TWO YEAR COURSE STRUCTURE

FOR

M.TECH –ELECTRICAL POWER SYSTEMS

w.e.f.

2013-2014 ADMITTED BATCH

DEPARTMENT OF ELECTRICAL POWER SYSTEMSENGINEERING

COLLEGE OF ENGINEERING (AUTONOMOUS) :: PULIVENDULA

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY ANANTAPUR

PULIVENDULA – 516390, Y.S.R. (DIST), ANDHRA PRADESH, INDIA

M. Tech. (ELECRICAL POWER SYSTEMS)

COURSE STRUCTURE AND SYLLABUS

I SEMESTER

S.NO	COURSE CODE	Subject	Theory	Lab	Credits
1	13D07101	Modern Control Theory	4	0	4
2	13D07107	Power system Stability & Control	4	0	4
3	13D07102	Renewable Energy Systems	4	0	4
4		**Elective –I**	4	0	4
	13D07111	Distribution Automation			
	13D07105	Power quality			
	13D07104	Power Electronic Converters			
5		**Elective –II**	4	0	4
	13D07110	System Reliability Concepts			
	13D07106	Reactive power compensation & Management			
	13D07103	HVDC Transmission			
6	13D07109	Machines & Power Systems Lab	0	3	2
7	13D07108	Power systems simulation Lab -I	0	3	2
	Contact Periods/Weeks		26		
	Total Credits (5 Theory + 2 Lab)		24		

II SEMESTER

S.NO	COURSE CODE	Subject	Theory	Lab	Credits
1	13D07202	Operation and Control of Power Systems	4	0	4
2	13D07203	Advanced Power System Protection	4	0	4
3	13D07201	Restructured Power systems	4	0	4
4		**Elective -III**			
	13D07205	Power System Reliability	4	0	4
	13D07204	ENERGY AUDITING, CONSERVATION AND MANAGEMENT			
	13D07206	Electric Smart grid			
5		**Elective –IV**			
	13D07208	Soft computing techniques to power Systems	4	0	4
	13D07209	EHVAC Transmission			
	13D07207	FACTS Controllers			
6	13D07211	Power Systems Simulation Lab-II	0	3	2
7	13D07210	Renewable Energy Systems Lab	0	3	2
	Contact Periods/Weeks		26		
	Total Credits (5 Theory + 2 Lab)		24		

II YEAR - I SEMESTER

S.NO	COURSE CODE	Subject	Max Marks	Min marks	Credits
1		Comprehensive Viva-voce	50(Internal)	25	2
2		Seminar-I	50(Internal)	25	-
		Total Credits			2

II YEAR - II SEMESTER

S.NO	COURSE CODE	Subject	Max. Marks	Min marks/Grades to pass		Credits
1		Seminar-II	50(Internal)	25		-
2		Project Work Grades :A, B, C, D A – Excellent B – Good C – Satisfactory D - Unsatisfactory				18
		Total Credits				18

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EPS I-ISEMESTER

POWER SYSTEM STABILITY & CONTROL

UNIT-I: THE ELEMENTARY MATHEMATICAL MODEL AND SYSTEM RESPONSE TO SMALL DISTURBANCES

A Classical model of one machine connected to an infinite bus – Classical model of multimachine system – Problems – Effect of the excitation system on Transient stability. The unregulated synchronous Machine – Effect of small changes of speed – Modes of oscillation of an unregulated multimachine system – Regulated synchronous machine – Voltage regulator with one time lag – Governor with one time lag – Problems.

UNIT-II: DYNAMIC STABILITY & TRANSIENT ANALYSIS

Concept of Dynamic stability – State space model of one machine system connected to infinite bus – Effect of excitation on Dynamic stability – Examination of dynamic stability by Routh's criterion - Transient Analysis of Three-Phase Power Systems Symmetrical Components in Three-Phase Systems - Sequence Components for Unbalanced Network Impedances - The Sequence Networks - The Analysis of Unsymmetrical Three-Phase Faults - The Single Line-to-Ground Fault - The Three-Phase-to-Ground Fault.

UNIT-III: POWER SYSTEM STABILIZERS

Introduction to supplementary stabilizing signals - Block diagram of the linear system - Approximate model of the complete exciter – Generator system – Lead compensation – Stability aspect using Eigen value approach.

UNIT-IV: EXCITATION SYSTEMS

Excitation system response – Non-continuously regulated systems – Continuously regulated systems – Excitation system compensation – State space description of the excitation system - Simplified linear model – Effect of excitation on generator power limits. Type –2 system: Rotating rectifier system, Type-3 system: Static with terminal potential and current supplies - Type –4 system: Non – continuous acting - Block diagram representation – State space modeling equations of these types.

UNIT-V: STABILITY ANALYSIS

Review of Lyapunov's stability theorems of non-liner systems using energy concept – Method based on first concept – Method based on first integrals – Quadratic forms – Variable gradient method – Zubov's method – Popov's method, Lyapunov function for single machine connected to infinite bus. What is voltage stability – Factors affecting voltage instability and collapse – Comparison of Angle and voltage stability – Analysis of voltage instability and collapse – Integrated analysis of voltage and Angle stability – Control of voltage instability.

TEXT BOOKS:

1. P.M.Anderson, A.A.Fouad, "Power System Control and Stability", IOWA State University Press, Galgotia Publications, Vol-I, 1st Edition.

2. Transients in Power System, Lou Van Der Sluis, John Wiley & Sons.

REFERENCE BOOKS:

2. M.A.Pai, Power System Stability-Analysis by the direct method of Lyapunov, North Holland Publishing Company, New York, 1981.

JNTUA COLLEGE OF ENGINEERING (Autonomous)PULIVENDULA

EPS I-ISEMESTER

MODERN CONTROL THEORY

Unit I

Introductory matrix algebra and linear vector space. State space representation of systems. Linearization of a non - linear System. Solution of state equations. Evaluation of State Transition Matrix (STM) - Simulation of state equation using MATLAB/ SIMULINK program.

Unit II

Similarity transformation and invariance of system properties due to similarity transformations. Minimal realization of SISO, SIMO, MISO transfer functions. Discretization of a continuous time state space model. Conversion of state space model to transfer function model using Fadeeva algorithm. Fundamental theorem of feedback control - Controllability and Controllable canonical form - Pole assignment by state feedback using Ackermann's formula – Eigen structure assignment problem.

Unit III

Linear Quadratic Regulator (LQR) problem and solution of algebraic Riccati equation using eigenvalue and eigen vector methods, iterative method. Controller design using output feedback.

Unit IV

Observability and observable canonical form - Design of full order observer using Ackermann's formula - Bass Gura algorithm. Duality between controllability and observability - Full order Observer based controller design. Reduced order observer design.

Unit V

Internal stability of a system. Stability in the sense of Lyapunov, asymptotic stability of linear time invariant continuous and discrete time systems. Solution of Lyapunov type equation. Model decomposition and decoupling by state feedback. Disturbance rejection, sensitivity and complementary sensitivity functions.

Text Books:

1. K. Ogata, Modern Control Engineering, Prentice Hall, India 1997
2. T. Kailath, T., Linear Systems, Perntice Hall, Englewood Cliffs, NJ, 1980.
3. N. K. Sinha , Control Systems, New Age International, 3rd edition, 2005**.**

References:

1. Panos J Antsaklis, and Anthony N. Michel, Linear Systems, New - age international (P) LTD. Publishers, 2009.
2. John J D'Azzo and C. H. Houpis , "Linear Control System Analysis and Design Conventional and Modern", McGraw - Hill Book Company, 1988.
3. B.N. Dutta, Numerical Methods for linear Control Systems - , Elsevier Publication, 2007.
4. C.T.Chen Linear System Theory and Design - PHI, India.
5. Richard C. Dorf and Robert H. Bishop, Modern Control Systems, 11th Edition, Pearson Edu, India, 2009.

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EPS I-ISEMESTER

REACTIVE POWER COMPENSATION& MANAGEMENT

UNIT - I :LOAD COMPENSATION

Objectives and specifications – Reactive power characteristics – Inductive and capacitive approximate biasing – Load compensator as a voltage regulator – Phase balancing and power factor correction of unsymmetrical loads - Examples.

UNIT-II :

STEADY – STATE & TRANSIENT STATE REACTIVE POWER COMPENSATION IN TRANSMISSION SYSTEM

Uncompensated line – Types of compensation – Passive shunt and series and dynamic shunt compensation – Characteristic time periods – Passive shunt compensation – Static compensations - Series capacitor compensation – Compensation using synchronous condensers –Examples.

UNIT-III :REACTIVE POWER COORDINATION & DEMAND SIDE MANAGEMENT

Objective – Mathematical modeling – Operation planning – Transmission benefits – Basic concepts of quality of power supply – Disturbances - Steady – state variations – Effects of under Voltages – Frequency – Harmonics, radio frequency and electromagnetic interferences.Load patterns – Basic methods load shaping – Power tariffs - KVAR based tariffs penalties for voltage flickers and Harmonic voltage levels.

UNIT-IV :DISTRIBUTION & USER SIDE REACTIVE POWER MANAGEMENT

System losses – Loss reduction methods – Examples – Reactive power planning – Objectives – Economics Planning capacitor placement – Retrofitting of capacitor banks - KVAR requirements for domestic appliances – Purpose of using capacitors – Selection of capacitors – Deciding factors – Types of available capacitor, characteristics and Limitations.

UNIT-V : REACTIVE POWER MANAGEMENT IN ELECTRIC TRACTION SYSTEMS AND ARC FURNACES

Typical layout of traction systems – Reactive power control requirements – Distribution transformers - Electric arc furnaces – Basic operations- Furnaces transformer – Filter requirements – Remedial measures – Power factor of an arc furnace.

TEXT BOOKS:

1. J.E.Miller, Reactive Power Control in Electric Power Systems, John Wiley and Sons, 1982 (Units I to IV).
2. D.M.Tagare, Reactive power Management, Tata McGraw Hill, 2004 (Units V toVIII).

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EPS I-ISEMESTER

RENEWABLE ENERGY SYSTEMS

UNIT –I : INTRODUCTION-

Energy Economics: Simple pay back period, Internal (simple) arte of return, Net present valve, Internal rate of return (IRR), NPV and IRR with Fuel Escalation.
Solar resource-Solar spectrum, Altitude angle of sun at solar noon, solar position at any time of day, solar time, sun rise and sunset, solar radiation-direct beam, diffuse radiation, reflected radiation, and radiation measurements.
Semiconductor physics- Band gap energy, Solar spectrum, Band gap impact on Photo voltaic efficiency, P-n junction diode.

UNIT – II : PHOTO VOLTAICS:

Generic photo voltaic cell- Simple equivalent circuits, accurate equivalent circuit, Cells to modules to arrays, I-V curve under STC, Impacts of temperature & insolation on I-V curves, Shading impacts on i-V curves, Crystalline silicon technologies, thin film photovoltaics.
Photovoltaic systems-Introduction to major Photovoltaic systems types, current-voltage curves for loads, Maximum power point trackers
Grid connected systems- Interfacing with utility, DC and AC rated power, Peaks hours approach to estimate PV performance, Grid connected system sizing

UNIT – III STAND ALONE PV SYSTMES

Stand alone PV systems- Load estimation, Batteries- storage capacity, Sizing, Coulomb efficiency instead of energy, Blocking diodes, Sizing of PV array, Stand alone system design
PV powered water pumping- Hydraulic system curves, Hydraulic curves, Hydraulic system curve and pump curve, A simple directly coupled PV-pump design approach- numerical

UNIT – IV: Wind and Tidal Power:

Wind power-Wind power- Historical development, types of wind turbines, power in wind, Temperature and altitude correction, Impact of tower height, Maximum rotor efficiency, wind turbine generators, Average power in the wind, wind turbine- Aerodynamics
Tidal power-Tides and tidal power stations, modes of operation, **Tidal power calculation**, Tidal project examples, turbines and generators for tidal power generation.

UNIT – V: Fuel Cells & Wave Energy

Fuel Cells – Historical Development, Basic Operation of Fuel cells, Fuel cell Thermodynamics: Enthalpy, Entropy and theoretical efficiency of Fuel Cells, Gibbs free Energy and Fuel cell efficiency, Electrical output of an ideal cell electrical characteristics.
Wave energy conversion:Wave power calculation, Properties of waves and power content, vertex motion of Waves, device applications. Types of ocean thermal energy conversion systems Application of OTEC systems examples

TEXT BOOKS

1. Renewable and Efficient Electric Power systems: Gilbert M. Masters, John Wiley & Sons, Inc., Publication.
2. Renewable Energy Sources and Emerging Technologies, D.P. Kothari, K. C. Singal, Rakesh Ranjan, Kothari D.p., singal K. C., ranjan Rakesh

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EPS I-ISEMESTER

HVDC TRANSMISSION

(Elective-I)

UNIT-I: INTRODUCTION

General consideration, Power Handling Capabilities of HVDC Lines Basic Conversion principles, static converter configuration.

UNIT-II:STATIC POWER CONVERTERS

3-pulse, 6-pulse, and 12-pulse converters, converter station and Terminal equipment, commutation process, Rectifier and inverter operation, equivalent circuit for converter – special features of converter transformers. Harmonics in HVDC Systems, Harmonic elimination, AC and DC filters.

UNIT-III:CONTROL OF HVDC CONVERTERS AND SYSTEMS

Constant current, constant extinction angle and constant ignition angle control Individual phase control and equidistant firing angle control DC power flow control. Interactionbetween HV AC and DC systems – Voltage interaction Harmonic instability problems and DC power modulation.

UNIT-IV:MTDC SYSTEMS & OVER VOLTAGES

Series parallel and series parallel systems their operation and control.

Over voltages due to disturbances on DC side, over voltages due to DC and AC side line faults.

UNIT-V:CONVERTER FAULTS & PROTECTION

Converter faults, over current protection – valve group, and DC line protection over voltage protection of converters, surge arresters.

REFERENCE BOOKS:

1. E.W. Kimbark: Direct current Transmission, Wiely Inter Science – New York.
2. J. Arillaga HVDC Transmission Peter Peregrinus ltd. London UK 1983
3. KR Padiyar : High Voltage Direct current Transmission Wiely Esatern Ltd New Delhi – 1992.
4. E. Uhlman : Power Transmission by Direct Current , Springer Verlag, Berlin Helberg. 1985.

