NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

DEPARTMENT OF ELECTRICAL ENGINEERING

Revised Curriculum and Syllabi

Program Name
Master of Technology in Power Electronics and Machine Drives
Effective from the Academic Year: 2021-2022

Recommended by DPAC	: 29.07.2021
Recommended in PGAC	: 16.08.2021
Approved by the Senate	: 22.08.2021

CURRICULUM

		Semester – I					
Sl. No.	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	EE1011	Advanced Power Electronics – I	3	1	0	4	4
2	EE1012	Machine Drives – I	3	1	0	4	4
3	EE1013	Advanced Control System – I	3	1	0	4	4
4	EE90XX	Specialization Elective – I	3	0	0	3	3
5	EE90XX	Specialization Elective – II	3	0	0	3	3
6	EE1061	Advanced Power Electronics	0	0	4	2	4
7	EE1062	Computational Laboratory	0	0	4	2	4
		Total	**15**	**3**	**8**	**22**	**26**
		Semester – II					
Sl. No.	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	EE2011	Advanced Power Electronics – II	3	1	0	4	4
2	EE90XX	Specialization Elective – III	3	1	0	4	4
3	EE90XX	Specialization Elective – IV	3	0	0	3	3
4	EE90XX	Specialization Elective – V	3	0	0	3	3
5	EE2061	Machine Drives Laboratory	0	0	4	2	4
6	EE2062	Advanced Control Laboratory	0	0	4	2	4
7	EE2063	Mini Project with Seminar	0	0	6	3	6
		Total	**12**	**2**	**14**	**21**	**28**
		Semester – III					
1	EE907X	Audit Lectures/Workshops					2
2	EE3061	Dissertation – I	0	0	24	12	24
3	EE3062	Seminar – Non-Project / Evaluation of Summer Training	0	0	4	2	4
		Total	**0**	**0**	**28**	**14**	**30**
		Semester – IV					
1	EE4061	Dissertation – II / Industrial Project	0	0	24	12	24
2	EE4062	Project Seminar	0	0	4	2	4
		Total	**0**	**0**	**28**	**14**	**28**

Electives I and II

Subject Code	Subject Name
EE9032	Machine Analysis
EE9020	Electric Vehicles
EE9011	Soft Computing Techniques
EE9016	Machine Learning and Expert System

Elective III

Subject Code	Subject Name
EE9012	Machine Drives – II
EE9021	Digital Signal Processing
EE9030	Distributed Generation System and Microgrid

Electives IV and V

Subject Code	Subject Name
EE9029	Advanced Control System – II
EE9017	Renewable Energy Systems
EE9018	Embedded System
EE9019	FACTS Devices
EE9022	Estimation of signals and Systems
EE9026	Biomedical Instrumentation
EE9031	Special Electrical Machines

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EE1011	ADVANCED POWER ELECTRONICS -I	PCR	3	1	0	4	4

Pre-requisites	Course Assessment methods: Continuous Assessment (CA) and End Assessment (EA))
Power Electronics, Electrical Machines, Control Systems, Power Systems.	CA+EA

Course Outcomes	• CO1: To get acquainted with non-isolated & isolated switch-Mode DC-DC converters. • CO2: To understand the concept of converter dynamics and control. • CO3: To familiarize with different gate and base drive circuits for power devices & wide band gap devices. • CO4: To understand the concept of switch mode inverters, different PWM techniques for Inverters &Multilevel Inverter • CO5: To familiarize with EMI & EMC issues in power electronic systems. • CO6: To get acquainted with the state of the art applications of power electronics in Industry and utility systems.
Topics Covered	Basic power electronic converters, Switch-Mode DC-DC Converters, Isolated Switching DC Power Supplies, Other switching converters, Control requirements & techniques, Voltage & current mode control, Practical converter design considerations, Protection in converter circuits. [10] Converter dynamics and control [4] Gate and Base Drive circuits for Power Devices, Introduction to Wide Band Gap Devices[6] Switch Mode Inverters, Different PWM techniques for Inverters: Space Vector PWM technique. Introduction of Multilevel Inverter [12] Electromagnetic Interference (EMI) and Electromagnetic Compatibility (EMC) Issues: EMI reduction at Source, EMI Filters, EMI Screening, EMI Measurement and Specifications. [4] Applications: (i) Renewable Energy Generation Schemes, (ii) Power System Quality Improvement, (iii) Other Industrial Applications CTLI based applications in Generation and Distribution. ---------------- [20]
Text Books, and/or reference material	Text Books: 1. N. Mohan, T. M. Undeland and W. P. Robbins, Power Electronics, Converters, Applications and Design, John-Wiley & Sons 2. L. Umanand, Power Electronics, Essential and Applications,Wiley India Pvt. Ltd.

	3. Joseph Vithayathil, "Power Electronics - Principles and Applications", McGraw Hill Inc., New York, 1995. Reference Books: 1. E. Acha, V. G. Agelidis, O. Anaya-Lara and T. J. E. Miller, Power Electronic Control in Electrical Systems, Newnes 2. H. W. Whittington, Switch Mode Power Supplies: Design and Construction, Research Studies Press.

CO vs PO mapping

Map in terms of 0,1,2,3

	Program Outcomes					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	3	2	2	1
CO2	3	3	3	3	0	0
CO3	3	3	3	3	2	1
CO4	3	3	3	3	2	1
CO5	3	3	3	3	2	2
CO6	3	3	3	3	3	3

Department of Electrical Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EE1012	MACHINE DRIVES-I	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods: Continuous Assessment (CA) and End Assessment (EA))					
Electrical Machines, Power Electronics and Control System		CA+EA					
Course Outcomes	• CO1: Upon completing this course, students must be able to choose their electric drive system based on the applications. • CO2: The students must be able to understand the dynamics of an electric drive under starting and braking conditions. • CO3: The students must be able to understand single and multi-quadrant operation of drive; they must be able to analyze any type of 1Φ & 3Φ rectifiers fed DC motors as well as chopper fed DC motors. • CO4: Upon completing this course, students must be able to control the speed of an AC-AC & DC-AC converter feeding an electric drive. • CO5: Students must be able to model an Electric Drive.						

Topics Covered	Review of electric drive system, electrical machines, power converters and control system. [2] Characteristics of different types of loads encountered in modern drive applications. [2] Dynamics of electric drive system, stability of an electric drive, Combined torque-speed characteristics of Motor-Load systems, speed-torque characteristics of electric drives under starting and braking conditions. [8] Transient in electric drives under starting and braking conditions, Energy, associated with transient process of DC and AC motors, Rotor heating. [4] Modeling of DC machines: Equivalent Circuit and Electromagnetic torque, Electromechanical Modeling, State-space modeling. [6] Phase Controlled DC Motor Drives: Introduction, principles of DC Motor Speed Control, Phase-Controlled Converters, Steady state analysis of the single-phase and three-phase Converter-Controlled DC motor drive, Chopper-Controlled DC Motor Drive. [14] Introduction Closed-Loop Operation, Dynamic simulation of the Speed controlled DC Motor drive, Applications. [6] Speed control of induction motor: Basic Principles of Speed Control, Controlling Speed Using Rotor Resistance, Rotor Voltage Injection, Controlling Speed by the Slip Energy Recovery Method, Torque-Current Relationship, Controlling Speed by Adjusting the Stator Voltage, Controlling Speed by Adjusting the Supply Frequency, Effect of Excessively High Frequency, Effect of Excessively Low Frequency, Voltage/Frequency Control. [8] Synchronous motor variable speed drives, variable frequency control of synchronous motors, self-controlled synchronous motor drive using load-commutated thyristor inverter. [4] Example studies on commercial industrial drive products [2]
Text Books, and/or reference material	TEXT BOOKS: • Werner Leonhard, Control of Electrical Drives, 3rd edition, Springer 2001. • R. Krishnan, Electric Motor Drives: Modeling, Analysis, and Control, Prentice Hall, edition 1, 2001. • Advanced Electrical Drives- De Doncker, Rik, Pulle, Duco W.J., Veltman, André • Modern Power Electronics and AC Drives- B. K. Bose Reference Books: 1. Power Electronics and Motor Control – Shepherd, Hulley, Liang – II Edition, Cambridge University Press 2. Control of Electric Machines and Drives System-Seung Ki Su-Wiley

