NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

DEPARTMENT OF ELECTRICAL ENGINEERING

Revised Curriculum and Syllabi

Program Name

Master of Technology in Power Systems

Effective from the Academic Year: 2021-2022

Recommended by DPAC	: 23.07.2021
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	EE1001	EHV Transmission	3	1	0	4	4
2	EE1002	Power System Operation and Control	3	1	0	4	4
3	EE1003	High Voltage Engineering	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	EE1051	High Voltage Engineering Lab	0	0	4	2	4
7	EE1052	Computational Laboratory	0	0	4	2	4
		Total	**15**	**3**	**8**	**22**	**26**
		Semester - II					
Sl. o.	**Code**	**Subject**	**L**	**T**	**S**	**C**	**H**
1	EE2001	Power System Protection and Transients	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	EE2051	Advanced Power System Laboratory	0	0	4	2	4
6	EE2052	Power System Simulation Laboratory	0	0	4	2	4
7	EE2053	Mini Project with Seminar	0	0	6	3	6
		Total	**12**	**2**	**14**	**21**	**28**
		Semester - III					
1	EE907X	Audit Lectures/Workshops					2
2	EE3051	Dissertation – I	0	0	24	12	24
3	EE3052	Seminar – Non-Project / Evaluation of Summer Training	0	0	4	2	4
		Total	**0**	**0**	**28**	**14**	**30**
		Semester - IV					
1	EE4051	Dissertation – II / Industrial Project	0	0	24	12	24
2	EE4052	Project Seminar	0	0	4	2	4
		Total	**0**	**0**	**28**	**14**	**28**

Electives I and II

Subject Code	Subject Name
EE9011	Soft Computing Techniques
EE9014	Advanced Control system-I
EE9015	Power System Modelling
EE9016	Machine Learning & Expert System
EE9020	Electric Vehicles

Elective III

Subject Code	Subject Name
EE9027	Power System Dynamics and Control
EE9028	Power System Control and Instrumentation
EE9030	Distributed Generation System and Microgrid

Electives IV and V

Subject Code	Subject Name
EE9017	Renewable Energy Systems
EE9018	Embedded System
EE9019	FACTS Devices
EE9021	Digital Signal Processing
EE9022	Estimation of signals and Systems
EE9023	Process Instrumentation and Control
EE9024	Power System Optimization
EE9025	Power System Reliability and Planning
EE9026	Biomedical Instrumentation

Syllabus

Semester – I

EHV Transmission:

<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>EE1001</td><td>EHV Transmission</td><td>PCR</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">Power System-I, Power System-II, Power Electronics</td><td colspan="5">CA+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">On completion of the course, the students will be able to:
• CO1: Apply the knowledge of EHVAC and HVDC transmission to carry out research and to mitigate different real life problems of power system.
• CO2: Explain the cause, effect and control of overvoltage in EHV transmission line.
• CO3: Estimate the field intensity at any point in EHV system and design the EHV Transmission lines accordingly.
• CO4: Understand the basics of HVDC transmission and able to analyse the operation of HVDC transmission systems with different types of converters.
• CO5: Learn the different modes of control and protection techniques in order to operate the HVDC transmission system effectively and mitigate the negative impact of converter malfunctions.
• CO6: Acquire knowledge about causes, troubles and suppression of harmonics by filters.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">AC Transmission: Role of EHV transmission, standard transmission voltages, power handling capacity and line loss, calculation of line and ground parameters, sequence inductances and capacitances. (05)
Voltage gradients on conductors: field of line charges, surface voltage gradient on conductors, charge potential relations for multi-conductor lines, maximum gradient on actual lines. (06)
Electrostatic field of EHV lines: Electric shock currents, capacitance of long object, calculation of electrostatic field of AC lines, electrostatic induction in un-energized circuit, induced voltages in insulated ground wires. (06)
Over voltages in EHV lines caused by switching operations: origin of over voltages, over voltages caused by interruption of low inductive currents, interruption of capacitive currents, ferro-resonance over voltages, calculation of switching surges. (06)
Power frequency voltage control and over voltages: Generalized constant, no-load voltage conditions and charging current, power circle diagram, voltage control using synchronous condensers, shunt and series compensation, static reactor compensating systems. (07)

DC Transmission: Introduction, Comparison of AC and DC Transmission, Types of DC links, Schematic diagram of a typical HVDC converter station. Recent trends in DC Transmission. (04)
Analysis of Converters: Single-phase and three-phase converters, 12-pulse converter, Analysis of bridge converter with grid control but no overlap, Analysis of bridge converter</td></tr>
</table>

	with grid control and with overlap (rectification, inversion, average direct current and voltage), Equivalent circuit of two-terminal DC link. (10) Misoperation of converters: Arcback, Arcthrough, Quenching, Misfire, Commutation failure. (02) Control of DC Transmission: Control of converters, Basic means of control, Power Reversal, Control characteristics, Starting and stopping of DC link. (05) Protection of DC Transmission: DC reactors, clearing line faults and reenergizing the line, HVDC circuit breakers, Overvoltage Protection. (05) Harmonics and Filters: Characteristic and uncharacteristic harmonics in converters; Causes, troubles and suppression of harmonics, Harmonic Filters. (04)
Text Books, and/or reference material	**Text Books:** 1. R. D. Begamudre, Extra High Voltage AC Transmission Engineering 2. E. W. Kimbark, Direct Current Transmission: Vol.1, Wiley-Interscience. **Reference Books:** 1. K. R. Padiyar, HVDC Power Transmission Systems, New Age International (P) Limited

