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)

EEE Department M.E. Power Electronics PEOs

PEO1: To acquire in-depth knowledge of complex Electrical Engineering problems especially in Power Electronics to impart ability to discriminate, evaluate, analyze critically and synthesize knowledge pertaining to state of art and innovative research.

PEO2: To solve complex Power Electronics 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.

PEO3: To possess wisdom regarding group dynamics to efficaciously utilize opportunities for positive contribution to collaborative multidisciplinary engineering research and rational analysis to manage projects economically.

PEO4: To communicate with engineering community and society at large adhering to relevant safety regulations as well as quality standards.

PEO5: 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)

EEE Department M.E. Power Electronics POs
A student should be able to

PO1: Independently carry out research /investigation and development work to solve practical problems.

PO2: Write and present a substantial technical report/document.

PO3: 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 oneself to create, select and apply appropriate techniques and modern engineering and IT tools to solve complex Power Electronics 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

- **Engineering Knowledge**: Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.
- **Problem Analysis**: Identify, formulate, research literature and analyze complex engineering problems
  reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.
- **Design/ Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal and environmental considerations.
- **Conduct investigations of complex problems** using research-based knowledge and research methods including design of experiments, analysis and interpretation of data and synthesis of information to provide valid conclusions.
- **Modern Tool Usage**: Create, select 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.
- **The Engineer and Society**: Apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice.
- **Environment and Sustainability**: Understand the impact of professional engineering solutions in societal and environmental contexts and demonstrate knowledge of and need for sustainable development.
- **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice.
- **Individual and Team Work**: Function effectively as an individual, and as a member or leader in diverse teams and in multi-disciplinary settings.
- **Communication:** Communicate effectively on complex engineering activities with the engineering
  community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations and give and receive clear instructions.
- **Project Management and Finance**: Demonstrate knowledge and understanding of engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
- **Life-long Learning**: Recognize the need for and have the preparation and ability to engage in independent and life- long learning in the broadest context of technological change.

1st 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: 03 L:3 T:0 P:0 C: 03
Class schedule per week: 3 Lectures
Class: M.Tech.
Semester / Level: I/05
Branch: Electrical Engineering

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 by employing different 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.	Design digital IIR and FIR filters using filter approximation theory, frequency transformation techniques, and 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	Design FIR 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

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. Buttorworth, 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.Nagoor Kani, 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	H	M	L			
CO2	H	M	L	M		L
CO3	H	L	M	H		L
CO4	M	M	M	H	M	M

CO5	M	M	H	L	H	H

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

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: 03 L:3 T:0 P:0 C: 03
Class schedule per week: 03
Class: M.Tech.
Semester / Level: I/05
Branch: Electrical Engineering

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 modeling 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

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 Mc-graw Hill (**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):
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

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	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: EE507
Course title: ADVANCED POWER ELECTRONICS
Pre-requisite(s): Operating Principle of Semiconductor Devices
Credits: 03 L:3 T:0 P: 0 C: 03
Class schedule per week: 03
Class: M.Tech.
Semester / Level: I/05
Branch: Electrical Engineering

Course Objectives:

This course enables the students to:

1.	Recognize of different type of modern semiconductor based switching devices and their operating characteristics.
2.	Explain working principle of power converters and relate them with different area of application
3.	Capable to analyse closed loop control of electrical drives based on power converters.
4.	Differentiate between different control strategy of electrical drives in terms of dynamic parameters of system and overall efficiency.
5.	Evaluate performance evaluation, plan and design procedure for a complex power electronics based system.

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 converters and solve those using proper modifications. Identify potential area for power electronics applications.
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

Module I:

Power Electronic Devices: (Diodes, Thyristor), Transistors, MOSFET, IGBT, IGCT, etc. - operating principle, Static & dynamic characteristics, Data sheet ratings; Thermal characteristics of power devices; Sample Gate drive circuits

(8L)

Module II:

Switched Mode Power Supply:

Forward and flyback converter circuits: operation of flyback converter and waveforms analysis, operation of forward converter and waveforms analysis, Double ended forward converter, Push Pull converter, Half Bridge isolated converter, Full bridge isolated converter, Bidirectional power supplies ,small signal analysis of DC-DC converters and closed loop control.

(8L)

Module III:

PWM inverter modulation strategies & dual bridge: Sine wave with third harmonic, space vector modulation and predictive current control techniques; PWM rectifier; Input side bidirectional power flow requirement for regeneration & Dual Thyristor Bridge.

Multi- level inverter : Basic topology and waveform, Diode clamped multilevel inverter, Flying capacitor multilevel inverter, cascaded multilevel inverter improvement in harmonics and high voltage application, comparison of different multilevel inverters, application of multilevel inverters;

(8L)

Module IV:

Resonant Inverters: Operating principle of series resonant inverter, waveforms analysis, switching trajectory, losses and control, Operating principle of series resonant inverter with bidirectional switches, Frequency response of resonant series loaded, parallel loaded, and series parallel- loaded inverter, Parallel resonant inverter, ZCS resonant converter, ZVS resonant converter.

(8L)

Module V:

Introduction to application oriented chips: Industrial PWM driver chips for power supplies such as UC 3843, 3825 or equivalent; Industrial gate driver chips for PWM voltage source inverters with isolation and protection circuits. Intelligent power modules.

(8L)

Books recommended:

TEXT BOOK

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 BOOK

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) Application of artificial intelligence in power electronics.
(3) 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 adaptive algorithms in power electronics 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	H	H	M	M	M	L
CO2	H	H	H	H	M	M
CO3	H	H	H	H	H	M
CO4	H	H	H	H	H	H
CO5	H	H	H	H	H	H

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

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 Elective-I)

Course code: EE511
Course title: Optimization in Engineering Design
Pre-requisite(s):
Co- requisite(s):
Credits: 03 L:03 T:0 P:0 C: 03
Class schedule per week: 03
Class: M.Tech.
Semester / Level: I/05
Branch: Electrical Engineering

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 programs.

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

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

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

Topics beyond syllabus/Advanced topics/Design:
Genetic Algorithm based machine 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**
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	H		L	H		
CO2	H		L	H		L
CO3	H	L	M	H		L
CO4	H	M	M	H	M	M
CO5	H	H	H	H	H	H

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

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: EE521
Course title: Dynamic Behaviour of Electrical Machine
Pre-requisite(s): Electrical machine
Co- requisite(s): Linear Algebra
Credits: 03 L:3 T:0 P:0 C: 03
Class schedule per week: 03
Class: M.E.
Semester / Level: 01
Branch: Electrical Engineering

Course Objectives:

This course enables the students to:

1.	Understand the basic axis transformation
2.	Apply mathematical approach to model the machine in different frames
3.	Analyze the dynamic performance of the machine under transient and steady state
4.	Evaluate cost of practical design for controllers of rotating machine
5.	Design of optimal controller for controlling the speed and torque of the machine

Course Outcomes:

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

CO1	Understand of Kron's primitive machine
CO2	Apply the mathematical modeling for analysis of machine in different reference frame
CO3	Examine the transient behavior of the machine when subjected to sudden load change or during fault
CO4	Evaluate cost of practical design of such nonlinear machine for the design of industrial electrical drives
CO5	Design a high performance sensorless drive system with optimal dynamic response .

