, Neural Networks, Fuzzy logic and Genetic algorithms, PHI publication.
3. Fuzzy logic with Engineering Applications - Timothy J. Ross, McGraw-Hill International Editions.
4. Fuzzy Sets and Fuzzy logic: Theory and Applications - George J. Klir and Bo. Yuan, Prentice- Hall of India Private Limited.

Reference Books:

1. Chaturvedi, Devendra K, Soft Computing Techniques and its Applications in Electrical Engineering, Hardcover ISBN:- 978-3-540-77480-8, Springer.
2. Kalyanmoy Deb, Optimization for Engineering Design, PHI publication
3. Kalyanmoy Deb, Multi-objective Optimization using Evolutionary Algorithms, Willey Publication
4. Kevin Warwick, Arthur Ekwue, Rag Agarwal, Artificial intelligence techniques in power systems. IEE Power Engineering Series-22.

Course Evaluation: Individual assignment, Seminar before a committee, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements)
1. Visualize different soft computing techniques in real time.
2. Hardware implementation of soft computing techniques in real time.

POs met through Gaps in the Syllabus: PO5, PO6

Topics beyond syllabus/Advanced topics/Design: Soft computing application to image processing, video processing.

POs met through Topics beyond syllabus/Advanced topics/Design: PO5, PO6

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment

Assessment Tools	**% Contribution during CO Assessment**
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	**% Distribution**
3 quizzes	30 (3×10)
Assignment(s)	10
Seminar before a committee	10

Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	2	1			
CO2	3	2	1	2		1
CO3	3	1	2	3		1
CO4	2	2	2	3	2	2
CO5	2	2	3	1	3	3

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD6
CO2	CD1, CD6,CD7
CO3	CD1, CD2, CD3,CD6,CD7
CO4	CD1, CD3,CD6,CD7
CO5	CD1,CD2,CD3,CD4,CD5,CD7

COURSE INFORMATION SHEET

Course code: EE553
Course title: Non-linear Control System
Pre-requisite(s): Modern Control Theory
Co- requisite(s): Control system design
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 03
Class: M.Tech
Semester / Level: 05
Branch: EEE
Name of Teacher:

Course Objectives:

To state students with concepts:

1	of nonlinear properties and their types and linearization of nonlinear state differential equation
2	to extend comprehensive knowledge of graphical and mathematical analysis of nonlinear physical system for study of stability;
3	to illustrate basics of different design methods;
4	to summarize them on regulation and tracking problems.
5	to validate the design

Course Outcomes: At the end of the course, student will be able to:

CO1	List the different types of nonlinear properties.
CO2	Relate an appropriate methodology for analysis of the various types of nonlinearities.
CO3	Organize different methodologies to demonstrate stability of different nonlinear control problems.
CO4	Categorize different techniques like, feedback linearization, sliding mode, gain scheduling to regulation and tracking problems.
CO5	Appraise and compile the different properties and methods of analysis and design for the need of continuous learning in order to create state of art based on advanced mathematical tools.

Syllabus

Module – 1 Introduction to Nonlinear system, Types of nonlinearities, Characteristics, Linear approximation of nonlinear systems, Linearization of nonlinear state differential equation, Phase plane analysis: Phase plane representation, Phase portrait, graphical method to obtain phase trajectory, Singular points, Limit cycle. [8L]

Module – 2 Describing function analysis: Definition, Derivation of Describing functions for common nonlinear elements, Determination of amplitude and frequency of limit cycle using describing function technique. [8L]

Module - 3 Direct method of Liapunov: Introduction, Basic concepts, Stability definitions, Stability theorems, Liapunov functions for nonlinear systems, Methods for determination of Liapunov functions, popov stability criteria. [8L]

Module – 4 Feedback Linearization: Motivation, Input-output linearization, Full state linearization, State feedback control: Stabilization, Tracking [8L]

Module – 5. Sliding mode control: Sliding mode control: Sliding mode control: Motivation, Stabilization, Tracking, Regulation via integral control; Gain Scheduling: Scheduling variables; Gain scheduled controller for nonlinear systems. [8L]

Books Recommended:

1. Slotine & Li, "Applied Nonlinear Control", Prentice Hall, Englewood Cliffs, New Jersey 07632
2. M. Gopal, "Digital Control & State Variable Method", TMH.
3. B. C. Kuo, "Automatic Control System"7th Edition PHI
4. Hassan K. Khalil, "Non Linear Systems".
5. S. Banerjee, "Nonlinear Dynamics" (NPTEL Lectures)

Course Evaluation: Individual assignment, Seminar before a committee, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements)

(1) Practical design of controllers.

(2) Design optimization for industrial projects.