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EPS I-ISEMESTER

DISTRIBUTION AUTOMATION

(Elective-II)

UNIT-I: DISTRIBUTION AUTOMATION AND THE UTILITY SYSTEM

Introduction to Distribution Automation (DA), control system interfaces, control and data requirements, centralized (Vs) decentralized control, DA System (DAS), DA Hardware, DAS software.

UNIT-II: DISTRIBUTION AUTOMATION FUNCTIONS

DA capabilities, Automation system computer facilities, management processes, Information management, system reliability management, system efficiency management, voltage management, Load management.

UNIT-III: COMMUNICATION SYSTEMS FOR DA

DA communication requirements, Communication reliability, Cost effectiveness, Data rate Requirements, Two way capability, Ability to communicate during outages and faults, Ease of operation and maintenance, Conforming to the architecture of data flow

Communication systems used in DA : Distribution line carrier (Power line carrier), Ripple control, Zero crossing technique, telephone, cable TV, Radio, AM broadcast, FM SCA, VHF Radio, UHF Radio, Microwave satellite. Fiber optics, Hybrid Communication systems, Communication systems used in field tests.

UNIT-IV: TECHNICAL BENEFITS

DA benefit categories, Capital deferred savings, Operation and Maintenance savings, Interruption related savings, Customer related savings, Operational savings, improved operation, Function benefits, Potential benefits for functions, and function shared benefits, Guidelines for formulation of estimating equations Parameters required, economic impact areas, Resources for determining benefits impact on distribution system, integration of benefits into economic evaluation.

UNIT-V: ECONOMIC EVALUATION METHODS

Development and evaluation of alternate plans, Select study area, Select study period, Project load growth, Develop Alternatives, Calculate operating and maintenance costs, Evaluate alternatives. Economic comparison of alternate plans, Classification of expenses and capital expenditures, Comparison of revenue requirements of alternative plans, Book Life and Continuing plant analysis, Year by year revenue requirement analysis, short term analysis, end of study adjustment, Break even analysis, Sensitivity analysis computational aids.

REFERENCES:

1. IEEE Tutorial Course "Distribution Automation"
2. IEEE Working Group on "Distribution Automation"
3. Control and Automation of Electrical Distribution Systems, James. Northcote – Green Robert Wilson, CRC Press.

4. Electric Power Distribution Automation, Dr. M. K. Khedkar, Dr. G.M.Dhole, University Science press.

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EPS I-ISEMESTER

SYSTEM RELIABILITY CONCEPTS
(Elective- I)

UNIT-I: BASIC PROBABILITY THEORY
Basic concepts – Rules for combining Probabilities of events – Failure Density and Distribution functions – Bernoulli's trials – Binomial distribution – Expected value and standard deviation for binomial distribution – Examples.

UNIT-II: NETWORK MODELING AND RELIABILITY EVALUATION
Basic concepts – Evaluation of network Reliability / Unreliability – Series systems, Parallel systems, Series - Parallel systems, partially redundant systems – Types of redundancies - Evaluation of network Reliability / Unreliability using conditional probability method – Paths based and Cutset based approach – complete event tree and reduced event tree methods - Examples.

UNIT-III: TIME DEPENDENT PROBABILITY

Basic concepts – Reliability functions f(t), F(t), R(t), h(t) – Relationship between these functions – Baths tubs curve – Exponential failure density and distribution functions - Expected value and standard deviation of Exponential distribution – Measures of reliability – MTTF, MTTR, MTBF – Evaluation of network reliability / Unreliability of simple Series, Parallel, Series-Parallel systems - Partially redundant systems - Evaluation of reliability measure – MTTF for series and parallel systems – Examples.

UNIT-IV: DISCRETE MARKOV CHAINS & CONTINUOUS MARKOV PROCESSES

Basic concepts – Stochastic transitional Probability matrix – time dependent probability evaluation – Limiting State Probability evaluation – Absorbing states – Markov Processes- Modelling concepts – State space diagrams – time dependent reliability evaluation of single component repairable model – Evaluation of Limiting State Probabilities of one, two component repairable models – Frequency and duration concepts – Frequency balance approach - Examples.

UNIT-V: MULTI COMPONENT & APPROXIMATE SYSTEM RELIABILITY EVALUATION
Recursive relation for evaluation of equivalent transitional rates, cumulative probability and cumulative frequency and 'n' component repairable model - Series systems, Parallel systems, Basic reliability indices – Cutset approach – Examples.

REFERENCE BOOKS:

1. Reliability Evaluation of Engineering Systems by Roy Billinton and Ronald N. Allan, Reprinted in India B. S. Publications, 2007.
2. Reliability Engineering by E. Balagurusamy, Tata McGraw Hill, 2003.
3. Reliability and Maintainability Engineering by Charles E. Ebeling, Tata McGraw Hill, 2000.
4. Probability concepts in Electric Power system – G.J.Anders- 1st edition –1990 – John wiley & sons.

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EPS I-ISEMESTER

POWER QUALITY
(Elective I)

UNIT - I: INTRODUCTION TO POWER QUALITY

Definition of Power Quality - Power Quality Progression - Power Quality Terminology - Power Quality Issues - Susceptibility Criteria - Responsibilities of Power Suppliers and Users - Power Quality Standards.

UNIT -II: POWER FREQUENCY DISTURBANCE & TRANSIENTS

Introduction to Power Frequency Disturbance - Common Power Frequency Disturbances - Cures for Low Frequency Disturbances - Voltage Tolerance Criteria - ITIC Graph - Introduction to Transients - Transient System Model - Examples of Transient Models and Their Response - Power System Transient Modeling - Types and Causes of Transients - Examples of Transient Waveforms.

UNIT - III: HARMONICS & ELECTROMAGNETIC INTERFERENCE (EMI)

Definition of Harmonics - Harmonic Number (h) - Odd and Even Order Harmonics - Harmonic Phase Rotation and Phase Angle - Voltage and Current Harmonics - Individual and Total Harmonic Distortion - Harmonic Signatures - Effect of Harmonics On Power System Devices - Guidelines For Harmonic Voltage and Current Limitation - Harmonic Current Mitigation - Introduction to EMI - Frequency Classification - Electrical Fields - Magnetic Fields - EMI Terminology - Power Frequency Fields - High Frequency Interference - EMI Susceptibility - EMI Mitigation - Cable Shielding - Health Concerns of EMI.

UNIT - IV: GROUNDING AND BONDING

Introduction to Grounding and Bonding - Shock and Fire Hazards - NEC Grounding Requirements - Essentials of a Grounded System - Ground Electrodes - Earth Resistance Tests - Earth Ground Grid Systems - Power Ground System - Signal Reference Ground (SRG) - SRG Methods - Single and Multipoint Grounding - Ground Loops - Electrochemical Reaction - Examples of Grounding Anomalies.

UNIT - V: MEASURING AND SOLVING POWER QUALITY PROBLEMS

Introduction to Power Quality Measurements - Power Quality Measurement Devices - Power Quality Measurements - Test Locations - Test Duration - Instrument Setup - Instrument Guidelines

TEXT BOOKS:

1. Power quality by C. Sankaran, CRC Press
2. Electrical Power Systems Quality, Roger C. Dugan, Mark F. McGranaghan, Surya Santoso, H.Wayne Beaty, 2nd Edition, TMH Education Pvt. Ptd.

REFERENCE BOOKS:

1. Understanding Power quality problems by Math H. J. Bollen IEEE Press
2. Power quality enhancement using custom power devices by Arindam Ghosh,Gerard Ledwich,Kluwer academic publishers

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EPS I-ISEMESTER

POWER ELECTRONIC CONVERTERS
(Elective II)

Unit – I: RECTIFIERS

Single phase full converters with resistive load and inductive load – Three phase full converter with resistive load – principle and operation of dual converter -– Two quadrant operation –Four quadrant operation.

Unit –II: DC –DC CONVERTERS

Analysis of step-down and step-up dc to dc converters with resistive and Resistive-inductive loads – Switched mode regulators -Analysis of Buck Regulators - Boost regulators - buck and boost regulators - Cuk regulators -Condition for continuous inductor current and capacitor voltage (Continuous Conduction & Discontinuous Conduction modes) - comparison Of regulators -Multiouput boost converters - advantages - applications - Numerical problems.

Unit – III: DC – AC CONVERTERS

single phase bridge inverter- evaluation of output voltage and current with resistive, inductive loads - Voltage control of single phase inverters - single PWM – multi pulse PWM- Three phase inverters - analysis of 180 degree condition for output voltage and current - analysis of 120 degree Conduction - voltage control of three phase inverters - sinusoidal PWM - Third Harmonic PWM - 60 degree PWM - space vector modulation - advantages - applications - numerical problems.

Unit – IV: Multilevel Inverters

Concept of multilevel inverters – Classification of multilevel inverters – single phase to single phase cyclo converters – single phase voltage controller with R load and RL load- Comparison of multi level inverter topologies – Basics of matrix converters – Grid Synchronization-applications and advantages.

Unit – V : Utility applications of power electronics
Power Semiconductor Devices and their capabilities, Distributed Generation applications, Power electronic loads, power quality solutions, Transmission and distribution applications

TEXT BOOKS:

1. Power Electronics - Mohammed H. Rashid - Pearson Education -Third Edition - First Indian Reprint 2004.
2. Power Electronics - Ned Mohan, Tore M. Undeland and William P. Robbins -John Wiley and Sons Second Edition.
3. Modern Power electronics and AC drives – Bimal K. Bose – Prentice Hall india.

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EPS I-ISEMESTER

POWER SYSTEMS SIMULATIONLAB-I

MATLAB

1. Y - Bus Formation Using MATLAB
2. Gauss – Seidel Load Flow Analysis using MATLAB
3. N-R Method for Load flow Analysis using MATLAB
4. Fast Decoupled Load Flow Analysis using MATLAB
5. Point by Point Method using MATLAB
6. Step Response of Two Area System with Integral Control and Estimation of Tie Line Power Deviation using SIMULINK
7. Step Response of Two Area System with Integral Control and Estimation of Tie Line Frequency Deviation using SIMULINK

MiPower

8. Load Flow Analysis using MiPower
    i) Gauss Seidel Method
    ii) Newton Raphson Method
9. Short Circuit Analysis using MiPower
10. Transient Stability Analysis using MiPower
11. Economic Load Dispatch Analysis using MiPower

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MACHINES & POWER SYSTEMS LAB

1. Determination of Subtransient Reactance of a Salient Pole Machine
2. Determination of Sequence Impedances of a Cylindrical Rotor Synchronous Machine
3. Fault Analysis
   i) LG Fault

   ii) LL Fault

   iii) LLG Fault

   iv) LLLG Fault
4. Equivalent Circuit of a Three Winding Transformer
5. Separation of No Load losses of a Three Phase Squirrel Cage Induction Motor
6. Power Angle Characteristics of a Salient Pole Synchronous Machine
7. Scott Connection
8. Characteristics of IDMT Over Current Relay (Electro Magnetic Type)
9. Characteristics of Static Negative Sequence Relay
10. Characteristics of Over Voltage Relay
    i) Electromagnetic Type
    ii) Microprocessor Type
11. Characteristics of Percentage Biased Differential Relay
    i) Electromagnetic Type
    ii) Static Type

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EPS **I-IISEMESTER**

OPERATION AND CONTROL OF POWER SYSTEM

UNIT-I: Economic operation- Load forecasting - Unit commitment – Economic dispatch problem of thermal units – Gradient method- Newton's method –Base point and participation factor method. Unit Commitment and Solution Methods: Optimal Unit Commitment, Constraints in unit commitment, Spinning reserve, Thermal Unit Constraints, Other constraints, Hydro constraints, Must Run, Fuel constraints, Unit commitment Solution methods : Priority-List methods, Dynamic Programming solution. Backward DP Approach, Forward DP Approach, Restricted Search Ranges, Strategies- Reliability considerations

UNIT-II:Hydrothermal co-ordination: Short-term hydrothermal scheduling problem -gradient approach – Hydro units in series - pumped storage hydro plants-hydro-scheduling using Dynamic programming and linear programming.

UNIT-III: Automatic generation control: Review of LFC and Economic Dispatch control(EDC) using the three modes of control viz. Flat frequency – tie-line control and tie-line bias control. AGC implementation – AGC features - static and dynamic responses of uncontrolled & controlled two-area system.

UNIT-IV: Interchange of Power & Energy: Economic interchange between interconnected utilities – Inter utility energy evaluation – Power pools – Transmission effects and Issues: Limitations – Wheeling

UNIT-V:Power system security-Contingency analysis – linear sensitivity factors – AC power flow methods – contingency selection – concentric relaxation – bounding-security constrained optimal power flow-Interior point algorithm-Bus incremental costs.– Maximum likelihood Weighted least squares equation – orthogonal Decomposition estimation method – Algorithm

REFERENCES:

1. Allen J.Wood and Wollenberg B.F., 'Power Generation Operation and control', John Wiley & Sons, Second Edition.
2. Nagrath, I.J. and Kothari D.P., 'Modern Power System Analysis', TMH,N.Delhi,1980
3. D.P.Kothari & J.S.Dhillon, Power System Optimization , PHI,2004

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EPS I-IISEMESTER

FACTS Controllers

UNIT-I: FACTS CONCEPTS

Transmission interconnections power flow in an AC system, loading capability limits, Dynamic stability considerations, importance of controllable parameters basic types of FACTS controllers, benefits from FACTS controllers.

UNIT-II: VOLTAGE SOURCE & CURRENT SOURCE CONVERTERS

Single phase three phase full wave bridge converters transformer connections for 12 pulse 24 and 48 pulse operation. Three level voltage source converter, pulse width modulation converter, basic concept of current source Converters, and comparison of current source converters with voltage source converters.

UNIT – III: SHUNT COMPENSATION

Objectives of shunt compensation - Methods of controllable var generation - variable impedance type static var generators - switching converter type var generators - hybrid var generators – Comparison of SVC and STATCOM.

UNIT – IV: SERIES COMPENSATION

Objectives of series compensation – GTO Thyristor Controlled Series Capacitor (GCSC) - Thyristor Switched Series Capacitor (TSSC) - Thyristor Controlled Series Capacitor (TCSC) - Control schemes for TCSC, TSSC and TCSC.