SYLLABUS

Module I:

Principles of Electromagnetic Energy Conversion and Introduction to Reference Frame Theory: General expression of stored magnetic energy, co-energy and force/torque, example using single and doubly excited system; Calculation of air gap mmf and per phase machine inductance using physical machine data; Voltage and torque equation of dc machine, three phase symmetrical induction machine and salient pole synchronous machines in phase variable form. Concept of two pole generalized machine, Rotating & transformer voltage, principle of Kron's primitive machine, transformation of three-phase to two-phase variables and it's vice versa, physical concept of park transformation,

(8L)

Module II:
Dc Machine Dynamic Analysis: Voltage and torque equations, modelling of different dc motor under normal motoring and fault condition, steady state analysis, state space and transfer function modelling, regenerative braking, counter current and dynamic braking (8L)

Module III:
Dynamic Modelling of IM: Dynamic direct and quadrature axis model in arbitrarily rotating reference frames, voltage and torque equations, derivation of steady state phasor relationship from dynamic model, Dynamic model state space equations, Dynamic modelling of high torque cage motors and single-phase IM. (8L)

Module IV:
Determination of Synchronous Machine Dynamic Equivalent Circuit Parameters: Dynamic d-q axis modelling of wound field SM, Voltage and torque equation with respect to arbitrary reference and rotating reference frame, steady-state analysis, Dynamic performance under load and torque variation, under fault condition. (8L)

Module V:
Especial Machine: Surface permanent magnet (square and sinusoidal back emf type) and interior permanent magnet machines, construction, operating principle and true synchronous characteristics, dynamic modelling and self-controlled operation: construction and operation of BLDC Motor, mathematical model of BLDC motor, commutation torque ripples, Impact

of motor inductance on the dynamic performance. Stepper motors operation, classification, features of stepper motor, operation of switched reluctance motor, expressions of torque. (8L)

Books recommended:

TEXT BOOK

1. P.S. Bimbra, Generalized Theory of Electric Machines, Khanna Publications, 7th Edition, Delhi, 2010
2. D.P. Kothari & I.J.Nagrath, Electric Machines-. A.R. Fitzgrald Electric Machinery-
3. Chee- Mun Ong, Dynamic Simulation of Electric Machinery using Matlab/Simulink
4. B.K. Bose, Modern Power Electronics and AC drives.

REFERENCE BOOK

1. Analysis of Electrical Machinery and drive systems- Paul C. Krause, Oleg Wasynczuk & Scott D. Sudhoff.
2. B. Adkins & R.G. Harley Generalized Theory of AC Machines.
3. Electric Drive- G.K. Dubey.

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

Gaps in the syllabus (to meet Industry/Profession requirements) :
Real times close loop for induction motor drive
POs met through Gaps in the Syllabus: PO5 & PO6

Topics beyond syllabus/Advanced topics/Design:
Assignment: Modeling and simulation of close loop control of zeta converter in MATLAB.

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

Course Code and name EE453 Design of Converters												
Course Outcomes/POs	**a**	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**	**l**
1.	H	H	H	H	H	L	L	L	L	L	L	L
2.	H	H	H	H	H	M	M	L	L	L	L	L
3.	H	H	H	H	H	M	M	M	M	L	L	L
4.	H	H	H	H	H	H	M	M	M	M	M	M
5.	H	H	H	H	H	H	H	H	H	H	M	M

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

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: EE523
Course title: Intelligent Motor Controllers
Pre-requisite(s): Soft Computing
Co- requisite(s):
Credits: 03 L:03 T:0 P:0 C: 03
Class schedule per week: 03
Class: M.Tech.
Semester / Level: I/05
Branch: Electrical Engineering

Course Objectives:
This course enables the students:

1.	To remember basic principle behind soft computing algorithms.
2.	To apply intelligent controllers for speed control of motors.
3.	To analyse the performance of adaptive controllers.
4.	To evaluate intelligent controller for electrical drives.
5.	To develop intelligent controller based large scale plants.

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

CO1	Remember basic algorithms of intelligent controllers such as Neural Network based controllers, fuzzy Logic Based Controllers etc.
CO2	Apply intelligent controllers for adaptive electrical drives.
CO3	Analyse the performance of intelligent controller based electrical drive in order to provide cost effective solutions for complex engineering problems which are cost effective.
CO4	Predict the potential area of application for intelligent controller for societal benefit
CO5	Design intelligent controller based plant and led a team of technically skilled people for installation of such controllers.

SYLLABUS

Module I:

Introduction: Introduction to non-linearity's of electric machine; Parameter sensitivity in electrical machine; Need of adaptive control in electric machine;

(8L)

Module II:

Artificial Neural Network: Block diagram of controller design using ANN ,Morden reference adaptive system (MRAS), Feed forward network, Multilayer perceptron model, Activation function, Supervised learning, Unsupervised learning, Supervised learning, Reinforcement learning, Back Propagation algorithm, Back Propagation neural architecture, K-means learning, Back propagation training, ANN based DC motor control, ANN based V/F control of induction motor, ANN based vector control, d-q model of induction machine , ANN based speed and torque control of induction motor.

(8L)

Module III:

Fuzzy Based Electric motor drive: Introduction to fuzzy sets, Properties of fuzzy sets, Membership function generation using intuitive method, Membership function generation using probability distribution function method, Membership function generation using Genetic Algorithm, Determination of ruled based for speed control, De-fuzzification method, Min max method, Average method, Centroid method, Fuzzy control of DC motor, Fuzzy control of AC motor, Fuzzy control of BLDC motor.

(8L)

Module IV:

ANFIS: Introduction to ANFIS, Application of ANFIS for DC motor, Application of ANFIS for scalar control for IM, Application of ANFIS for vector control for IM, Application of ANFIS for BLDC motor.

