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 appropriate technology with responsibility.
- Creation of congenial atmosphere and ample research facilities for undertaking quality research to achieve national and international recognition by faculty and students.
- To strive for internationally recognized publication of research papers, books and to obtain patent and copyrights.
- To provide excellent technological services to industry for the benefit of society.

Programme Educational Objectives (PEOs)

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

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

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

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

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

Graduate Attributes (GAs)

GA 1: Scholarship of Knowledge

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

GA 2: Critical Thinking

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

GA 3: Problem Solving

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

GA 4: Research Skill

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

GA 5: Usage of modern tools

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

GA 6: Collaborative and Multidisciplinary work

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

GA 7: Project Management and Finance

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

GA 8: Communication

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

GA 9: Life-long Learning

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

GA 10: Ethical Practices and Social Responsibility

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

GA 11: Independent and Reflective Learning

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

PROGRAM OUTCOMES (POs) for ME

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

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

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

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

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

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

Course Structure & Syllabus

Postgraduate Programme

(Power Electronics)

Department of Electrical & Electronics Engg.

Birla Institute of Technology

Mesra, Ranchi-835215

Course Structure

Program: Master of Engineering

(Power Electronics)

Electrical & Electronics Engineering

Appendix II Syllabus

Course code: MEE1103
Course title: Advanced Digital Signal Processing

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

Class schedule per week: 3classes per week

Course Objectives:

This course enables the students to:

I. 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.;
II. Determine transfer function, impulse response and comment on various properties like linearity, causality, stability of a system;
III. Predict time and frequency response of discrete-time systems using various techniques like Z-transform**,** Hilbert transform**,** DFT, FFT;
IV. Design digital IIR and FIR filters using filter approximation theory, frequency transformation techniques, and window techniques and finally construct different realization structures.

Course Outcomes:

At the end of the course, student will be able to-

I. State sampling theorem and reproduce a discrete-time signal from an analog signal; acquire knowledge of multi rate digital signal processing, STFT and wavelets.
II. Classify systems based on linearity, causality, shift-variance, stability criteria and represent transfer function of the selected system;
III. Evaluate system response of a system using Z-transform, convolution methods, frequency transformation technique, DFT, DIF-FFT or DIT-FFT algorithm, window techniques;
IV. 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.
V. Construct (structure) and recommend environment-friendly filter for real- time applications.

Syllabus

Module-1

Introduction: Discrete time systems, Discrete time signals, Analysis of discrete-time linear time invariant systems, Difference equation description.

Module-2

Z-transform, Properties of Z-transform, Inverse of Z-transform, Chrip Z-transform, Zury's test for stability, Digital filter structures: Direct form I & II, Cascade, Parallel and ladder realizations.

Module-3

Frequency domain analysis, Discrete Fourier transform (DFT), Properties of DFT, Inverse DFT, Inter relationship with z-transform and Hilbert-transforms, Discrete Hilbert transform, FFT algorithms- Decimation in time and decimation in frequency.

Module-4

Filter function approximation and transforms: Review of approximation of ideal analog filter response. IIR filter: Designs based on analog filter approximation impulse invariant, Bilinear transformation, Direct design of IIR filters, Time domain design techniques. Butterworth, Chebyshev type I & II, Elliptical filters.

Module-5

Properties and design of FIR filters: Properties, Design techniques - window technique, Frequency sampling comparison of IIR and FIR filters.

Module-6

Multirate digital signal processing, Introduction, Decimation by factor D, I sampling rate conversion by a rational factor I/D.

Module-7

Introduction to continuous discrete and fast wavelet transforms. Families of Wavelets: orthogonal and biorthogonal wavelets, Daubechie's family of wavelets in detail.

Text Books:

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.
3. Raghuveer M. Rao, Ajit S. Bopardikar, "Wavelet Transforms: An Introduction.

Reference Book:

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

Course code: MEE1101
Course title: Modern Control Theory

Credits:	L	T	P	C
	3	1	0	4

Class schedule per week: 4 classes per week

Course Objectives:

I. To state students with concepts of state variables;
II. To extend comprehensive knowledge of mathematical modeling of physical system;
III. To illustrate basics of deigning a control problem;
IV. To summarize them on theory of model control theory.

Course Outcomes:

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

I. Apply the different ways of modeling of physical system and read basics of the theory of Fractional Order Controller;
II. Recommend linearization of a nonlinear system;
III. Recommend linearization of a nonlinear system;
IV. Summarize the controllability & observability conditions;
V. Explain the functionality of Model Control;
VI. Formulate potential design techniques from analysis.