CO vs PO mapping

Map in terms of 0,1,2,3

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

Power System Operation and Control:-

<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>EE1002</td><td>Power System Operation and Control</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous assessment (CA) and end assessment (EA))</td></tr>
<tr><td colspan="2">Power System-I, Power System-II</td><td colspan="6">CA+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: The students know the methods employed for continuous monitoring the performance of the systems, best possible operation, system design and planning.
• CO2: Get appropriate knowledge on modern methods of operation & control in energy management systems and security constrained operation.
• CO3: Knowledge provided enables the students to understand the impact of engineering solutions on economics, environment and sustainable development.
• CO4: Given Specification will give knowledge on the system, emphasise on the design of the system, planning, protection and application.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Power Flow Studies: Network model formulation, power flow problem, the Gauss-Seidel and the Network-Raphson methods of solution, modifications for voltage controlled buses, the decoupled method of solution, optimal power flow study, DC power flow, Distribution system load flows. [7]

Power Systems State Estimation: Problem formulation, weighted least-squares estimation, state estimation of ac network, solved examples, detection and identification of bad measurements, Phasor Measurement Unit (PMU), optimal placement of PMUs, state estimation with PMUs. [7]

Economic Load Dispatch: Economic dispatch problem, dispatching without and with network losses. Solution methods: the lambda-iteration method, the gradient methods, the Newton’s method, solution by dynamic programming. [7]

Unit Commitment: Introduction, Constraints in Unit Commitment. Solution Methods: the priority-list methods, the dynamic-programming solution. [4]

Hydrothermal Scheduling: Introduction, Hydroelectric Plant Models, Scheduling Problems, The Short-Term Hydrothermal Scheduling Problem, Short-Term Hydro-Scheduling: A Gradient Approach Dynamic-Programming Solution to the Hydrothermal Scheduling Problem, Hydro-Scheduling Using Linear Programming. [6]

Short-circuit Studies: Symmetrical fault calculation on 3-phase system, percentage reactance, reactors, Unsymmetrical Fault analysis and calculations 3-phase systems, symmetrical component, Sequence impedances, sequence network. Sequence network for fault calculation. [6]

Power Systems Stability Studies: Stability limits and power transmission capability, Power angle curve, Power angle relations for network configuration, Transfer impedance, Steady state stability, Transient Stability, Swing equation, equivalent systems, Swing Curve, equal area criterion, numerical solution methods of swing equation, methods of improving stability. [8]</td></tr>
</table>

	Automatic Generation Control: Control area, Model of Speed Governor, Turbine, Generator-load model, Block diagram representation of an isolated power system, steady state analysis and Dynamic response, Uncontrolled systems. multi-area load frequency control and state representation. [8] Introduction to Power Systems Security: Introduction, Factors Affecting Power System Security, Contingency Analysis. [3]
Text Books, and/or reference material	**Text Books:** 1. Power Generation, Operation and Control,By: A. J. Wood and B. F. Wollenberg Publisher: John Wiley & Sons, Inc.ISBN: 0-471-58699-4. 2. Modern Power System Analysis, By: D. P. Kothari & I. J. NagrathPublisher: Tata McGraw Hill Education, ISBN: 0-07-049489-4. **Reference Books:** 1. Electric Energy Systems Theory An Introduction, ByO. I. Elgerd, McGraw Hill Education. 2. Power System Operation and Control, By P. S. R. Murty, McGraw Hill.

CO vs PO mapping

Map in terms of 0,1,2,3

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

High Voltage Engineering:-

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	
EE1003	High Voltage Engineering	PCR	4	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous assessment (CA) and end assessment (EA))					
NIL		CA+EA					

Course Outcomes	On completion of the course, the students will be able to: • CO1: Design of the insulation requirement of the high voltage power apparatus • CO2: Employ suitable high voltage test methods for assessing the quality of electrical insulation. • CO3: Given details of high voltage generation scheme and load specification, design most suitable circuit. Also, deduce modification for further improvement in desired performance. • CO4: Given specification for measurement of high voltage, design a suitable measuring instrument with the help of primary sensing elements, so that the measuring instrument meets the specified measurement constraints. • CO5: Application of knowledge; in contemporary issues of high voltage engineering applied in various power system utility.
Topics Covered	Overview of High Voltage Engineering, Air as an Insulation, Concept of Dielectric Strength, Electric field and electrode configuration, Parameters for the dependence of Dielectric strength, Introduction to Breakdown of Insulation. [5] Breakdown of Gases, Solids, Liquids, and Vacuum. [5] Introduction to high voltage generation for testing, generation of high DC voltages from AC and electrostatic generator.. [5] Generation of AC high voltages, resonant circuit for generation of high frequency and high voltage, Tesla coils for high voltage, current, and frequency [4] Generation of impulse voltages and currents:- Analysis of different circuits, Marx multi-stage impulse generator. [6] Methods of measuring high DC and AC voltage (power frequency) and high currents. [4] Measurement of impulse voltage, switching impulse voltage. [4] Measurement of high current, impulse, and high-frequency transient currents. [4] Insulation testing, dissolve gas analysis, detection of partial discharges. [6]