(8L)

Module V:

Kalman Filter: State estimation technique, Introduction to Kalman Filter, Mathematical analysis, Kalman filter for speed estimation, advantages and limitations

(8L)

Books recommended:

Text book:

1. "Neural Networks and Fuzzy Systems: A Dynamical Systems Approach to Machine Intelligence/Book and Disk" by Bart Kosko, Prentice Hall.
2. "Modern Power Electronics & Drives" by B K Bose

Reference Books:

1. "Fuzzy Logic with Engineering Applications" by Timothy J Ross, 3rd Edition, Wiley
2. "Kalman Filtering and Neural Network" by Simon Haykin, Wiley Series

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

Gaps in the syllabus (to meet Industry/Profession requirements :
Hardware based project using intelligent controller
POs met through Gaps in the Syllabus: PO6

Topics beyond syllabus/Advanced topics/Design:
Hardware based project using intelligent controller
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	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	H	H	H	M	M	L
CO2	H	H	H	H	M	M
CO3	H	H	H	H	M	M
CO4	H	H	H	H	H	M
CO5	H	H	H	H	H	H

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

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: EE525
Course title: MODELING OF POWER ELECTRONIC SYSTEMS
Pre-requisite(s): Power electronics and signals and system
Credits: 03 L:3 T:0 P:0 C: 03
Class schedule per week: 03
Class: M.Tech.
Semester / Level: I/05
Branch: Electrical Engineering

Course Objectives:

This course enables the students to:

1.	Model the power electronics converter
2.	Explain the working of various power converters and design issues
3.	Analyze of modern converters in island mode and grid mode
4.	Perform evaluation of designed converter for harmonics and ripple.
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	Remember the basic operation and modelling feasibility of power electronics system
CO2	Apply the knowledge of mathematics to design and understand the operation of power electronics system
CO3	Analyse the complexity of the system and effective approach to overcome the problem
CO4	Evaluate the system both in terms cost and reliability.
CO5	Design and model the power electronic converter with high performance in terms of stability ,reliability and performance

SYLLABUS

Module I:

Introduction to Modelling of Power electronics system: Modelling and control introduction for power converters and systems, Introduction to power electronics systems, Review of power converters basics, Basics of converters dynamics, Fundamentals of modelling and control of power converters.

(8L)

Module II:

Modelling and control oriented to converter-level design: Averaged switch modelling of DC DC converters, Small Signal analysis of various switching modes, Simulation-oriented modeling, Control loop design, Digital control design, Bond graph for modeling of DC DC converter, Lagrange method for modeling of dc dc converter.

(8L)

Module III:

Modern Rectifier: Power and Harmonics in Non-sinusoidal Systems, Pulse-Width Modulated Rectifiers: Modeling, analysis, and control of low-harmonic rectifiers Boost, fly back, and other topologies for controlling the input current waveform of an ac-dc rectifier Average-current, peak-current-mode, critical conduction mode, and nonlinear carrier control techniques Determination of rms currents, and comparison of performances of popular topologies System considerations. Modeling losses. Simulation

(8L)

Module IV:

Modelling and control of inverters: Inverter concepts and inverter topologies Basic Output Voltage Control: Square wave operation, Fundamentals of PWM modulation, Advanced Modulation Techniques Modelling and control of Single-Phase Voltage Source Inverters. Three- phase inverter with d-q control for renewable energy applications.

(8L)

Module V:

Real cases design: Buck converter with voltage mode control loop, Boost converter with average current mode control loop, Adapter for battery charge in mobile phone applications, Multiphase converter for high performance

(8L)

Books recommended:

TEXT BOOK

1. Abraham I.Pressman . Switching Power Supply Design. Mc Graw Hill. 1997
2. M.H. Rashid,"Power Electronics: Circuits, Device and Applications",2nd Ed.n, PHI, New Jersey, 1993
3. Mohan, Underland, Robbins; Power Electronics Converters, Applications and Design, 3rd Edn., 2003, John Wiley & Sons Pte. Ltd.
4. M. D. Singh, K. B. Khanchandani, "Power Electronics", 2nd Edn., Tata McGraw-Hill, 2007.

REFERENCE BOOK

1. K. Billings. Switching power supply handbook. Mc Graw Hill . 2011.
2 Kislovski, R. Redl, N. O. Sokal. Dynamic Analysis of Switching-Mode DC/DC Converters. Van Nostrand Reinhold. 2013

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

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

1. Practical implementation of modern converters
2. Design of modern converter in LT spice and MATLAB

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	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	H	H	M	M	M	L
CO2	H	H	H	M	M	M
CO3	H	H	H	H	M	M
CO4	H	H	H	H	H	M
CO5	H	H	H	H	H	H

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

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 ELECTIVE

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: 03 L:3 T:0 P:0 C: 03

Class schedule per week: 03
Class: M.E.
Semester / Level: XX/05
Branch: EEE

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

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)

.

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>

<u>POs met through Gaps in the Syllabus:</u>

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

Assignments: Regenerative Braking, Self -Driven HEV

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

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	H	H	M	M	M	L
CO2	H	H	H	M	M	L
CO3	H	H	H	H	M	M
CO4	H	H	H	H	H	M
CO5	H	H	H	H	M	H

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

COURSE INFORMATION SHEET

Course code: EE587
Course title: ELECTROMECHANICAL ENRGY CONVERSION
Pre-requisite(s):
Credits: L:3 T:0 P:0
Class schedule per week: 03

Class: M.Tech.
Semester / Level: I/05
Branch: Electrical Engineering

Course Objectives:

This course enables the students to:

1.	To explore the basic principles of transformer, dc and ac machines and analyse comprehensively their steady –state behaviours
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

Module I:

Basic Concepts of Electromechanical Energy Conversion:
Electromagnetic induction, flux linkage, 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- Star-star, Delta-delta, Star-delta, Delta-star.

(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, Swinburne's.

(8L)

Module IV:

Synchronous Machine: 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, Crossfield theory, Torque-speed characteristic, Equivalent circuit model.

(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	H	H	M	M	M	L
CO2	H	H	H	H	M	M
CO3	H	H	H	H	H	M
CO4	H	H	H	H	H	H
CO5	H	H	H	H	H	H

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

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: 03 L:3 T:0 P:0 C: 03
Class schedule per week: 03
Class: B.Tech.
Semester / Level: I/05
Branch: Electrical Engineering

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

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 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.

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 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	H	H	M	M	M	L
CO2	H	H	M	M	L	L
CO3	H	H	H	M	L	L
CO4	H	H	H	H	M	L
CO5	H	H	H	H	H	M

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

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

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: 03 L: 03 T: 0 P: 0 C: 03
Class schedule per week: 3
Class: M. Tech
Semester / Level: I/05
Branch: EEE

Course Objectives: The course objectives are

A.	Introduction to grid operation, necessity of making grid more smart, and basic components of today's grid.
B.	To extend knowledge on different design challenges with grid interfacing systems for Renewable Energy Sources.
C.	To illustrate the basics of the working principle of PMU and its application.
D.	To educate the students about communication protocol and its application in smart grid.
E.	To make the students understood about different demand response programmes.