CO vs PO mapping

Map in terms of 0,1,2,3

	Program Outcomes					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	0	3	3	2	2
CO2	2	0	3	3	1	0
CO3	2	1	3	3	1	3
CO4	3	1	3	3	2	2
CO5	3	1	3	3	1	2

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EE1013	ADVANCED CONTROL SYSTEM I	PEL	3	1	0	4	4
Pre-requisites		Course Assessment methods: Continuous Assessment (CA) and End Assessment (EA))					
Control System Engineering in B. Tech.		CA+EA					
Course Outcomes	• CO1: To learn the performance goals of closed loop control system design and the methods of analysis • CO2: To illustrate different advanced control system topologies, their design methods and synthesis of the controller designed • CO3: To develop the concept of state variable approach for linear time invariant system modelling and control • CO4: To design feedback control in State space domain • CO5: To design observed based state feedback control system • CO6: To design Linear Quadratic Regulator, KalmanBucy Filter for optimal design in state space						
Topics Covered	<u>Performance Objectives/ Goals:</u> Response and Loop Goals, Stabilization, Pole-placement, Tracking, Robustness, Disturbance Rejection, Noise Attenuation [6] <u>Performance Analysis and Tests:</u> Time Domain Analysis, Internal Model Principle (IMP),Frequency Response analysis by bode diagram and Nyquist criterion, Loop Shaping Techniques, Sensitivity analysis, Utilities of Gain and Phase Margin determination [8] <u>Compensation:</u> Feedforward Control, Feedback Control, Classical Controller P, PI, PID, Lead and Lag, One degree-of-freedom (1 DOF) control, Two DOF configurations, Sylvester matrix Formulation, Internal Model Control (IMC), Internal Model Principle (IMP) [12] <u>State Space Representation of Continuous-time Systems:</u> State model state models for linear continuous time systems, conversion of state variables models to transfer functions in s-domain, solutions of state equations, state transition matrix, state transition flow graphs, eigenvalues, eigenvectors and stability similarity transformation, decompositions of transfer functions, canonical state variable models, controllability and observability, Linear State Variable Feedback (LSVF) control and pole placement, Full Order Observer and Reduced Order Observer, Design examples, MATLAB tools and practical case studies [20]						

	Optimal Control Linear Quadratic Regulator (LQR), Linear Quadratic Guassian (LQG), LQR with state estimator, Kalman-Bucy filter/state estimator, Design Examples, Practical case studies [10]
Text Books, and/or reference material	Text Books: 1.Modern Control Engineering, K. Ogata, 2.Modern Control System Theory, M. Gopal, 3.Feedback Control Theory, John Doyle, Bruce Francis, Allen Tannenbaum, 4.Kalman Filtering Theory and Practice, Mahinder S. Grewal and Angus P Andrews Reference Books: 1.Linear Control System Analysis And Design With MATLAB, John J. D'Azzo and Constantine H. Houpis and Stuart N. Sheldon 2.Linear Robust Control, Michael Green and David J.N. Limebeer

CO vs PO mapping

Map in terms of 0,1,2,3

	Program Outcomes					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	1	2	1	1	2
CO2	2	1	2	1	1	2
CO3	2	1	2	1	1	2
CO4	3	1	2	3	3	2
CO5	3	1	2	3	3	2
CO6	3	1	2	3	3	2

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EE9032	Machine Analysis	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods: Continuous Assessment (CA) and End Assessment (EA))					
Electrical Machines-I (EEC402) and Electrical Machines-II (EEC501)		CA+EA					
Course Outcomes	• CO1: To acquire knowledge about Generalized machines and Reference frame theory • CO2: To learn modeling and analysis of three-phase induction machine • CO3: To learn modeling and analysis of three-phase synchronous machine • CO4: To analyze steady-state and transient behavior of DC machines						

Topics Covered	Generalized Machines:Kron's primitive machine, Voltage, power and torque equations of Kron's primitive machine, Basic two-pole machine diagrams. [4] Reference Frame theory: Equations of transformation, 3-axis to 2-axis transformation, Park's transformation, Clarke's transformation, Stanley's equations. [4] Theory of symmetrical Induction machines:Voltage and torque equations in machine variables, dynamic modeling of three-phase induction machine, commonly used reference frames. [5] Generalized model of three-phase induction machine in arbitrary reference frame, derivation of induction machine model in stator, rotor and synchronously rotating reference frames from the arbitrary reference frame model, steady-state equivalent circuit from dynamic equations. [6] Per unit system, normalized model of induction machine, space-phasor model of induction machine, linearized equations of Induction machine, small-signal equations of induction machine, small displacement stability, eigenvalues. [5] Synchronous Machines:Stator and rotor flux linkages, Voltage and torque equations in machine variables, mathematical modeling of synchronous machine, Swing equation, state-space representation of Swing equation. [6] DC generator: Motional inductance, steady-state analysis, transient analysis under different conditions. [6] DC motor: Steady-state analysis, transient analysis under different conditions, sudden application of inertia load. [6]
Text Books, and/or reference material	Text Books: 1. Analysis of Electrical Machinery: P. C. Krause 2. Electric Motor Drives, Modelling Analysis and Control: R. Krishnan Reference Books: 1. Modern Power Electronics and AC Drives: B. K. Bose 2. Generalized Theory of Electrical Machines: P. S. Bimbhra

CO vs PO mapping

Map in terms of 0,1,2,3

	Program Outcomes					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	3	3	1	2
CO2	3	3	3	3	1	2
CO3	3	3	3	2	1	1
CO4	3	3	3	2	0	1
CO5	3	3	3	2	0	1

Department of Electrical Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EE9020	ELECTRIC VEHICLES	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods: Continuous Assessment (CA) and End Assessment (EA))
Electrical Technology Electrical Machines I	CA+EA

Course Outcomes	• **CO1:** To acquire an idea about electric vehicles (EVs) and hybrid electric vehicles (HEVs) • **CO2:** To learn the fundamentals of different types of EVs and HEVs systems and their components. • **CO3:** To study about the Electric Propulsion Units required in EVs and HEVs. • **CO4:** To learn about the different types of Energy Sources and Storage units used in EVs and HEVs systems. • **CO5:** To study the Impacts of EVs and HEVs on power system and Environment. • **CO6:** To learn about the EV simulation software and EV simulation for designing and modelling.
Topics Covered	**Introduction to Electric Vehicles:** History of Electric Vehicles and hybrid electric vehicles, Recent EVs and HEVs, EV Advantages, social and environmental importance of hybrid and electric vehicles, impact of modern HEVs on energy supplies. [6] **Conventional Vehicles:** Basics of vehicle performance, vehicle power source characterization, transmission characteristics, and mathematical models to describe vehicle performance. [4] **Structure and Components of EVs and HEVs:** EV systems, HEV systems, Concept and architecture of hybrid electric drive trains, series and parallel of hybrid electric drive trains, torque and speed coupling of hybrid electric drive trains. [6] **Electric Propulsion Unit:** Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, drive system efficiency [10]

	Energy Sources and Storage: Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Super Capacitor based energy storage and its analysis, Flywheel based energy storage and its analysis, Hybridization of different energy storage devices. [8] **Battery Charging Strategies for Electric Vehicles:** Introduction, Battery Charging Parameters, Constant Current (CC) charging for Electric Vehicle batteries, Constant Voltage (CV) charging for Electric Vehicle batteries, CC/CV charging for lead acid and Li-ion batteries, Pulse charging for lead acid, NiCd/NiMH and Li-ion batteries, Charging termination techniques, Charging infrastructure, Battery chargers, Conductive chargers, Inductive chargers, Home charging, Public charging, Opportunity charging stations, Fast charging stations, Battery swapping stations. [5] **Impacts on power system and Environment:** Harmonic impact, Harmonic compensation, Current demand impact, Current demand minimization, Transportation pollution, Environment-sound EVs. [2] **EV Simulation:** Simulation Softwares, System level simulation, case studies of EV simulation [4]
Text Books, and/or reference material	TEXTBOOK: Iqbal Husain, "Electric and Hybrid Vehicles Design Fundamentals" Published by: CRC Press, Boca Raton, Florida, USA, 2003. REFERENCES: Chan, "Modern Electric Vehicle Technology", Oxford 2002Chau, K. T., "Energy systems for electric and hybrid vehicles", Institution of Engineering and Technology 2016.