Syllabus:

1. Introduction
Systems, modelling, analysis and control, continuous-time and discrete-time. (2)

2. State Variable Descriptions
Introduction, concept of state, state equations for dynamic systems, state diagrams. (3)

3. Physical Systems & State Assignments
Linear continuous-time and discrete-time models, non-linear models, local linearisation of non-linear model. (5)

4. Solution of State Equations
Existence and uniqueness of solution, linear time-invariant continuous-time state equations, linear discrete-time state equations. (6)

5. Controllability & Observability
Concept of controllability & observability, controllability and observability tests for continuous -time systems, controllability and observability of discrete-time systems, canonical forms of state models. (10)

6. State models and input-output descriptions
Input-output maps from state model and vice-versa, transfer matrix, output controllability, reducibility. (6)

7. Modal Control
Introduction, Effect of state feedback on controllability and observability, pole placement

by state feedback; Full order observers, Reduced-order observers; deadbeat control by state feedback, deadbeat observers. (8)

8. Fractional Order Controller

Fractional order calculus, Fractional order transfer function modelling, Frequency domain analysis of fractional order controller, Time domain analysis of time domain controller

Books Recommended :

1. Digital Control & State Variable Mathods – M. Gopal, Tata Macgrow
2. Modern Control System Theory by M. Gopal
3. Linear Systems by Thomas Kailath.
4. Modern Control Engg. by K. Ogata.

Course code: MEE1151
Course title: Advanced Power Electronics

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

Class schedule per week:3 classes per week

Course Objectives:

Objective of this course is to provide students with:

I. Introduction of different type of modern semiconductor based switching devices and their operating characteristics.
II. Explanation of working principle of power converters and relate them with different area of application.
III. Capability to analyze closed loop control of electrical drives based on power converters. Differentiation between different control strategy of electrical drives in terms of dynamic parameters of system and overall efficiency.
IV. Ability to evaluate performance evaluation, plan and design procedure for a complex power electronics based system.

Course Outcomes:

At the end of the course, student will be able to-

I. List different types of semiconductor devices and *remember* their operating characteristics. *Explain* working principle of different semiconductor devices.
II. 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.
III. Outline shortcomings of each class of power converters and *solve* them using proper modifications. *Identify* potential area for power electronics applications.
IV. Estimate the cost and long term impact of power electronics technology on a large scale project of socio-economic importance.
V. 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 - 1

Characteristics of modern semiconductor power devices: Gate Turn-off Thyristor (GTO), Power Bipolar Transistor, Power MOSFET, Insulated Gate Bipolar Transistor (IGBT),Static Induction Thyristor (SIT), FET-BJT Combination Switch, MOS-Controlled Thyristor, Power Integrated Circuit (PIC), Protection Circuit. (7)

Module - 2

Linear voltage regulator: DC Voltage Regulator, Linear Regulator, Series Regulator, IC

Voltage Regulator, 3-Terminal & 4-Terminal Negative Voltage Regulator, 4-Terminal Positive Regulator, Adjustable 3 and 4-Terminal Regulators, Dual Voltage Regulators, Current Regulator. (7)

Module - 3

Switching Regulators: Introduction, Circuit Scheme, Basic Switching Regulator, Minimum Load Current and Critical Inductance, Determination of Filter Inductance, Determination of Filter Capacitor, Transistor Switching Losses, Free Wheel Diode Losses, Filter Inductor Losses, Thermal Analysis, Positive Switching Regulator Using IC, Negative Switching Regulator Using IC, Electrical Isolation in Switching Regulator, Optoelectronic Coupler. (7)

Module - 4

Resonant Converter: Basic Series Resonant Inverter, Series Resonant Inverters with Unidirectional Switches and Anti Parallel Diodes, Frequency-Domain Analysis of Series Resonant Converter, Parallel Link Capacitor Load Series Resonant Converter. (6)

Module - 5

Frequency-Domain Analysis of Parallel Link Capacitor Load SRC, Quasi-Resonant Converter, Control Scheme for Zero Voltage Switching, Zero Current Switching, Quasi-Resonant Converter. (6)

Module - 6

Uniterruptible Power Supply: Normal Disturbances in Commercial Power Supply, Power Conditioners Other Than UPS, Isolation Transformer, AC Voltage Regulator, Block Diagram of Tap Changer Regulator, Introduction to Ferro Resonant Regulator. (6)

Module - 7

Transient Suppressors, Electromagnetic Interference (EMI) and Radio Frequency Interference (RFI) and Their Suppression, Schematic Diagram of OFF-line and ON-line UPS Introduction to PLC and its application (6)

Text Book

1. M.D. Singh & K.B. Khanchandani, Power Electronics, TMH, Delhi, 2001.
2. P.C. Sen, Power Electronics Tata McGraw Hill.

References

1. V.R. Moorthi, Power Electronics, Device, Circuit and Industrial Applications, Oxford University Press, Delhi, 2005.
2. M.H. Rashid, ‘Power Electronics’ Pearson Education, 2nd Edition, Singapore, 2002.