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

1.	Demonstrate steps about building blocks of the smart grid.
2.	organise the steps involved in working principles of PMU and WAMS through PMUs
3.	Analysis the challenges involved with grid interactive converters connected with RES.
4.	Understand the design concept involved with demand response Programmes,

	communication standards, cyber security etc.
5	Aspire and confident for taking up challenge to adopt new technology needed for monitoring, control and operation of power system.

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

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

Test 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, Kithsiri Liyanage, 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):

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

Mapping between CO and PO

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	M	L	H	H	M	M
CO2	H	H	H	M	L	M
CO3	M	H	M	H	M	H
CO4	H	M	H	H	H	H
CO5	H	M	H	M	M	L

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

CD	**Course Delivery methods**	**Course Outcome**	**Course Delivery Method**
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1
CD2	Tutorials/Assignments	CO2	CD1
CD3	Seminars	CO3	CD1 and CD2
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		

COURSE INFORMATION SHEET

Course code: EE 597
Course title: Reliability Engineering
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: 03 L: 3 T: 0 P: 0 C: 03
Class schedule per week: 3 Classes per week
Class: M.Tech.
Semester / Level: I/05
Branch: Electrical Engineering

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:

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

Syllabus:

Module 1

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

Module 2

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 3

Network modelling 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 4

Discrete Markov chains and Continuous Markov processes: Introduction to Discrete 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 5

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:

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
(Programme Core)

Course code: EE506
Course title: Advanced Power Electronics Laboratory
Pre-requisite(s): Basics of signals and systems, transform methods, Filter theory.
Credits: 2 L: 0 T: 0 P: 04 C: 02
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”, 2ndEdn., Tata McGraw-Hill, 2007.

Reference Books:
1. R. Krishnan, “Electric Motor Drives: Modeling, Analysis and Control ”, 1stEdn., Prentice Hall,2001.
2. B. K. Bose, “Modern Power Electronics & AC Drives”, 1stEdn., Prentice Hall, 2001.
3. L. Umanand, “Power Electronics: Essentials & Applications”, 1stEdn. 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

2nd Semester
Program Core
COURSE INFORMATION SHEET

Course code: EE561
Course title: Embedded Control of Switching Power Converters
Pre-requisite(s): Power electronics,
Co- requisite(s):
Credits: 03 L:03 T:0 P: 0 C:03
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:

A.	Understand modeling and control power converters.
B.	Explain of PWM techniques the need for digital control
C.	Analyse of DPWM techniques and its implementation.
D.	Perform evaluation of close loop power converter
E.	Plan and design procedure for a complex power converter- based drives system.

Course Outcomes

After the completion of this course, students will be:

1.	*List the different PWM techniques for control.*
2.	*Associate with the architecture of DPWM*. *Show* suitability of a power converter for a particular application. *Solve* power management related problems with application of power electronics-based topologies.

3.	*Outline* shortcomings of analog PWM. *Identify the potential of DPWM in the control techniques*.
4.	*Estimate* the cost and long-term impact of control of power converters by DPWM on a large scale project of socio-economic importance.
5.	*Modify* existing power converter based. *Design a* new control topology for the control of power converter having superior performance. *Lead* or *support* a team of skilled professionals.

Syllabus

Module 1:
Introduction to power converters:
Introduction to switching power converters and emerging applications, such as dynamic voltage scaling, power amplifier, energy harvesting, etc.

(2 L)

Module 2:
Modelling and Control in PWM Switching Converters:
Introduction to basic DC-DC converter topologies, such as buck converter, boost converter, buck/boost converters, etc., PWM control techniques such as voltage mode control (VMC), current mode control (CMC); CCM and DCM operating modes, Modelling of PWM DC-DC converters, State-space averaging technique, small-signal modelling, Control challenges, limitations of analog control techniques and need for digital control in DC-DC converters

(10 L)

Module 3:
Digital Pulse Width Modulator (DPWM) Architecture and analysis:
DPWM architectures in DC-DC converters: Counter-based DPWM, tapped-delay line based DPWM, hybrid DPWM, segmented DPWM, Frequency domain analysis of digitally controlled DC-DC converters, special emphasis on effects of finite sampling and quantization, such as limit cycle oscillations, Discrete-time modelling and analysis for existence of sub-harmonic oscillations in DPWM DC-DC converters

(10 L)

Module 4:
Compensation Techniques in digitally controlled DC-DC converters:
Discrete-time compensation techniques in digitally voltage mode control, current mode control, and state-feedback control; Deadbeat control; Critical bandwidth formulation, compensator design for non-minimum phase converters, Auto-tuning in digitally controlled DC-DC converters such as Ziegler-Nichols tuning, relay-based tuning etc.

(10 L)

Module 5:
Non- linear control and embedded control implementation:
Sliding mode control in DC- DC converters, Time optimal control and physical limits in DC-DC converters. Introduction to Verilog HDL, Signal conditioning circuits: Selection of ADCs and DACs,

(8L)

Text Books (T):

- P.T. Krein, Elements of Power Electronics. New York: Oxford Univ. Press, 1998.

- R.W.Erickson and D. Maksimovic, Fundamentals of Power Electronics, 2nd ed . Dordrecht, The Netherlands: Kluwer, 2001.
- S. Banerjee and G. C. Verghese, Eds., Nonlinear Phenomenon Power Electronics: Attractors, Bifurcations, Chaos, and Nonlinear Control,New York: IEEE Press, 2001.
- F. Maloberti, "Data Converters", Springer, 2007
- Michael D. Ciletti, "Modeling, synthesis, and rapid prototyping with the Verilog HDL", Prentice Hall, 1999.
- V.Bobal, J.Bohm, and J.Fessl,"Digital Self-Tuning Controllers: Algorithms, Implementation and Applications"1 st Ed.,Springer,2005.
- Francesco Vasca, Luigi Iannell i,Eds,"Dynamics and Control of Switched Electronic Systems:Advanced
- Perspectives for Modeling, Simulation and Control of Power Converters", Springer,1st Ed.,2012

Reference Books (R):

- Fundamental of Electrical Drives: G K Dubey
- Electric Motor Drives, modelling analysis and control: R Krishnan
- Power Electronics: Circuits, Devices, and Applications:MH.Rashid

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

Controller implementation using fixed point arithmetic

POs met through Gaps in the Syllabus: PO5

Topics beyond syllabus/Advanced topics/Design

VHDL programming and FPGA based Prototyping

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					

<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	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	3	3	2	2	2	1
CO2	3	3	3	3	2	2
C03	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: EE557
Course title: Power Electronics Application
Pre-requisite(s): Power electronics
Co- requisite(s):
Credits: 03 L: 03 T: 0 P: 0 C: 03
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:

A.	Understand advanced concepts of various power electronics applications like HEV, HVDC and FACTS.
B.	Apply advanced concepts for analysis of existing power electronics based systems.
C.	Analyze power electronics topology of advance power electronics applications.
D.	Evaluate performance parameters of modern industrial chips for power electronics.
E.	Design methods for development and execution of new power electronics based installation

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

1.	Describe working principles of advanced power converters.
2.	Solve problems in existing power electronics based system using advanced concepts
3.	Analyze performance parameters of state of art of power electronic technology.
4.	Evaluate and design new type of converters for utilization of renewable energy.
5.	Aspire for pursuing a carrier in power electronics, 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

Module 1

Scope of Power electronics on modern world, Overview of Triac High Power Switches, GTO, Power BJT , Power MOSFET , IGBT , MCT and IGCT, Feature of Converter of Power Electronics Electric Vehicles: Introductions, Advantages ,types of electrical vehicle, Energy management in electrical vehicles, features various subsystem in electrical vehicles. Limitations of of EV, Future scopes.

(8L)

Module 2

Hybrid Electrical Vehicles:

Introduction, Types of hybrid electrical vehicle, series, parallel, series-parallel and complex According to hybridization, Micro, mild and heavy HEV, Road load, Aerodynamics Drag, Rolling Resistance, Climbing force , Mechanical power splitter and electrical power splitter advantages and disadvantages, sizing of series and HEV, Power flow, Battery and ultracapacitor.

(8L)

Module 3

Power Electronics for Green Energy:

Solar and Wind Energy, Buck-boost Converter, CUK converter, Single and Three phase boost inverter.Power Factor Correction devices:Extinction angle control, symmetrical angle control, PWM control, single and Three phase sinusoidal PWM control, Series and Parallel conversion of rectifiers.

(8L)

Module 4

Flexible AC transmission systems (FACTS):

Introduction, principle of Power transmission series and shunt power compensation, Description of: TCR, TSC, SVC, STATCOM, TSSC, Comparison of Compensators.

(8L)

Module 5

HVDC Transmission and Power Quality Management:

Introduction, advantages-Disadvantage of HVDC, type of HVDC Links, Monopolar, Bipolar, Homopolar Configuration,12-pulse converter in HVDC, Series and Parallel Converter.

(8L)

Text books:

1. Understanding FACTS**:** concepts and technology of flexible AC transmission systems Narain G. Hingorani, Laszlo Gyugyi ,IEEE Press, 2000

2. Muhammad H. Rashid, "Power Electronics - Circuits, Devices and Applications", Prentice -Hall of India Private Ltd. New Delhi

3. Rao, S.,"EHVAC and HVDC Transmission", Khanna Publishers, 1991.

Reference books:

1. Rai, G.D.,"Solar Energy Utilisation", Khanna Publishers, New Delhi, 1991.

2. Gray.L.Johnson, "Wind energy systems", Prentice Hall Inc., 1985

Course Evaluation:

Individual assignment, Theory (Quiz and End Semester) examinations

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

Practical design of converters using power electronics converter.

POs met through Gaps in the Syllabus:PO5

Topics beyond syllabus/Advanced topics/Design:

Assignments: Three phase grid connection.

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 Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

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

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

Mapping Between COs and Course Delivery (CD) methods

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: EE559
Course title: Control of Electric Drives
Pre-requisite(s): Power electronics and Machine
Co- requisite(s):
Credits: 03 L: 03 T: 0 P: 0 C: 03

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:

A.	Understand different types of electrical drives system.
B.	Explanation of working principle of power converters and relate them with different types of drives system
C.	Analysis of closed loop control of electrical drives based on power converters.
D.	Differentiation between different control strategy of electrical drives in terms of dynamic parameters of system and overall efficiency.
E.	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:

1.	*List* different types of electrical drives.
2.	*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.
3.	*Outline* shortcomings of each class of conventional drives control strategy and *solve* them using proper modifications. *Identify* potential area for power electronics applications.
4.	*Estimate* the cost and long term impact of power electronics based drives technology on a large scale project of socio-economic importance.
5.	*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 operation, referred inertia and load torque for different coupling mechanism, thermal selection of machines

(4L)

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.

(12L)

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

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 Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

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

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

Mapping Between COs and Course Delivery (CD) methods:

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

Program Elective II
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.
Co-requisite (s):
Credits: L: 03 T: 0 P: 03 C: 03
Class schedule per week: 04
Class: M.Tech
Semester/level: II/05
Branch: EEE
Name of Teacher:

Course Objectives:

This course enables the students to:

A	Understand the basic of Soft Computing Techniques.
B.	Acquainted with the solving methodology of soft computing technique in power systems operation and control.
C.	Analysis of ANN based systems for function approximation in application to load forecasting.
D.	Evaluate fuzzy based systems for load frequency control in power systems.
E.	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:

1.	Identify the soft computing techniques and their roles in building intelligent machines.
2.	Recognize an appropriate soft computing methodology for an engineering problem.
3.	Apply fuzzy logic and reasoning to handle uncertainty while solving engineering problems.
4.	Analysis of neural network and genetic algorithms to combinatorial optimization problems.
5.	Classify neural networks to pattern classification and regression problems and evaluate its impotance 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:

1. Neural 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 Aggarwal, Artificial intelligence techniques in power systems. IEE Power Engineering Series-22.

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: EE581
Course title: Advanced DSP Architecture and Programming
Pre-requisite(s): Digital Signal Processing
Co- requisite(s):
Credits:03 L: 03 T:0 P: 0 C: 03
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:

A.	Understand of different architecture of DSP processors.
B.	Apply DSP processors for signal processing.

C.	Analyse a program and optimize it for fast execution in real time.
D.	Creativity to design a real time signal processing unit based on architecture of a DSP processor.
E.	Design adaptive signal processing based application.

Course Outcomes

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

1.	Remember different architectures of DSP processors.
2.	Explain various steps of process involving execution of software-based project.
3.	Analyse different component of DSP processor in order to optimize the code.
4.	Estimate the cost of DSP processor-based application.
5.	Realize the need of continuous learning in order to create state of ART signal processing application based on advanced mathematical tools.

Syllabus

Module 1

Introduction to DSP processor programming:
DSP Development System: Introduction to DSP, Example of DSP system A to D signal conversion, DSP support tools, code composer studio, compiler, assembler and linker, input and output with the DSK.