CO vs PO mapping

Map in terms of 0,1,2,3

	Program Outcomes					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	1	1	0	1	1
CO2	2	1	1	0	1	1
CO3	3	2	3	3	2	3
CO4	3	2	2	1	1	2
CO5	3	2	1	3	3	3
CO6	3	3	3	3	1	3

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EE9011	SOFT COMPUTING TECHNIQUES	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods: Continuous Assessment (CA) and End Assessment (EA))					
Basic knowledge of algorithm/Logic/Programming		CA+EA					

Course Outcomes	On completion of the course, the students will be able to: • CO1: For the given linear and non-linear problems under practical limitations, compare classical analytical method and soft computing technique. • CO2: For a given single objective problem (SOP), apply binary coded genetic algorithm (BCGA) and real coded genetic algorithm (RCGA) with different types of crossover, mutation and also understand the impact of different parent selection strategies. • CO3: For a given non-linear or non-derivative problem, tune the control parameters of adaptive particle swarm optimization (APSO) for efficiently controlling the global exploration and local exploitation. • CO4: For a given standard benchmark problem, explain the significance of Difference vector in Differential Evolutionary (DE) technique and also illustrate self-adaptive differential evolutionary (SADE) technique. • CO5: For a given problem, logically clarify the impact of hidden layers in an artificial neuron network (ANN) and also stepwise explicate the back-propagation algorithm of ANN. • CO6: For a given problem, describe a fuzzy knowledge base controller (FKBC) showing information and computational flow with membership function, rule base and defuzzification.
Topics Covered	Hard Computing and Soft-Computing techniques, Conventional & non-conventional approaches, limitations of hard computing techniques, merits & demerits of soft-computing techniques, practical examples associated with soft-computing techniques. [3] Fundamental concept of optimization techniques and necessity of optimization techniques, types of optimization techniques, coding, fitness/objective function, algorithms. [2] Introduction of genetic algorithm, Binary coding & decoding, Genetic modelling, Reproduction, Crossover, Mutation, importance of crossover and mutation operators, parent selection strategy, parent selection methods, Flowchart/algorithm, drawback of

	binary coded genetic algorithm (BCGA), real coded genetic algorithm (RCGA), examples. [7] Introduction of Particle Swarm Optimization (PSO) algorithm, Bird flocking & fish schooling, velocity, inertia weight factor, pbest solution, gbest solution, local optima, global optima, Flowchart/algorithm, examples, new modifications of PSO, Parameter Selection in PSO. [7] Fundamentals of Differential Evolution algorithm, difference vector and its significance, Mutation and crossover, comparisons among DE, PSO and GA, Examples, new modifications of DE, Improved DE schemes for noisy optimization problems. [7] Fuzzy set theory, Fuzzy systems, crisp sets and fuzzy sets, fuzzy set operations and approximate reasoning, Fuzzification, inferencing and defuzzification, Fuzzy knowledge and rule bases, examples. [7] Biological neural networks, Model of an artificial neuron, neural network architecture, Characteristics of neural network, learning methods, Taxonomy of neural network architecture, Back propagation networks, architecture of a backpropagation network, back propagation learning, Examples, RBF network, Associative memory, Adaptive resonance theory. [7] Applications of Soft Computing to various fields of engineering. [2]
Text Books, and/or reference material	Text Books: 1. Devendra K. Chaturvedi, “Soft Computing- techniques and its application in electrical engineering”, Springer, 2008. 2. Carlos A. Coello,Garry B. Lamont, David A. van Veldhuizen, “Evolutionary Algorithms for solving Multi-objective Problems”, Second Edition, Springer, 2007. Reference Books: 1.Jyh-Shing Roger Jang, Chuen-Tsai Sun &EijiMizutani, Neuro-Fuzzy and Soft Computing: A Computational Approach to Learning and Machine Intelligence, Prentice Hall 2.S. Rajasekaran and G. A. VijayalakshmiPai, Neural Networks, Fuzzy Logic and genetic Algorithm Synthesis and Applications, PHI 3.Simon Haykin, Neural Networks: A Comprehensive Foundation, Prentice Hall 4.L. A. Zadeh, Fuzzy Sets and Applications, John Wiley & Sons

CO vs PO mapping

Map in terms of 0,1,2,3

	Program Outcomes					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	1	3	1	1	1	1
CO2	2	2	1	1	1	1
CO3	2	2	2	2	1	1
CO4	2	2	2	2	1	1
CO5	2	3	2	2	2	1
CO6	2	3	3	2	2	2

<table>
<tr><td colspan="9">Department of Electrical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EE9016</td><td>MACHINE LEARNING & EXPERT SYSTEM</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites: NA</td><td colspan="5">Course Assessment methods: Continuous Assessment (CA) and End Assessment (EA))</td></tr>
<tr><td colspan="3">EE1001(Fundamentals of power systems), EE1002 (Power System Operation)</td><td colspan="5">CA+EA</td></tr>
<tr><td colspan="2">Course Outcomes</td><td colspan="6">
• CO1: Understand complexity of machine learning algorithms and their limitations
• CO2: Be capable of confidently applying common Machine Learning algorithms in practice and implementing their own
• CO3: Understand modern notions in data analysis oriented computing
• CO4: Be capable of performing experiments in machine learning using real-world data.
• CO5: Be capable of designing machine learning based expert system using real-world data</td></tr>
<tr><td colspan="2">Topics Covered</td><td colspan="6">
Introduction: Definition of learning systems. Goals and applications of machine learning. Aspects of developing a learning system [4]
Inductive Classification: Concept learning. General-to-specific ordering of hypotheses. Finding maximally specific hypotheses. Version spaces and the candidate elimination algorithm. [5]

Decision Tree Learning: Concepts as decision trees. Recursive induction of decision trees. Picking the best splitting attribute: entropy and information gain. Searching for simple trees and computational complexity. Occam's razor. Overfitting, noisy data, and pruning. [4]

Bayesian Learning: Probability theory and Bayes rule. Naive Bayes learning algorithm. Parameter smoothing. Generative vs. discriminative training. Logistic regression. Bayes nets and Markov nets for representing dependencies. [4]

Instance-Based Learning: Constructing explicit generalizations versus comparing to past specific examples. k-Nearest-neighbor algorithm. Case-based learning. Experimental [4]</td></tr>
</table>

	Rule Learning: Translating decision trees into rules. Heuristic rule induction using separate and conquer and information gain. First-order Horn-clause induction. [3] **Evaluation of Learning Algorithms:** Measuring the accuracy of learned hypotheses. Comparing learning algorithms: cross-validation, learning curves, and statistical hypothesis testing. [3] **Artificial Neural Networks**: Neurons and biological motivation. Linear threshold units. Perceptrons: representational limitation and gradient descent training. Multilayer networks and backpropagation. Hidden layers and constructing intermediate, distributed representations. Overfitting, learning network structure, recurrent networks. [3] **Support Vector Machines:** Maximum margin linear separators. Quadractic programming solution to finding maximum margin separators. Kernels for learning non-linear [4] **Expert System design:** Face detection algorithm, Computer-aided diagnosis system [4]
Text Books, and/or reference material	Text Books: 1. Tom M. Mitchell, Machine Learning 2. Christopher Bishop, Pattern Recognition and Machine Learning.