POs met through Gaps in the Syllabus: PO5 & PO6

<u>Topics beyond syllabus/Advanced topics/Design:</u>

Chaos, fractals and solitans

POs met through Topics beyond syllabus/Advanced topics/Design: PO5 & PO6

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

<u>Direct Assessment</u>

Assessment Tools	**% Contribution during CO Assessment**
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	**% Distribution**
3 quizzes	30 (3×10)
Assignment(s)	10
Seminar before a committee	10

Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Continuous Internal Assessment					
Semester End Examination					

<u>Indirect Assessment</u>

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	1	1	1	1
CO2	3	1	1	3	1	1
CO3	3	1	2	3	1	2
CO4	3	3	3	3	3	3
CO5	3	3	3	3	3	3

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD6
CO2	CD1, CD6,CD7
CO3	CD1, CD2, CD3,CD6,CD7
CO4	CD1, CD3,CD6,CD7
CO5	CD1,CD2,CD3,CD4,CD5,CD7

COURSE INFORMATION SHEET
(Programme Core)

Course code: EE562
Course title: Power System Simulation Lab
Pre-requisite(s): Principles of Electrical Engineering, Basic Courses on Power System, Basics of MATLAB.
Co- requisite(s):
Credits: L: 0 T: 0 P: 4 C: 2
Class schedule per week: 04
Class: M.Tech
Semester / Level: II
Branch: EEE
Name of Teacher:

Course Objectives: This course enables the students to:

1	Understand the purposes and use of different tools like LF, SC, and Contingency through simulating the network and disturbances.

2	Expose the students about the necessity of economic operation and AGC controller through cost effective approach.
3	Employ the MPPT controller in SPV converter and realization of PMU.
4	Expose Different Software Environments for power system Analysis.

Course Outcomes: After the completion of this course, students will be able to:

CO1	Simulate the systems for applying the Load flow, Contingency and Short circuit analyses at different system conditions arised due to load change and other contingency situations.
CO2	Determine the optimum power dispatch including system constraints through only ELD and OPF.
CO3	Design and observe the effects of the droop and AGC controllers for single and multi area systems.
CO4	Observe the effect of MPPT programming to extract power from SPV system and phasor realization through PMUs.
CO5	Apply MATLAB, Power World, ETAP software, Power Factory in some applications of Power Systems.

LIST OF EXPERIMENTS:

1. (a) Simulation of IEEE 14 and IEEE 30 bus system.
   (b) Study and Analysis of the Load Flow for IEEE14 and IEEE30 bus system

2. Comparison of Gauss-Seidel method, Newton-Raphson method and Fast Decoupled method.

3. Study of single and multiple contingency for generation outage and line outage by K & L sensitivity factors for IEEE 14 bus system.
4. Application of linear programming for line overloading removal using Line outage distribution factor (L) & Generation shift outage factor (K) of IEEE 14 bus system

5. i) Economic Load Dispatch of Generators Considering without Transmission Losses.
   ii) Economic Load Dispatch of Generators Considering Transmission Losses.
   iii) Effect of Loss co-efficient parameters and cost parameters on Economic Dispatch
6. **To study optimal power flow using Power World software.**
7. Simulation and analysis of an isolated micro-grid on MATLAB.
8. Development of MPPT algorithm of Solar Photo Voltaic cell.

9. Short Circuit Analysis using ETAP
10. (a) Develop the simulation block diagram for Automatic Generation Control (AGC)
    (b) Study of AGC considering the effect of primary controller for single area.
11. (a) Develop simulation block diagram of Automatic Generation Control(AGC) for two area system.
    (b) Study of AGC considering the effect of secondary controller for two area system.
12. To simulate PMU model in MATLAB and to analyze the voltage and current signal for two bus system.

LIST OF ASSIGNMENTS

ASSIGNMENT 1: Load flow analysis using Power Factory software.

ASSIGNMENT 2: Impact of DG on system losses and voltage.

Text Books:

- Power System Analysis – HadiSaadat, Tata McGraw-Hill Edition, 2002.
- Electric Power System – C. L. Wadhwa, 6th edition, 2013, New Age International Publishing.

Reference Books:

- Modern Power System Analysis – D. P. Kothari, I. J. Nagrath, 4^{th} edition, 2014, Tata-McGraw Hill.
- Electric Energy Systems Theory - An Introduction – O. I. Elgerd, 27^{th} reprint, 2007, TMH.
- Power System Engineering – A. Chakrabarti, M. L. Soni, P. V. Gupta, U. S. Bhatnagar, 4^{th} edition, 2008, Dhalpat Rai & Co.