Course code: MEE1105

Course title: Optimization in Engineering Design

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

Class schedule per week: 3 classes per week

Course Objectives:

The course objective is to provide students with an ability to:

I. Conceptualize the optimizations in engineering design and model the problem mathematically.
II. Understand various optimization methods and algorithms for solving optimization problems.
III. Develop substantial interest in research, for applying optimization techniques in problems of engineering and technology;
IV. 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, the student will be able to:

I. Have a basic understanding of traditional and non-traditional optimization algorithms.
II. Formulate engineering design problems as mathematical optimization problems.
III. Use mathematical software for the solution of engineering problems.
IV. Differentiate the various optimization concepts and equivalently apply them to engineering problems.
V. Evaluate pros and cons for different optimization techniques.

Syllabus

MEE 1105 OPTIMIZATION IN ENGINEERING DESIGN

Module - 1

INTRODUCTION

Optimal problem formulation, Design variables constraints, Objective function, Variable bounds, Engineering optimization problems, Optimization algorithms.

Module - 2

ONE DIMENSIONAL SEARCH METHODS

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.

Module - 3

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

Module - 4

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.

Module - 5

MULTIVARIABLE OPTIMIZATION ALGORITHM

Optimality criteria, Unidirectional search, Direct search methods: Simplex search method, Hooke-Jeeves pattern search method.

Module - 6

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.

Module - 7

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.

Books Recommended:

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. Hadley

Elective-I:

Course code: MEE1155

Course title: Dynamic Analysis of Electrical Machines

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

Class schedule per week: 3 classes per week

Course Objectives:

The course objective is to provide student with;

I. Generalized concepts of dynamic of electric machines.
II. Capability to apply the principle of orthogonal axis transformation for close loop speed control of dc and ac machine drives.
III. Technique to perform analysis and compare different control schemes for evaluation of dynamic performance of the rotating machines.
IV. Motivation to continuously upgrade their knowledge and aspire a team of professionals to implement industrial projects in the field of electrical drive

Course Outcomes:

At the end of the course, student will be able to-

I. Describe modelling of an electric motor system from various reference frames.
II. Apply the techniques to provide solutions to drive related problems in industry.
III. Analyze the dynamic parameters and design the control schemes for high performance electrical drives
IV. Predict the cost for installation of high power AC DC machine drives.
V. Recognize the need to learn, to engage and to adapt in a world of constantly changing technology.

Syllabus

Module 1:

Principles of Electromagnetic Energy Conversion:

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. (8)

Module 2:

Introduction to Reference Frame Theory:

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, d-q axis transformations for three-phase R-L and capacitive circuit. (6)

Module 3:

Dc Machine Dynamic Analysis:

Voltage and torque equations, modeling of different dc motor under normal motoring and fault condition, steady state analysis, state space and transfer function modeling, regenerative braking, counter current and dynamic braking. (4)

Module 4:

Dynamic Modeling 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 modeling of high torque cage motors and single-phase IM. (8)

Module 5:

Determination of Synchronous Machine Dynamic Equivalent Circuit Parameters:

Dynamic d-q axis modeling 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. (6)

Module 6:

Permanent Magnet Synchronous and BLDC Machine:

Surface permanent magnet (square and sinusoidal back emf type) and interior permanent magnet machines, construction, operating principle and true synchronous characteristics, dynamic modeling 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. (8)

Module 7:

Analysis of Stepper Motors and Switch Reluctance Motors:

Stepper motors operation, classification, features of stepper motor, operation of switched reluctance motor, expressions of torque. (4)

Text Book:

1. P.S. Bimbra, Generalised 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 code: MEE1137
Course title: Modeling & Simulation of Power Electronics Systems

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

Class schedule per week: 3 classes per week

Course Objectives:

The course objective is to provide student with;

I. Mathematical concepts of dynamic of electric machines.
II. Capability to apply the principle of orthogonal axis transformation for close loop speed control of dc and ac machine drives.
III. Technique to perform analysis and compare different control schemes for evaluation of dynamic performance of the rotating machines.
IV. Motivation to continuously upgrade their knowledge and aspire a team of professionals to implement industrial projects in the field of electrical drive

Course Outcomes:

At the end of the course, student will be able to-

I. Interpret modelling of an electric motor system from various reference frames.
II. Administer the simulation techniques to provide solutions to drive related problems in industry.
III. Theoretical analyze the dynamic parameters and design the control schemes for high performance electrical drives
IV. Predict the cost for installation of high power AC DC machine drives.
V. Recognize the need to learn, to engage and to adapt in a world of constantly changing technology.