(8L)

Module 2

Programming of C6000 Series Processors:
Architecture of C6x Processor: Introduction TMS320 C6x architecture, functional units, fetch and execute packets, pipe lining, registers, Linear and circular addressing modes, Instruction Set of C6x Processor: Instruction set assembly directives, linear assembly, ASM statement within C, timers, interrupts, multi channel buffering serial ports, direct memory access, memory consideration, fixed and floating points format, code improvement and constraints.

(8L)

Module 3

Programming of FIR Filters:
Real Time FIR Filtering: Design of FIR filter, FIR lattice structure, FIR implementation using fourier series, windows function, programming examples using C language,

(8L)

Module 4

Programming of IIR Filters:
Real Time IIR Filtering: Design of IIR filter, IIR lattice structure, impulse invariance, bilinear transformation programming examples using C language.

(8L)

Module 5

Programming of FFT Algorithm:

Fast Fourier Transform: Introduction, DIT FFT algorithm with Radix 2, DIF FFT algorithm with Radix 2, inverse fast Fourier transform, fast convolution, programming example using C language, Real Time Data Exchange (RTDX), Applications of WAVELETs

(8L)

Text Book:

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

Reference Book:

1. Antonious, Digital Filter Design, Mc-Graw-Hill International Editions.
2. Wavelet Transform, S. Rao.
3. Wavelet Analysis: "The scalable structure of Information" Springer 2008 – Howard L. Resinkoff, Raymond O. Wells.

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

Practical Implementation of IIR and FIR Filters.

POs met through Gaps in the Syllabus: PO3

Topics beyond syllabus/Advanced topics/Design:

Assignments: Practical Implementation of band pass filter IIR and FIR Filters

POs met through Topics beyond syllabus/Advanced topics/Design:PO3

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 Method

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 Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

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

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

Mapping Between COs and Course Delivery (CD) methods:

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: EE583
Course title: Renewable Sources of Electrical Energy and Grid Integration

Pre-requisite(s): Power Electronics and Power System
Co- requisite(s):
Credits: 03 L: 03 T: 0 P: 0 C: 03
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	Analyze maximum generation from SPV, and it’s 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:

Upon completion of the course, student will be able to:

1	Articulate the basic operation of different renewable sources and storage method of electrical energy
2	Develop the mathematical modelling of SPV with controllers and design the controllers.
3	Explain mathematical modelling of Wind turbine system and devise the controllers.
4	Carry out the designing power converters and controllers in grid interactive mode.
5	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 modelling 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.

(5L)

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

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
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

Mapping between CO and PO

	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

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 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): Fundamental of Electronic Devices
Co- requisite(s):
Credits: 03 L: 03 T: 0 P: 0 C: 03
Class schedule per week: 03
Class: M.Tech
Semester / Level: II/05
Branch: EEE

Course Objectives

This course enables the students to:

A.	Comprehend the basic functions, structure, concept and definition of embedded systems.
B.	Interpret ATMEGA8 microcontroller, FPGA & CPLD, TMS320C6713 processors in the development of embedded systems.
C.	Correlate different serial interfacing protocols (SPI, TWI, I2C, USART).
D.	Interface different peripherals (ADC, DAC, LCD, motors).

E.	Evaluate design cost of any given embedded system application.

Course Outcomes

After the completion of this course, students will be:

1.	Visualize the basic elements and functions of ATMEGA8 and FPGA/CPLD in building an embedded system.
2.	Work with modern hardware/software tools (Xilinx project navigator for synthesis of VHDL codes) for building prototypes of embedded systems.
3.	Interface various sensors, ADC, DAC, LCD, stepper motors with FPGA/CPLD and ATMEGA8.
4.	Employ various bus protocols like SPI, TWI, I2C for interfacing peripherals.
5.	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.

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

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 Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

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

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

Mapping Between COs and Course Delivery (CD) methods

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

Program Core
Course Information Sheet

Course code: EE560
Course title: Electric Drive Lab
Pre-requisite(s): Electrical Machines, Power System, Power Electronics, MATLAB
Credits: 02 L: 0 T: 0 P: 04 C: 2
Class schedule per week: 4
Class: M.Tech.
Semester / Level: II/05

Branch: Electrical Engineering
Name of Teacher:
Class schedule per week: 3
Course Objectives:

This course enables the students to:

A.	Understand system dynamics of machines, power electronics and power system
B.	Observe speed control of DC motor , induction motors drives , BLDC motor and generator speed control for arresting the frequency of power system network
C.	Discriminate and predict the change in dynamics owing to various disturbances
D.	Design the proper controller to achieve time domain and frequency domain specifications
E.	Evaluate the performance of close loop controlled electric drive in terms of cost and efficiency.

Course Outcomes:

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

1.	List different MATLAB blocks required for power electronics and machine simulation.
2.	Relate the concepts of power electronics in the simulation domain.
3.	Analyze simulation models in the field of power conversion and transmission
4.	Evaluate accuracy of simulation based systems as compared to real system
5.	Design complex systems in simulation environment and lead a team of experts in power electronics and electrical drives system.

1	**Four Quadrant Chopper based 1H.P. DC motor drive with closed loop speed control.** *Objective:*	
	i	*Dynamic analysis of speed curve under no load and load condition.*
	ii	*Analysis of speed with respect to duty cycle.*
2	**Class C-Chopper based 1H.P. DC motor drive open loop speed control**	
	i	Dynamic analysis of speed curve under no load and load condition.
	ii	Analysis of speed with respect to duty cycle.
3	**Single phase fully controlled rectifier based DC drive using microcontroller**	
	i	*Design logic for firing scheme for rectifier.*
	ii	*Dynamic analysis of speed curve under no load and load condition.*
	iii	*Derive experimental relationship between firing angle and speed.*
4	**LabVIEW based semi-controlled rectifier fed DC drive**	
	i	*Design logic for firing scheme for rectifier in LabVIEW*
	ii	*Dynamic analysis of speed curve under no load and load condition.*
	iii	*Derive experimental relationship between firing angle and speed.*
5	**Real time flux estimation of three phase induction motor using LabVIEW.**	
	i	*Mathematical implementation of flux estimation using LabVIEW.*
	ii	*Estimation of torque*
6	**Microcontroller (DSPIC) based V/F ratio based control of three phase induction motor**	
	i	*Getting acquainted with DSPIC microcontroller*
	ii	*Experimental verification of V/F ratio for different speed command*
7	**Arduino microcontroller based position control of servo motor.**	

	i	*Design logic for position control of servo motor*
	ii	*Derive experimental relationship between duty cycle and angular position.*
8	**dSPACE based constant V/F ratio based induction motor drive in closed loop.**	
	i	*Design logic for gate pulse for three phase inverter in accordance with V/F speed control algorithm*
	ii	*Observation of speed in open loop*
9	**Mini Project: Mathematical modeling and simulation**	
	i	*Mathematical modeling of a system as given in assigned project*
	ii	*Simulation of assigned project*
10	**Mini Project: Hardware implementation**	
	i	*Prototype of assigned project for testing*
	ii	*PCB Layout of the developed circuit topology*

Text Books:

1. P.S. Bimbhra, Generalised Theory of Electric Machines, Khanna Publications, 7th Edition, Delhi, 2010
2. M.H. Rashid, Power Electronics, PHI,

Reference Books:

1. B K Bose: Modern Power Electronics and A C Drives, PHI , Delhi
2. G K Dubey, Fundamental of Electric Drives, 2nd Edition, PHI, Delhi.
3. C.M. Ong, Dynamic Simulation of Electric Machinery, PH, NJ.