	Introduction to the Lightning phenomenon, Insulation Co-ordination. Brief reviews of high voltage testing-Methods for different power system equipment. [4] Introduction to H.V. testing transformer design. Capacitive voltage transformer Introduction to partial discharge, and partial discharge testing. [4] Planning & design of a high voltage laboratory, Introduction to Safety in High Voltage Technology, Introduction of virtual Laboratory and ICT enabled concept for high voltage testing. [3]
Text Books, and/or reference material	Text Books: 1. High Voltage Engineering by M. S. Naidu and V. Kamaraju, 2nd Ed., McGraw-Hill 2. High Voltage Engineering by C. L. Wadhwa, 2nd Ed., New Age International Reference Books: 1. High Voltage Engineering by J R Lucas, 2001 2. High Voltage Engineering: Fundamentals by E. Kuffel, W.S. Zaengl and J. Kuffel, 2nd Ed., Newnes 3. High-Voltage Engineering: Theory and Practice by Khalifa M. (Ed.), Dekker Inc. 4. High Voltage Engineering and Testing by H. M. Ryan, IET, 2001 5. High-voltage Test Techniques by Dieter Kind and Kurt Feser, Newnes, 2001. 6. High Voltage Technology by L. L. Alston, Oxford University Press, 2006

CO vs PO mapping

Map in terms of 0,1,2,3

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

SOFT COMPUTING TECHNIQUES

<table>
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<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>EE 9011</td><td>SOFT COMPUTING TECHNIQUES</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous assessment (CA) and end assessment (EA))</td></tr>
<tr><td colspan="2">Basic knowledge of algorithm/Logic/Programming</td><td colspan="6">CA+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">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.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">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]</td></tr>
</table>

	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

	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

ADVANCED CONTROL SYSTEM I

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	
EE9014	ADVANCED CONTROL SYSTEM I	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous assessment (CA) and end assessment (EA))					
Control System Engineering in B Tech		CA+EA					
Course Outcomes	On completion of the course, the students will be able to: • 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, Kalman Bucy Filter for optimal design in state space						
Topics Covered	Performance Objectives/ Goals: Response and Loop Goals, Stabilization, Pole-placement, Tracking, Robustness, Disturbance Rejection, Noise Attenuation [6] Performance Analysis and Tests:						

	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] Compensation: 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] State Space Representation of Continuous-time Systems: 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

Power System Modelling:-

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	
EE 9015	Power System Modelling	PEL	**3**	**0**	**0**	**3**	**3**
Pre-requisites		Course Assessment methods (Continuous assessment (CA) and end assessment (EA))					
Power System-I, Power System-II		CA+EA					
Course Outcomes	On completion of the course, the students will be able to: • CO1: Acquire an idea about modelling of power system elements and their interaction in power system. • CO2: Acquire knowledge about fault analysis. • CO3: Learn control strategies for active and reactive power management in power system. • CO4: Understand the concept of power system synchronous machine model. • CO5: Understand the concept of power system protection as a whole.						
Topics Covered	Static Analysis and Model: background, motivation for modelling of physical systems, hybrid dynamic model, power system architecture. [4] Formulation: network equations, equality and inequality constraints, active and reactive power flow with in-phase transformers and phase shifting transformers, decoupling properties, ac and DC power flow model. [6] Fault analysis: transients on a transmission line, short circuit of a synchronous machine, generator model and Takahashi method for short circuit studies, examples. [7] Power System Dynamics and Stability: power system stability, dynamics of power system and their modelling, examples. [7]						

	Synchronous Machine Models: Design and operating principle of rotor, stator and magnetic torque, stationary and dynamic operation of single phase equivalent circuit, phasor diagram, operational limits. [10] Control of Electric Power Systems: Control of Active Power and Frequency, Spinning reserve, Supplementary reserves, Back-Up Reserves; Control of Reactive Power and Voltage, Supervisory Control of Electric Power Systems. [6] Protections in Electric Power Systems: Design of Protections, Distance Protections, Out of Step Protections, System Protections. [4]
Text Books, and/or reference material	Text Books: 1. Design of Machine Elements – V.B. Bhan S. Krishna, "An Introduction to Modelling of Power System Components", springer, 2014. 2. Nasser D. Tleis, "Power Systems Modelling and Fault Analysis", Elsevier, 2008 Reference Books: 1. G¨oran Andersson, "Modelling and Analysis of Electric Power Systems", ETH Z¨urich, 2008. 2. Mircea Eremia, Mohammad Shahidehpour, "Handbook of Electrical Power System Dynamics: Modeling, Stability, and Control", Wiley-IEEE Press, 2013. 3. Milano, Federico, "Power System Modelling and Scripting", Springer, 2010.

CO vs PO mapping

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

Machine Learning & Expert System:-

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	
EE 9016	Machine Learning and Expert System	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous assessment (CA) and end assessment (EA))					
NIL		CA+EA					
Course Outcomes	On completion of the course, the students will be able to: • 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						
Topics Covered	**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] **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 Christopher Bishop, Pattern Recognition and Machine Learning.

CO vs PO mapping

	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

Electric Vehicles:-

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	
EE 9020	Electric Vehicles	PEL	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous assessment (CA) and end assessment (EA))					

Electrical Technology, Electrical Machines I	CA+EA
Course Outcomes	On completion of the course, the students will be able to: • **CO1:**Acquire an idea about electric vehicles (EVs) and hybrid electric vehicles (HEVs) • **CO2:** Learn the fundamentals of different types of EVs and HEVs systems and their components. • **CO3:** Study about the Electric Propulsion Units required in EVs and HEVs. • **CO4:** Learn about the different types of Energy Sources and Storage units used in EVs and HEVs systems. • **CO5:** Study the Impacts of EVs and HEVs on power system and Environment. • **CO6:** 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. [10] **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: 1. Iqbal Husain, "Electric and Hybrid Vehicles Design Fundamentals" Published by: CRC Press, Boca Raton, Florida, USA, 2003. REFERENCES: 1. Chan, "Modern Electric Vehicle Technology", Oxford 2002