Syllabus

Module-I

Basics of Simulation: Block diagram, Transfer Function and State Variable representation of different mechanical and Electrical systems. Classification of systems as linear, nonlinear, continuous time and discrete time systems. (6)

Module-II

Modeling and Simulation of phase controlled DC Converter: Modeling and simulation of single-phase and three-phase AC to DC controlled converter with various load. Modeling and simulation of Buck converter, Boost Converter and Buck-Boost converter. (6)

Module-III

Simulation of DC Drives: Simulation tools and their application in DC drive simulation. Open-loop control of DC motor. Close-loop control of DC Motor. Design of P, PI and PID controller. PWM techniques for DC applications. (6)

Module-IV
Simulation of phase controlled AC Drives: Modeling and simulation of variable voltage variable frequency ac drives, speed control using constant flux, constant slip control. PWM based induction motor drives. (5)

Module-V
Modeling of Different PWM techniques for inverter: Sine-triangle PWM for single and three phase converter. Modelling and simulation of Space vector PWM, Modeling of Three-level inverter, SPWM techniques for multi-level inverter. (5)

Module-VI
Modeling and simulation of vector controlled AC drives: Direct field oriented current control, direct field oriented voltage control, and indirect field oriented methods. Modeling and simulation of vector controlled induction motor drives, direct torque control of induction motors drives. (8)

Module-VII
Modeling and simulation of Synchronous motor drives: Transient models, simulation of three phase synchronous machines, simulate the permanent magnet synchronous motor, linearized analysis of synchronous generator under various values of field flux, mechanical loading and inertia. (8)

Books Recommended:
1. Dynamic Simulation of Electric Machinery using Matlab/Simulink-Chee-Mun Ong
2. Low power Electronics design – Christian Piguet
3. Modern Power Electronics & Drives-B.K.Bose
4. Electromagnetic modeling of power electronic converters – J A Ferreira
5. Electric Motor Drives, modelling analysis and control- R. Krishnan

Course code: MEE1104
Course title: Digital Signal Processing Lab

Credit:	**L**	**T**	**P**	**C**
	0	0	3	2

Class schedule per week: 3 classes per week

Course Objectives: -

This course enables the students to:

I. Enumerate the basic concepts of signals and systems and their interconnections in a simple and easy-to-understand manner through different mathematical operations like folding, shifting, scaling, convolutions, etc. using MATLAB; also gain Knowledge of TMS kit, digital image filter.
II. Construct different realization structures.
III. Determine transfer function and predict frequency response of discrete-time systems by applying various techniques like Z-transform, DFT and FFT using MATLAB
IV. Design and compose digital IIR and FIR filters using filter approximation theory, frequency transformation techniques, and window techniques in MATLAB environment.

Course Outcomes:

At the end of the course, student will be able to-

I. Convert analog signal into digital signals and vice-versa, generation of different signals and basic knowledge of TMS kit.
II. Examine system response using Z-transform, convolution methods and interpret transfer function of the selected system;
III. Evaluate frequency response of the systems using frequency transformation technique, DFT, DIF-FFT or DIT-FFT algorithm, window techniques and visualization using MATLAB;
IV. Design FIR and IIR filters.
V. Recommend environment-friendly filter for different real- time applications such as optical filter design, acoustic filter design etc.

LIST OF EXPERIMENTS:

1. **Name: Introduction to MATLAB.**
   Aim: An introduction to MATLAB.
2. **Name: Generation and representation of different types of signal.**
   Aim: To perform generation of different signals in MATLAB.
3. **Name: The Z-Transform and Inverse Z-Transform.**
   Aim: To write a program to find z-transform of given signal.

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

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

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

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

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

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

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

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

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

Books Recommended:

1. Digital signal processing and applications with C6713 and C6416 DSK by 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 Books:

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

Course code: MEE1152
Course title: Power Electronics Lab

Credit:	**L**	**T**	**P**	**C**
	0	0	3	2

Class schedule per week: 3 classes per week

Course Objectives:

This course enables the students to:

I. Identify high power semiconductor switches and determine their I-V characteristics.
II. Describe firing circuit, commutation circuits for the semiconductor switches and various energy conversion topologies through experimentation.
III. Analyze the waveforms of the circuit variables through and across the switches and load in different energy conversion topologies, though experimentation.
IV. Estimate the performance parameters of energy conversion topologies through experimental and analytical approach. Design assigned circuit topology for given specification and fabricate the circuitry of any of the power converter.

Course Outcomes:

After the completion of this course students will be able to perform following tasks.

I. Differentiate between various types of semiconductor based switching devices available in market.
II. Obtain switching characteristics of power switches.
III. Choose a suitable and proper switching device for a required power electronics based design.
IV. Experiment with conventional power converters.
V. 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.

LIST OF EXPERIMENTS:

1. Name: Study and performance evaluation of single phase modified series Inverter
Aim: (i) To obtain load voltage waveform.
(ii) To observe load voltage waveform with dead time and without dead time.

2. Name: Evaluate performance parameters of single phase full wave Thyristor rectifier with R, R-L loads.
Aim: (i) To observe load voltage waveform with and without LC filter.
(ii) To find ripple factor of load voltage waveform with and without LC filter.

3. Name: Do a test determination of IGBT characteristics.
Aim: (i) Obtain output characteristics.
(ii) Obtain transfer characteristics.

4. Name: Study class A and class C commutations of a Thyristor and observe various circuit waveforms.
Aim: (i) Observe current waveform across Thyristor.

(ii) Obtain the reverse recovery time of SCR.