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:

POs met through Topics beyond syllabus/Advanced topics/Design: PO6

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment

Assessment Tools	**% Contribution during CO Assessment**
Progressive Evaluation	60
End Semester Evaluation	40

Progressive Evaluation	**% Distribution**
Day to day performance & Lab files	30
Quiz (zes)	10
Viva	20

End Semester Evaluation	**% Distribution**
Examination Experiment Performance	30
Quiz	10

Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Progressive Evaluation					
End Semester Evaluation					

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery methods	
CD1	Lecture by use of boards/LCD projectors
CD2	Tutorials/Assignments
CD3	Seminars
CD4	Mini projects/Projects

CD5	Laboratory experiments/teaching aids
CD6	Industrial/guest lectures
CD7	Industrial visits/in-plant training
CD8	Self- learning such as use of NPTEL materials and internets
CD9	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	2
CO2	3	3	3	3	2	2
CO3	3	3	3	3	2	2
CO4	1	3	2	3	2	3
CO5	2	3	2	3	2	2

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcome	Course Delivery Method
CO1	CD1,CD8,CD9
CO2	CD1,CD8,CD9
CO3	CD1,CD8,CD9
CO4	CD1,CD8,CD9
CO5	CD1,CD8,CD9

COURSE INFORMATION SHEET

Course code: EE564
Course title: Advanced Power System Lab
Pre-requisite(s): Principles of Electrical Engineering, Basic Courses on Power System, power system protection
Co- requisite(s):
Credits: L: 0 T: 0 P: 4 C: 2
Class schedule per week: 04
Class: M.Tech
Semester / Level: II
Branch: EEE
Name of Teacher:

Course Objectives: This course enables the students:

1	To state the performance index of an Optimal Control System with specific design requirements and design objectives.
2	To understand the concepts of calculus of variations, Euler Lagrange Equations and apply it to specific real time numerical problems.
3	To identify and then establish the Hamiltonian and Pontryagin's formulation from a assumed performance index and apply it to specific real time numerical problems.
4	To develop methodologies that uses the concept of Finite and Infinite time LQR along with

	Dynamic Programming procedure to generate control law for a single variable and a multivariable processes subjected to uncertainties.

Course Outcomes: At the end of the course, the student will be able to:

CO1	Identify the design objectives and requirements to set up a performance index for an Optimal Control System.
CO2	Interpret the concepts of calculus of variations to establish Euler Lagrange Equation and apply it to solve some design problems.
CO3	Establish the Hamiltonian and Ponryagin's formulation from the performance index and apply this concept to develop an optimal control law.
CO4	Develop methodologies to formulate a control law by Pontryagin's Minimum Principle using Dynamic Programming method and reproduce the results and write effective reports suitable for quality journal and conference publications.
CO5	Develop methodologies to formulate a control law using finite time and infinite time, time varying LQR concepts for regulator and tracking problems and simultaneously recognize the need to learn, to engage and to adapt in a world of constantly changing technology and play role of team leader or supporter of team.

List of Experiments:

1. Determination of ABCD parameters and voltage profile for an artificial transmission line.
2. Determination of over current relay characteristics using Relay Test kit.
3. A micro- computer controlled static VAR compensator for receiving end voltage.
4. Determination of negative and zero sequence reactance of a 3-phase alternator.
5. Ferro- resonance phenomenon for a transformer at no load.
6. Determination of zero sequence impedance of 3-phase transformer.
7. Active and reactive power control of an Alternator
8. Generator Protection using Over Current, Differential, Negative Sequence and Reverse power relay
9. SCADA based transmission line integrated with wind emulator
10. Numerical relay applications
11. Dynamic voltage and current phasor monitoring with Phasor Measurement Unit
12. Power factor control of an inductive load and Power system fault analysis using D.C network analyser.
13. Phase sequence determination using RC and two bulbs method and Earth resistance measurement using Earth tester.
14. Micro-grid hardware simulation

Books recommended:

i. Electric Machinery: Stephen Umans, 7th edition, Fitzgerald & Kingsley's Electric Machinery
ii. Power System Protection & Switchgear: Badriram and Vishwa Karma, TMH Publication 2nd edition, 2014.
iii. Performance and Design of DC Machines- A. E. Clayton, 1st edition, CBS Publisher, 2004.
iv. Extra High Voltage AC Transmission Engineering (2nd Ed.) by R. D. Begamudre, Wiley Eastern Ltd.
v. Alternating Current Machines, A. S. Langsdorf, Tata McGraw-Hill, 2001
vi. Microprocessor Architecture-Programming Applications by Ramesh S. Gaonkar, 5th edition, 1998 , Prentice Hall.
vii. Power System Analysis, Stevenson and Grainger, 1994, Mc-Graw Hill
viii. Electric Energy Systems Theory an Introduction, O.I. Elgerd, TMH,1973.
ix. Power Electronics, M.D. Singh, K.B. Khanchandani, TMH, Delhi, 2001.
x. I.J. Nagrath & Gopal, "Control systems Engineering," 4th ed., New Age International Publication.
xi. K. Ogata, "Modern Control Engineering," 3rd ed., Pearson Education.