UNIT- V: UNIFIED POWER FLOW CONTROLLER (UPFC)

Introduction - The Unified Power Flow Controller - Basic Operating Principles - Conventional Transmission Control Capabilities - Independent Real and Reactive Power Flow Control - Control Structure - Basic Control System for P and Q Control - Hybrid Arrangements: UPFC With a Phase Shifting Transformer.

REFERENCE BOOKS:

1. Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems by Narain G. Hingorani, Laszlo Gyugyi - Standard Publishers Distributors - IEEE Press – First Edition – 2001.

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EPS I-IISEMESTER

ADVANCED POWER SYSTEM PROTECTION

UNIT-I: STATIC RELAYS

Advantages of static relays - Basic construction of static relays – Level detectors – Replica impedance-mixing circuits-general equation for two input phase and amplitude comparators – Duality between amplitude and phase comparator.

UNIT-II: COMPARATORS

Amplitude:Circulating current type and opposed voltage type rectifier bridge comparators – Direct and Instantaneous comparators. Phase Comparators: Coincidence circuit type block spike phase comparator, techniques to measure the period of coincidence – Integrating type – Rectifier and vector product type phase comparators. Multi –Input Comparators:Conic section characteristics – Three input amplitude comparator – Hybrid comparator – Switched distance schemes – Polyphase distance schemes-Phase fault scheme – Three phase scheme – combined and ground fault scheme.

UNIT-III: STATIC OVER CURRENT, DIFFERENTIAL AND DISTANCE RELAYS

Introduction-Instantaneous over current relay – Time over current relays - Basic principles-Definite time and Inverse definite time over current relays. Analysis of static differential relays – static relay schemes – Dual bias transformer differential protection – Harmonic restraint relay. Static Relays: Static impedance – reactance - MHO and angle impedance relay sampling comparator – realization of reactance and MHO relay using a sampling comparator.

UNIT-IV: POWER SWINGS

Effect of power swings on the performance of Distance relays - Power swing analysis – Principle of out of step tripping and blocking relays – Effect of line length and source impedance on distance relays.

UNIT-V: MICROPROCESSOR BASED PROTECTIVE RELAYS

Over current relays – Impedance relays – Directional relay – Reactance relay (Block diagram and flow chart approach only). Generalized mathematical expression for distance relays - Measurement of resistance and reactance – MHO and offset MHO relays – Realization of MHO characteristics – Realization of Offset MHO characteristics (Block diagram and flow chart approach only) Basic principle of Digital computer relaying.

TEXT BOOKS:

1. T.S.Madhava Rao, Power system Protection static relay, Tata McGraw Hill,
2. 2^{nd} Edition, 1989.

REFERENCE BOOKS:

Badri Ram and D.N.Vishwakarma, Power system Protection and Switchgear, Tata McGraw Hill, First Edition -1995.

EPS I-IISEMESTER

RESTRUCTUREDPOWER SYSTEM

UNIT - I: KEY ISSUES IN ELECTRIC UTILITIES

Introduction – Restructuring models – Independent System Operator (ISO) – Power Exchange - Market operations – Market Power – Standard cost – Transmission Pricing – Congestion Pricing – Management of Inter zonal/Intra zonal Congestion.

UNIT-II: OPEN ACCESS SAME-TIME INFORMATION SYSTEM (OASIS) &MARKET POWER

Structure of OASIS - Posting of Information – Transfer capability on OASIS. Market Power: Introduction - Different types of market Power – Mitigation of Market Power - Examples.

UNIT-III: AVAILABLE TRANSFER CAPABILITY (ATC) &ELECTRICITY PRICING

Transfer Capability Issues – ATC – TTC – TRM – CBM Calculations – Calculation of ATC based on power flow. Electricity Pricing: Introduction – Electricity Price Volatility Electricity Price Indexes – Challenges to Electricity Pricing – Construction of Forward Price Curves – Short-time Price Forecasting.

UNIT - IV: POWER SYSTEM OPERATION IN COMPETITIVE ENVIRONMENT

Introduction – Operational Planning Activities of ISO- The ISO in Pool Markets – The ISO in Bilateral Markets – Operational Planning Activities of a GENCO.

UNIT- V: TRANSMISSION COST ALLOCATION METHODS&ANCILLARY SERVICES MANAGEMENT

Introduction - Transmission Cost Allocation Methods : Postage Stamp Rate Method - Contract Path Method - MW-Mile Method – Unused Transmission Capacity Method - MVA-Mile method – Comparison of cost allocation methods. Ancillary Services Management: Introduction – Reactive Power as an Ancillary Service – a Review – Synchronous Generators as Ancillary Service Providers.

TEXT BOOKS :

1. Kankar Bhattacharya, Math H.J. Boller and Jaap E.Daalder, Operation of Restructured Power System, Kulwer Academic Publishers, 2001.
2. Mohammad Shahidehpour and Muwaffaq alomoush, Restructured Electrical Power Systems, Marcel Dekker, Inc., 2001.

REFERENCE BOOKS:

1. Loi Lei Lai, Power System Restructuring and Deregulation, John Wiley & Sons Ltd., England.

EPS I-IISEMESTER

POWER SYSTEM RELIABILITY

(Elective III)

UNIT-I : GENERATING SYSTEM RELIABILITY ANALYSIS – I

Generation system model – Capacity outage probability tables – Recursive relation for capacitive model building – Sequential addition method – Unit removal – Evaluation of loss of load and energy indices – Examples.

UNIT-II : GENERATING SYSTEM RELIABILITY ANALYSIS – II

Frequency and Duration methods – Evaluation of equivalent transitional rates of identical and non-identical units – Evaluation of cumulative probability and cumulative frequency of non-identical generating units – 2-level daily load representation - Merging generation and load models – Examples.

UNIT-III : BULK POWER SYSTEM RELIABILITY EVALUATION

Basic configuration – Conditional probability approach – System and load point reliability indices – Weather effects on transmission lines – Weighted average rate and Markov model – Common mode failures.

UNIT-IV : DISTRIBUTION SYSTEM RELIABILITY ANALYSIS – I (RADIAL CONFIGURATION)

Basic Techniques – Radial networks – Evaluation of Basic reliability indices, performance indices - Load point and system reliability indices – Customer oriented, loss and energy oriented indices – Examples.

UNIT-V : DISTRIBUTION SYSTEM RELIABILITY ANALYSIS - II(PARALLEL CONFIGURATION)

Basic techniques – Inclusion of bus bar failures, scheduled maintenance – Temporary and transient failures – Weather effects – Common mode failures – Evaluation of various indices – Examples.

TEXT BOOKS:

1. Roy Billinton and Ronald N. Allan, Reliability Evaluation of Power Systems, Plenum Press, New York and London, 2nd Edition, 1996.

J. Endrenyi , Reliability Modeling in Electric Power Systems, John Wiley & Sons, 1st Edition, 1978.

EHV AC TRANSMISSION
(Elective III)

UNIT – I: PRELIMINARIES

Necessity of EHV AC transmission – Advantages and problems – Power handling capacity and line losses- Mechanical considerations – Resistance of conductors – Properties of bundled conductors – Bundle spacing and bundle radius - Examples.

UNIT – II: LINE AND GROUND REACTIVE PARAMETERS

Line inductance and capacitances – Sequence inductances and capacitances – Modes of propagation – Ground return – Examples. Electrostatics – Field of sphere gap – Field of line changes and properties – Charge – potential relations for multi-conductors – Surface voltage gradient on conductors – Distribution of voltage gradient on sub-conductors of bundle – Examples.

UNIT – III: CORONA EFFECTS

Power loss and audible noise (AN) – corona loss formulae – Charge voltage diagram – Generation, characteristics - Limits and measurements of AN – Relation between 1-phase and 3 -phase AN levels – Radio interference (RI) - Corona pulses generation, properties, limits – Frequency spectrum – Modes of propagation – Excitation function – Measurement of RI, RIV and excitation functions - Examples.

UNIT – IV: ELECTRO STATIC FIELD & TRAVELING WAVE THEORY

Electrostatic field: calculation of electrostatic field of EHV/AC lines – Effect on humans, animals and plants – Electrostatic induction in unenergised circuit of double - circuit line – Electromagnetic interference - Examples. Traveling wave expression and solution - Source of excitation - Terminal conditions - Open circuited and short circuited end - Reflection and refraction coefficients - Lumped parameters of distributed lines - Generalized constants - No load voltage conditions and charging current.

UNIT –V: VOLTAGE CONTROL

Power circle diagram and its use – Voltage control using synchronous condensers – Cascade connection of shunt and series compensation – Sub synchronous resonance in series capacitor – Compensated lines – Static VAR compensating system.

TEXT BOOKS:

1. R. D. Begamudre, EHVAC Transmission Engineering, New Age International (p) Ltd.
2. S. Rao, HVAC and DC Transmission.

EPS I-IISEMESTER

AI TECHNIQUES IN ELECTRICAL ENGINEERING

UNIT – I: ARTIFICIAL NEURAL NETWORKS

Introduction-Models of Neural Network - Architectures – Knowledge representation – Artificial Intelligence and Neural networks–Learning process – Error correction learning – Hebbian learning – Competitive learning –Boltzman learning –Supervised learning – Unsupervised learning – Reinforcement learning- learning tasks.

UNIT- II: ANN PARADIGMS

Multi – layer perceptron using Back propagation Algorithm-Self – organizing Map – Radial Basis Function Network – Functional link, network – Hopfield Network.

UNIT – III: FUZZY LOGIC

Introduction – Fuzzy versus crisp – Fuzzy sets - Membership function – Basic Fuzzy set operations – Properties of Fuzzy sets – Fuzzy cartesion Product –Operations on Fuzzy relations – Fuzzy logic – Fuzzy Quantifiers-Fuzzy Inference-Fuzzy Rule based system-Defuzzification methods.

UNIT – IV: GENETIC ALGORITHMS

Introduction-Encoding –Fitness Function-Reproduction operators-Genetic Modeling –Genetic operators-Crossover-Single – site crossover-Two point crossover –Multi point crossover-Uniform crossover – Matrix crossover-Crossover Rate-Inversion & Deletion –Mutation operator –Mutation –Mutation Rate-Bit-wise operators-Generational cycle-convergence of Genetic Algorithm.

UNIT–V: APPLICATIONS OF AI TECHNIQUES

Load forecasting – Load flow studies – Economic load dispatch – Load frequency control – Single area system and two area system – Small Signal Stability (Dynamic stability) Reactive power control – speed control of DC and AC Motors.

TEXT BOOK:

1. S.Rajasekaran and G.A.V.Pai, "Neural Networks, Fuzzy Logic & Genetic Algorithms"- PHI, New Delhi, 2003.

REFERENCE BOOKS:

1. P.D.Wasserman,Van Nostrand Reinhold,"Neural Computing Theory & Practice"- New York,1989.
2. Bart Kosko,"Neural Network & Fuzzy System" Prentice Hall, 1992.
3. G.J.Klir and T.A.Folger,"Fuzzy sets,Uncertainty and Information"-PHI, Pvt.Ltd,1994.
4. D.E.Goldberg," Genetic Algorithms"- Addison Wesley 1999.

EPS I-IISEMESTER

ELECTRIC SMART GRID

(Elective – III)

UNIT–I: INTRODUCTION

Introduction to smart grid- Electricity network-Local energy networks- Electric transportation-Low carbon central generation-Attributes of the smart grid- Alternate views of a smart grid.

SMART GRID TO EVOLVE A PERFECT POWER SYSTEM: Introduction- Overview of the perfect power system configurations- Device level power system- Building integrated power systems- Distributed power systems- Fully integrated power system-Nodes of innovation.

UNIT–II: DC DISTRIBUTION AND SMART GRID

AC vs DC sources-Benefits of and drives of DC power delivery systems-Powering equipment and appliances with DC-Data centers and information technology loads-Future neighborhood-Potential future work and research.

INTELLIGRID ARCHITECTURE FOR THE SMARTGRID: Introduction- Launching intelligrid-Intelligrid today- Smart grid vision based on the intelligrid architecture-Barriers and enabling technologies.

UNIT–III: DYNAMIC ENERGY SYSTEMS CONCEPT

Smart energy efficient end use devices-Smart distributed energy resources-Advanced whole building control systems- Integrated communications architecture-Energy management-Role of technology in demand response- Current limitations to dynamic energy management-Distributed energy resources-Overview of a dynamic energy management-Key characteristics of smart devices- Key characteristics of advanced whole building control systems-Key characteristics of dynamic energy management system.

UNIT–IV: ENERGY PORT AS PART OF THE SMART GRID:

Concept of energy -Port, generic features of the energy port.

POLICIES AND PROGRAMS TO ENCOURAGE END – USE ENERGY EFFICIENCY: Policies and programs in action -multinational - national-state-city and corporate levels.

MARKET IMPLEMENTATION: Framework-factors influencing customer acceptance and response - program planning-monitoring and evaluation.

UNIT–V: EFFICIENT ELECTRIC END – USE TECHNOLOGY ALTERNATIVES

Existing technologies – lighting - Space conditioning - Indoor air quality - Domestic water heating - hyper efficient appliances - Ductless residential heat pumps and air conditioners - Variable refrigerant flow air conditioning-Heat pump water heating - Hyper efficient residential appliances - Data center energy efficiency- LED street and area lighting - Industrial motors and drives - Equipment retrofit and replacement - Process heating - Cogeneration, Thermal energy storage - Industrial energy management programs - Manufacturing process-Electro-technologies, Residential, Commercial and industrial sectors.

TEXT BOOKS:

1. Clark W Gellings, “The Smart Grid, Enabling Energy Efficiency and Demand Side Response”- CRC Press, 2009.

2. Janaka Ekanayake, Kithsiri Liyanage,Jianzhong.Wu, Akihiko Yokoyama, Nick Jenkins, “Smart Grid: Technology and Applications”- Wiley, 2012.

3. James Momoh, “Smart Grid :Fundamentals of Design and Analysis”- Wiley, IEEE Press, 2012.

EPS I-IISEMESTER

ENERGY AUDITING, CONSERVATION AND MANAGEMENT

(Elective-III)

UNIT-I: BASIC PRINCIPLES OF ENERGY AUDIT

Energy audit- definitions, concept , types of audit, energy index, cost index ,pie charts, Sankey diagrams, load profiles, Energy conservation schemes- Energy audit of industries- energy saving potential, energy audit of process industry, thermal power station, building energy audit.