5. Name: Undertake experiment on impulse commutated chopper and observe its performance.
Aim: (i) Observe load voltage waveform.
(ii) Verify the under damped condition for impulse commutation.

6. Name: Do Real-time simulation of open loop speed control of a three phase Induction machine using Voltage Source Inverter
Aim: (i) Observe load voltage waveform of line voltage.
(ii) Observe dynamic parameter of induction motor speed response.

7. Name : Perform an experiment in order to draw V-I characteristics of TRIAC.
Aim: (i) Draw VI characteristics..
(ii) Compare with SCR characteristics..

8. Name: In order to find Voltage Harmonic Factor (VHF), do an experiment on TRAIC based voltage regulator and draw its various waveforms, also find the range of firing angles.
Aim: (i) To obtain the RMS load voltage for TRAIC based control of AC voltage
(ii) To identify various working modes of a TRAIC

9. Name: To execute an experiment in order to find the ripple factor of a single phase bridge diode rectifier.
Aim: (i) To find figure of merit

10. Name: 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 Book:

1. M.H. Rashid, Power Electronics: Circuits, Device and Applications, 2nd Ed.n, PHI, New Jersey, 1993.
2. M.D. Singh, K.B. Khanchandani, Power Electronics, TMH, Delhi 2001.

Reference Books:

1. S.N.Singh, A Text Book of Power Electronics, Dhanpat Rai & Co., New Delhi 1st Edn., 2000.
2. Mohan, Underland, Robbins; Power Electronics Converters, Applications and Design, 3rd Edn., 2003, John Wiley & Sons Pte. Ltd.
3. R.S. Ramshaw, Power Electronics Semiconductor Switches, 2nd Edition, 1993, Chapman & Hall, Chennai.
4. V.R. Murhty, Power Electronics, Oxford Publishers.

Course code: MEE2101

Course title: Soft Computing Techniques

Credits:	**L**	**T**	**P**	**C**
	3	1	0	4

Class schedule per week:4 classes per week

Course Objectives:

The course objective is to provide students with an ability to:

I. Conceptualize neural networks and its learning methods.
II. Infer the basics of genetic algorithms and their applications in optimization and planning.
III. Interpret the ideas of fuzzy sets, fuzzy logic and fuzzy inference system.
IV. Categorize the tools and techniques available for soft-computing, while employing them according to practical requirements of an engineering design.

Course Outcomes:

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

I. Identify the soft computing techniques and their roles in building intelligent machines.
II. Recognize an appropriate soft-computing methodology for an engineering problem.3.
III. Apply fuzzy logic and reasoning to handle uncertainty while solving engineering problems.
IV. Apply neural network and genetic algorithms to combinatorial optimization problems;
V. Classify neural networks to pattern classification and regression problems and evaluate its imparts while being able to demonstrate solutions through computer programs.

Syllabus

Module - 1

Introduction: Background, uncertainty and imprecision, statistics and random processes, uncertainty in Information. Fuzzy sets and membership, chance versus ambiguity, fuzzy control from an industrial perspective, Knowledge based systems for process control, knowledge based controllers, knowledge representation in knowledge based controllers.

Mathematics of Fuzzy Control: Classical sets, Fuzzy sets, Properties of fuzzy sets, operations on fuzzy sets. Classical relations and fuzzy relations - cartesian product, crisp relation, Fuzzy relations, Tolerance and Equivalence Relations, Fuzzy tolerance and equivalence relations, operation on fuzzy relations, The extension principle.

Module - 2

Membership Function: Features of membership functions, standard forms and boundaries, Fuzzyfication, Membership value assignment.

Fuzzy-to-Crisp conversions: Lambda-cuts for fuzzy sets, Lambda-cuts for fuzzy relations. Defuzzification Methods

Module – 3
Introduction : Structure and foundation of Single Neuron, Neural Net Architectures, Neural Learning Application, Evaluation of Networks, Implementation.
Supervised Learning - Single Layer Networks, Perceptions, Linear separability, Perception, Training algorithms, Guarantee of success, Modifications.

Module - 4
Multilayer Networks - Multilevel discrimination, preliminaries, backpropagation algorithm, setting the parameter values, Accelerating the learning process, Applications, RBF Network.

Module - 5
Unsupervised learnings - Winner take all networks, learning vector quantizers, ART, Topologically ortanised networks.
Associative Models - Non-iterative procedures for Association, hopfield networks,

Module - 6
Discussion of Neural Networks and Fuzzy Logic Application in areas of Power Electronics and motor control.