CO vs PO mapping

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

High Voltage Laboratory:-

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	
EE1051	High Voltage Laboratory	PCR	0	0	3	3	2
Pre-requisites		Course Assessment methods (Continuous assessment (CA) and end assessment (EA))					
NIL		CA+EA					
Course Outcomes	On completion of the course, the students will be able to: • CO1: Employ suitable high voltage test methods for assessing the quality of electrical insulation. • CO2: Ascertain the adequate level of insulation by performing suitable test and measurement of applied stress. • CO3: Design and Testing the insulation requirement of the high voltage power apparatus. • CO4: Assess the ability of the insulation to withstand the operating stresses						
Topics Covered	1. Calibration of power frequency high voltage and measurement of partial discharge with sphere-sphere gap arrangement						

	2. Measurement of Power Frequency voltage withstand test on HV line materials 3. Study BDV strength test of insulating oils using 100 kV motorized kit 4. Study BDV strength test for various pressure and vacuum 5. Analysis of Electrostatic Field in a Parallel Plate Capacitor for Single & Multi Dielectrics Using ANSYS Software 6. Analysis of Field Distribution of Dielectric Under Different Electrode Configuration Using ANSYS Software 7. Study the characteristics of impulse voltage and wave shape of lightning impulse voltage 8. Study of capacitance and tan delta of insulating material 9. Measurement of solid insulation resistance 10. To measure the current - voltage characteristics of a crystalline silicon solar cell 11. Measurement by using 4 quadrant power supply and solar cell as load 12. Measurement by using solar cell as power source under illumination 13. Measurement of Partial Discharge in different types of insulation mediums
Text Books, and/or reference material	Text Books: 1. High Voltage Engineering by M. S. Naidu and V. Kamaraju, 2nd Ed., McGraw-Hill 2. High Voltage Engineering by C. L. Wadhwa, 2nd Ed., New Age International Reference Books: 1. High-Voltage Engineering: Theory and Practice by Khalifa M. (Ed.), Dekker Inc. 2. High Voltage Engineering and Testing by H. M. Ryan, IET, 2001 3. High-voltage Test Techniques by Dieter Kind and Kurt Feser, Newnes, 2001

CO vs PO mapping

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

Computation Laboratory:-

<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>EE 1052</td><td>Computation Laboratory</td><td>PCR</td><td>0</td><td>0</td><td>4</td><td>4</td><td>2</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous assessment (CA) and end assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">CA+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">On completion of the course, the students will be able to:
• CO1: Acquire knowledge on hard computing, soft computing, flowchart, algorithm and programming.
• CO2: Develop programming skill for different optimization techniques.
• CO3: Design tuning parameters of optimization techniques to obtain better results under practical limitations.
• CO4: Achieve the ability to solve realistic problems using non-conventional approaches like Fuzzy logic. Artificial neural network.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">1. Introduction & Basic concepts of MATLAB. Different array and matrix operations.

2. Perform basic fundamental programing using ‘if else’ and ’for loop’

3. Study hard computing and soft computing for the linear and non-linear problems under practical limitations.

4. Apply binary coded genetic algorithm (BCGA) for a given single objective problem (SOP).

5. Develop real coded genetic algorithm (RCGA) with different types of crossover, mutation, and parent selection strategies for a minimization problem. Compare the results.

6. Execute particle swarm optimization (PSO) for a given non-linear / standard benchmark problem with defined /given population, maximum iteration, tolerance value, constriction factors, upper and lower limits of state variables.

7. Design the control parameters of adaptive particle swarm optimization (APSO) for efficiently controlling the global exploration and local exploitation to obtain optimum result.

8. Write code of Differential Evolutionary (DE) technique for a standard benchmark problem with security constraints.

9. Develop fuzzy knowledge base controller (FKBC) for a realistic problem and show information and computational flow with membership function, rule base and defuzzification.</td></tr>
</table>

	10. For a given single training set with two inputs, two outputs and two hidden layers, execute "Forward Pass" to obtain outputs for the given initial weights, biases and inputs. Determine the total error. Apply backpropagation (Backward Pass) to update each of the weights. Assume learning rate.
Text Books, and/or reference material	Lab manual

CO vs PO mapping

	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

Semester – II

Power System Protection and Transients

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	
EE 2001	Power System Protection and Transients	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous assessment (CA) and end assessment (EA))					
EE 1002; Power Systems Operation and Control		CA+EA					
Course Outcomes	• CO1: Given specification will give knowledge about the different switching transient conditions and its severity, by which one can incorporate/design circuitry for Transients. • CO2: Given specification leads to knowledge about the lightning, protection, insulation coordination which will help to design the reliability of the system and to design of system/ equipment. • CO3: The students learn methods employed for primary and backup relaying- design of system protection in electric power systems. Further, they get acquainted with various						