UNIT-II: ENERGY MANAGEMENT

Principles of energy management, organizing energy management program, initiating, planning, controlling, promoting, monitoring, reporting- Energy manger, Qualities and functions, language, Questionnaire – check list for top management.

UNIT-III: ENERGY EFFICIENT MOTORS

Energy efficient motors , factors affecting efficiency, loss distribution , constructional details , characteristics - variable speed , variable duty cycle systems, RMS hp- voltage variation-voltage unbalance- over motoring- motor energy audit

UNIT-IV: POWER FACTOR IMPROVEMENT, LIGHTING AND ENERGY INSTRUMENTS

Power factor – methods of improvement, location of capacitors, Pf with non linear loads, effect of harmonics on power factor, power factor motor controllers - Good lighting system design and practice, lighting control ,lighting energy audit - Energy Instruments- wattmeter, data loggers, thermocouples, pyrometers,lux meters, tongue testers ,application of PLC's.

UNIT-V: ECONOMIC ASPECTS AND ANALYSIS

Economics Analysis-Depreciation Methods, time value of money, rate of return , present worth method , replacement analysis, life cycle costing analysis- Energy efficient motors- calculation of simple payback method, net present worth method- Power factor correction, lighting - Applications of life cycle costing analysis, return on investment .

REFERENCE BOOKS:

1. Energy management by W.R. Murphy AND G. Mckay Butter worth, Heinemann publications.
2. Energy management by Paul o' Callaghan, Mc-graw Hill Book company-1st edition, 1998
3. Energy efficient electric motors by John .C. Andreas, Marcel Dekker Inc Ltd-2nd edition, 1995-
4. Energy management hand book by W.C.Turner, John wiley and sons
5. Energy management and good lighting practice : fuel efficiency- booklet12-EEO

EPS I-IISEMESTER

RENEWABLE ENERGY SYSTEMS LAB

1. Demonstration of I-V and P-V characteristics of two modules in series and parallel.
2. Draw charging and discharging characteristics of battery.
3. Perform the experiment of manually finding the MPP by varying the resistive load across the PV panel.
4. Perform the experiment of finding the MPP by varying the duty cycle of DC-DC converter.
5. Observation of current for linear & nonlinear loads and voltage waveform at PCC.
6. Synchronization of grid tied inverter, observation of current waveform and calculations for distortion, displacement and power factor of grid tied inverter
7. Evaluation of the active, reactive power and net energy flow between grid tied inverter, artificial grid & load.
8. MPPT Algorithm for SOLAR PV Panel Testing.
9. P, V and F measurement of output of wind generator.
10. Impact of load and wind speed on power output and its quality.
11. Performance of Frequency drop characteristic of induction generator at different loading conditions.
12. Design of DC –DC Converter for different types of variable DC Loads trough SIMULINK.
13. Design of DC –AC Converter for different types of variable AC Loads trough SIMULINK.

EPS I-IISEMESTER

POWER SYSTEMS SIMULATION LAB –II

1. Z - Bus Formation Using MATLAB
2. Fast Decoupled Load Flow Analysis for Distribution Systems using MATLAB
3. Reliability analysis of distribution systems.
4. Simulation of faults through power system fault analysis.
5. Voltage stability assessment in distribution systems.
6. Economic load dispatch using MATLAB
7. Transient stability analysis through single machine.
8. Transient stability analysis through multi machine system.

Simulation of FACTS devices in power system

9. SVC
10. TCSC
11. Analysis of dynamic stability using Mi Power
12. Network reduction using Mi Power
13. Relay coordination using Mi Power for Phase to earth over current relay
14. Line and cable parameters calculation using Mi Power

TWO YEAR COURSE STRUCTURE

FOR

M.TECH – ELECTRICAL POWER SYSTEMS

w.e.f.

2017-2018 ADMITTED BATCH

R-17 REGULATIONS

DEPARTMENT OF ELECTRICAL POWER SYSTEMS ENGINEERING

COLLEGE OF ENGINEERING (AUTONOMOUS) :: PULIVENDULA

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY ANANTAPUR

PULIVENDULA – 516390, Y.S.R. (DIST), ANDHRA PRADESH, INDIA

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY ANANTAPUR
COLLEGE OF ENGINEERING (Autonomous) PULIVENDULA – 516 390 (A. P.)

Academic regulations for M. Tech. (Regular) program with effect from academic year 2017-18

1. ELIGIBILITY FOR ADMISSION:

Admission to the above program shall be made subject to the eligibility, qualification and specialization prescribed by the University for each Program from time to time.

i. Admission shall be made either on the basis of merit/rank obtained by the qualifying candidates in GATE/PGECET or otherwise specified, whichever is relevant.

2. AWARD OF M.TECH. DEGREE:

A student will be declared eligible for the award of the M. Tech. degree if he/she fulfills the following academic regulations:

i. He/she has pursued a course of study for not less than four semesters and not more than eight semesters.
ii. Students, who fail to fulfill all the academic requirements for the award of the degree within eight semesters from the year of their admission, shall forfeit their seat in the course and their seat shall stand cancelled.
iii. Register for 68 credits and secure all 68 credits

3. COURSES OFFERED:

s.no.	Department	Specialization
01.	Electrical & Electronics Engineering (EEE)	*Electrical Power Systems (EPS)*
02.	Mechanical Engineering (ME)	*Computer Aided Design & Computer Aided Manufacturing (CAD&CAM)*
03.	Electronics & Communication Engineering (ECE)	*Digital Electronics & Communication Systems (DECS)*
04.	Computer Science & Engineering (CSE)	*Computer Science & Engineering (CSE)*

And any other course as approved by the competent authorities from time to time.

4. COURSE WORK:

The programs are offered on a Semester basis consisting of four Semesters.

i. The candidates shall undergo ***five theory*** and ***two laboratory*** courses in ***each semester*** during the first and second semesters. During the third and fourth semesters the candidates pursue the dissertation in the concerned specialization only. The theme of dissertation should conform to the specialization.
ii. There shall be one comprehensive online examinations conducted by the respective department one at the end of 1st year with 60 objective questions for 60 marks on the subjects studied in the respective years of both semesters. The heads of the respective department are given the responsibility of preparing question paper and conducting the online examination by maintaining confidentiality. A student shall acquire Two credit assigned to the online examination only when he/she secure 40% or more marks. In case, if a student fails in comprehensive online examination, he shall re- register by following a similar procedure adopted for the lab examinations.

iii. There shall be ***two seminars*** (*seminar-I, and seminar -II*) related to thesis/dissertation. Out of two seminars related to thesis/dissertation, *seminar-I* shall be conducted in the 3rd semester and the *seminar-II* will be in 4th semester.

iv. A candidate has to either present a paper in any national or international conference organized by AICTE recognized college/institution, or, publish a paper in peer-reviewed journals/Conferences proceedings before the submission of thesis.

v. Only on completion of all the prescribed courses, the candidate will be permitted to submit the thesis/dissertation. Three copies of the thesis / dissertation certified by the concerned supervisor in the prescribed form shall be submitted to the College. Once a student fails to submit the thesis within the stipulated period of four semesters, extension of time up to eight semesters may be permitted by the Principal with recommendation of the College Academic Committee.

vi. The Thesis/Dissertation will be adjudicated by one external examiner from reputed institutions/industry appointed by the competent authority.

vii. If the report of the external examiner is favorable, a viva-voce examination shall be conducted by a board consisting of Head of the department as Chairman, the supervisor and the examiner who adjudicated the thesis/ dissertation. The board shall jointly report the candidate's work as:

A - Excellent
B - Good
C - Satisfactory
D - Unsatisfactory

viii. If the report of the viva-voce is not satisfactory, the candidate will retake the viva-voce examination after three months. If he/she fails to get a satisfactory report at the second viva-voce examination, he/she will not be eligible for the award of the degree unless the candidate is asked to revise and resubmit the thesis/dissertation. The resubmitted copy shall be evaluated by the same board.

5. EVALUATION:

The performance of the candidate in each semester program shall be evaluated subject wise, with a maximum of 100 marks for theory and 100 marks for practical examination, on the basis of Internal Evaluation and End Examination.

i. For the theory subjects, 60% of the marks will be for the End Examination and 40% of the marks will be for Internal Evaluation.

Final Internal marks for a total of 40 marks shall be arrived at by considering the marks secured by the student in both the mid examinations with 80% weightage to the better mid exam and 20% to the other. The two midterm examinations shall be held during the semester, one in the middle of the program and the other one during the last week of instruction. **A student shall answer all three questions in 2 hours of time without seeking any choice**.

The following pattern shall be followed in the End-Examination.

a. Five questions shall be set from each of the five units with either/or type for 12 marks each, and the total marks of 60.
b. All the questions have to be answered compulsorily.
c. Each question may consist of one, two or more bits.

ii. For practical subjects, 60 marks shall be for the End Examinations and 40 marks will be for internal evaluation based on the day to day performance. The end semester practical examination shall be conducted by the concerned laboratory teacher and senior expert in the same subject of the department nominated by the Principal.

iii. Comprehensive Online Examination shall be evaluated for 60 marks ad seminar-I and seminar-II shall be evaluated for internal marks of 50 each. There is no external evaluation for them. A candidate has to secure a minimum of 50% to be declared successful in all the three evaluations. If the candidate fails, he/she has to re-register for Comprehensive Online Examination /seminars. Assessment of these three shall be done by a board consisting of Head of the Department, concerned thesis supervisors, and senior faculty members of the department.

iv. A candidate shall be deemed to have secured the minimum academic requirement in a subject if he secures a minimum of 40% of marks in the End Examination and a minimum aggregate of 50% of the total marks in the End Semester Examination and Internal Evaluation taken together.

v. In case the candidate does not secure the minimum aggregate marks as specified in 5 (iv) he/she has to reappear for the semester examination either the supplementary or regular in that subject or repeat the course as and when next offered or do any other specified subject as may be required. *However the candidate is permitted to appear for two courses per semester only*.

6. ATTENDANCE:

A student shall be eligible to appear for end semester examinations if he/she acquires a minimum of 75% of attendance in aggregate of all the subjects in a semester.

i. Condonation of shortage of attendance up to 10% in any subject i.e. from 65% and above and less than 75% may be given by the College Academic Committee.

ii. **Shortage of Attendance below 65% in aggregate shall in NO case be condoned**.

iii. Condonation of shortage of attendance in aggregate up to 10% (65% and above and below 75%) in each semester may be granted by the College Academic Committee.

iv. Students whose shortage of attendance is not condoned in any semester are not eligible to take their external Examination of that class and their registration shall stand cancelled.

v. A student will not be promoted to the next semester unless he/she satisfies the attendance requirements of the present semester, as applicable. They may seek readmission for that semester as and when offered next.

vi. A stipulated fee shall be payable towards condonation of shortage of attendance to the institution.

7. Grading System is to be introduced. After each subject is evaluated for 100 marks, the marks obtained in each subject will be converted to a corresponding letter grade as given below, depending on the range in which the marks obtained by the student fall.

vii. Table – Conversion into Grades and Grade Points assigned

Academic performance	Letter Grade	Grade points Assigned
≥ 95%	S	10
≥90% - < 95%	A++	9.5
≥ 85% - <90%	A+	9
≥80% - <85%	A	8.5
≥75% - <80%	B++	8
≥70% - <75%	B+	7.5
≥65% - <70%	B	7
≥60% - <65%	C++	6.5
≥55% - <60%	C+	6
≥50% - <55%	C	5.5
≥45% -< 50%	D	5
≥40%- < 45%	E	4.5
Below 40%	F(Fail)	0
Absent	Ab (Absent)	0

i. The following procedure shall be adopted to compute the Semester Grade Point Average (SGPA) and Cumulative Grade Point Average (CGPA);

ii. The Semester Grade Point Average (SGPA) is the ratio of sum of the product of the number of credits with the grade points scored by a student in all the courses taken by a student and the sum of the number of credits of all the courses undergone by a student, i.e.

$$SGPA = \Sigma (C_i \times G_i) / \Sigma C_i$$

Where, Ci is the number of credits of the i^{th} subject and Gi is the grade point scored by the student in the i^{th} course.

ii. The Cumulative Grade Point Average (CGPA) will be computed in the same manner taking into account all the courses undergone by a student over all the semesters of a program, i.e.

$$CGPA = \Sigma (C_i \times S_i) / \Sigma C_i$$

Where 'Si' is the SGPA of the i^{th} semester and C_i is the total number of credits in that semester.

iii. Both SGPA and CGPA shall be rounded off to 2 decimal points and reported in the transcripts.

iv. While computing the GPA/CGPA the subjects in which the student is awarded Zero grade points will also be included.

Grade Point: It is a numerical weight allotted to each letter grade on a 10-point scale.
Letter Grade: It is an index of the performance of students in a said course. Grades are denoted by letters S, A, B, C, D, E and F.

8. AWARD OF DEGREE AND CLASS:

After a student has satisfied the requirements prescribed for the completion of the program and is eligible for the award of B. Tech. Degree he/she shall be placed in one of the following four classes:

Class Awarded	**CGPA Secured**
First Class with Distinction	≥ 7.5
First Class	≥ 6.5 < 7.5
Second Class	≥ 5.5 < 6.5
Pass Class	≥ 4.0 < 5.5

(The marks in internal evaluation and external Examination shall be shown separately in the marks memorandum)
Further, CGPA to a maximum of extent of 0.05 shall be added which is just sufficient to effect change of class from pass class to Second class, Second class to First class, First class to First class with distinction for all the courses being offered, without adding any marks to the original marks secured by the students
A candidate shall be eligible for the award of respective degree if he/she satisfies the minimum academic requirements in every subject and secures at least satisfactory report on his/her thesis / dissertation and viva-voce.

9. WITHHOLDING OF RESULTS

The result of a candidate shall be withheld if:

i. He/she has not cleared any dues to the Institution / Hostel.
ii. A case of disciplinary action against him/her is pending disposal.

10. TRANSITORY REGULATIONS:

Candidates who have discontinued or have been detained for want of attendance or who have failed after having undergone the course are eligible for re-admission to the same or equivalent subjects as and when subjects are offered, subject to the conditions mentioned in 5-(iv) and 2-(ii).

11. GENERAL:

The academic regulations should be read as a whole for purpose of any interpretation.

i. The college reserves the right of altering the regulations as and when necessary. The regulations altered may be applicable to all the candidates on rolls.

ii. Wherever the word he, him or his occur, it will also includes she, her, hers.

iii. There shall be no place for transfer of candidate within the constituent colleges of Jawaharlal Nehru Technological University during the entire course of the programme.