Text Books
1. Fuzzylogic with Engineering Applications - Timothy J. Ross, McGraw-Hill International Editions.
2. Fuzzy Sets and Fuzzy logic: Theory and Applications - George J. Klir and Bo. Yuan, PrenticeHall of India Private Limited.
3. Neural Networks: A Comprehensive Foundation - Siman Haykin, IEEE, Press, MacMillan, N.Y. 1994.
References:
1. Elements of Artificial Neural Networks - Kishan Mehrotra, Chilakuri K. Mohan, Sanjay Ranka (Penvam International Publishing (India)

Course code: MEE2153
Course title: Control of Electric Drives

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

Class schedule per week:3 classes per week

Course Objectives:
Objective of this course is to provide students:

I. Introduction of different type of electrical drives system.
II. Explanation of working principle of power converters and relate them with different types of drives system
III. Analysis of closed loop control of electrical drives based on power converters. Differentiation between different control strategy of electrical drives in terms of dynamic parameters of system and overall efficiency.
IV. Performance evaluation, planning and design procedure for a complex power electronics based drives system.

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

I. *List* different types of electrical drives.
II. *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.
III. *Outline* shortcomings of each class of conventional drives control strategy and *solve* them using proper modifications. *Identify* potential area for power electronics applications.
IV. Estimate the cost and long term impact of power electronics based drives technology on a large scale project of socio-economic importance.
V. *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

1 **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 (7)

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. Modeling 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. (9)

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 (5)

4 **Vector control of Induction machines:**
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. (7)

5 **Speed control of wound rotor induction machine:**
Static rotor resistance control, static Scherbius drive using line commutated converter cascade & cycloconverter, 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. (6)

6 **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. (5)

7 **Control of Stepper Motors and Switch Reluctance Motors:**
Stepper motors operation, excitation table, control of stepper motor, operation of switched reluctance motor (SRM), expressions of torque, speed control of SRM. (5)

Books Recommended :

- Fundamental of Electrical Drives: G K Dubey
- Modern Power Electronics & Drives: B K Bose
- Electric Motor Drives, modeling analysis and control: R Krishnan

Course code: MEE 2154
Course title: Electric Drive L Lab
Pre-requisite(s): Electrical Machines, Power System, Power Electronics, MATLAB

Credits:	L	T	P
	0	0	3

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 and to evaluate the performance of close loop controller.

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 **Micocontroller (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. Bimbra, 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.

Course code: MEE2155
Course title: Power Electronics Applications

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

Class schedule per week: 3 classes per week

Course Objectives:

The course objective is to provide students with:

I. Advanced concepts of various power electronics applications like HEV, HVDC and FACTS.
II. Capability to apply advanced concepts for analysis of existing power electronics based systems.
III. Methodology to evaluate performance parameters of modern industrial chips for power electronics.
IV. Design methods for development and execution of new power electronics based installation.

Course Outcomes:

At the end of the course, student will be able to-

I. Describe working principles of advanced power converters.
II. Solve problems in existing power electronics based system using advanced concepts
III. Analyze performance parameters of state of art of power electronic technology.
IV. Evaluate and design new type of converters for utilization of renewable energy.
V. 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-I: Electrical vehicles:

Introductions, types of electrical vehicle, energy management in electrical vehicles, features, various subsystem in electrical vehicles. Future scopes (7)

Module-II: Hybrid Electrical Vehicle:

Introduction, Types of hybrid electrical vehicle, series, parallel, series parallel and complex. According to hybridization- micro, mild and heavy HEV, mechanical power splitter and electrical power splitter, advantages and disadvantages, sizing of HEV, Power flow, Energy management, (6)

Module-III: **Introduction to Flexible AC transmission systems (FACTS)**

Steady state and dynamic problems in AC systems - Principles of series and shunt compensation. Description of: static var compensation (SVC), Thyristor Controlled series compensators (TCSC) - Static phase shifters (SPS) - Static condenser (STATCON) (8)

Module-IV : **Wind Energy Systems**
Basic Principle of wind energy conversion - nature of wind - components of a wind energy - conversion system - Performance of induction generators for WECS - classification of WECS. Self-excited induction generator for isolated power generators - Theory of self-excitation - Capacitance requirements - Power conditioning schemes - controllable DC Power from SEIGs system performance. Grid Connected WECS. (8)

Module-V: Photovoltaic Energy Conversion
Solar radiation and measurement - solar cells and their characteristics - influence of insulation and temperature - PV arrays - Electrical storage with batteries - solar energy availability in India- Switching devices for solar energy conversion, Maximum power point tracking. DC Power conditioning converters, AC power conditioners - Line commutated inverters - synchronized operation with grid supply (8)

Module VI : HVDC Transmission
HVDC system control : CC and CEA controls, Static characteristics of converters, Combined characteristics of rectifier and inverter, Power reversal, Asynchronous & synchronous HVDC links, Frequency Control of A.C. system, Stabilisation & damping of A.C. networks, CP Control.