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

Hardware design of close loop control of motor drives

POs met through Gaps in the Syllabus: PO6

Topics beyond syllabus/Advanced topics/Design

Group assignments on practical use of power electronics in industry.

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 (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

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

< 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

Course Information Sheet

Course code: EE558
Course title: Power Electronics Simulation Lab
Credits: 02 L: 0 T: 0 P: 4 C: 02
Class schedule per week: 4
Class: M.Tech.
Semester / Level: II/05
Branch: Electrical Engineering
Name of Teacher:

Class schedule per week: 3 classes per week
Course Objectives:
This course enables the students to:

A	Understand system dynamics of machines, power electronics and power system;
B	Observe speed control of DC motor, induction motors drives, BLDC motor
C	Discriminate and predict the change in dynamics owing to various disturbances
D	Design the proper simulation model of complex power electronics system.
E	Evaluate the performance of actual system and simulation model.

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

1.	List different MATLAB blocks required for power electronics and machine simulation.
2.	Relate the concepts of power electronics in the simulation domain.
3.	Analyze simulation models in the field of power conversion and transmission
4.	Evaluate accuracy of simulation based systems as compared to real-system
5.	Design complex systems in simulation environment and lead a team of experts in power electronics and electrical drives system.

LIST OF EXPERIMENTS:
1. Name: Modelling and simulation of 2nd order RLC series circuit with step input.
Aim: (a) To find solution to 2nd order system mathematically
(b) Verify mathematical solution with simulation response
2. Name: Simulate the open loop control of unsaturated DC motor. Find torque, speed and armature current response.
Aim: (a) Develop transfer function model of DC machine
(b) Obtain speed, torque and armature current response for step excitation.
3. Name: Simulate the closed loop control of unsaturated DC motor. Obtain speed response.
Aim: (a) Determine gain of controller for speed loop.
(b) Observe dynamic parameters of DC machine with closed loop along-with controller.
4. Name: Simulate current control for closed loop model of separately excited DC motor.
Aim: (a) Determine gain of controller for current loop inside speed loop.
(b) Observe dynamic parameters of DC machine with closed loop along-with controller.
5. Name: Simulate Unipolar and Bipolar PWM techniques for VSI.
Aim: (a) Develop Unipolar PWM generator block.
(b) Develop bipolar PWM generator block and observe difference in load voltage waveform.
6. Name: Simulate open loop and closed loop response of a Boost converter.
Aim: (a) Develop Mathematical Model of Boost Converter.
(b) Simulate boost converter using MATLAB/Simulink.
7. Name: Design a flux estimator for direct torque control of 3 phase induction motor.
Aim: (a) Develop mathematical equation for flux estimation

(b) Implement mathematical equation using computational block of MATLAB

8. Name: Simulate a 3 phase pulse width modulated inverter with 3 phase induction motor load and observe its performance.

Aim: (a) Develop three phase sine pulse width modulated gate pulses

(b) Observe dynamic parameters of Induction machine with closed loop along with controller

9. Name: Simulate a 3 phase torque estimator for induction motor and obtain waveforms.

Aim: (a) Develop mathematical equation for flux estimation

(b) Implement mathematical equation using computational block of MATLAB

10. Name: Simulate and obtain response of a CUK regulator.

Aim: (a) develop output voltage and output current expression.

(b) Verify Input and Output voltage and current waveform using MATLAB based Simulink.

Text Books:

3. P.S. Bimbra, Generalised Theory of Electric Machines, Khanna Publications, 7th Edition, Delhi, 2010
4. M.H. Rashid, Power Electronics, PHI,

Reference Books:

4. B K Bose: Modern Power Electronics and A C Drives, PHI , Delhi
5. G K Dubey, Fundamental of Electric Drives, 2nd Edition, PHI, Delhi.
6. C.M. Ong, Dynamic Simulation of Electric Machinery, PH, NJ.

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations.

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

1. Design of real-time industrial projects.

POs met through Gaps in the Syllabus: PO6

Topics beyond syllabus/Advanced topics/Design

Group assignments on practical use of power electronics in industry.

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
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 of Course Outcomes onto Program Outcomes

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

< 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

EE600 Thesis (Part I) **Credit: 8**

COURSE INFORMATION SHEET

Course code: EE 603
Course title: Power Electronics System Design
Pre-requisite(s): Power electronics and Machine
Co- requisite(s):
Credits: 03 L:03 T:0 P:0 C:03
Class schedule per week: 03
Class: M.Tech.
Semester / Level :03/6th
Branch: EEE

Course Objectives

This course enables the students to:

A.	Understand different types of active and passive components of power electronics based topology
B.	Explain methods of components selection and switching devices.
C.	Analyse power electronic system under practical design constraints.
D.	Apply control algorithms on power converter based complex electrical systems
E.	Perform evaluation, planning and design a complex power electronics based system.

Course Outcomes

After the completion of this course, students will be:

1.	List different types of semiconductor devices and components as well as remember their operating characteristics. Explain working principle of different semiconductor devices.
2.	Demonstrate suitability of a power converter for a particular application. Solve power management related problems with application of power electronics based topologies.
3.	Outline shortcomings of each class of power converters and solve them using proper modifications. Identify potential area for power electronics applications.
4.	Estimate the cost and long term impact of power electronics technology on a large scale project of socio-economic importance.
5.	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**: Design and selection of passive and active components. Design of Driver circuits and commutation circuits**
Design of low power single phase step down transformers, inductors (choke) and filter circuits, Selection of switching devices for specific applications, Design of snubber circuit for

them. Driver circuits for Thyristor, BJT, MOSFET/IGBT, design of commutation circuits for forced commutated converter, selection of current, voltage and speed sensor for complete close loop system design.

(8L)

Module 2: **AC/DC converter design:**
Diode based single phase half & full converter, Three-phase converter, Thyristor based half and full converter, selection of power components & filter design, different schemes for firing circuits.