	types of relays along with their characteristics and connections, used in practice for protection of different power systems elements. • CO4: Knowledge provided enables the students to employ and design of in future diverse protective schemes used in practice for protection transmission lines, transformers and generators.
Topics Covered	Normal Switching Transients: Circuit breaker making and breaking transients, Resistance switching, Load Switching, Capacitance Switching, Reactor Switching. [6] Abnormal Switching Transients: Current chopping, Arc furnace switching, Transformer Magnetizing Inrush Current, Arcing Ground Phenomenon, Current Limiting Static Circuit Breaker. [6] Lightning Protection: Mechanism of Lightning, over voltage due to lightning, protection of electrical apparatus against lightning strokes, behaviour of machine windings under transient conditions, Kilometric Fault. [6] Lighting protection schemes: Arrestors, Surge absorbers, Neutral Grounding.Lighting Over voltages and Protection of Substation Equipment, Switching Over voltages in EHV Substations, Switching Overvoltage in Medium Voltage Substations, Rating of Surge Arrester, Installation as Surge Arresters, Overhead Shielding Screen, Protective Angle. [6] Introduction to Insulation coordination, Over voltages and their Significance, Standard Voltage Levels, Insulation Level of an Equipment, Insulation Co-ordination of a Substation. [4] Protective Relays: Basic requirement; classification on the applications; principles of operation; over current relay, directional relay- characteristics and connections; distance relays - impedance, reactance and mho types; differential relays and percentage differential relays- voltage and current balance types; biased beam relay, negative sequence relay. [10] Protection of transmission lines: Unit and non-unit types; time and current graded systems; setting of relays for coordination; distance protection- impedance, reactance and mho types; three zone distance protection; pilot wire protection using current and voltage balance; Translay system; carrier current protection. [6] Protection of transformer: Types of faults- faults in auxiliary equipments, winding faults, overloads and external short circuits; gas actuated devices- pressure relief and pressure relay, rate of rise pressure relay, gas accumulator relay; biased differential protection for different transformer connections; earth fault protection; over current protection. [6] Protection of generator: Types of faults- stator faults, rotor faults, abnormal running conditions; biased differential protection for different stator connections; protection against earth fault, turn to turn fault, rotor earth fault, loss of field excitation; negative sequence protection. [6]
Text Books, and/or reference material	**Text Books:** 1. The Art and Science of Protective Relaying,By: C. R. Mason , Published by: Wiley Eastern Limited, ISBN: 978-81-7409-232-3 2. Electrical Transients in Power Systems, By: A. Greenwood, Published by: John Wiley& Sons, ISBN: 8126527293, 9788126527298 **Reference Books:** 1. Power System Engineering By: D. P. Kothari and I. J. Nagrath, Published by: Tata McGraw Hill, ISBN: 9780070647916. 2. Power System Transients: A Statistical approach, By: C. S. Indulkar, D. P. Kothari& K. Ramalingam, Published by: PHI Learning Pvt. Ltd. ISBN: 978-81-203-4079-4

CO vs PO mapping

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

Power System Dynamics and Control:-

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	
EE9027	Power System Dynamics and Control	PCR	**3**	**1**	**0**	**4**	**4**
Pre-requisites		Course Assessment methods (Continuous assessment (CA) and end assessment (EA))					
EE1001 (Fundamentals of Modern Power System)		CA+EA					

Course Outcomes

On completion of the course, the students will be able to:

- **CO1:** Understand the fundamental concept of stability and the characteristics of power system dynamics when subjected to different stresses.
- **CO2:** Learn to model the components of the power system for stability studies.
- **CO3:** Able to analyze the stability of the power system using different numerical methods.
- **CO4:** Learn to apply different control techniques to improve the dynamics of power systems

Topics Covered	Small Signal Stability: Introduction to machine modelling and different transformations. Modelling of different elements of power systems, Small Signal stability of a single machine infinite bus system, Effects of excitation system, Power system stabilizer, Small-signal stability of multi machine systems and very large systems, Small-signal stability enhancement. [18] Steady State Stability: Analysis of steady state stability of unregulated and regulated systems. [6] Transient Stability: An elementary view of transient stability, Numerical integration methods, Multimachine Stability Studies, Transient Stability Studies with the change of excitation of synchronous machine, Analysis of Transient Stability for different kinds of fault, Rapid Reclosing, Performance of protective relaying, Improvement of Transient Stability. [18] Voltage Stability: Basic concepts related to voltage stability, Voltage stability analysis, Voltage collapse, Examples of Voltage collapse, Prevention of voltage collapse. [6] Subsynchronous Oscillations:Turbine-generator torsional characteristics, Subsynchronous resonance, Impact of network-switching disturbances. [5] Mid-term and Long-term Stability: Nature of system response to severe upsets, Distinction between mid-term and long-term stability, Power plant response during severe upsets. [3]
Text Books, and/or reference material	Text Books :- 1. Prabha Kundur, Power System Stability and Control, TMH 2. P. M. Anderson & A. A. Fouad, Power System Control and Stability, IEEE Series on Power Engineering Reference Books: 1. Power Systems Stability, Vol. -1 – E. W. Kimbark, Dover Publications, New York. 2. Power Systems Stability, Vol. -2 – E. W. Kimbark, Dover Publications, New York. 3. Power Systems Stability, Vol. - 3 – E. W. Kimbark, Dover Publications, New York.

CO vs PO mapping

	Program Outcomes					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	1	1	2	2
CO2	2	1	2	2	1	1

CO3	3	3	3	3	2	2
CO4	3	3	3	2	2	2

Power System Control and Instrumentation:-

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	
EE9028	Power System Control and Instrumentation	PEL	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous assessment (CA) and end assessment (EA))					
EE1001 (Fundamentals of Power System)		CA+EA					
Course Outcomes	On completion of the course, the students will be able to: • CO1: Understand various methods of OPF • CO2: Gain insight of controlling active and reactive power flow with UPFC/IPFC • CO3: Understand the concept and implementation of PMU • CO4: Understand the concept and implementation of smart grid • CO5: Get acquainted with concept of errors and various transducers • CO6: Know various aspects of SCADA and PLC						
Topics Covered	Overview of Power System, Optimal Power Flow: Gradient method and Newton method Conventional Control Scheme for active and reactive power; [6] Power System Stability: Energy function approach for SMIB and multimachine power systems; [5] Power Flow Control: Compensators for power flow control, Unified Power Flow Controller, Interline Power Flow Controller; [5] Phasor Measurement Unit (PMU): Overview of Synchro phasor, PMU architecture, Phasor computation, Structures of WAMS and WAMPAC, PMU Applications, PMU placement; [6] Smart Grid (SG): SG concept, Architecture, Impact of SG for power system control & measurement, Demand Response,Smart metering and their functionalities in Smart Grid;[8] Power systems instrumentation:						