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment

Assessment Tools	**% Contribution during CO Assessment**
Progressive Evaluation	60
End Semester Evaluation	40

Progressive Evaluation	**% Distribution**
Day to day performance & Lab files	30
Quiz (zes)	10
Viva	20

End Semester Evaluation	**% Distribution**
Examination Experiment Performance	30
Quiz	10

Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Progressive Evaluation					
End Semester Evaluation					

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery methods	
CD1	Lecture by use of boards/LCD projectors
CD2	Tutorials/Assignments
CD3	Seminars
CD4	Mini projects/Projects
CD5	Laboratory experiments/teaching aids
CD6	Industrial/guest lectures
CD7	Industrial visits/in-plant training
CD8	Self- learning such as use of NPTEL materials and internets
CD9	Simulation

Mapping between course outcomes and program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	2
CO2	3	3	3	3	2	2
CO3	3	3	3	3	2	2
CO4	3	3	2	3	2	3
CO5	2	3	2	3	2	3

< 34% = 1, 34-66% = 2, > 66% = 3

Mapping between COs and Course Delivery (CD) methods

Course Outcome	Course Delivery Method
CO1	CD1,CD8,CD9
CO2	CD1,CD8,CD9
CO3	CD1,CD8,CD9
CO4	CD1,CD8,CD9
CO5	CD1,CD8,CD9

3rd Semester

Program Core

EC600 Thesis (Part I) Credit: 8

COURSE INFORMATION SHEET

Course code: EE 605
Course title: Micro Grid Operation and Control
Pre-requisite(s): Power system courses, power electronics.
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 3
Class: M. Tech
Semester / Level: III
Branch: EEE
Name of Teacher:

Course Objectives

This course enables the students:

A.	To enumerate the active distribution network and understand the principle of operation of microgrid.
B.	To outline power generation from renewable energy sources and assess different controllers for voltage and frequency restoration in microgrid.
C.	To evaluate salient features of demand response management in microgrid.
D.	To outline power quality and reliability issues for micro grids

Course Outcomes

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

1.	Outline the significance of various micro-grid configurations and explain the principle of their operation for meeting the load demand.
2.	Analyze the significance of different types of Distributed energy resources.
3.	Apply different control methods for voltage and frequency control in microgrids.
4.	Analyze and estimate demand response management in microgrid.
5.	Assess and integrate power quality and reliability issues for microgrids.

Syllabus

Module 1:
Distributed generation and Microgrid concept: Introduction, Active distribution network, concept of microgrid , typical micro grid configuration, distributed renewable energy technologies, non-renewable distributed generation technologies, interconnection of micro grids, technical and economical advantages of micro grid, challenges and disadvantages of micro grid development, management and operational issues of a micro grid, dynamic interactions of microgrid with main grid.

[8L]

Module 2:
Distributed energy resources: Introduction, Combined heat and power (CHP) systems, Micro-CHP systems, Wind energy conversion systems (WECS), Wind turbine operating systems, Solar photovoltaic (PV) systems, Types of PV cell, Small-scale hydroelectric power generation, Other renewable energy sources, Storage devices

[8L]

Module-3:
Control of single converter in grid connected mode, Master and slave control of microgrids, Primary droop control, Secondary voltage and frequency control in microgrids, Centralized and decentralized Energy Management System (EMS) in microgrids, Bidding Strategy in Microgrid market operation

[8L]

Module-4:
Advanced metering system, Demand response, Types of Demand Response Programmes, Real-time control effect in microgrid EMS, Voltage and frequency restoration, communication protocols

[8L]

Module-5:
Protection, power quality and reliability issues for microgrids: Islanding, different islanding scenarios, major protection issues of stand-alone microgrid, microgrid distribution system protection, Protection of micro-sources, neutral grounding requirements, impact of DG integration on power quality and reliability, power quality disturbances, power quality sensitive customers, power quality improvement technologies

[8L]

Text books:

1. S. Chowdhury, S.P. Chowdhury and P. Crossley, "Microgrids and Active Distribution Networks", The Institution of Engineering and Technology, 2009.