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JNTUA COLLEGE OF ENGINEERING (AUTONOMUS),PULIVENDULA

Course structure for M.Tech - I Semester ELECTRICAL POWER SYSTEMS (Regular) with effective from 2017-18

I M.Tech I Semester

S.NO	COURSE CODE	Subject	Theory	Lab	Credits
1	17D07101	MODERN CONTROL THEORY	4	-	4
2	17D07102	OPERATION AND CONTROL OF POWERR SYSTEMS	4	-	4
3	17D07103	SWITCHED MODE POWER CONVERTERS	4	-	4
4		Elective –I	4	-	4
	17D07104	POWER QUALITY			
	17D07105	RENEWABLE ENERGY SYSTEMS			
	17D07106	POWER SYSTEM OPTIMIZATION			
5		Elective –II	4	-	4
	17D07107	RELIABILITY APPLICATIONS TO POWER SYSTEMS			
	17D07108	REACTIVE POWER COMPENSATION AND MANAGEMENT			
	17D07109	HVDC TRANSMISSION			
6	17D07110	POWER SYSTEMS SIMULATION LAB-I	0	3	2
7	17D07111	MACHINES AND POWER SYSTEMS LAB	0	3	2
		Contact Periods/Weeks	26		
		Total Credits (5 Theory + 2 Lab)	24		

I M.Tech II Semester

S.NO	COURSE CODE	Subject	Theory	Lab	Credits
1	17D07201	POWER SYSTEM STABILITY AND CONTROL	4	-	4
2	17D07202	ADVANCED POWER SYSTEM PROTECTION	4	-	4
3	17D07203	RESTRUCTURED POWER SYSTEMS	4	-	4
4		Elective -III			
	17D07204	POWER SYSTEM DYNAMICS	4	-	4
	17D07205	ENERGY AUDITING, CONSERVATION AND MANAGEMENT			
	17D07206	MODELING OF RENEWABLE ENERGY SOURCE IN SMART GRID			
5		Elective –IV			
	17D07207	SOFT COMPUTING TECHNIQUES TO POWER SYSTEMS	4	-	4
	17D07208	EHVAC TRANSMISSION			
	17D07209	FACTS CONTROLLERS			
6	17D07210	POWER SYSTEM SIMULASTION LAB-II	0	3	2
7	17D07211	POWER CONVERTERS AND ENERGY LAB	0	3	2
8	17D07212	COMPREHENSIVE ONLINE EXAMINATION			2
	Contact Periods/Weeks		26		
	Total Credits (5 Theory + 2 Lab + 1 online Exam)		26		

II M.Tech I Semester

S.NO	Course Code	Subject	Maximum Marks		Total	Min. Marks/ Grades to Pass	Credits
			Internal	External			
1	17D07301	Seminar-I	50	-	50	25	0

M.Tech (EPS) II Year II Semester

S.NO	Course Code	Subject	Maximum Marks		Total	Min. Marks/ Grades to Pass	Credits
			Internal	External			
1	17D07401	Seminar-II	50	-	50	25	0
2	17D07402	**Project Work** Grades : A, B, C, D A - Excellent B - Good C – Satisfactory D - Unsatisfactory	-	-	-	-	18

I M.TECH I SEMESTER

JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS) PULIVENDULA

MODERN CONTROL THEORY (17D07101)

L T P C
4 0 0 4

COURSE OBJECTIVES:

- To evaluate the solution of state equation and state transition matrix
- To design controllers, access the design through the constraint specifications, and decide whether the initial design is acceptable or can be improved by iterating.
- To explain of full order observer using Ackermann's formula
- To simulate state equation using MATLAB/ SIMULINK program.
- To identify the solution of a system using Lyapunov stability

UNIT I

Introductory matrix algebra and linear vector space. State space representation of systems. Linearization of a non-linear System. Solution of state equations. Evaluation of State Transition Matrix (STM)

UNIT II

Similarity transformation and invariance of system properties due to similarity transformations. Minimal realization of SISO, SIMO, MISO transfer functions. Discretization of a continuous time state space model. Conversion of state space model to transfer function model using Fadeeva algorithm. Fundamental theorem of feedback control - Controllability and Controllable canonical form - Pole assignment by state feedback using Ackermann's formula – Eigen structure assignment problem.

UNIT III

Linear Quadratic Regulator (LQR) problem and solution of algebraic Riccati equation using Eigen value and Eigen vector methods, iterative method. Controller design using output feedback.

UNIT IV

Observability and observable canonical form - Design of full order observer using Ackermann's formula - Bass Gura algorithm. Duality between controllability and observability - Full order Observer based controller design. Reduced order observer design.

UNIT V

Internal stability of a system. Stability in the sense of Lyapunov, asymptotic stability of linear time invariant continuous and discrete time systems. Solution of Lyapunov type equation. Model decomposition and decoupling by state feedback. Disturbance rejection, sensitivity and complementary sensitivity functions.

COURSE OUTCOMES:

The students will have knowledge on the following concepts:

- **Test** the controllability and observability of a given system
- **Identify** and **analyze** non-linear systems using describing function analysis
- Design Pole assignment by state feedback using Ackermann's formula
- Identify the Lyapunov stability of a system.
- Design of Model decomposition and decoupling of system by state feedback.

TEXT BOOKS:

1. K. Ogata, Modern Control Engineering, Prentice Hall, India 1997
2. T. Kailath, T., Linear Systems, Perntice Hall, Englewood Cliffs, NJ, 1980.
3. N. K. Sinha, Control Systems, New Age International, 3rd edition, 2005.

REFERENCES:

1. Panos J Antsaklis, and Anthony N. Michel, Linear Systems, New - age international (P) LTD. Publishers, 2009.
2. John J D'Azzo and C. H. Houpis , "Linear Control System Analysis and Design Conventional and Modern", McGraw - Hill Book Company, 1988.
3. B.N. Dutta, Numerical Methods for linear Control Systems - , Elsevier Publication, 2007.
4. C.T.Chen Linear System Theory and Design - PHI, India.
5. Richard C. Dorf and Robert H. Bishop, Modern Control Systems, 11th Edition, Pearson Edu., India, 2009

I M.TECH I SEMESTER

OPERATION AND CONTROL OF POWER SYSTEM (17D07102)

L T P C
4 0 0 4

Course Objectives:

This course will enable the students

- To learn the concepts of unit- commitment and load scheduling
- To know the hydro thermal scheduling problems.
- To know the load frequency control in single area and double area power systems.
- To understand the concepts of economic interchange between the interconnected power utilities.
- To understand the power system security and contingency analysis.

UNIT-I: Economic Operation- Load forecasting - Unit commitment – Economic dispatch problem of thermal units – Gradient method- Newton's method –Base point and participation factor method. Unit Commitment and Solution Methods: Optimal Unit Commitment, Constraints in unit commitment, spinning reserve, Thermal Unit Constraints, Other constraints, Hydro constraints, Must Run, Fuel constraints, Unit commitment Solution methods: Priority-List methods, Dynamic Programming solution. Backward DP Approach, Forward DP Approach, Restricted Search Ranges, Strategies- Reliability considerations.

UNIT-II: Hydrothermal co-ordination: Short-term hydrothermal scheduling problem -gradient approach – Hydro units in series - pumped storage hydro plants-hydro-scheduling using Dynamic programming and linear programming.

UNIT-III: Automatic generation control: Review of LFC and Economic Dispatch control (EDC) using the three modes of control viz. Flat frequency – tie-line control and tie-line bias control. AGC implementation – AGC features - static and dynamic responses of uncontrolled & controlled two-area system.

UNIT-IV: Interchange of Power & Energy: Economic interchange between interconnected utilities – Inter utility energy evaluation – Power pools – Transmission effects and Issues: Limitations – Wheeling.

UNIT-V: Power system security: Contingency analysis – linear sensitivity factors – AC power flow methods – contingency selection – concentric relaxation – bounding-security constrained optimal power flow-Interior point algorithm-Bus incremental costs.– Maximum likelihood Weighted least squares equation – orthogonal Decomposition estimation method – Algorithm.

Course outcomes:

After completion of the course the students will have the knowledge on the following concepts

- Dispatch of the load economically among the thermal and hydrothermal plants.
- Unit commitment problems and solution methods.
- Load frequency control of single area and double area power systems.
- Necessity of maintaining the power system security.
- Importance of economic interchange between interconnected utilities.

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TEXT BOOKS:

1. Allen J. Wood and Wollenberg B.F., 'Power Generation Operation and control', John Wiley & Sons, Second Edition.
2. Nagrath, I.J. and Kothari D.P., 'Modern Power System Analysis', TMH,N.Delhi,1980

REFERENCE BOOKS:

1. S. Siva Nagaraju & G. Sreenivasan. "Power system operation and control"- Pearson Publishers-Chennai-Delhi-Chandigarh.
2. D. P. Kothari & J.S.Dhillon, Power System Optimization , PHI,2004

I M.TECH I SEMESTER

SWITCHED MODE POWER CONVERTERS (17D07103)

L T P C
4 0 0 4

COURSE OBJECTIVES:

- To understand the concept of fundamental switching regulators i.e Buck and Boost topologies
- To know the concepts of representing push-pull and forward converter topologies
- To understand the importance of half and full bridge converter topologies
- To know the representation of Discontinuous and continuous fly back converter topologies
- To know the concept of voltage-Fed and current-Fed topologies

UNIT-1: Fundamental Switching Regulators – Buck and Boost Topologies

Buck Switching Regulator Topology: Basic Operation, Significant Current waveforms, Buck regulator efficiency, Design relations of output filter inductor and capacitor. Boost Switching Regulator Topology: Basic Operation, Quantitative relations, Discontinuous and Continuous modes, Design relations

UNIT-2: Push-Pull and Froward converter topologies

Push-Pull Topology: Basic Operation – Master/slave outputs, Flux imbalance, Power transformer design relations, Primary, secondary peak and RMS currents, output power and input voltage limitations, output filter design relations. Forward Converter Topology: Basic operation, Design relations, Slave output voltages, secondary load, freewheeling diode and inductor currents. Forward converter with unequal power and reset winding turns, power transformer design and output filter design

UNIT-3: Half and Full bridge Converter Topologies

Half Bridge Converter Topology: Basic operation, Half bridge magnetic, output filter calculations, blocking capacitor to avoid flux imbalance, Half bridge leakage inductance problems. Full Bridge Converter Topology: Basic operation, Full Bridge magnetic, output filter calculations, transformer primary blocking capacitor

UNIT-4: Fly back Converter Topologies

Discontinuous-Mode Fly backs: Basic operation, relation between output voltage versus input voltage, on time, output load, design relations and sequential decision requirements, flyback magnetic, fly back disadvantages. Continuous Mode Fly backs: Basic operation, Discontinuous mode to continuous mode transition, design relations – continuous mode fly backs.

UNIT-5: Voltage-Fed and Current-Fed topologies

Introduction and definitions, deficiencies of voltage fed, width modulated full wave bridge, buck voltage fed full wave bridge topology – basic operation, buck voltage fed full wave bridge – advantages, drawbacks in buck voltage fed full wave bridge, buck current fed full wave bridge topology – basic operation, fly back current fed push pull topology.

COURSE OUTCOMES:

The students will have knowledge on the following concepts

- The fundamental buck-boost switching regulator topologies
- Procure knowledge on the topologies of push-pull & forward converter topologies
- The concepts of half & full bridge converter topologies
- Knowledge on the basic operation on continuous and dis-continuous Fly back converter topologies
- The concept of basic operation on voltage & current fed topologies.

Text Books:

1. Pressman A.I, Switching Power Supply Design, McGraw Hill, 2nd edition, 1999.
2. Mitchell D.M, DC-DC Switching Regulator Analysis, McGraw Hill ,1988

Reference Books

1. Ned Mohan et al, , Power Electronics, John Wiley ,1989
2. Otmar Kingenstein Switched Mode Power Supplies in Practice, John Wiley, 1994.
3. Billings K.H., Handbook of Switched Mode Power Supplies, McGraw Hill, 1989.
4. Nave M.J, Power Line Filter Design for Switched-Mode Power Supplies, Van Nostrand Reinhold, 1991.

I M.TECH I SEMESTER

POWER QUALITY (17D07104)

L T P C
4 0 0 4

COURSE OBJECTIVES:

This course enables the students to

- Know power quality definition, standards.
- Understand power frequency disturbances, transient system modelling.
- Understand types and effects of harmonics & Electromagnetic Interference.
- Know the importance of grounding & bonding.
- Understand measuring & solving power quality problems.

UNIT - I: Introduction to Power Quality

Definition of Power Quality - Power Quality Progression - Power Quality Terminology - Power Quality Issues – Responsibilities of Power Suppliers and Users - Power Quality Standards.

UNIT -II: Power Frequency Disturbance & Transients

Introduction to Power Frequency Disturbance - Common Power Frequency Disturbances – Characteristics of Low Frequency Disturbances - Voltage Tolerance Criteria - ITIC Graph - Introduction to Transients - Transient System Model - Examples of Transient Models and Their Response - Power System Transient Modeling - Types and Causes of Transients - Examples of Transient Waveforms.

UNIT - III: Harmonics & Electromagnetic Interference (EMI)

Definition of Harmonics - Harmonic Number (h) - Odd and Even Order Harmonics - Harmonic Phase Rotation and Phase Angle - Voltage and Current Harmonics - Individual and Total Harmonic Distortion - Harmonic Signatures - Effect of Harmonics On Power System Devices - Guidelines For Harmonic Voltage and Current Limitation - Harmonic Current Mitigation - Introduction to EMI - Frequency Classification - Electrical Fields - Magnetic Fields - EMI Terminology - Power Frequency Fields - High Frequency Interference - EMI Susceptibility - EMI Mitigation - Cable Shielding - Health Concerns of EMI.

UNIT - IV: Grounding and Bonding

Introduction to Grounding and Bonding - Shock and Fire Hazards - NEC Grounding Requirements - Essentials of a Grounded System - Ground Electrodes - Earth Resistance Tests - Earth Ground Grid Systems - Power Ground System - Signal Reference Ground (SRG) - SRG Methods - Single and Multipoint Grounding - Ground Loops - Electrochemical Reaction - Examples of Grounding Anomalies.