	Measurement, Errors, Statistical Analysis of Errors; [4] Signal Conditioning Circuit, Converters, Optical Insulator, Sensor and Transducer; Instrument transformers: C.T. and P. T., principle, characteristics, construction, errors, and transient behaviour etc.; [5] Power System Measurement: Voltage, Current, Phase, Power, Energy, Frequency, Power factor etc.; [3] Supervisory control and data acquisition system: Functional blocks, Software and Hardware features, operation, PLC architecture, Instructions and programming, Overview of DCS; [10] Measurement of transients and harmonic distortion: THD, Power Quality meter; [4]
Text Books, and/or reference material	**Text Books:** 1. D.P. Kothari & J.S. Dhillon, " Power System Optimization", PHI, 2010. 2. S. Sivanagaraju & G. Sreenivasan, "Power System operation and Control", Pearson 2010. 3. Ernest O. Doebelin, Measurement system, Tata McGraw-Hill Education. 4. A.G. **Phadke** & J.S. **Thorp**, "Synchronized Phasor Measurements and Their Applications" Springer publication, 2008. 5. P.W.Sauer & M.A. Pai, " Power System Dynamics and Control", Pearson 2010. **Reference Books:** 1. Stuart A., Supervisory Control and Data Acquisition, Boyer International Society of Automation 2. Surya Santoso, Mark F. McGranaghan, Roger C. Dugan, H. Wayne Beaty, Electrical Power Systems Quality, Access Engineering.

CO vs PO mapping

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

CO5	1	0	2	0	0	1
CO6	1	1	2	2	2	1

Distributed Generation System and Microgrid:-

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 generation and 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.Godoy Simoes, 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

CO vs PO mapping

	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

Renewable Energy systems:-

Department of Electrical Engineering				
	Title of the course		Total Number of contact hours	Credit

<table>
<tr><td>Course Code</td><td></td><td>Program Core (PCR) / Electives (PEL)</td><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td><td></td></tr>
<tr><td>EE9017</td><td>Renewable Energy Systems</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous assessment (CA) and end assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">CA+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">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</td></tr>
<tr><td>Topics Covered</td><td colspan="7">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, Introduction to Power Trading; [10]

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]</td></tr>
</table>

	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

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

Embedded System:-

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	On completion of the course, the students will be able to: • 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. • CO6: Given single task application design a microprocessor based system.
Topics Covered	Introduction to Embedded systems: Introduction – Features – Microprocessors – ALU - Von Neumann and Harvard Architecture, Classification, SPP, ASIC, ASIP; [3] CISC and RISC - Instruction pipelining. Fixed point and Floating point processor; [2] General characteristics of embedded system, introduction to different components etc; [5] Microcontroller 89CX51/52 Series: Characteristics and Features, Overview of architectures, and Peripherals, Timers, Counters, Serial communication, Digital I/O Ports; [5] 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 [5] Digital Signal Processor [5] 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

	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

Flexible AC Transmission Systems Devices:-

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	Flexible AC Transmission Systems Devices	PEL	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous assessment (CA) and end assessment (EA))					
EEC401(Power Systems-I) EEC501(Power Systems– II) EEC503(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”, **Reference Books:** 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

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

Digital Signal Processing:-

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	
EE9021	Digital Signal Processing	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous assessment (CA) and end assessment (EA))					
Signal and Systems in BTech		CA+EA					
Course Outcomes	On completion of the course, the students will be able to: • CO1: Understand the properties signals and systems. • CO2: Understand the concept of signal processing. • CO3: Analyze discrete time signals and systems in time as well as frequency domain. • CO4: Design digital filters. • CO5: Get acquainted with digital processors recently used.						
Topics Covered	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]
Text Books, and/or reference material	**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

CO vs PO mapping

	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

Estimation of Signals and Systems:-

<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 and Systems</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous assessment (CA) and end assessment (EA))</td></tr>
<tr><td colspan="2">Advanced Control System I</td><td colspan="6">CA+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">On completion of the course, the students will be able to:
CO1: 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: 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: 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: 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>Topics Covered</td><td colspan="7">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]

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]</td></tr>
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<table>
<tr><td></td><td>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]</td></tr>
<tr><td>Text Books, and/or reference material</td><td>Text Books:

1. Modelling and Parameter Estimation of Dynamic Systems by J.R. Raol, G. Girija and J. Singh, Institution of Engineering and Technology, London, United Kingdom
2. Optimal State Estimation: Kalman, H∞ and Nonlinear Approaches by Dan Simon.

Reference Books:

1. Introduction to Random Signals and Applied Kalman Filtering by Robert Grover Brown & Patrick Y. C. Hwang, John Wiley & Sons
2. Bayesian Filtering and Smoothing by Simo Sarkka, Cambridge University Press</td></tr>
</table>

CO vs PO mapping

	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

Process Instrumentation and Control:-

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	
EE9023	Process Instrumentation and Control	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous assessment (CA) and end assessment (EA))					
NIL		CA+EA					
Course Outcomes	On completion of the course, the students will be able to: • CO1: Given an application for measurement of liquid flow, choose suitable sensor and also justify the selection. • CO2: Given an application for measurement of temperature, choose suitable sensor and also justify the selection.. • CO3: Given single-parameter control application of an industrial process design suitable instrumentation loop using PLC • CO4: Integration of different given elements of a process for control application. • CO5: Compare different actuators for a given process control application. • CO6: Given application design of a PID control system.						