Reference books:

1. Bansal, Ramesh, "Handbook of Distributed Generation: Electric Power Technologies, Economics and Environmental Impacts", Springer, ISBN 978-3-319-51342-3

Course Evaluation: Individual assignment, Seminar before a committee, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements):

POs met through Gaps in the Syllabus:
Topics beyond syllabus/Advanced topics/Design:

POs met through Topics beyond syllabus/Advanced topics/Design:

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment

Assessment Tools	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 quizzes	30 (3×10)
Assignment(s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD	Course Delivery methods
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Tutorials/Assignments
CD3	Seminars
CD4	Industrial visits/in-plant training
CD5	Self- learning such as use of NPTEL materials and internets
CD6	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	2	3	3	2
CO2	3	2	3	3	2	3
CO3	3	2	3	3	3	3
CO4	2	2	1	2	2	2
CO5	3	2	3	3	3	3

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Mapping Between COs and Course Delivery (CD) methods	
Course Outcome	**Course Delivery Method**
CO1	CD1, CD2, CD3,CD5
CO2	CD1, CD2, CD3,CD5
CO3	CD1, CD2, CD3,CD5
CO4	CD1, CD2, CD3,CD5
CO5	CD1, CD2, CD3,CD5

COURSE INFORMATION SHEET

Course code: EE 606
Course title: Smart Grid Laboratory
Pre-requisite(s): Power system courses, power electronics.
Co- requisite(s):
Credits: L: 0 T: 0 P: 4 C: 2

Class schedule per week: 04
Class: M.Tech
Semester / Level: III
Branch: EEE
Name of Teacher:

Course Objectives:

This course enables the students:

A.	To understand the basic concept of SPV and wind integrated system and challenges involved in microgrid operation (grid connected and islanded mode) under different contingencies.
B.	To impart basic concept of various RESs and their control system components.
C.	To provide skills for application of appropriate tools in order to solve various technical power system problems; in order to apprehend about efficient network by applying PMUs and Demand Response Programs.
D.	To provide knowledge of current state of art in the field of power electronics and control system applications applying on power system in order to motivate students to take up research activities.

Course Outcomes
After the completion of this course, students will be able to:

1.	State the grid interface issues of solar and wind power and methods to resolve them.
2.	Analysis the challenges involved with grid interactive converters connected with RES in microgrid operation.
3.	Demonstrate the function of PMUs and its application.
4.	Analyze the design concept involved with demand response Programmes.
5.	undertake design projects involving inter disciplinary nature in the domain of power system and power electronics;

LIST OF EXPERIMENTS

1. I-V and P-V curve for a given SPV system.
2. Simulation of MPPT algorithm using Perturb & Observe method.
3. Experiment on Boost converter for MPPT implementation for SPV system.
4. Bidirectional power flow between wind energy connected system and grid.
5. Wind and battery-based grid connected system and DC bus utilization.
6. Study and analyze generation control of RESs in isolated mode.
7. Study and analyze generation control of RESs in grid connected mode.
8. Risk assessment of generation from RESs in microgrid bidding operation.
9. Design and analysis of Demand Response program.

10. Analyzing the voltage and current in two bus system using Phasor Measurement Unit

11. To simulate PMU model by using MATLAB and to analyse the voltage and current signal for two bus system.

12. Design and analysis of Electric vehicle-grid application.

13. Modelling of Hybrid Electric vehicle batteries.

14. IOT based renewable energy management system.

Books recommended:

1.Takuro Sato, Daniel M. Kammen, , Bin Duan, , Martin Macuha, , Zhenyu Zhou, , Jun Wu, , Muhammad Tariq, , and Solomon A. Asfaw, "Smart Grid Standards : Specifications, Requirements, and Technologies" **PUBLISHER** John Wiley & Sons, Incorporated.

2. A.G. Phadke J.S. Thorp, "Synchronized Phasor Measurements and their Applications", springer 2008.

3.James Momoh**, "**SMART GRID: Fundamentals of Design and Analysis", IEEE (Power engineering series) – Wiley- Blackwell, April 2012.

4.Janaka Ekanayake, KithsiriLiyanage, JianzhongWu, Akihiko Yokoyama, Nick Jenkins "Smart Grid Technology and Applications", Wiley, New- Delhi, August 2015.

5. Wind and solar systems by Mukund Patel, CRC Press.

6. Solar Photovoltaics for terrestrials, Tapan Bhattacharya.

7. Wind Energy Technology – Njenkins, John Wiley & Sons

8. Solar & Wind energy Technologies – McNeils, Frenkel, Desai, Wiley Eastern.

9. Solar Energy – S.P. Sukhatme, Tata McGraw Hill.

10.Solar Energy – S. Bandopadhay, Universal Publishing. 7. Guide book for National Certification Examination for EM/EA – Book 1

Course Evaluation:
Group project evaluation, Progressive and End semester evaluations

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:

POs met through Topics beyond syllabus/Advanced topics/Design: PO6

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

<u>Direct Assessment</u>

Assessment Tools	**% Contribution during CO Assessment**
Progressive Evaluation	60
End Semester Evaluation	40

Progressive Evaluation	**% Distribution**
Day to day performance & Lab files	30
Quiz	10
Viva	20

End Semester Evaluation	**% Distribution**
Examination Experiment Performance	30
Quiz	10

Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Progressive Evaluation					
End Semester Evaluation					

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	2	1	2	2	2
CO2	3	2	1	2	2	1
CO3	3	1	2	3	2	1
CO4	2	2	2	3	2	2
CO5	2	2	3	1	3	3

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	**Course Delivery Method**
CO1	CD1,CD6
CO2	CD1, CD6,CD7
CO3	CD1, CD2, CD3,CD6,CD7
CO4	CD1, CD3,CD6,CD7
CO5	CD1,CD2,CD3,CD4,CD5,CD7

COURSE INFORMATION SHEET
(Programme Electives-III)

Course code: EE 635
Course title: Wide Area Monitoring System
Pre-requisite(s): Power system courses, power electronics.
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 3
Class: M. Tech
Semester / Level: III
Branch: EEE
Name of Teacher:

Course Objectives

This course enables the students to:

A.	Grasp and apply the principles pertaining to power system monitoring and protection
B.	Analyse, compare and imbibe the efficacy of synchro-phasor technology over conventional monitoring techniques
C.	Design and implement improved network protection during stressed conditions
D.	Develop adequate skills to integrate appropriate protective measures for states estimation and enhanced situational awareness
E.	Commensurate technological up-gradation related to state-of-the art wide area monitoring system

Course Outcomes

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

CO1.	Comprehend the evolution of computer relaying and analyze its potent applications in a wide area measurement system
CO2.	Apply the concepts of synchro-phasors for wide area monitoring and protection
CO3.	Design and implement concepts of synchro-phasors for adaptive protection
CO4.	Compare and contrast the unique advantages of phasor measurement unit over conventional protection
CO5.	Skilfully design emerging advanced power system integrity protection schemes for enhancing power system reliability and situational awareness

Syllabus

MODULE 1:

Introduction to Computer Relaying: Evolution of power system relaying from electromagnetic to static to computer relaying; Relay operating principles for computer relaying; Expected benefits of computer relaying, Computer relay architecture. Protection of Transmission Line using Computer Relaying Three zone protection of transmission line, algorithms for impedance calculations- Mann-Morrison algorithm - Three sample technique - Two sample technique - First and second derivative algorithms - Numerical integration methods. Protection of power system equipment using Frequency domain techniques Problems associated with differential protection of transformer and bus-bar, magnetic inrush current, LSQ algorithm, Fourier analysis of transformer protection

MODULE 2:

Introduction: Synchrophasor technology, advantages of synchrophasors over supervisory control and data acquisition (SCADA) system, challenges with synchrophasor measurement, world wide deployment of wide area measurement system (WAMS), application of synchrophasor data.

MODULE 3:

Phasor measurement units (PMUs) for wide area grid observability: Introduction, optimal placement of phasor measurement units (PMUs), need for optimal PMU placement for synchrophasors, algorithm for optimal PMU placement, observability index, optimal redundancy criterion.

MODULE 4:

WAMS based power network protection: WAMS architecture and communication, improved network protection during stressed conditions, online identification of protection element failure, adaptive protection.

MODULE 5:

Wide area security assessment: Introduction, state estimation, wide area severity index, data mining model, reliability evaluation and enhancement, situational awareness.

Text books:

1. A.G. Phadke, J.S. Thorp, 'Computer Relaying for Power Systems', John Wiley and Sons Ltd., Research Studies Press Limited, 2nd Edition, 2009.
2. A.G. Phadke, J.S. Thorp, 'Synchronized Phasor Measurements and Their Applications', Springer Publications, 2008
3. James Momoh**, "**SMART GRID: Fundamentals of Design and Analysis", IEEE (Power engineering series) – Wiley- Blackwell, April 2012.
4. D.K. Mohanta and J.B. Reddy (editors), "Synchronized phasor measurement for smart grid", Institution of Engineering and Technology 2017.

Course Evaluation: Individual assignment, Seminar before a committee, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements):

POs met through Gaps in the Syllabus:
Topics beyond syllabus/Advanced topics/Design:

POs met through Topics beyond syllabus/Advanced topics/Design:

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment

Assessment Tools	**% Contribution during CO Assessment**
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	**% Distribution**
3 quizzes	30 (3×10)
Assignment(s)	10
Seminar before a committee	10

Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD	**Course Delivery methods**
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Tutorials/Assignments
CD3	Seminars
CD4	Industrial visits/in-plant training
CD5	Self- learning such as use of NPTEL materials and internets
CD6	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	2	2	3	3	2
CO2	3	2	3	3	2	3
CO3	3	2	3	3	3	3
CO4	2	2	1	2	2	2
CO5	3	2	3	3	3	3

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Mapping Between COs and Course Delivery (CD) methods	
Course Outcome	**Course Delivery Method**
CO1	CD1, CD2, CD3,CD5
CO2	CD1, CD2, CD3,CD5
CO3	CD1, CD2, CD3,CD5
CO4	CD1, CD2, CD3,CD5
CO5	CD1, CD2, CD3,CD5

COURSE INFORMATION SHEET

Course code: EE 633
Course title: Power Quality
Pre-requisite(s): Power system courses, power electronics.
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 3
Class: M. Tech
Semester / Level: III
Branch: EEE
Name of Teacher:

Course Objectives

This course enables the students:

A.	To enumerate different standards of common power quality phenomena.
B.	To Understand power quality monitoring and classification techniques.
C.	To Investigate different power quality phenomena causes and effects.
D.	To Understand different techniques for power quality problems mitigation.