UNIT - V: Measuring and Solving Power Quality Problems

Introduction to Power Quality Measurements - Power Quality Measurement Devices - Power Quality Measurements - Test Locations - Test Duration - Instrument Setup - Instrument Guidelines

COURSE OUTCOMES:

The students will have knowledge on the following concepts:

- The fundamentals & terminology of power quality.
- The concept of power frequency disturbances, types of transients & transient waveforms.
- Understanding the harmonics & Electromagnetic Interference concepts.
- Necessity of grounding and methods of grounding.
- Understanding different techniques of measuring & solving power quality problems.

TEXT BOOKS:

1. Power quality by C. Sankaran, CRC Press
2. 2.Electrical Power Systems Quality, Roger C. Dugan, Mark F. McGranaghan, Surya Santoso, H.Wayne Beaty, 2nd Edition, TMH Education Pvt. Ptd.

REFERENCE BOOKS:

1. Understanding Power quality problems by Math H. J. Bollen IEEE Press
2. Power quality enhancement using custom power devices by Arindam Ghosh,Gerard Ledwich, Kluwer academic publishers

I M.TECH I SEMESTER

RENEWABLE ENERGY SYSTEMS (17D07105)

L T P C
4 0 0 4

COURSE OBJECTIVES:

This course enables the students to

- Understand the concepts of energy conservation.
- Identify the use of renewable energy sources for electrical power generation
- Understand the different energy storage methods and its operation
- Know environmental effects of energy conversion

UNIT –I: Introduction-

Energy Economics: Simple payback period, Internal (simple) rate of return, Net present value, Internal rate of return (IRR), NPV and IRR with Fuel Escalation.
Solar resource-Solar spectrum, Altitude angle of sun at solar noon, solar position at any time of day, solar time, sun rise and sunset, solar radiation-direct beam, diffuse radiation, reflected radiation, and radiation measurements.
Semiconductor physics- Band gap energy, solar spectrum, Band gap impact on Photo voltaic efficiency, P-n junction diode.

UNIT – II: Photo Voltaic Cell & systems:

Generic photo voltaic cell- Simple equivalent circuits, accurate equivalent circuit, Cells to modules to arrays, I-V curve under STC, Impacts of temperature & isolation on I-V curves, Shading impacts on I-V curves, Crystalline silicon technologies, thin film photovoltaic's.
Photovoltaic systems-Introduction to major Photovoltaic systems types, current-voltage curves for loads, Maximum power point trackers
Grid connected systems- Interfacing with utility, DC and AC rated power, Peaks hours approach to estimate PV performance, Grid connected system sizing

UNIT – III: Stand Alone PV Systems

Stand alone PV systems- Load estimation, Batteries- storage capacity, Sizing, Coulomb efficiency instead of energy, Blocking diodes, Sizing of PV array, Stand alone system design
PV powered water pumping- Hydraulic system curves, Hydraulic curves, Hydraulic system curve and pump curve, a simple directly coupled PV-pump design approach- numerical

UNIT – IV: Wind and Tidal Power:

Wind power-Wind power- Historical development, types of wind turbines, power in wind, Temperature and altitude correction, Impact of tower height, Maximum rotor efficiency, wind turbine generators, Average power in the wind, wind turbine- Aerodynamics
Tidal power-Tides and tidal power stations, modes of operation, Tidal power calculation, Tidal project examples, turbines and generators for tidal power generation.

UNIT – V: Fuel Cells & Wave Energy

Fuel Cells – Historical Development, Basic Operation of Fuel cells, Fuel cell Thermodynamics: Enthalpy, Entropy and theoretical efficiency of Fuel Cells, Gibbs free energy and Fuel cell efficiency, Electrical output of an ideal cell electrical characteristics.
Wave energy conversion: Wave power calculation, Properties of waves and power content, vertex motion of Waves, device applications. Types of ocean thermal energy conversion systems Application of OTEC systems examples

COURSE OUTCOMES:

The students will have knowledge on the following concepts:

- Find different renewable energy sources to produce electrical power.
- Estimate the use of conventional energy sources to produce electrical energy.
- Role-play the fact that the conventional energy resources are depleted.
- Arrange Store energy and to avoid the environmental pollution.

TEXT BOOKS:

1. Renewable and Efficient Electric Power systems: Gilbert M. Masters, John Wiley & Sons, Inc., Publication.
2. Renewable Energy Sources and Emerging Technologies, D.P. Kothari, K. C. Singal, Rakesh Ranjan, Kothari D.P., singal K. C., Rakesh Ranjan

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References books:

1. "Energy conversion systems" by Rakosh das Begamudre, New age International publishers, New Delhi - 2000.
2. John twidell & wier, renewable energy sources, CRC press, 2009.

I M.TECH I SEMESTER

POWER SYSTEM OPTIMIZATION (17D07106)

L T P C
4 0 0 4

COURSE OBJECTIVES:

This course enables the students to:

- The fundamental concepts of Optimization Techniques
- The importance of optimizations in real scenarios
- The concepts of various classical and modern methods of for constrained and unconstrained problems in both single and multivariable.

UNIT I: Fundamentals of Particle Swarm Optimization (PSO) Techniques

Introduction – Basics of Particle Swarm Optimization – Background of PSO, Original PSO, Variation of PSO – Discrete PSO,PSO for MINLPs, Constriction Factor Approach (CFA), Hybrid PSO (HPSO), Lbest Model, Adaptive PSO (APSO) Evolutionary PSO (EPSO) – Applications.

UNIT II: Fundamentals of Ant Colony Search Algorithms

Introduction – Ant Colony Search Algorithm – Behaviour of Real Ants – Ant Colony Algorithms, The Ant System, The Ant Colony System, The Max-Min Ant System – Major Characteristics of Ant Colony Search Algorithm, Distributed Computation: Avoid Premature Convergence, Positive Feedback: Rapid Discovery of Good Solution, Use of Greedy Search and Constructive Heuristic Information: Find Acceptable Solutions in the Early Stage of the Process

UNIT III: Fundamentals of Tabu Search

Introduction – Overview of the Tabu Search Approach, Problem Formulation, Coding and Representation, Neighborhood Structure, Characterization of the Neighborhood – Functions and Strategies in Tabu Search, Recency-Based Tabu Search – Basic Tabu Search Algorithm, Candidate List Strategies, Tabu tenure, Aspiration Criteria – The Use of Long Term Memory in Tabu Search, Frequency-Based Memory, Intensification, Diversification - Other TS Strategies, Path Relinking, Strategic Oscillation – Applications of Tabu Search

UNIT -IV: Application to power systems

Introduction to power system applications, model identifications—Dynamic load modeling, short term load forecasting, Distribution system applications—Network reconfiguration for loss reduction, optimal protection and switching devices placements—examples.

UNIT-V: Power system controls

Introduction, power system controls: Particle Swarm Technique—problem formulation of VVC, state variables, problem formulation – Expansion of PSO for MINLP, voltage security assessment, VVC using PSO—treatment of state variables, VVC algorithm using PSO, Numerical Examples—IEEE 14 Bus system

COURSE OUTCOMES:

The students will have knowledge on the following concepts:

- formulate optimization problems
- understand and apply the concept of optimality criteria for various type of optimization problems
- solve various constrained and unconstrained problems in single variable as well as multivariable
- apply the methods of optimization in real life situation

Textbooks

1. Kwang Y. Lee and Mohamed A. EI- Sharkawi “Modern Heuristic Optimization Techniques Theory and Applications to Power Systems” A John Wiley & Sons. INC.Publication
2. D. P. Kothari and J. S. Dhillon, “Power System Optimization”, Second Edition-PHI Learning Private Limited- 2011.

REFERENCE BOOKS:

1. Jizhong Zhu , ‘’ Optimization of power system operation ’’ Second Edition –Wiley- Blackwell publishers.
2. Joshua adam Taylor,“Convex optimization of power systems’’ Cambridge University Press

I M.TECH I SEMESTER

RELIABILITY APPLICATIONS TO POWER SYSTEMS (17D07107)

L	T	P	C
4	0	0	4

COURSE OBJECTIVES:

This course enables the students to:

- The Probability Density and Distribution Functions
- Analyse the Decomposition Method.
- Identify the Expected Value and Standard Deviation of Exponential Distribution
- Analyse the Concept of Stochastic Transitional Probability Matrix
- Evaluate the Transition Rates for Merged State Model

UNIT–I BASICS OF PROBABILITY THEORY, DISTRIBUTION & NETWORK MODELLING

Basic Probability Theory – Rules for Combining Probabilities of Events – Bernoulli's Trials – Probability Density and Distribution Functions – Binomial Distribution – Expected Value and Standard Deviation of Binomial Distribution. Analysis of Series, Parallel, Series-Parallel Networks – Complex Networks – Decomposition Method.

UNIT–II RELIABILITY FUNCTIONS

Reliability Functions F(T), F(T), R(T), H(T) and Their Relationships – Exponential Distribution – Expected Value and Standard Deviation of Exponential Distribution – Bath Tub Curve – Reliability Analysis of Series Parallel Networks Using Exponential Distribution – Reliability Measures MTTF, MTTR, MTBF.

UNIT–III MARKOV MODELLING AND FREQUENCY & DURATION TECHNIQUES

Markov Chains – Concept of Stochastic Transitional Probability Matrix, Evaluation of Limiting State Probabilities – Markov Processes One Component Repairable System – Time Dependent Probability Evaluation Using Laplace Transform Approach – Evaluation of Limiting State Probabilities Using Stpm – Two Component Repairable Models. Frequency and Duration Concept – Evaluation of Frequency of Encountering State, Mean Cycle time, For One, Two Component Repairable Models – Evaluation of Cumulative Probability and Cumulative Frequency of Encountering of Merged States – Approximate System Reliability analysis – series parallel configuration – Basic probability indices – cutest approach

UNIT–IV APPLICATIONS TO POWER SYSTEMS -I

Generation System Reliability Analysis: Reliability Model of a Generation System– Recursive Relation for Unit Addition and Removal – Load Modeling - Merging of Generation Load Model – Evaluation of Transition Rates for Merged State Model – Cumulative Probability, Cumulative Frequency of Failure Evaluation – LOLP, LOLE, LOEE.

UNIT–V APPLICATIONS TO POWER SYSTEMS - II

Basic Techniques - Radial Networks – Evaluation of Basic Reliability Indices, Performance Indices – Load Point and System Reliability Indices – Customer Oriented, Loss and Energy Oriented Indices -Examples single feeder - parallel configuration RDS – Network reduction technique – cut set approaches – weather effects – repairable and non – repairable effects modeling and evaluation of basic probability indices.

COURSE OUTCOMES:

The students will have knowledge on the following concepts:

- *The concept of probability theory , distribution , network modeling* and reliability analysis.
- Describing the reliability functions with their relationships and Markov-modelling.
- Evaluate reliability models using frequency and duration techniques and generate Various reliability models.
    - The reliability composite systems and distribution systems.

TEXT BOOKS:

1. Reliability Evaluation of Engg. System – R. Billinton, R.N.Allan, Plenum Press, New York, reprinted in India by B.S.Publications, 2007.
2. Reliability Evaluation of Power systems – R. Billinton, R.N.Allan, Pitman Advance Publishing Program, New York, reprinted in India by B.S.Publications, 2007.

REFERENCE BOOKS:

1. System Reliability Concepts by Dr.V.Sankar, Himalaya Publishing House Pvt.Ltd,, Mumbai

I M.TECH I SEMESTER

REACTIVE POWER COMPENSATION & MANAGEMENT (17D07108)

L	T	P	C
4	0	0	4

COURSE OBJECTIVES:

This course enables the students to:

- Know the objectives of load compensation and its importance.
- Analyse the characteristics of different methods of compensation and to explain the steady state and transient state responses of compensation.
- Understand the concepts of reactive power coordination and demand side management.
- Evaluate the methods of capacitor placement and capacitor selection.
- Understand the basic operation of distribution transformer, furnace transformer and electric arc furnaces.

UNIT - I: Load Compensation

Objectives and specifications – Reactive power characteristics – Inductive and capacitive approximate biasing – Load compensator as a voltage regulator – Phase balancing and power factor correction of unsymmetrical loads - Examples.

UNIT-II: Steady – State & Transient State Reactive Power Compensation in Transmission System

Uncompensated line – Types of compensation – Passive shunt and series and dynamic shunt compensation – Characteristic time periods – Passive shunt compensation – Static compensations - Series capacitor compensation – Compensation using synchronous condensers –Examples.

UNIT-III: Reactive Power Coordination & Demand Side Management

Objective – Mathematical modeling – Operation planning – Transmission benefits – Basic concepts of quality of power supply – Disturbances - Steady – state variations – Effects of under Voltages – Frequency – Harmonics, radio frequency and electromagnetic interferences. Load patterns – Basic methods load shaping – Power tariffs - KVAR based tariffs penalties for voltage flickers and Harmonic voltage levels.

UNIT-IV: Distribution & User Side Reactive Power Management

System losses – Loss reduction methods – Examples – Reactive power planning – Objectives – Economics Planning capacitor placement – Retrofitting of capacitor banks - KVAR requirements for domestic appliances – Purpose of using capacitors – Selection of capacitors – Deciding factors – Types of available capacitor, characteristics and Limitations.

UNIT-V: Reactive Power Management in Electric Traction Systems and ARC Furnaces

Typical layout of traction systems – Reactive power control requirements – Distribution transformers - Electric arc furnaces – Basic operations - Furnaces transformer – Filter requirements – Remedial measures – Power factor of an arc furnace.

COURSE OUTCOMES:

The students will have knowledge on the following concepts:

- Load compensation and its importance to society and industry.
- Analyze and evaluate the characteristics of power frequency disturbances.
- Electrical transient effects, harmonic, power factor, grounding, bonding and electromagnetic interferences.
- Importance of reactive power management.
- Methods of capacitor placement and selection of types of capacitors.

TEXT BOOKS:

1. J.E.Miller, Reactive Power Control in Electric Power Systems, John Wiley and Sons, 1982.
2. D.M.Tagare, Reactive power Management, Tata McGraw Hill, 2004.