CO vs PO mapping

Map in terms of 0,1,2,3

	Program Outcomes					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	3	1	2	0
CO2	3	3	3	2	2	0
CO3	3	3	3	2	1	1
CO4	3	3	3	2	1	1
CO5	3	3	3	3	1	1

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EE1061	ADVANCED POWER ELECTRONICS LABORATORY	PCR	0	0	4	4	2
Pre-requisites		Course Assessment methods: Continuous Assessment (CA) and End Assessment (EA))					
EE1012 (Advanced Power Electronics - I)		CA+EA					
Course Outcomes	• CO1: To understand the principle of power electronics devices						

	• CO2: To understand the detail operation of the ac-dc/ dc-dc/ ac-ac/ dc-ac components • CO3: To understand the implementation of the components for dc and ac machine control. • CO4: To develop the ability to design and implement different converters and gate driver circuits • CO5: To understand the control of the converters
Topics Covered	1. Single Phase Bridge Inverter Using IGBT 2. Three Phase SCR Module (a) Three Phase Half Controlled Bridge Rectifier with R and R-L load (b)Three Phase Fully Controlled Bridge Rectifier R and R-L load (c) Three Phase AC Voltage Controller with R and R-L load 3. Speed Control of 3Ø AC Induction Motor Using IPM and MICRO–2407 (a) Open Loop Control of Three Phase Induction Motor by using V/F control. (b)Closed Loop Control of Three Phase Induction Motor by using V/F control. 4. Speed Control of DC Motor by Using Single Phase Triggering and Device module Some new experiments are to be added -------NPC Multilevel Inverter, Z-Source Inverter, Matrix Inverter 5. Speed Control of 3-phase Induction Motor using PSIM 6. Study of Characteristic of Buck, Boost & Buck-Boost Converter 7. Modelling and control of Buck and Boost Converter by Using MATLAB 8. Closed Loop Control of Boost Converter by Using Multisim
Text Books, and/or reference material	Text Books: 1. N. Mohan, T. M. Undeland and W. P. Robbins, Power Electronics, Converters, Applications and Design, John-Wiley & Sons 2. Joseph Vithayathil, "Power Electronics - Principles and Applications", McGraw Hill Inc., New York, 1995. Reference Books: 1.Laboratory Manuals

CO vs PO mapping

Map in terms of 0,1,2,3

	Program Outcomes					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	3	1	0	0
CO2	3	3	3	3	2	1
CO3	3	3	3	3	2	1
CO4	3	3	3	3	2	1
CO5	3	3	3	3	2	1

<table>
<tr><td colspan="9">Department of Electrical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2" colspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EE1062</td><td>COMPUTATION LABORATORY</td><td>PCR</td><td>0</td><td>0</td><td>4</td><td>4</td><td colspan="2">2</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="7">Course Assessment methods: Continuous Assessment (CA) and End Assessment (EA))</td></tr>
<tr><td colspan="2">Computer Programming in MATLAB</td><td colspan="7">CA+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">CO1: Acquire an idea about different computation techniques.
CO2: To develop programming skill in MATLAB for solving logical problems.
CO3: To acquire skill to develop different optimization techniques.
CO4: To acquire skill to solve ANN/Fuzzy based problems</td></tr>
<tr><td>Topics Covered</td><td colspan="8">To study and practice the basic MATLAB programming.
To solve the benchmark problems using Particle Swarm Optimization (PSO) technique.
Tuning of PID Controller using Adaptive Particle Swarm Optimization (APSO) technique.
Tuning of PID Controller using Real Coded Genetic Algorithm (RCGA).
Speed Control of DC motor using Binary Coded Genetic Algorithm (BCGA).
To solve the benchmark problems using Differential Evolution (DE) technique.
To study the Air conditioning system using Fuzzy Logic.
To study and perform the application of Artificial Neural Network (ANN) technique.</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="8">Text Books:
Laboratory manuals</td></tr>
</table>

CO vs PO mapping

Map in terms of 0,1,2,3

	Program Outcomes					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	1	3	1	1	1	1
CO2	2	2	1	1	1	1
CO3	2	2	2	2	1	1
CO4	2	2	2	2	2	1

<table>
<tr><td colspan="9">Department of Electrical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2" colspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EE2011</td><td>ADVANCED POWER ELECTRONICS-II</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td colspan="2">4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="7">Course Assessment methods: Continuous Assessment (CA) and End Assessment (EA))</td></tr>
<tr><td colspan="2">Advanced Power Electronics – I (EE1012), Machine Drives-I (EE1013)</td><td colspan="7">CA+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">CO1: To understand the concept of modelling, controller design & stability analysis non-linear dynamics of converters.
CO2: To get acquainted with advanced converters & their modeling.
CO3: To get acquainted with Resonant& soft-switching converters.
CO4: To understand the concept & operation of Multilevel Inverters.
CO5: To learn the advanced modulation techniques for Converters/Inverters
CO6: To get acquainted with practical applications & literature survey.</td></tr>
<tr><td>Topics Covered</td><td colspan="8">Converter Control: Modelling &controller design, stability analysis, Non-linear phenomenon [8]
Some advanced converters: Modelling & control of Tri-state, Interleaved, Multiphase & Higher order converters, High Gain converters[12]
Resonant Converters: Classification of Resonant Converters, Series-Loaded and Parallel-Loaded Resonant Converter Topology, Soft Switching converters, Dual Active Bridge (DAB) converter [8]
Multilevel Converters: Fundamental topologies, Neutral Point Clamped (NPC), Flying Capacitor Converter, Cascaded Multilevel Converters, Other Multilevel voltage source inverters, applications. [10]
Advanced modulation techniques for Converters/Inverters; space vector modulation, carrier based modulation, Phase shifted multicarrier modulation, level shifted multicarrier modulation, third harmonic injection PWM, Max-Min Zero Sequence Injected PWM, Double Signal PWM (DSPWM) [8]
Some practical applications of PE converters, literature study. [10]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="8">Text Books:
1. Fundamentals of Power Electronics, Robert W. Erickson & D. Maksimovic, Kluwer Academic Publisher
2.Power-Switching Converters, Simon Ang, Alejandro Oliva, Taylor & Francis
3.Advanced DC/AC Inverters: Fang Lin Luo, Hong Ye, CRC Press
Reference Books:
1. The Power Electronics Hand Book- Timothy L. Skyarnina, CRC Press</td></tr>
</table>

	2. Power Electronic Converters: Dynamics and Control in Conventional & Renewable Energy Applications. WILEY-VCH

CO vs PO mapping

Map in terms of 0,1,2,3

	Program Outcomes					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	3	3	0	0
CO2	3	3	3	3	2	1
CO3	3	3	3	3	2	1
CO4	3	3	3	3	2	1
CO5	3	3	3	3	1	0
CO6	3	3	3	3	3	3

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EE9012	MACHINE DRIVES-II	PEL	3	1	0	4	4
Pre-requisites		Course Assessment methods: Continuous Assessment (CA) and End Assessment (EA))					
Machine Drives-I (EE1013), Advanced Power Electronics, Control System Theory		CA+EA					
Course Outcomes	CO1: To learn mathematical modeling and analysis of different types of three-phase machines in general CO2: To learn about control strategies of squirrel cage induction machine CO3: To learn about control strategies of wound rotor induction machine CO4: To learn about control strategies of permanent magnet synchronous machine CO5: To perform analysis and control of Switched reluctance motors CO6: To analyze and control Brushless dc motors						
Topics Covered	Introduction to synchronously rotating reference frame and implementation in simulation environment. [8] Direct and Indirect Vector Control of Squirrel Cage Induction Machine (SQIM). Speed Sensorless Vector Control of SQIM. [8] Direct torque control (DTC) of SQIM, speed sensorless DTC of SQIM [5] Vector control of Wound Rotor Induction Machine with different power circuits [7]						

	Synchronous machines: Introduction, voltage and torque equations in machine variables, arbitrary reference frame variables and rotor reference variables, simulation of three-phase synchronous machines. [5] Vector control of cycloconverter fed synchronous motor drive [5] Vector control of Permanent magnet synchronous machine, different control strategies, flux weakening operation, constant torque mode controller, flux weakening controller, sensorless control. [8] Switched reluctance motor drives: Basic principle of operation, Torque equation, analysis, power electronics control of switched reluctance motor drives. [5] Brushless dc motor drives: Construction. Principle of operation, Modelling and control of Brushless dc motors. [5]
Text Books, and/or reference material	Text Books: 1. Modern Power Electronics and AC Drives- B. K. Bose 2. Electric Motor Drives, Modelling Analysis and Control – R. Krishnan Reference Books: 1. Electric Drives- Ion Boldea, Syed A. Nasar 2. Power Electronics and Variable Frequency Drives- B. K. Bose