Topics Covered	Review of measurement principles, statistical analysis of measurement errors and error analysis; [4] Measurement of Flow; Orifice, venturi, pitot tube, rotameter, ultrasonic flow meter, electromagnetic flow meter, mass flow meter, etc.; [4] Measurement of temperature, RTD, Thermistor, Thermocouple, Semiconductor type temperature sensor, IR sensor etc.; [3] Measurement of liquid level; float, capacitive, ultrasonic, radar gauge etc.; [4] Pressure measurement, Differential pressure, starin, force, displacement; [5] Measurement of Torque, Linear and angular displacement/speed etc.; [4] Actuators and Finalcontrol elements, Valves, Electrical, pneumatic, and hydraulic; [4] Programmable Logic Controller (PLC), Distributed Control System; [4] Process signal transmission; [3] Process Control; ON-OFF Control, PID Control, of interactive and non-interactive systems; [7]
Text Books, and/or reference material	Text Books 1. A. D. Helfrick and William David Cooper, Modern electronic instrumentation and measurement techniques, Prentice Hall. 2. John-G. Webster (ed.), The Measurement, Instrumentation, and Sensors: Handbook, Springer. Reference Books: 1. Curtis D. Johnson, Process control instrumentation technology, Prentice Hall 2. Robert N. Thurston and Allan D. Pierce, Ultrasonic measurement methods, Academic Press 3. William Bolton, Programmable Logic Controllers, Newness 4. Stuart A. Boyer, Supervisory Control And Data Acquisition, International Society of Automation 5. T. V. Kenneth and B. T. Meggitt, Optical Fiber Sensor Technology, Springer.

CO vs PO mapping

	Program Outcomes					
	PO1	PO2	PO3	PO4	PO5	PO6

CO1	1	3	3	2	1	0
CO2	1	3	1	2	2	0
CO3	1	2	2	3	3	2
CO4	1	1	2	3	2	1
CO5	1	2	1	2	1	1
CO6	1	1	1	3	2	1

Power System Optimization:-

<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>EE9024</td><td>Power Systems Optimization</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">Power System Operation and Analysis</td><td colspan="5">CA+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">On completion of the course, the students will be able to:
• CO1: identify and understand different power system optimization problem.
• CO2: learn the basic design procedure for representing different power system problems in the context of optimization.
• CO3: understand different solution strategies to solve power system optimization problems.
• CO4: understand different solution strategies to optimally tune different controllers used in power system.</td></tr>
</table>

Topics Covered	Solution Tools for Economic Load Dispatch (ELD) without losses and with losses; security constraint combined Economic and Emission Dispatch (SC-CEED), Examples; [6] Solution Tools for Optimal Hydrothermal Scheduling for short-range fixed head and variable head hydrothermal systems; [6] Solution Tools for Optimal Power Flow: Transmission loss optimization, Cost optimization and total voltage deviation optimization with and without compensating devices; [8] Solution Tools for Optimal Reactive Power Dispatch; [6] Optimal Automatic Generation Control, Optimal AVR control and optimal tuning of Controller coefficients; [6] Solution Tools for Optimal allocation of FACTS devices considering both technical and economical aspects; [6] Solution Tools for finding Optimal size and location of DG for the improvement system voltage profile and overall losses; [6] Optimization tools for optimally tuning the power system stabilizers for Small Signal stability improvements; [10]
Text Books, and/or reference material	Text Books: 1. D.P. Kothari and J.S. Dhillon, Power System Optimzation, Prentice Hall of India 2. J. A. Momoh, Electric Power system Applications of Optimization, CRC Press Reference Books: J. Zhu, Optimization of power system operation, John Wiley & Sons

CO vs PO mapping

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

CO4	2	0	2	2	1	0

Power System Reliability and Planning:-

<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>EE9025</td><td>Power System Reliability and Planning</td><td>PEL</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous assessment (CA) and end assessment (EA))</td></tr>
<tr><td colspan="2">EEC401(POWERSYSTEMS-I)
EEC501(POWER SYSTEMS– II)</td><td colspan="6">CA+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">On completion of the course, the students will be able to:
• CO1: Understand the importance of maintaining reliability of power system components
• CO2: Apply the probabilistic methods for evaluating the reliability of generation, transmission and distribution systems using different reliability indices.
• CO3: Assess the different models of system components used in reliability studies.
• CO4: Formulate expressions for Reliability analysis of series-parallel and Non-series parallel systems
• CO5: Derive expressions for Time dependent and Limiting State Probabilities using Markov models.
• CO6: Perform necessary analysis required for generation, transmission and distribution systems expansion.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Basic Reliability Concepts:

The general reliability function. The exponential distribution, Definition of different reliability indices, Mean time to failures, series and parallel systems. Markov process, continuous Markov process, Recursive techniques, Simple series and parallel system models. [10]

Generating Capacity – Basic Probability Methods:

The generation system model, Loss of load indices, Capacity expansion analysis, scheduled outages. Load forecast uncertainty Loss of energy indices. The frequency and duration method. [8]

Transmission Systems Reliability Evaluation:

Radial configuration, Conditional probability approach, Network configurations, State selection, System and load point Indices. [8]</td></tr>
</table>