Module-VII: Power Quality problems in distribution systems , Harmonics - Harmonics creating loads -modeling - Harmonic propagation, Mitigation of harmonics – Filters -Passive filters Active filters – Shunt, Series Hybrid filters (5)

Books Recommended:

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.
4. Rai, G.D.,"Solar Energy Utilisation", Khanna Publishers, New Delhi, 1991.
5. Gray.L.Johnson, "Wind energy systems", Prentice Hall Inc., 1985

Elective II:

Course code: MEE2151

Course title: Advanced DSP Architecture and Programming

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

Class schedule per week: 3 classes per week

Course Objectives:-

Objective of this course is to provide students with:

I. Understanding of different architecture of DSP processors.
II. Ability to apply DSP processors for signal processing.
III. Capability to analyze a program and optimize it for fast execution in real time.
IV. Creativity to design a real time signal processing unit based on architecture of a DSP processor.

Course Outcomes:

At the end of the course, student will be able to-

I. Remember different architectures of DSP processors.
II. Explain various steps of process involving execution of software based project.
III. Analyze different component of DSP processor in order to optimize the code.
IV. Estimate the cost of DSP processor based application.
V. Realize the need of continuous learning in order to create state of ART signal processing application based on advanced mathematical tools.

Syllabus

Module I

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

Module II

Architecture of C6x Processor: Introduction TMS320 C6x architecture, functional units, fetch and execute packets, pipe lining, registers, Linear and circular addressing modes

Module III

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.

Module IV

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

Module V

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

Module VI

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.

Module VII

DSP/BIOS and RTDX Using MATLAB & Lab VIEW: Introduction to DSP/BIOS, RTDX using MATLAB provide interface between PC and DSK, RTDX using Lab VIEW provide interface between PC and DSK.

Books Recommended:

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.

Course code: MEE2115
Course title: Embedded Systems & Applications

Credits: L T P C

3 0 0 3

Class schedule per week: 3 classes per week

Course Objectives:

The course objective is to provide students with an ability to:

I. Comprehend the basic functions, structure, concept and definition of embedded systems;
II. Interpret ATMEGA8 microcontroller, FPGA & CPLD, TMS320C6713 processors in the development of embedded systems;
III. Correlate different serial interfacing protocols(SPI,TWI,I2C,USART);
IV. Understand interfacing of different peripherals (ADC, DAC, LCD, motors).

Course Outcomes:

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

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

Introduction: 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.

(5)

MODULE – II

Basic Concepts of Computer Architecture: Concepts, Memory, Input/ Output, DMA, Parallel and Distributed computers, Embedded Computer Architecture, etc.

(5)

MODULE – III

Embedded Processors & Systems: Atmel AVR ATMEGA 8 Micro-controller: Introduction, Major features, Architecture, Application and programming. Timers/Counters, ADC, USART, SPI, TWI, Vectored Interrupts. (5)

MODULE – IV
FPGA: Xilinx XC3S400 FPGA Architecture, XC9572 CPLD Architecture, VHDL Programming (VHDL Synthesis) (5)

MODULE – V
dsp-based controllers: Texas Instrument's TMS320C6713 DSP processor: Introduction, Major features, Architecture, Application and programming. (5)

MODULE – VI & VII
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. (10)

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

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

Course Code: MEE2157
Course Title: Renewable Sources of Electrical Energy

Credits:	L	T	P	C
	3	0	0	3

Class schedule per week: 3 classes per week

Course Objectives:

I. To educate students about different sources of energy (conventional, non-conventional, renewable etc.)
II. To give an exposure of solar energy, wind energy, bio-mass and small hydro-energy generation.
III. To impart knowledge about the storage of electrical energy.
IV. To train the students for integration of renewable electrical energy sources to the electrical grid.

Course Outcomes:
Student will be able to:

I. Gain knowledge of different renewable sources and storage method of electrical energy
II. Perform experiments to measure characteristics of photovoltaic cell
III. Design renewable/non-conventional source of energy
IV. Design circuits for generation of maximum power from solar energy
V. Integrate renewable sources to the electrical grid.

Syllabus

Module – 1
Energy Scenario: Classification of Energy Sources, Energy resources (Conventional and nonconventional), Energy needs of India, and energy consumption patterns. Worldwide Potentials of these sources. Energy efficiency and energy security. Energy and its environmental impacts. Global environmental concern, Kyoto Protocol, Concept of Clean Development Mechanism (CDM) and Prototype Carbon Funds (PCF). Factors favoring and against renewable energy sources, IRP [6]

Module – 2
Solar Energy: Solar thermal Systems: Types of collectors, Collection systems, efficiency calculations, applications. Photo voltaic (PV) technology: Present status, - solar cells , cell technologies, characteristics of PV systems, equivalent circuit, array design , building integrated PV system, its components , sizing and economics. Peak power operation, Solar tracking system Standalone and grid interactive systems. [8]

Module – 3

Wind Energy: Wind speed and power relation, power extracted from wind, wind distribution and wind speed predictions. Wind power systems: system components, Types of Turbine, Turbine rating Choice of generators, turbine rating, electrical load matching, Variable speed operation, maximum power operation, control systems, system design features, stand alone and grid connected operation. [6]

Module – 4

Biomass Energy System: Biomass – various resources, energy contents, technological advancements, conversion of biomass in other form of energy – solid, liquid and gases. Gasifiers, Biomass fired boilers, Cofiring, Generation from municipal solid waste, Issues in harnessing these sources. [3]