CO vs PO mapping

Map in terms of 0,1,2,3

	Program Outcomes					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	3	3	3	3
CO2	3	3	3	3	3	1
CO3	3	3	3	3	3	1
CO4	3	3	3	3	3	1
CO5	3	3	3	3	2	1
CO6	3	3	3	3	2	1

<table>
<tr><td colspan="9">Department of Electrical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EE9021</td><td>DIGITAL SIGNAL PROCESSING</td><td>PEL</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods: Continuous Assessment (CA) and End Assessment (EA))</td></tr>
<tr><td colspan="3">Signal and Systems in B. Tech.</td><td colspan="5">CA+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: To understand the properties signals and systems.
• CO2: To understand the concept of signal processing.
• CO3: To analyze discrete time signals and systems in time, frequency domain.
• CO4: To design digital filters.
• CO5: To get acquainted with digital processors recently used.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Discrete time signals and systems, properties, convolution, analysis of discrete time systems in time-domain [4]
Frequency domain representation of discrete time systems and signals, Gibbs phenomenon, band limited signals, sampling theorem aliasing sampling of continuous time signals [6]
Z- transforms, region of convergence, Z- transform theorems and properties, methods of Inverse Z-transforms, analysis of discrete time signals and systems in Z-domain, pole-zero plots, stability [4]
Realization of FIR Systems and IIR systems [4]
Discrete time Fourier transform of discrete time signals and systems, Inverse discrete time Fourier transform, Eigen function [6]
Discrete Fourier transform (DFT), properties of DFT, Linear convolution using DFT, Computation of DFT by FFT algorithms like decimation in frequency and decimation in time [8]
Various Filter design techniques for FIR and IIR filters [10]
Sampling rate conversion, up and down rate sampling, interpolation and decimation [4]
Introduction to discrete Hilbert Transform, Complex Capstrum, Application of Capstral analysis [6]
Practical applications of DSP, DSP processors. [4]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1.Discrete Signal Processing by A.V. Oppenheim and R.W. Schafer (Prentice-Hall).
2.J. G. Proakis& D. G. Manolakis, Digital Signal Processing: Principles, Algorithms and Applications, Prentice Hall of India.
Reference Books:
1.Digital Signal processing by Sanjit K. Mitra (Tata McGraw-Hill).
2.Theory and Application of Digital Signal Processing by L. R. Rabiner and B. Gold, Pearson Education, 2004</td></tr>
</table>

CO vs PO mapping

Map in terms of 0,1,2,3

	Program Outcomes					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	3	2	2	1
CO2	3	3	3	2	2	1
CO3	3	3	3	2	2	1
CO4	3	3	3	2	2	1
CO5	3	3	3	2	1	0
CO6	3	3	3	2	1	0

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EE9030	DISTRIBUTED GENERATION SYSTEM AND MICROGRID	PEL	3	1	0	4	4
Pre-requisites		Course Assessment methods: Continuous Assessment (CA) and End Assessment (EA))					
Power System I and II		CA+EA					

Course Outcomes	On completion of the course, the students will be able to: • CO1: Understand the concept of distributed generation (DG) • CO2: Find optimal size, placement of DGs • CO3: Analyze the impact of grid integration and control aspects of DGs. • CO4: Model and analyze a micro grid taking into consideration the planning and operational issues of the DGs to be connected in the system • CO5: Study concept of Micro grid and its configuration.
Topics Covered	Introduction of Distributed generation technologies,Need for distributed generation, Renewable sources in distributed generation, Current scenario in distributed generation, Planning of DGs, Siting and sizing of DGs, Optimal placement of DG sources in distribution systems, Solar and Wind Resources for distributed generationand Models [13]. Grid integration of DGs, Different types of interfaces, Inverter based DGs and rotating machine-based interfaces, Aggregation of multiple DG units, Energy storage elements, Batteries, ultracapacitors, flywheels [10].

	Technical impacts of DGs on Transmission systems, Distribution systems, De-regulation, Impact of DGs upon protective relaying, Impact of DGs upon transient and dynamic stability of existing distribution systems [10]. Economic and control aspects of DGs, Market facts, issues and challenges, Limitations of DGs, Voltage control techniques, Reactive power control, Harmonics, Power quality issues, Reliability of DG based systems, Steady state and Dynamic analysis [12]. Introduction to micro-grids, Types of micro-grids, Autonomous and non-autonomous grids, Sizing of micro-grids,Modeling& analysis of Micro-grids with multiple DGs, Micro-grids with power electronic interfacing units,Grid Interface and Synchronization, Transients in micro-grids, Protection of micro-grids, Case studies on microgrid, Smart Grid Concepts, Control Methods and Applications [13].
Text Books, and/or reference material	TEXT BOOKS: 1. H. Lee Willis, Walter G. Scott , 'Distributed Power Generation – Planning and Evaluation', Marcel Decker Press, 2000. 2. M.GodoySimoes, Felix A.Farret, 'Renewable Energy Systems – Design and Analysis with Induction Generators', CRC press. 3. Robert Lasseter, Paolo Piagi, ' Micro-grid: A Conceptual Solution', PESC 2004, June 2004. REFERENCE BOOKS: 1 F. Katiraei, M.R. Iravani, 'Transients of a Micro-Grid System with Multiple Distributed Energy Resources', International Conference on Power Systems Transients (IPST'05) in Montreal, Canada on June 19-23, 2005. 2. Z. Ye, R. Walling, N. Miller, P. Du, K. Nelson, 'Facility Microgrids', General Electric Global Research Center, Niskayuna, New York, Subcontract report, May 2005.

CO vs PO mapping

Map in terms of 0,1,2,3

	Program Outcomes					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	2	0	0	1	1
CO2	2	3	3	2	1	0
CO3	1	2	2	0	1	1
CO4	3	1	2	0	1	1
CO5	1	1	1	0	1	0

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EE9029</td><td>ADVANCED CONTROL SYSTEMS II</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods: Continuous Assessment (CA) and End Assessment (EA))</td></tr>
<tr><td colspan="3">Advanced Control System I (EE9014)</td><td colspan="5">CA+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: To acquire the knowledge of sampled data system, the sampling and hold process, understand, investigate and analyze the stability of the discrete time systems
CO2: To analyze the sample data system both in time and frequency domain
CO3: To learn digital control for sample data systems
CO4: To get the idea of state variable analysis for discrete-time systems
CO5: To understand dynamic property and stability of nonlinear systems
CO6: To design control system for nonlinear systems</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Introduction to Digital Control: Sample Data System, The sampling process, Discrete-time signals and their classifications, Representation of discrete-time signals as sequences, Sampling Process; Sampling Theorem; Aliasing Sampling of Continuous-time signals, Signal reconstruction, Discrete-time Systems and their classifications, Finite dimensional LTI systems [8]

Difference equations, z-transform theory, z-transfer functions (pulse transfer functions), inverse z-transform and response of linear discrete systems, z-transform analysis of sampled data control systems, z and s domain relationship [6]

Stability analysis in z-plane, Jury's stability criteria, Root Locus Analysis, Frequency Response of Sample data system, Bilinear Transformation, Bode diagram in w-plane [6]
Digital Controllers: Feedback Control, Classical Controller P, PI, PID, Lead and Lag [6]
State Space Representation of Discrete-time Systems: State model state models for linear discrete time systems, conversion of state variables models to transfer functions in z-domain, solutions of state equations, state transition matrix, state</td></tr>
</table>

	transition flow graphs, eigenvalues, eigenvectors and stability similarity transformation, decompositions of transfer functions, canonical state variable models, controllability and observability, state feedback and pole placement, Observer Design, MATLAB tools and case studies [10] **Nonlinear Systems and Control:** Fundamentals of Nonlinear systems, dynamics, concept of stability and equilibrium point, Jacobian matrix and stability, domain of convergence, Phase plane analysis Steady state frequency response analysis, Describing function, Extended Nyquist criteria Lypunov stability Criteria, Application of Lyapunov stability, Popov criteria, stabilization via state feedback, Feedback linearization [20]
Text Books, and/or reference material	Text Books: 1. Discrete Time Control Systems, K Ogata 2. Digital Control System, B. C. Kuo 3. Applied Nonlinear Control, Slotine and Li, Prentice-Hall 1991 Reference Books: 1. Digital Control and State Variable Methods, M. Gopal 2. Digital Control Of Dynamic Systems, G.Franklin, J.Powell, M.L. Workman. 3. Nonlinear System, H. K. Khalil