Course Outcomes

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

1.	Outline the various power quality phenomenons, their origin and monitoring.
2.	Analyze the significance of transient over voltages, their origin and mitigation methods.
3.	Analyze the impact of harmonic distortion and mitigation methods through filter design.
4.	Analyze the voltage regulation methods with distributed resources.
5.	Assess and integrate power quality issues for microgrids with distributed energy resources.

Syllabus

Module-I

Introduction–Overview of Power Quality–Concern about the Power Quality–General Classes of Power Quality Problems – Transients – Long-Duration Voltage Variations – Short-Duration Voltage Variation – Voltage Unbalance – Waveform Distortion – Voltage fluctuation – Power Frequency Variation – Power Quality Terms – Voltage Sags and Interruptions – Sources of Sags and Interruptions – Nonlinear loads. [8L]

Module-II

Transient Over Voltages – Source of Transient Over Voltages – Principles of Over Voltage Protection – Devices for Over Voltage Protection – Utility Capacitor Switching Transients – Utility Lightning Protection – Load Switching Transient Problems – Computer Tools for Transient Analysis. [8L]

Module-III

Harmonic Distortion and Solutions – Voltage vs. Current Distortion – Harmonic vs. Transients – Power System Quantities under Nonsinusoidal Conditions – Harmonic Indices – Sources of harmonics – Locating Sources of Harmonics – System Response Characteristics – Effects of Harmonic Distortion – Interharmonics– Harmonic Solutions Harmonic Distortion Evaluation – Devices for Controlling Harmonic Distortion – Harmonic Filter Design – Standards on Harmonics. [8L]

Module-IV

Long Duration Voltage Variations – Principles of Regulating the Voltage – Device for Voltage Regulation – Utility Voltage Regulator Application – Capacitor for Voltage Regulation – End-user Capacitor Application – Regulating Utility Voltage with Distributed Resources – Flicker. [8L]

Module-V

Distributed Generation and Power Quality – Resurgence of Distributed Generation – DG Technologies – Interface to the Utility System – Power Quality Issues – Operating Conflicts – DG on Low Voltage Distribution Networks – Interconnection standards – Wiring and Grounding – Typical Wiring and Grounding Problems – Solution to Wiring and Grounding Problems [8L]

Text Books:

1. Electrical Power Systems Quality, Dugan R C, McGranaghan M F, Santoso S, and Beaty H W, Second Edition, McGraw-Hill, 2002.
2. Power Quality Primer, Kennedy B W, First Edition, McGraw-Hill, 2000.

References:

1. Understanding Power Quality Problems: Voltage Sags and Interruptions, Bollen M H J,First Edition, IEEE Press; 2000.
2. Power System Harmonics, Arrillaga J and Watson N R, Second Editon, John Wiley & Sons, 2003.
3. Electric Power Quality control Techniques, W. E. Kazibwe and M. H. Sendaula, Van Nostrad Reinhold, New York.
4. Power Qualityc.shankaran, CRC Press, 2001.
5. Harmonics and Power Systems – Franciso C.DE LA Rosa-CRC Press (Taylor & Francis)
6. Power Quality in Power Systems And Electrical Machines-Ewald F. fuchs, Mohammad A.S. Masoum-Elsevier.

Course Evaluation: Individual assignment, Seminar before a committee, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements):

POs met through Gaps in the Syllabus:
Topics beyond syllabus/Advanced topics/Design:

POs met through Topics beyond syllabus/Advanced topics/Design:

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment

Assessment Tools	**% Contribution during CO Assessment**
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	**% Distribution**
3 quizzes	30 (3×10)
Assignment(s)	10
Seminar before a committee	10

Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD	**Course Delivery methods**
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Tutorials/Assignments
CD3	Seminars
CD4	Industrial visits/in-plant training
CD5	Self- learning such as use of NPTEL materials and internets
CD6	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	2	2	3	3	2
CO2	3	2	3	3	2	3
CO3	3	2	3	3	3	3
CO4	2	2	1	2	2	2
CO5	3	2	3	3	3	3