	Distribution Systems Reliability Evaluation: Evaluation Techniques, Additional interruption indices, Application to radial systems, Effect of lateral distribution protection, Effect of disconnects, Effect of protection failures, Effect of transferring loads. [10] Generation Planning: Comparative economic assessment of individual generation projects, Investigation and simulation models, Heuristic and linear programming models, Probabilistic generator and load models. [8] Transmission Planning: Deterministic contingency analysis, Probabilistic transmission system, reliability analysis. Reliability calculations for single area and multi,-area power systems. [8] Distribution Planning: Network configuration design consisting of different schemes. [4]
Text Books, and/or reference material	TEXT BOOKS: 1. "Reliability evaluation of Engineering systems", Roy Billinton and Ronald N Allan, BS Publications. 2. "Reliability Engineering", Elsayed A. Elsayed, Prentice Hall Publications. 3. Roy Billinton and Ronald Allan Pitam: Reliability Evaluation of Power Systems, springer, 1996. REFERENCES: 1. "Reliability Engineering: Theory and Practice", By Alessandro Birolini, Springer Publications. 2. "An Introduction to Reliability and Maintainability Engineering", Charles Ebeling, TMH Publications. 3. "Reliability Engineering", E. Balaguruswamy, TMH Publications.

CO vs PO mapping

	Program Outcomes					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	0	0	0	0	0
CO2	1	0	1	0	0	0
CO3	1	0	1	0	0	0

CO4	1	0	1	0	0	0
CO5	1	0	1	0	0	0
CO6	2	0	2	1	1	0

Biomedical Instrumentation:-

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	
EE9026	Biomedical Instrumentation	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous assessment (CA) and end assessment (EA))					
EEC 302 (Electrical & Electronic Instrumentation)		CA+EA					
Course Outcomes	On completion of the course, the students will be able to: • 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						
Topics Covered	Introduction to biomedical Instrumentation, biomedical electronics, Components of Analog and digital circuits, Analog & digital circuit design, Multistage amplifier gain, Gain Bandwidh 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 constraints, Various biomedical transducers. [4] Generation of Nernst Potential, Establishment of diffusion potential, Goldman Equation, Measurement of membrane potential, resting potential, action potential, Voltage Clamp, Hodgkin 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] 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

	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

Advanced Power System Laboratory:-

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	
EE2051	Advanced Power System Laboratory	PCR	0	0	4	4	2

Pre-requisites	Course Assessment methods (Continuous assessment (CA) and end assessment (EA))
Basic Idea on Power System Laboratory	CA+EA

Course Outcomes	On completion of the course, the students will be able to: • **CO1:** Develop suitable experimental schemes for different power system relays and understand their operation for protecting real power system. • **CO2:** Develop suitable experimental schemes for evaluating different performance parameters of a power system with and without considering Static Var Compensator. • **CO3:** Understand and analyze the performance of series and parallel connected solar PV systems. • **CO4:** Know the appropriate connections of CT and PT in the power system after performing initial tests on them. • **CO5:** Interpret the experimental results and correlate them with the practical power system.
Topics Covered	1. Study of directional and non- directional over-current relay 2. Development of and validation of Over-current and Earth fault protection scheme for three phase system 3. Development and validation of Parallel feeder protection 4. Development of and validation of Negative sequence protection scheme of three-phase induction motor 5. Study of biased differential relay and biased differential protection of a single phase transformer 6. Study of Numerical Distance protection Relay MiCOM P442 7. Development of and validation of Restricted E/F protection scheme of 3-phase transformer 8. Study of simulated transmission line 9. Testing of ratio, polarity, magnetizing characteristic of CT and PT. 10. To demonstrate the I-V and P-V characteristics of PV module with varying Radiation and temperature level. 11. To demonstrate the I -V and P-V characteristics of series and parallel combination of PV modules. 12. To study the effect of variation in tilt angle on PV module power. 13. To study the shading effect on module output power. 14. To study the use of Bypass Diode and Blocking Diode on module output power. 15. To workout power flow calculations of stand-alone PV system considering DC & AC load with battery.

Text Books, and/or reference material	Reference Books: 1. Protective Relays Application Guide by GEC Measurements (1983) 2. Laboratory Manuals

CO vs PO mapping

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

Power System Simulation Laboratory:-

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	
EE2052	Power System Simulation Laboratory	PCR	0	0	4	4	2
Pre-requisites		Course Assessment methods (Continuous assessment (CA) and end assessment (EA))					
Power system Operation and Analysis		CA+EA					
Course Outcomes	On completion of the course, the students will be able to: CO1: develop coding skill using MATLAB. CO2: Implement MATLAB software to solve load flow analysis problem by Gauss-Seidel method and Newton Raphson method CO3: Implement MATLAB software to solve Economic Load Dispatch Problems CO4: Acquire skill to develop and study different models of power system in MATLAB SIMULINK.						

1. Topics Covered	1. Introduction & Basic concepts of MATLAB. Different array and matrix operations. 3. Perform advanced programing using 'if else' and 'for loop' 4. Perform advanced programing using 'while loop' 5. Perform hand calculation for YBUS matrix for a given Power System. Write Matlab program for obtaining the same YBUS matrix. 6. Perform hand calculation for obtaining Load Flow solution using Gauss-Seidel method for one iteration. Write Matlab program for the same. Obtain the converged solution. 7. Perform hand calculation for obtaining Load Flow solution using Newton Raphson method for one iteration. Write Matlab program for the same. Obtain the converged solution. 8. Study of Economic Load Dispatch Problems considering various linear and non-linear constraints in MATLAB. 2. 8. MATLAB Simulink to study the load-frequency analysis.
Text Books, and/or reference material	Lab manual

CO vs PO mapping

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