CO vs PO mapping

Map in terms of 0,1,2,3

	Program Outcomes					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	2	1	3	1	0
CO2	3	2	1	3	0	1
CO3	3	2	3	3	2	3
CO4	1	1	1	3	3	1
CO5	2	2	1	2	3	0
CO6	3	2	1	2	3	3

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EE9017	RENEWABLE ENERGY SYSTEMS	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods: Continuous Assessment (CA) and End Assessment (EA))					
Power System I and II		CA+EA					

Course Outcomes	On completion of the course, the students will be able to: • CO1: know the National and International Energy Scenario • CO2:.gain insight of the solar photovoltaic system and application • CO3: get acquainted with wind power technology and use • CO4: understand the technology of bio-fuel and tidal power generation • CO5: know about functioning of Fuel Cell • CO6: understand issues of Energy Audit and Energy Management
Topics Covered	Introduction: Energy system as electrical system, Energy chain, National and International Energy scenario, various non-conventional energy resources-importance, World Energy Challenges and Pledges, Energy Sustainability, Changing Pattern of uses of Energy resources, classification, relative merits and demerits, Keys for Energy Security, Carbon emission, carbon credit, Calculation of Carbon Credit with Solar Plant, Protocol regarding the Carbon emission [9] Solar photovoltaic: Introduction, solar radiation & its relation with photovoltaic effect. Photovoltaic concentration, Application of Solar Energy,Thermal Energy Conversion, Solar Air Heating System, Commercial/Residential and Industrial Solar Air Heater (SAH), Solar Pond, Design of a SAH, Solar Water Heater (SWH), Solar Constants, Introduction to Solar Cell, Principle of Solar Cell, Working of Solar Cell, Construction of Solar Cell , Calculation of Solar Energy from PV cell, Variation of V-I characteristic of PV cell, Grid Connected and OFF grid PV power System, Hybrid Power System, Structure for PV power System[10] Wind power and its sources, site selection criterion, wind characteristics, momentum theory, Classification of wind machines. Wind mills-different design & their control, wind generators- different types, wind farms & grid. Wind generation in India. Wind Power and maximum power equation. Wind penetration & its effects, economic issues, recent developments, international scenario. Wind energy collector, Application of wind energy [7] Principles of tidal power generation, components of power plant, Single and two basin systems, Estimation of energy, Maximum and minimum power ranges. Ocean and

	geothermal Energy, geothermal power plant. OTEC Principle, Open cycle and closed cycle. [4] Bio fuel, Conversion of biomass, Biofuel classification, Biomass production for Energy farming, direct combustion for heat-pyrolysis-thermochemical process, Anaerobic digestion- Digester sizing- waste and residues, vegetable oils and biodiesels, Applications of Biogas, Social and environmental aspects.[4] Fuel Cell: Basic construction & principle of operation of fuel cell, Fuel cell power plants & its integration with wind and solar photovoltaic systems. Geothermal Energy, Dry Steam power plant, Single and Double Flash power plant and integration in electrical system/Grid.[4] Energy conservation opportunities, Energy Audit, Saving of energy with energy economics. Energy Management and its basic principle with case studies [5]
Text Books, and/or reference material	TEXT BOOKS: 1. G.D. Rai, Non-conventional energy resources, Khanna Publishers, New Delhi, 2003. 2. N. G. Clavert, Wind Power Principle, their application on small scale, Calvert Technical Press. REFERENCE BOOKS: 1. Fuel Cell Handbook, Parsons Inc. 2. Earnest and T. Wizelius, Wind Power Plants and Projects development, PHI

CO vs PO mapping

Map in terms of 0,1,2,3

	Program Outcomes					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	1	2	0	0	1	1
CO2	2	2	2	2	1	0
CO3	2	2	2	0	1	1
CO4	0	1	1	0	1	1
CO5	1	1	1	0	1	0
CO6	2	2	2	0	1	2

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EE9018	EMBEDDED SYSTEM	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods: Continuous Assessment (CA) and End Assessment (EA))
NIL	CA+EA

Course Outcomes	• CO1: Comparing different microprocessor architectures and justifying their field of application. • CO2: Given peripheral devices such as memory, ADC, DIOs, etc., design of interfacing circuit, and writing algorithms to fulfil a given specific application. • CO3: Programming processor specific and processor independent software for different complex embedded system applications. • CO4: Developing hardware and software for a given applications. • CO5: Knowledge of advanced microcontrollers and RTOS features and their field of applications.
Topics Covered	Introduction to Embedded systems: Introduction – Features – Microprocessors – ALU - Von Neumann and Harvard Architecture, Classification, SPP, ASIC, ASIP [4] CISC and RISC - Instruction pipelining. Fixed point and Floating point processor [3] General characteristics of embedded system, introduction to different components etc [6] Microcontroller 89CX51/52 Series: Characteristics and Features, Overview of architectures, and Peripherals, Timers, Counters, Serial communication, Digital I/O Ports [4] Microcontroller PIC Series: Characteristics and Features, Overview of architectures, and Peripherals, Interrupts, Timers, watch-dog timer, I/O port Expansion, analog-to-digital converter, UART, I2C and SPI Bus for Peripheral Chips, Accessories and special features. [5] ARM Architecture: Evolution, Characteristics and Features, Overview of architectures, Modes, Registers etc [8] Digital Signal Processor [4] Software architecture and RTOS: Software Architecture: Round Robin- Round Robin with interrupts -Function Queue. Scheduling Architecture RTOS: Architecture -Tasks and Task States -Tasks and Data -Semaphores and Shared Data Message Queues -Mail Boxes and pipes -Timer Functions -Events - Memory Management, Interrupt Routines. [6] Basic design using a real time operating system: Overview. General principles. Design of an embedded system.

	Development Tool: Cross-Compiler, Cross-Assemblers, Linker/locator. PROM Programmers, ROM, Emulator, In-Circuit Emulators. Debugging Techniques. Instruction set simulators. The assert macro. [6]
Text Books, and/or reference material	Text Books: 1. Douglas V. Hall, *Microprocessors & Interfacing*, Tata McGraw-Hill 2. M. Predko, *Programming & Customising 8051 Microcontroller*, TMH Reference Books: 1. John Uffenbeck, *Microcomputers and Microprocessors*, Pearson Education 2. Michel Slater, *Microprocessor Based Design*, PHI

CO vs PO mapping

Map in terms of 0,1,2,3

	Program Outcomes					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	3	2	1	0	1
CO2	1	2	3	1	1	1
CO3	3	2	1	3	2	1
CO4	1	2	1	3	0	0
CO5	1	3	2	1	1	1
CO6	1	2	3	3	2	2

Department of Electrical Engineering								
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EE9019	FACTS DEVICES	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods: Continuous Assessment (CA) and End Assessment (EA))
Power Systems I and II, Power Electronics	CA+EA
Course Outcomes	On completion of the course, the students will be able to: ● CO1: Understand the concept of FACTS devices as a whole. ● CO2: Acquire knowledge about different applications of FACTS devices in power system. ● CO3: Acquire an idea about modelling and control of various FACTS devices and their interaction in power system. ● CO4: Understand how FACTS devices improve various power system performances like power flow control, stability etc.
Topics Covered	FACTS concept and General System of Considerations.[2] Checklist of possible benefits from FACTS technology.[1] Lumped/Distributed model analysis for Series and Shunt compensation.[5]

	Methods of Controllable Var Generation: Variable Impedance Type Static Var Generators, lumped/distributed model analysis, TCR, TSR, TSC, FC-TCR.[8] Switching Converter Type Var Generators, STATCOM, basic concepts, lumped/distributed model analysis, basic converter configurations. [8] Static Series Compensators: Basic principles of operation of TSSC, TCSC, SSSC, lumped/distributed model analysis Applications. [8] Static Voltage and Phase angle regulators: TCVR and TCPAR, lumped/distributed model analysis, Applications.[7] Combined Compensators: Unified Power Flow Controller (UPFC), basic operating principles, conventional transmission control capabilities. Functional control of shunt converter and series converter, basic control systems for P and Q control, lumped/distributed model analysis.[11] Introduction to steady state analysis and control, oscillation stability analysis and control by UPFC. Transient stability control by CSC, SSSC, SVC, STATCOM and UPFC. [8]
Text Books, and/or reference material	**Text Books:** 1. Y.H. Song and A.T. Johns," Flexible AC Transmission Systems (FACTS), IET Power and Energy Series, Shankar's Book Agency Publisher (Indian Edition). 2. K.R. Padyyar," FACTS Controller in Power Transmission and Distribution", **<u>Reference Books:</u>** 1. Mey Ling Sen, Kalyan K. Sen," Introduction To FACTS Controllers – Theory, Modeling And Applications, Wiley (IEEE) Publisher. 2. N.G. Hingorani& L. Gyugyi, "Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems".