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Mapping Between COs and Course Delivery (CD) methods	
Course Outcome	**Course Delivery Method**
CO1	CD1, CD2, CD3,CD5
CO2	CD1, CD2, CD3,CD5
CO3	CD1, CD2, CD3,CD5
CO4	CD1, CD2, CD3,CD5
CO5	CD1, CD2, CD3,CD5

COURSE INFORMATION SHEET

Course code: EE 631
Course title: Power System Reliability Evaluation
Pre-requisite(s): Power system courses
Credits: L: 3 T: 0 P: 0 C: 3
Class schedule per week: 3
Class: M. Tech
Semester / Level: III
Branch: EEE
Name of Teacher:

Course objectives:
This course enables the students to:

1.	Define the concept of reliability of systems and reliability mathematics applicable to power systems
2.	To understand the different hierarchical levels of power system on reliability perspective
3.	Evaluate power system reliability using different techniques and available reliability parameters of systems.
4.	Propose on design modification to estimate the reliability enhancement

Course outcomes:

1.	To Interpret the general reliability concept and mathematics
2.	To relate the general reliability perspective with power system reliability
3.	To evaluate the different hierarchical levels of power system on reliability perspective
4.	To apply engineering knowledge and design techniques to prevent or to reduce the likelihood or frequency of failures at different hierarchical levels of power system
5.	To apply methods for estimating the reliability of new designs, and for analyzing reliability data.

Syllabus

Module 1:
Reliability Principles : Failure Rate Model , Concept of Reliability of Population, Mean Time to Failures, Reliability of Series, Parallel and Complex Systems, Standby System Modeling, Concepts of Availability

and Dependability, Reliability Measurement, General reliability function, Exponential distribution. [8L]

Module 2:
Power System Reliability in Perspective: Introduction, Need for Power system Reliability Evaluation, Definition of Power System Reliability, Functional Zones, Hierarchical Levels, Adequacy Analysis at different Hierarchical Levels, Typical reliability criteria, Reliability worth, Markov processes, System reliability using network and state space method. [8L]

Module 3:
Generating System Reliability Evaluation : Static Generating Capacity Reliability Evaluation: Introduction, Capacity outage probability tables, Loss of load probability (LOLP) method, Loss of energy probability (LOLE) method, Frequency and duration approach. Spinning Generating Capacity Reliability Evaluation: Introduction, Spinning capacity evaluation, Derated capacity levels. [8L]

Module 4:
Transmission System Reliability Evaluation: Average interruption rate method, the frequency and duration approach, Stormy and normal weather effects, The Markov processes approach, System studies. Direct Current Transmission System Reliability Evaluation: System models of failure, Loss of load approach, Frequency and duration approach, Spare -valve assessment, multiple bridge equivalents. [8L]

Module 5:
Composite System Reliability Evaluation Considering Interconnection: Service quality criterion, Conditional probability approach, Two-plant single load and two load systems. The probability array for two interconnected systems, Loss of load approach, Interconnection benefits. [8L]

Text Books:
1. Power System Reliability Evaluations - R. Billinton, Gordon and Breach Science Publishers, New York.
2. Reliability Modeling in Electric Power Systems, J. Endrenyi, John Wiley & Sons, New York.

Reference Books:
1. Practical Reliability Engineering, Patrick D.T. O'Connor, John Wiley & Sons, (Asia) Pte Ltd., Singapore.
2. Reliability of Engineering Systems - Principles and Analysis, I. Ryabinin, MIR Publishers, Moscow

Course Evaluation: Individual assignment, Seminar before a committee, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements):

POs met through Gaps in the Syllabus:
Topics beyond syllabus/Advanced topics/Design:

POs met through Topics beyond syllabus/Advanced topics/Design:

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

<u>Direct Assessment</u>

Assessment Tools	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	**% Distribution**
3 quizzes	30 (3×10)
Assignment(s)	10
Seminar before a committee	10

Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Continuous Internal Assessment					
Semester End Examination					

<u>Indirect Assessment</u>

1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD	**Course Delivery methods**
CD1	Lecture by use of boards/LCD projectors/OHP projectors
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CD5	Self- learning such as use of NPTEL materials and internets
CD6	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	3	2	2	2
CO2	3	3	3	3	2	2
CO3	3	3	3	3	2	2
CO4	3	3	3	3	3	2
CO5	3	3	3	3	3	3

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Mapping Between COs and Course Delivery (CD) methods	
Course Outcome	**Course Delivery Method**
CO1	CD1, CD2, CD3,CD5
CO2	CD1, CD2, CD3,CD5
CO3	CD1, CD2, CD3,CD5
CO4	CD1, CD2, CD3,CD5
CO5	CD1, CD2, CD3,CD5

4^{th} Semester

Program Core

EC650 Thesis (Part II) Credit: 16