Module – 5

Hydro energy: Feasibility of small, mini and micro hydel plants scheme layout economics. Tidal and wave energy, Geothermal and Ocean-thermal energy conversion (OTEC) systems – schemes, feasibility and viability. [3]

Module – 6

Energy storage and hybrid system configurations: Energy storage: Battery – types, equivalent circuit, performance characteristics, battery design, charging and charge regulators.Battery management. Fly wheel- energy relations, components, benefits over battery. Fuel Cell energy storage systems. Ultra Capacitors. [4]

Module – 7

Grid Integration: Grid integration with the system: Interface requirements, Stable operation, Transient-safety, Operating limits of voltage, frequency, stability margin, energy storage, and load scheduling. [5]

Books Recommended:

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

Reference Books :

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

Course code: MEE2133

Course title: Power Electronics System Design

Credits:	**L**	**T**	**P**	**C**
	2	1	0	3

Class schedule per week: 3 classes per week

Course Objectives:

The course objective is to provide students with:

I. Introduction to different types of active and passive components of power electronics based topology

II. Explanation of methods to select components and switching devices.

III. Analysis of power electronic system under practical design constrains.

IV. Performance evaluation, planning and design procedure for a complex power electronics based system.

Course Outcomes:

At the end of the course, student will be able to-

I. *List* different types of semiconductor devices and components as well as *remember* their operating characteristics. *Explain* working principle of different semiconductor devices.

II. *Demonstrate* suitability of a power converter for a particular application. *Solve* power management related problems with application of power electronics based topologies.

III. *Outline* shortcomings of each class of power converters and *solve* them using proper modifications. *Identify* potential area for power electronics applications.

IV. *Estimate* the cost and long term impact of power electronics technology on a large scale project of socio-economic importance.

V. *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

1. Design and selection of passive and active components:

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. (9) Ref: Power Electronics: essentials and applications - L Umanand, Microchip SMPS AC/DC Reference Design, User's Guide,

2. Design of Driver circuits and commutation circuits:

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. (5)

Ref: Power Electronics: essentials and applications - L Umanand

3. 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. (7)
Ref: Power Electronics: essentials and applications - L Umanand,

4. DC/DC swithed mode converter design:
Design of chopper based Buck converter, Boost converter, Buck-Boost converter; Isolated converter, Flyback converter, Schemes for firing circuits. (6)
Ref: Power Electronics: essentials and applications - L Umanand,

5. 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. (5)
Ref: Power Electronics: essentials and applications - L Umanand

6. Switched mode power supply 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. (6)
Ref: Microchip SMPS AC/DC Reference Design, User's Guide, Power Electronics: essentials and applications - L Umanand,

7. Thermal design:
Thermal problems in power electronics, Understanding of General thermal flow process, Design of heat sink, selection of cooling techniques. (5)
Ref: Power Electronics: essentials and applications - L Umanand.

Text Books:

1. M.H. Rashid,"Power Electronics: Circuits, Device and Applications",2nd Ed.n, PHI, New Jersey, 1993. (T1)
2. Mohan, Underland, Robbins; Power Electronics Converters, Applications and Design, 3rd Edn., 2003, John Wiley & Sons Pte. Ltd. (T2)
3. M. D. Singh, K. B. Khanchandani, "Power Electronics", 2nd Edn., Tata McGraw-Hill, 2007. (T3)

Reference Books:

1. R. Krishnan, "Electric Motor Drives: Modeling, Analysis and Control", 1st Edn., Prentice Hall,2001. (R1)
2. B. K. Bose, "Modern Power Electronics & AC Drives" , 1st Edn., Prentice Hall, 2001.(R2)
3. L. Umanand, "Power Electronics: Essentials & Applications", 1st Edn. Wiley India Private Limited, 2009. R(3)
4. Jeremy Rifkin, "Third Industrial Revolution: How Lateral Power Is Transforming Energy, the Economy, and the World", 1st Edn., St. Martin's, Press, 2011. R(4)

Course code: MEE2156
Course title: Power Electronics Simulation Lab

Credits:	**L**	**T**	**P**	**C**
	0	**0**	**3**	**2**

Class schedule per week: 3 classes per week

Course Objectives:

This course enables the students to:

I. Understand system dynamics of machines, power electronics and power system;
II. Observe speed control of DC motor, induction motors drives, BLDC motor and generator speed control for arresting the frequency of power system network;
III. Discriminate and predict the change in dynamics owing to various disturbances;
IV. Design the proper controller and to evaluate the performance of close loop controller.

Course Outcomes:

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

I. List different MATLAB blocks required for power electronics and machine simulation.
II. Relate the concepts of power electronics in the simulation domain.
III. Analyze simulation models in the field of power conversion and transmission
IV. Evaluate accuracy of simulation based systems as compared to real-system
V. 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.