CO vs PO mapping

Map in terms of 0,1,2,3

	Program Outcomes					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	2	2	1	0	1
CO2	3	3	2	1	1	1
CO3	2	3	3	2	1	1
CO4	2	3	3	2	0	1

<table>
<tr><td colspan="9">Department of Electrical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EE9022</td><td>ESTIMATION OF SIGNALS & SYSTEMS</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods: Continuous Assessment (CA) and End Assessment (EA))</td></tr>
<tr><td colspan="3">Advanced Control System I</td><td colspan="5">CA+EA</td></tr>
<tr><td colspan="2">Course Outcomes</td><td colspan="6">

CO1: To develop insight on well-known techniques for parameter estimation and identification of unknown parameters using these estimation methods for linear as well as nonlinear systems.
CO2: Familiarization with Random variables , Stochastic Processes and Probabilistic state space models, categorization of noise, Investigation of controllability and observability of linear as well as nonlinear systems.
CO3: To develop concept on Bayesian filtering, derivation of Kalman filter as a special case of Bayesian filter, familiarization with the properties of Kalman filters and its variants, ability to design and tuning Kalman filter.
CO4: To augment the concept of Kalman filtering for nonlinear dynamic systems, to appreciate Linearized Kalman filter and Extended Kalman filter as the nonlinear version of Kalman filter.
CO5: Understanding the general framework of Gaussian filter as a special case of Bayesian filter and deriving the variants of sigma point filters and Quadrature filter from the framework.
CO6: To develop knowledge on Maximum likelihood estimation and its application for state and parameter estimation for dynamic system, Derivation of Cramer-Rao lower bound to investigate the accuracy aspects of the estimators.
</td></tr>
<tr><td colspan="2">Topics Covered</td><td colspan="6"> Parameter Estimation: Least Squares Estimation, The Recursive Least-Squares Algorithm, Initial Conditions and Properties of RLS, Estimation of Time-varying Parameters, Multi-Output, Weighted Least Squares Estimation, Generalized least squares, A probabilistic version of the LS, Nonlinear least squares, Equation error method, Application of these methods [6]
Introduction to Linear Systems and Probability theory: Matrix algebra and matrix calculus, Stability, Controllability and observability for linear and nonlinear systems, Disceretization, The Gauss -Markov Discrete-time Model, Random variables, Transformations of random variables, Multiple random variables, Stochastic Processes and Probabilistic state space models, White noise and colored noise [6] </td></tr>
</table>

	Bayesian Filtering and introduction to Kalman filter: Origins of Bayesian filtering, Optimal filtering as Bayesian inference, Algorithms for Bayesian filtering and smoothing, Bayesian filtering equations and exact solutions, Framework of the Kalman Filter, The Discrete Kalman Filter as a Linear Optimal Filter [4] Properties of Kalman filters: Minimum Variance and Linear Minimum, Variance Estimation; Orthogonality and Projection, The Innovations Sequence, True Filtered Estimates and the Signal-to –Noise Ratio Improvement Property, Inverse Problems [3] Variants of Kalman Filter: Information filtering, Square root filtering, Correlated process and measurement noise, Colored process and measurement noise, Steady-state filtering, Adaptive Kalman filters, Gaussian Sum filters [8] Introduction to Nonlinear Kalman filtering: The linearized Kalman filter, The extended Kalman filter, Higher-order approaches [3] General Gaussian filtering: Unscented transformations, Unscented Kalman filtering, Quadrature rules for Gaussian Integral Approximations, Gauss Hermite filters, Cubature filters, Cubature Quadrature filters [6] Output error method of Estimation: Principle of maximum likelihood, Cramer-Rao lower bound, Maximum likelihood estimation for dynamic system, Accuracy aspects, Output error method [6]
Text Books, and/or reference material	Text Book: Modelling and Parameter Estimation of Dynamic Systems by J.R. Raol, G. Girija and J. Singh, Institution of Engineering and Technology, London, United Kingdom Optimal State Estimation: Kalman, H∞ and Nonlinear Approaches by Dan Simon, Reference Book: Introduction to Random Signals and Applied Kalman Filtering by Robert Grover Brown & Patrick Y. C. Hwang, John Wiley & Sons Bayesian Filtering and Smoothing by Simo Sarkka, Cambridge University Press

CO vs PO mapping

Map in terms of 0,1,2,3

	Program Outcomes					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	1	0	2	3	1	3
CO2	1	0	1	2	1	2
CO3	1	0	2	3	1	3
CO4	1	0	2	3	2	3
CO5	1	0	1	2	1	1
CO6	1	0	1	3	1	3

<table>
<tr><td colspan="8">Department of Electrical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EE9026</td><td>BIOMEDICAL INSTRUMENTAION</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods: Continuous Assessment (CA) and End Assessment (EA))</td></tr>
<tr><td colspan="3">Electrical & Electronic Measurement</td><td colspan="5">CA+EA</td></tr>
<tr><td colspan="2">Course Outcomes</td><td colspan="6">● CO1: Familiarise with biomedical transducers
● CO2: Able to design of biomedical equipments and signal processing circuitry
● CO3: Acquire knowledge about various electrodes used in bio instrumentation.
● CO4: Expertise for measurement of various physiological parameters in vivo and vitro.
● CO5: Gaining knowledge about medical imaging</td></tr>
<tr><td colspan="2">Topics Covered</td><td colspan="6">Introduction to biomedical Instrumentation, biomedical electronics, Components of Analog and digital circuits, Analog & digital circuit design, Multistage amplifier gain, Gain Bandwidth product, frequency response. [4]

Various types of signal conditioners, signal conditioning processes, Signal Acqusition, graphical user interface, Transformer based and transformer less power supply. [4]

Medical instrumentation constrains, Various biomedical transducers. [4]

Generation of Nernst Potential, Establishment of diffusion potential, Goldmann Equation, Measurement of membrane potential, resting potential, action potential, Voltage Clamp, Hodgekin Huxley Model. [4]

Use of electrodes for measurement of bio potentials, polarization in electrodes, principle of operation of Ag/AgCl electrode, Equivalent circuit of electrode, motion artifact, various types of electrodes for bio potential measurement. [4]

Measurement of ECG, Einthoven triangle method, unipolar and bipolar limb leads, ECG amplifiers, Problems encountered in ECG recording. [4]

Analysis of ECG Signals, Pacemakers, Different types of pacing modes, Physiological effects of electric currents, Defibrillators. [4]</td></tr>
</table>

	Measurement of blood pressure, measurement of blood pH, measurement of blood flow, measurement of heart sounds, use of Surface PlasmonResonance for detection of toxins. [6] Introduction to medical imaging, Radiography, Computerized tomography, X Ray,-CT, MRI, PET, SPET, Gamma Camera, Ultrasound Imaging, Color Doppler, Recent trends in medical imaging, EIT, DOT, PAT, AEI. [8]
Text Books, and/or reference material	Text Books: 1. John Enderle. Joseph Brinzino, *Introduction to Biomedical Engineering*, Elsevier, 2012. 2.John G Webster, *Medical Instrumentation, Application & Design*, John Wiley & Sons, 2009 Reference Books: 1. L. Cromwell, Fred J. Weibell, Erich A. Pfeiffer, ,*Biomedical Instrumentation & Measurements*, PHI, 2014 2. Arthur C Guyton, John E Hall, *Textbook of Medical Physiology*, Elsevier, 2006