(8L)

Module 3**: DC/DC Switched mode converter design:**
Design of chopper based Buck converter, Boost converter, Buck-Boost converter; Isolated converter, Flyback converter, Schemes for firing circuits

(8L)

Module 4: **DC/AC converter design:**
Single phase half, full and three phase square wave inverters, Three phase Voltage source inverter, Fourier analysis of output voltage waveform, selection of active and passive components and their ratings, Design of firing circuit.

(8L)

Module 5: **SMPS and Thermal Design**
System specification, Block diagram of SMPS, Design of PFC booster, Full bridge zero voltage transition converters, Single and three phase synchronous buck converter, Auxiliary power supply etc. Thermal problems in power electronics, Understanding of General thermal flow process, Design of heat sink, selection of cooling techniques.

(8L)

Text Books (T):

1. Power Electronics: essentials and applications - L Umanand, TMH, New Delhi.
2. Microchip SMPS AC/DC Reference Design, User's Guide.
3. Power Electronics- Applications, Converters and Design- Ned Mohan, John Wiley

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 Boost Converter

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

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids

Industrial/guest lectures
Industrial visits/in-plant training
Self- learning such as use of NPTEL materials and internets
Simulation

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

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	PO1	PO2	PO3	PO4	PO5	PO6
1	H	H	M	M	M	L
2	H	H	H	M	M	L
3	H	H	H	H	M	M
4	H	H	H	H	H	M
5	H	H	H	H	H	H

Mapping Between COs and Course Delivery (CD) methods				
CD	**Course Delivery methods**		**Course Outcome**	**Course Delivery Method**
CD1	Lecture by use of boards/LCD projectors/OHP projectors		CO1	CD1
CD2	Tutorials/Assignments		CO2	CD1
CD3	Seminars		CO3	CD1 and CD2

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			

COURSE INFORMATION SHEET

Course code: EE 604
Course title: Power Converter Design Laboratory
Credits: 02 L: 0 T:0 P: 04 C: 02
Class schedule per week: 4
Class: M.Tech.
Semester / Level: III/06
Branch: Electrical Engineering
Name of Teacher:
Class schedule per week: 4

Course Objectives:
This course enables the students to:

I	List different Real Time processors required for power electronics and drives application.
II	Mathematical model different converters.
III.	Analyze simulation models in the field of electrical drives, power conversion and transmission.
IV	Evaluate accuracy of simulation based systems as compared to real-system
V.	Design hardware model of complex systems and lead a team of experts in power electronics and electrical drives system.

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

CO1.	List different DSPACE and OPALRT blocks required for power electronics and drives simulation as well as control.
CO2	Develop State Space Model of power converters.
CO3.	Analyze simulation models for evaluating dynamic performance parameters.
CO4.	Evaluate accuracy of simulation based systems as compared to hardware based prototype.
CO5.	Design hardware based complex systems and lead a team of experts in power electronics and electrical drives system.

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LIST OF EXPERIMENTS:

1. Name: Mathematical modelling of a Boost Converter and controller design.
Aim: (a) To develop state space model in DCM and CCM
(b) Obtain controller gains for obtaining particular time domain specifications.
2. Name: Simulate the closed loop control of Boost Converter with computed controller gains.
Aim: (a) Simulate developed State Space model to find step response
(b) Obtain frequency domain response using MATLAB
3. Name: Develop the firing circuit and power circuit of Boost Converter
Aim: (a) Design optically isolated firing circuit for Boost converter on a varo-board.
(b) Design power circuit on a varo-board using Power MOSFET
4. Name: Conduct experiment on hardware model of Boost converter to obtain efficiency vs duty cycle curve.
Aim: (a) Determine boost factor vs duty cycle curve
(b) Observe dynamic parameters in time domain and compare it with simulated result.
5. Name: Mathematical computation for filter design of a 3 Phase voltage source inverter.
Aim: (a) Obtain Fourier transform of Line voltage and phase voltage waveform.
(b) Compute the value of inductor and capacitor for filter design.
6. Name: Simulate 3 Phase VSI with filter and obtain filter response in terms of improvement in THD
Aim: (a) Simulate 3 Phase VSI without and with filter and obtain THD in each case.
(b) Implement Selected harmonics elimination based PWM technique in MATLAB environment.
7. Name: Design firing circuit of 3 phase VSI.
Aim: (a) Develop hardware model of firing circuit for 3 Phase VSI
(b) Interface Microcontroller and Gate terminal of Switches with correct biasing.
8. Name: Design Power Circuit of a 3 phase VSI
Aim: (a) Develop three phase VSI hardware on varo-board
(b) Design hardware of filter circuit
9. Name: Perform experiment on 3 phase VSI.
Aim: (a) Obtain MI vs RMS line voltage
(b) Obtain THD vs Carrier Frequency curve
10. Name: Simulate and obtain response of a CUK regulator.
Aim: (a) develop output voltage and output current expression.
(b) Verify Input and Output voltage and current waveform using MATLAB based Simulink.

Text Books:

1. P.S. Bimbra, Generalised Theory of Electric Machines, Khanna Publications, 7th Edition, Delhi, 2010
2. M.H. Rashid, Power Electronics, PHI,

Reference Books:

3. B K Bose: Modern Power Electronics and A C Drives, PHI , Delhi
4. G K Dubey, Fundamental of Electric Drives, 2nd Edition, PHI, Delhi.
5. C.M. Ong, Dynamic Simulation of Electric Machinery, PH, NJ.

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

Gaps in the syllabus (to meet Industry/Profession requirements):
1. Design of real-time industrial projects.
POs met through Gaps in the Syllabus PO6
Topics beyond syllabus/Advanced topics/Design
Group assignments on practical use of power electronics in industry.

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
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 of Course Outcomes onto Program Outcomes

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

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

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

Program Elective III

COURSE INFORMATION SHEET

Course code: EE 621
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	**% 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 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

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

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/PO	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 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: L: 3 T: 0 P: 0 C: 3
Class: M.Tech.
Semester / Level: III/05
Branch: Electrical Engineering
Course Objectives
This course enables the students to:

1	Identify the significance of HVDC System and its components;
2	Understanding the AC/DC 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

1. Padiyar, K.R., 'HVDC transmission systems', Wiley Eastern Ltd., 2010.
2. Kimbark, E.W., 'Direct Current Transmission-vol.1', Wiley Inter science, New York, 1971.
3. Hingorani,L.Gyugyi,'Concepts and Technology of Flexible AC Transmission System', IEEE Press New York, 2000 ISBN –078033 4588.
4. 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:

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

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

4th Semester
Programme Core

EE650 Thesis (Part II) **Credit: 16**