REFERENCE BOOKS:

1. Reactive Power Compensation:A Practical Guide,Wolfgang Hofmann, Jurgen Schlabbach , Wolfgang Just
2. Arrillaga.J, Bradley. D.A. and Bodger. P.S., "Reactive Power Compensation", John Wiley and sons, New York,1989.
3. R.M. Mathur : Static compensation for reactive power control, Cantext publications, Winnipeg, CANADA – 1984

I M.TECH I SEMESTER

HVDC TRANSMISSION (17D07109)

L T P C
4 0 0 4

COURSE OBJECTIVES:

This course enables the students to

- Technical and economic aspects of HVAC and HVDC transmission and their comparison.
- To study power handling capabilities of HVDC Lines and Static converter configuration.
- Control of HVDC converter systems.
- The occurrence of faults and transients in HVDC system and their protection.

UNIT-I: Introduction

General consideration, Power Handling Capabilities of HVDC Lines Basic Conversion principles, static converter configuration.

UNIT-II: Static Power Converters

3-pulse, 6-pulse, and 12-pulse converters, converter station and Terminal equipment, commutation process, Rectifier and inverter operation, equivalent circuit for converter – special features of converter transformers. Harmonics in HVDC Systems, Harmonic elimination, AC and DC filters.

UNIT-III: Control of HVDC Converters and Systems

Constant current, constant extinction angle and constant ignition angle control Individual phase control and equidistant firing angle control DC power flow control. Interaction between HV AC and DC systems – Voltage interaction Harmonic instability problems and DC power modulation.

UNIT-IV: MTDC Systems & Over Voltages

Series parallel and series parallel systems their operation and control.
Over voltages due to disturbances on DC side, over voltages due to DC and AC side line faults.

UNIT-V: Converter Faults & Protection

Converter faults, over current protection – valve group, and DC line protection over voltage protection of converters, surge arresters.

COURSE OUTCOMES:

The students will have knowledge on the following concepts

- The operation of various converters used in HVDC transmission systems.
- Analysation of Constant extinction angle and Constant ignition angle control of dc power flow.
- Design HVDC and AC Filters.
- The DC line protection and over voltage protection of converters.

TEXT BOOKS:

1. K R Padiyar: High Voltage Direct current Transmission Wiely Eastern Ltd New Delhi – 1992.
2. J. Arillaga HVDC Transmission Peter Peregrinus ltd. London UK 1983

REFERENCE BOOKS:

1. E.W. Kimbark: Direct current Transmission, Wiely Inter Science – New York.
2. E. Uhlman: Power Transmission by Direct Current , Springer Verlag, Berlin Helberg 1985

I M.TECH I SEMESTER

POWER SYSTEM SIMULATION–I LAB (17D07110)

L	T	P	C
0	0	3	2

COURSE OBJECTIVES:

This course enables the students to:

- Acquire skills of using computer packages MATLAB, SIMULINK and Mi POWER in Electrical and Electronics Engineering.
- Identify, formulate, and solve engineering problems.

List of experiments:-

MATLAB

1. Y - Bus Formation Using MATLAB.
2. Gauss – Seidel Load Flow Analysis using MATLAB.
3. N-R Method for Load flow Analysis using MATLAB.
4. Fast Decoupled Load Flow Analysis using MATLAB.
5. Fast Decoupled Load Flow Analysis for Distribution Systems using MATLAB.
6. Point by Point Method using MATLAB.
7. Step Response of Two Area System with Integral Control and Estimation of Tie Line Power Deviation using SIMULINK.
8. Step Response of Two Area System with Integral Control and Estimation of Tie Line Frequency Deviation using SIMULINK.

MiPower

9. Load Flow Analysis using MiPower
   i) Gauss Seidel Method.
   ii) Newton Raphson Method.
10. Short Circuit Analysis using MiPower.
11. Transient Stability Analysis using MiPower.
12. Economic Load Dispatch Analysis using MiPower.

COURSE OUTCOMES:

The students will have ability to:

- Apply knowledge of mathematics, science, and engineering.
- Design and conduct experiments, as well as to analyze and interpret results.
- Understand the impact of engineering solutions in a global perspective.

REFERENCE BOOKS:

- MATLAB DeMYSTiFieD A SELF TEACHING GUIDE By David McMahon(Tata Mc Graw Hill)

I M.TECH I SEMESTER

MACHINES & POWER SYSTEMS LAB (17D07111)

L	T	P	C
0	0	3	2

COURSE OBJECTIVES:

- To enable the students gain a fair knowledge on the Fault analysis
- To understand the characteristics of different types of relays and Power Angle Characteristics of a Salient Pole Synchronous Machine.

List of experiments:-

1. Determination of Sub-transient Reactance of a Salient Pole synchronous Machine.
2. Determination of Sequence Impedances of a Cylindrical Rotor Synchronous Machine.
3. Fault Analysis.
i) LG Fault.
ii) LL Fault.
iii) LLG Fault.
iv) LLLG Fault.
4. Equivalent Circuit of a Three Winding Transformer.
5. Separation of No Load losses of a Three Phase Squirrel Cage Induction Motor.
6. Power Angle Characteristics of a Salient Pole Synchronous Machine.
7. Scott Connection of two single phase transformers.
8. Characteristics of IDMT over Current Relay (Electro Magnetic Type).
9. Characteristics of Static Negative Sequence Relay.
10. Characteristics of Over Voltage Relay.
i) Electromagnetic Type.
ii) Microprocessor Type.
11. Characteristics of Percentage Biased Differential Relay.
i) Electromagnetic Type.
ii) Static Type.

COURSE OUTCOMES:

The students will have knowledge on the following concepts:

- Analyse the characteristics of Relays, Separation of No Load losses of a Three Phase Squirrel Cage Induction Motor, analyse different types of faults.

Reference Books:

1. Badri Ram and D.N.Vishwakarma, "Power system protection and Switch gear ", TMH publication New Delhi 1995.
2. T.S.Madhava Rao , "Static relays", TMH publication, second edition 1989
3. Electrical Power System Protection, C. Christopoulos and A. Wright, Springer International

I M.TECH II SEMESTER

POWER SYSTEM STABILITY & CONTROL (17D07201)

L T P C
4 0 0 4

COURSE OBJECTIVES:

- To know the mathematical model and system response to small disturbances.
- To have over all idea on dynamic & transient Stability
- To have an importance of Power system stabilizers in bringing the system stable
- To know the various types of Excitation systems and its state space representation
- To have knowledge on non-linear system stability analysis using Lyapunov, Zubov's method – Popov's methods and voltage stability as well.

UNIT- I: The Elementary Mathematical Model and System Response to Small Disturbances

A Classical model of one machine connected to an infinite bus – Classical model of multi-machine system – Problems – Effect of the excitation system on Transient stability. The unregulated synchronous Machine – Effect of small changes of speed – Modes of oscillation of an unregulated multi-machine system – Regulated synchronous machine – Voltage regulator with one time lag – Governor with one time lag – Problems.

UNIT- II: Dynamic Stability & Transient Analysis

Concept of Dynamic stability – State space model of one machine system connected to infinite bus – Effect of excitation on Dynamic stability – Examination of dynamic stability by Routh's criterion - Transient Analysis of Three-Phase Power Systems Symmetrical Components in Three-Phase Systems - Sequence Components for Unbalanced Network Impedances - The Sequence Networks - The Analysis of Unsymmetrical Three-Phase Faults - The Single Line-to-Ground Fault - The Three-Phase-to-Ground Fault.

UNIT- III: Power System Stabilizers

Introduction to supplementary stabilizing signals - Block diagram of the linear system - Approximate model of the complete exciter – Generator system – Lead compensation – Stability aspect using Eigen value approach.

UNIT- IV: Excitation Systems

Excitation system response – Non-continuously regulated systems – Continuously regulated systems – Excitation system compensation – State space description of the excitation system - Simplified linear model – Effect of excitation on generator power limits. Type –2 system: Rotating rectifier system, Type-3 system: Static with terminal potential and current supplies - Type –4 system: Non – continuous acting - Block diagram representation – State space modeling equations of these types.

UNIT - V: Stability Analysis

Review of Lyapunov's stability theorems of non-liner systems using energy concept – Method based on first concept – Method based on first integrals – Quadratic forms – Variable gradient method – Zubov's method – Popov's method, Lyapunov function for single machine connected to infinite bus. Voltage stability – Factors affecting voltage instability and collapse – Comparison of Angle and voltage stability – Analysis of voltage instability and collapse – Integrated analysis of voltage and Angle stability – Control of voltage instability.

COURSE OUTCOMES:

After completion of the course the student will able to

- Procure knowledge on classical model of single, multimachine systems, modes of oscillations, regulated and unregulated synchronous machines
- Apply and explain different methods for analyzing power system stability
- Know the importance of power system stabilizers in stability aspects
- Analysis excitation systems to improve transient stability and power oscillations damping
- The effect of voltage stability on power system network

TEXT BOOKS:

1. P.M.Anderson, A.A.Fouad, "Power System Control and Stability", IOWA State University Press, Galgotia Publications, Vol-I, 1st Edition.
2. Transients in Power System, Lou Van Der Sluis, John Wiley & Sons.

REFERENCE BOOKS:

1. M.A.Pai, Power System Stability-Analysis by the direct method of Lyapunov, North Holland Publishing Company, New York, 1981.
2. P. Kundur, "Power System Stability and Control" – TMGH publications – First Edition – Fifth Reprint.

I M.TECH II SEMESTER

ADVANCED POWER SYSTEM PROTECTION (17D07202)

L T P C
4 0 0 4

COURSE OBJECTIVES:

This course enables the students to

- Explicate the function of various types of static relays.
- Express the concept of static distance protection and pilot relaying schemes.
- Illustrate concepts of transformer protection and various schemes protection of alternators.
- Familiarize the concepts of Bus bar protection and numerical protection.

UNIT-I: Introduction to Static Relays

Advantages of static relays - Basic construction of static relays – Level detectors – Replica impedance-mixing circuits-general equation for two input phase and amplitude comparators –Duality between amplitude and phase comparator.

UNIT-II: Static Relays

Introduction-Instantaneous over current relay – Time over current relays - Basic principles-Definite time and Inverse definite time over current relays. Static Differential Relays-Analysis of static differential relays – static relay schemes- Dual bias transformer differential protection – Harmonic restraint relay. Static Distance Relays- Static impedance – reactance - MHO and angle impedance relay sampling comparator – realization of reactance and MHO relay using a sampling comparator.

UNIT-III: Power Swings

Effect of power swings on the performance of Distance relays - Power swing analysis – Principle of out of step tripping and blocking relays – Effect of line length and source impedance on distance relays.

UNIT-IV: Microprocessor Based Protective Relays

Over current relays – Impedance relays – Directional relay – Reactance relay (Block diagram and flow chart approach only). Generalized mathematical expression for distance relays - Measurement of resistance and reactance – MHO and offset MHO relays – Realization of MHO characteristics – Realization of Offset MHO characteristics (Block diagram and flow chart approach only) Basic principle of Digital computer relaying.

UNIT-V: Numerical Relays

Advantages of Numerical Relays- Numerical network- Digital Signal processing – Estimation of Phasors – Full Cycle Fourier Algorithm – Half Cycle Fourier Algorithm- practical considerations for selection of Algorithm – Discrete Fourier Transform

COURSE OUTCOMES:

The students will have knowledge on the following concepts:

- The basic concepts of relays, comparators and its operation in power system.
- Different methods for the protection of alternators, transformer, feeder and bus bars from over voltages and other hazards.
- The operation and control of microprocessor based and numerical relays.

TEXT BOOKS:

1. Badri Ram and D.N.Vishwakarma, "Power system protection and Switch gear ", TMH publication New Delhi 1995.
2. T.S.Madhava Rao , "Static relays", TMH publication, second edition 1989.
3. **"** Power System Protection and Switchgear**",** Bhuvanesh A Oza, Nirmal kumar C Nair et.al. Mc Graw Hill

REFERENCE:

1. Protection and Switchgear, Bhavesh Bhalja, R. P. Mahesheari, Nilesh G. Chothani, Oxford University Press.
2. Electrical Power System Protection, C. Christopoulos and A. Wright, Springer International.

I M.TECH II SEMESTER

RESTRUCTURED POWER SYSTEM (17D07203)

L T P C
4 0 0 4

Course Objectives:

This course will enable the students

- To Introduce the restructured power systems and market models.
- To impart knowledge on fundamental concepts of congestion management.
- To analyze the concepts of locational marginal pricing and financial transmission rights.
- To Illustrate about various power sectors in India.
- To know the issues like congestion management, Transmission pricing, Ancillary Services Management.

UNIT - I: Key Issues In Electric Utilities

Introduction – Restructuring models – Independent System Operator (ISO) – Power Exchange - Market operations – Market Power – Standard cost – Transmission Pricing – Congestion Pricing – Management of Inter zonal/Intra zonal Congestion.

UNIT-II: Open Access Same-Time Information System (Oasis) & Market Power

Structure of OASIS - Posting of Information – Transfer capability on OASIS. Market Power: Introduction - Different types of market Power – Mitigation of Market Power - Examples.

UNIT-III: Available Transfer Capability (Atc) & Electricity Pricing

Transfer Capability Issues – ATC – TTC – TRM – CBM Calculations – Calculation of ATC based on power flow. Electricity Pricing: Introduction – Electricity Price Volatility Electricity Price Indexes – Challenges to Electricity Pricing – Construction of Forward Price Curves – Short-time Price Forecasting.

UNIT - IV: Power System Operation In Competitive Environment

Introduction – Operational Planning Activities of ISO- The ISO in Pool Markets – The ISO in Bilateral Markets – Operational Planning Activities of a GENCO.

UNIT- V: Transmission Cost Allocation Methods & Ancillary Services Management

Introduction - Transmission Cost Allocation Methods : Postage Stamp Rate Method - Contract Path Method - MW-Mile Method – Unused Transmission Capacity Method - MVA-Mile method – Comparison of cost allocation methods. Ancillary Services Management: Introduction – Reactive Power as an Ancillary Service – a Review – Synchronous Generators as Ancillary Service Providers.

Course outcomes:

After completion of the course the students will have the knowledge on the following concepts

- Understand the developments of restructuring worldwide.
- Identify the roles and responsibilities of different entities in power market.
- Explore/analyse the issues like congestion management, Transmission pricing, Ancillary Services Management.

TEXT BOOKS :

1. Kankar Bhattacharya, Math H.J. Boller and Jaap E.Daalder, Operation of Restructured Power System, Kulwer Academic Publishers, 2001.
2. Mohammad Shahidehpour and Muwaffaq alomoush, Restructured Electrical Power Systems, Marcel Dekker, Inc., 2001.