CO vs PO mapping

Map in terms of 0,1,2,3

	Program Outcomes					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	1	1	1	0	0	2
CO2	3	2	3	0	0	3
CO3	2	2	2	0	0	1
CO4	3	3	3	0	0	3
CO5	2	2	2	0	0	1

<table>
<tr><td colspan="9">Department of Electrical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EE9031</td><td>SPECIAL ELECTRICAL MACHINES</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods: Continuous Assessment (CA) and End Assessment (EA))</td></tr>
<tr><td colspan="3">EEC 01 (Electrical Technology)</td><td colspan="5">CA+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: To analyze and control the operation of Stepper motor
• CO2: To analyze the operation of Switched Reluctance motor
• CO3: To understand the operation of PM dc motor and Brushless dc motor
• CO4: To learn the working of Single-phase synchronous motors
• CO5: To acquire knowledge about Linear Induction and Synchronous motor</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Stepper Motors: Constructional features, Principle of operation, Permanent magnet stepper motor, Variable reluctance motor, Hybrid motor, Single and multi-stack configurations, Torque equations, Modes of excitations, Characteristics, Drive circuits, Control of stepping motors. [10]
Switched Reluctance Motors: Constructional features – Principle of operation – Torque production, Steady state performance prediction, Power Converters, Methods of Rotor position sensing, Closed loop control of SRM. [10]
Brushless D.C. Motors: Construction, Types, Principle of operation, Magnetic circuit analysis, Motor characteristics and control. [8]
Permanent Magnet Materials and Motors: Introduction; minor hysteresis loops and recoil line; stator frames of conventional PM dc motors; Equivalent circuit of a permanent magnet, Permanent Magnet Synchronous Motors- Principle of operation, EMF and Torque equations, Synchronous Reactance, Phasor diagram, Torque/speed characteristics. [8]
Linear Induction and Synchronous Motors: Development of a Double-sided LIM from Rotary type IM, Schematic of LIM drive for electric traction, Development of one-sided LIM, Equivalent circuit of LIM, Linear Synchronous motor. [4]
Single-Phase Synchronous Motors: Single Phase Reluctance and hysteresis motors. [4]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. K. Venkataratnam, Special Electric Machines, Universities Press.
2. T. Kenjo and A. Sugawara, Stepping Motors and Their Microprocessor Controls,
Reference Books:
1. T. Kenjo and S. Nagamori, Permanent Magnet and Brushless DC Motors2. T.J.E. Miller, Brushless Permanent Magnet and Reluctance Motor Drives, Clarendon Press, 1989.</td></tr>
</table>

CO vs PO mapping

Map in terms of 0,1,2,3

	Program Outcomes					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	2	3	1	1	0
CO2	2	2	3	1	1	0
CO3	2	2	3	2	1	1
CO4	2	2	3	0	0	0
CO5	2	2	3	0	0	0

<table>
<tr><td colspan="9">Department of Electrical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2" colspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>EE2061</td><td>MACHINE DRIVES LABORATORY</td><td>PCR</td><td>0</td><td>0</td><td>4</td><td>4</td><td colspan="2">2</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="7">Course Assessment methods: Continuous Assessment (CA) and End Assessment (EA))</td></tr>
<tr><td colspan="2">Machine Drives-I (EE1013)</td><td colspan="7">CA+EA</td></tr>
<tr><td colspan="2">Course Outcomes</td><td colspan="7">• CO1: To learn about TMS320F2812 and TMS320F28335 DSP processors and interfacing with CC Studio
• CO2: Ability to control the speed of an induction motor using Intelligent Power Module (IPM), Micro-28335 and also Micro-2812 DSP processors.
• CO3: Ability to control the speed of a BLDC motor using Intelligent Power Module (IPM), Micro-28335 and also Micro-2812 DSP processors.
• CO4: Ability to control the speed of a PMSM using Intelligent Power Module (IPM), Micro-28335 and also Micro-2812 DSP processors.
• CO5: Ability to control the speed of an induction motor using Multi-Level Inverter, Micro-28335 and also Micro-2812 DSP processors.</td></tr>
<tr><td colspan="2">Topics Covered</td><td colspan="7">1. Introduction to TMS320F2812 DSP processor and interfacing with CC Studio and Micro-2812 trainer Kit.
2. Introduction to TMS320F28335 DSP processor and interfacing with CC Studio and Micro-28335 trainer Kit.
3. Speed control of Induction Motor using Intelligent Power Module (IPM) and Micro-28335 trainer (open and closed loop control).
4. Speed control of BLDC motor using Intelligent Power Module (IPM) and Micro-28335 trainer (open and closed loop control).
5. Speed control of Induction Motor using Intelligent Power Module (IPM) and Micro-2812 trainer (open and closed loop control).
6. Speed control of BLDC motor using Intelligent Power Module (IPM) and Micro-2812 trainer (open and closed loop control).
7. Speed control of PMSM motor using Intelligent Power Module (IPM) and Micro-28335 trainer (open and closed loop control).
8. Speed control of PMSM using Intelligent Power Module (IPM) and Micro-2812 trainer (open and closed loop control).
9. Speed control of Induction Motor using Micro-28335 trainer and Multi-Level Inverter (open and closed loop control).
10. Speed control of Induction Motor using Micro-2812 trainer and Multi-Level Inverter (open and closed loop control).</td></tr>
</table>

Text Books, and/or reference material	Text Books: 1. Modern Power Electronics and AC Drives: B. K. Bose 2. Electric Motor Drives, Modelling Analysis and Control: R. Krishnan Reference Books: 1. Laboratory manuals

CO vs PO mapping

Map in terms of 0,1,2,3

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

Department of Electrical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EE2062	ADVANCED CONTROL LABORATORY	PCR	0	0	4	4	2
Pre-requisites		Course Assessment methods: Continuous Assessment (CA) and End Assessment (EA))					
Control System Theory		CA+EA					
Course Outcomes	• CO1: To understand the dynamic behaviour of real-time nonlinear systems. • CO2: To simulate physical systems in real-time environment. • CO3: To design control system to improve the performance characteristics of real-time systems. • CO4: To determine the parameters and transfer function of physical systems from real-time experimentation. • CO5: To get acquainted with MATLAB programming, MATLAB-SIMULINK in order to simulate, analyze and design of control system design for different plants under consideration						
Topics Covered	Hardware experiments: 8 working days Design and Real-time implementation of PID, LSVF & LQR controllers for 1. Cart-inverted pendulum system 2. Twin rotor MIMO system 3. Magnetic levitation (MAGLAV) system 4. Servo system Software Experiments: 7 working days						

	1. Design of a suitable controller for a given time delayed unity negative feedback closed loop system using root locus technique. 2. Design of lead, lag, lead-lag controller for a given unity negative feedback closed loop system using frequency domain design methods. 3. Design of linear quadratic optimal controller for a given continuous-time LTI plant. 4. Design of optimal state feedback controller for LTI plant where some of the states are not measurable. 5. Design of Kalman estimator when the sensors give noisy measurement for problem 3. 6. Design of H∞ full information controller for a given LTI plant. 7. Design of a controller using frequency domain design technique for a unity negative feedback closed loop system with a given continuous-time plant
Text Books, and/or reference material	Text Books: 1. Modern Control Engineering, K. Ogata, 2. Modern Control System Theory, M. Gopal, 3. Discrete Time Control Systems, K Ogata 4. Control System Engineering, 7th Edition, Norman S. Nise, Wiley 5. Digital Control System, B. C. Kuo 6 Kalman Filtering Theory and Practice, Mahinder S. Grewal and Angus P Andrews Reference Books: 1. Linear Control System Analysis And Design With MATLAB,John J. D'Azzo and Constantine H. Houpis and Stuart N. Sheldon 2. Linear Robust Control, Michael Green and David J.N. Limebeer

CO vs PO mapping

Map in terms of 0,1,2,3

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