REFERENCE BOOKS:

1. Loi Lei Lai, Power System Restructuring and Deregulation, John Wiley & Sons Ltd., England.

I M.TECH II SEMESTER

POWER SYSTEM DYNAMICS (17D07204)

L T P C
4 0 0 4

COURSE OBJECTIVES:

This course enables the students to

- Study about the Power system stability and security.
- Know about the park's Transformation-analysis of steady state performance.
- Analyse Excitation system modelling.
- Study about the synchronizing and damping torque analysis.
- Study the concepts on power system stabilizers.

UNIT-I: BASIC CONCEPTS

Power system stability states of operation and system security - system dynamics - problems
system model analysis of steady State stability and transient stability - simplified representation of Excitation control.

UNIT-II: MODELING OF SYNCHRONOUS MACHINE

Synchronous machine - park's Transformation-analysis of steady state performance per - unit
quantities- Equivalent circuits of synchronous machine-determination of parameters of equivalent circuits.

UNIT-III: EXCITATION SYSTEM

Excitation system modeling-excitation systems block Diagram - system representation by state equations- Dynamics of a synchronous generator connected to infinite bus - system model Synchronous machine model-stator equations rotor equations - Synchronous machine model with field circuit - one equivalent damper winding on q axis (model 1.1) - calculation of Initial conditions.

UNIT-IV: ANALYSIS OF SINGLE MACHINE SYSTEM

Small signal analysis with block diagram - Representation Characteristic equation and application of Routh Hurwitz criterion- synchronizing and damping torque analysis-small signal model – State equations.

UNIT-V: APPLICATION OF POWER SYSTEM STABILIZERS

Basic concepts in applying PSS - Control signals - Structure and tuning of PSS - Washout circuit - Dynamic compensator analysis of single machine infinite bus system with and without PSS.

COURSE OUTCOMES:

The students will have knowledge on the following concepts:

- Analyse the steady State stability and transient stability of power system.
- Identify the Dynamics of a synchronous generator connected to infinite bus.
- Design of small signal model and State equations.
- Analyse Dynamic compensator of single machine infinite bus system.
- Identify the application of power system stabilizer.

TEXT BOOKS:

1. K.R. Padiyar, "Power system dynamics"- B.S. Publications.
2. P. Kundur, "Power System Stability and Control" – TMGH publications – First Edition – Fifth Reprint.

REFERENCE BOOKS:

1. P.M. Anderson and A.A. Fouad, "Power system control and stability",IEEE Press
2. R. Ramanujam, "Power Systems Dynamics"- PHI Publications.
3. Jan Machawski, Janusz Bialek, Dr.Jim Bum,"Power System Dynamics: Stability and Control" by WILEY publications.

I M.TECH II SEMESTER

ENERGY AUDITING, CONSERVATION AND MANAGEMENT (17D07205)

L	T	P	C
4	0	0	4

COURSE OBJECTIVES:

This course enables the students to know

- The growing worldwide concern for conservation of energy has reawakened interest in ecologically sustainability, processes and sources of energy.
- The better ways to conserve the energy from energy audit concepts, Representations and energy conservation schemes.
- Management skills and communication of energy manager.
- Various operational problems and remedies of motor and electrical devices.
- Evaluation of life time of machine based on time value money and demand.

UNIT-I: Basic Principles Of Energy Audit

Energy audit- definitions, concept , types of audit, energy index, cost index ,pie charts, Sankey diagrams, load profiles and Energy conservation schemes- Energy audit of industries- energy saving potential, energy audit of process industry, thermal power station, building energy audit.

UNIT-II: Energy Management

Principles of energy management, organizing energy management program, initiating, planning, controlling, promoting, monitoring, reporting- Energy manger, Qualities and functions, language, Questionnaire – check list for top management.

UNIT-III: Energy Efficient Motors

Energy efficient motors , factors affecting efficiency, loss distribution , constructional details , characteristics - variable speed , variable duty cycle systems, RMS hp- voltage variation-voltage unbalance- over motoring- motor energy audit

UNIT-IV: Power Factor Improvement, Lighting and Energy Instruments

Power factor – methods of improvement, location of capacitors, Pf with non linear loads, effect of harmonics on power factor, power factor motor controllers - Good lighting system design and practice, lighting control ,lighting energy audit - Energy Instruments- wattmeter, data loggers, thermocouples, pyrometers, lux meters, tongue testers and application of PLC's.

UNIT-V: Economic Aspects and Analysis

Economics Analysis-Depreciation Methods, time value of money, rate of return , present worth method , replacement analysis, life cycle costing analysis- Energy efficient motors- calculation of simple payback method, net present worth method- Power factor correction, lighting - Applications of life cycle costing analysis, return on investment.

COURSE OUTCOMES:

The student will have knowledge on the following concepts:

- Current energy scenario, energy management, auditing, conservation, economic analysis.
- Systematic knowledge and skill about assessing the energy efficiency, energy auditing and energy management.

TEXT BOOKS:

1. Energy management by W.R. Murphy AND G. McKay Butter worth, Heinemann
2. publications.
3. Electrical Energy Utilization and Conservation by S.C.Tripathy(Tata Mc Graw Hill)

REFERENCE BOOKS:

1. Energy management by Paul o' Callaghan, Mc-graw Hill Book company-1st edition, 1998
2. Energy efficient electric motors by John .C. Andreas, Marcel Dekker Inc Ltd-2nd edition, 1995
3. Energy management hand book by W.C. Turner, John wiley and sons
4. Energy management and good lighting practice: fuel efficiency- booklet12-EEO

I M.TECH II SEMESTER

MODELING OF RENEWABLE ENERGY SOURCES IN SMART GRID (17D07206)

L	T	P	C
4	0	0	4

COURSE OBJECTIVES:

This course enables the students

- To have an over view and local impacts of renewable energy sources in power system
- To have an idea on Induction Machine Modelling, Dynamic performance of FSIG Wind Turbines Control Strategies for a DFIG
- To know FRC Synchronous Generator-based (FRC-SG) Wind Turbine- steady state performance and its Characteristics of the FRC-IG Wind Turbine
- To have an over view of Dynamic Modelling of Fuel Cells
- To have knowledge on Photovoltaic systems & its grid integration

UNIT 1 Introduction

Indian and global scenario of renewable energy sources in power system, local impacts of renewable energy sources on circuit power flow, bus bar voltage, power quality, protection schemes, switchgear ratings, power quality, side wide impact of renewable energy sources on power system dynamics & stability, reactive power & voltage support, frequency support, grid code regulations for integration of renewable energy resources

UNIT 2 Fixed speed & Doubly fed induction generator based wind turbine generating system

Induction Machine Construction, Steady state Characteristics, FSIG configurations for wind generation, Induction Machine Modelling, Dynamic performance of FSIG Wind Turbines, typical DFIG Configuration, steady state Characteristics, control for Optimum Wind Power Extraction, control Strategies for a DFIG, Dynamic Performance Assessment

UNIT 3 Fully rated convertor (FRC) based wind turbine generating system

FRC Synchronous Generator-based (FRC-SG) Wind Turbine, Direct-driven Wind turbine Generators, Permanent Magnets Versus Electrically Excited Synchronous Generator, Permanent Magnets Synchronous Generator, Wind Turbine Control and Dynamic Performance Assessment, FRC induction generator based (FRC-IG) Wind turbine: steady state performance, control of the FRC-IG wind turbine, Performance Characteristics of the FRC-IG Wind Turbine

UNIT 4 Dynamic Modeling of Fuel Cells

Fuel Cell Basics, Types of Fuel Cells, Fuel Cell Equivalent Circuit, Need for Fuel Cell Dynamic Models, PEMFC Dynamic Model Development, PEMFC Model Structure, Equivalent Electrical Circuit Model of PEMFC, SOFC Dynamic Model Development, Effective Partial Pressures, Material Conservation, SOFC output voltage, Thermodynamic Energy Balance, SOFC dynamic model structure

UNIT 5 Photovoltaic systems & its grid integration

Introduction to PV systems, a generic photovoltaic cell, the simplest equivalent circuit for a photovoltaic cell, current voltage curves for loads, grid connected systems: interfacing with the utility, grid connected system sizing, battery storage capacity, battery sizing, sizing the pv array, hybrid pv system, stand alone system design summary, load analysis, pv sizing, battery sizing, generator sizing system cost

COURSE OUTCOMES:

The students will have knowledge on the following concepts:

- Understand the concepts of renewable energy sources on power system dynamics & stability, reactive power & voltage support, frequency support, grid code regulations for integration of renewable energy resources
- Know the concept of FSIG configurations for wind generation and Typical DFIG Configuration
- Understand the (FRC) based wind turbine generating system
- Will have an idea of Dynamic Modelling of Fuel Cells
- Concept on photo voltaic systems & its grid integration

Text Books:

1. Wind Energy Generation Modelling and Control, Olimpo Anaya-Lara, Nick Jenkins, Janaka Ekanayake, Phill Cartwright, Mike Hughes, Wiley, A John Wiley & Sons, Inc, Publication.
2. Small Signal Analysis of Isolated Hybrid Power Systems Reactive Power and Frequency Control Analysis, R.C.Bansal, T.S.Bhatti, Narosa Series in Power and Energy Systems, Narosa Publishing House.
3. Variable Speed Generators, Ion Boldea, CRC press, Taylor & Francis Group.
4. Modeling and Control of Fuel Cells: Distributed Generation Applications, M. Hashem Nehrir and Caisheng Wang, IEEE Press Series on Power Engineering, Wiley-Inter science, A John Wiley & Sons, Inc, Publication.
5. Renewable and Efficeint Electric Power Systems, Gilbert. M. Masters, Wiley-Inter science, A John Wiley & Sons, Inc, Publication.

Reference Books:

1. John twidell & wier, renewable energy sources, CRC press, 2009.
2. “Energy conversion systems” by Rakosh das Begamudre, New age International publishers, New Delhi - 2000.

I M.TECH II SEMESTER

SOFT COMPUTING TECHNIQUES TO POWER SYSTEMS (17D07207)

L T P C
4 0 0 4

COURSE OBJECTIVES:

This course Enable the students to :

- Artificial Intelligence and Neural networks.
- Back propagation Algorithm.
- Fuzzification and Defuzzification methods.
- Applications of AI techniques (Load flow studies , Economic load dispatch etc.).

UNIT – I: Artificial Neural Networks

Introduction-Models of Neural Network - Architectures – Knowledge representation – Artificial Intelligence and Neural networks–Learning process – Error correction learning – Hebbian learning –Competitive learning –Boltzman learning –Supervised learning – Unsupervised learning – Reinforcement learning- learning tasks.

UNIT- II: ANN Paradigms

Multi – layer perceptron using Back propagation Algorithm-Self – organizing Map – Radial Basis Function Network – Functional link, network – Hopfield Network.

UNIT – III: Fuzzy Logic

Introduction – Fuzzy versus crisp – Fuzzy sets - Membership function – Basic Fuzzy set operations – Properties of Fuzzy sets – Fuzzy cartesion Product –Operations on Fuzzy relations – Fuzzy logic – Fuzzy Quantifiers-Fuzzy Inference-Fuzzy Rule based system-Defuzzification methods.

UNIT – IV: Genetic Algorithms

Introduction-Encoding –Fitness Function-Reproduction operators-Genetic Modeling –Genetic operators-Crossover-Single – site crossover-Two point crossover –Multi point crossover-Uniform crossover – Matrix crossover-Crossover Rate-Inversion & Deletion –Mutation operator –Mutation –Mutation Rate-Bit-wise operators-Generational cycle-convergence of Genetic Algorithm.

UNIT–V: Applications Of Ai Techniques

Load forecasting – Load flow studies – Economic load dispatch – Load frequency control – Single area system and two area system – Small Signal Stability (Dynamic stability) Reactive power control – speed control of DC and AC Motors.

COURSE OUTCOMES:

The students will have knowledge on the following concepts:

- At the end of the course students are able to
- Understand the concepts of Neural networks and learning methods.
- Analyse the Fuzzy Rule base system.
- Matrix cross over, Mutation operator, Cross over rate inversion and deletion.
- Understand the applications of AI techniques (Small Signal Stability Reactive power control and Speed control of AC & DC Motors) .

TEXT BOOK:

1. S. Rajasekaran and G.A.V.Pai, "Neural Networks, Fuzzy Logic & Genetic Algorithms"- PHI, New Delhi, 2003.

REFERENCE BOOKS:

1.P.D.Wasserman, Van Nostrand Reinhold,"Neural Computing Theory & Practice"- New York, 1989.
2. Bart Kosko," Neural Network & Fuzzy System" Prentice Hall, 1992.
3. G.J.Klir and T.A.Folger,"Fuzzy sets,Uncertainty and Information"-PHI, Pvt.Ltd,1994.
4. D.E.Goldberg," Genetic Algorithms"- Addison Wesley 1999.

I M.TECH II SEMESTER

EHV AC TRANSMISSION (17D07208)

L T P C
4 0 0 4

COURSE OBJECTIVES:

This course enables the students to

- Understand the different aspects of EHVAC Transmission, design and analysis of the same.
- Calculate the inductance and capacitance effect on the EHVAC Transmission system.
- Understand the importance of Corona, RI and its effects on EHVAC Transmission system.
- Evaluate the electrostatic field effects on EHVAC Transmission system.
- Understand the importance of voltage control methods on Transmission systems.

UNIT – I: Introduction:

Necessity of EHV AC transmission – Advantages and problems – Power handling capacity and line losses- Mechanical considerations – Resistance of conductors – Properties of bundled conductors – Bundle spacing and bundle radius - Examples.

UNIT – II: Line and Ground Reactive Parameters:

Line inductance and capacitances – Sequence inductances and capacitances – Modes of propagation – Ground return – Examples. Electrostatics – Field of sphere gap – Field of line changes and properties – Charge – potential relations for multi-conductors – Surface voltage gradient on conductors – Distribution of voltage gradient on sub-conductors of bundle – Examples.

UNIT – III: Corona Effects:

Power loss and audible noise (AN) – corona loss formulae – Charge voltage diagram – Generation, characteristics - Limits and measurements of AN – Relation between 1-phase and 3 -phase AN levels – Radio interference (RI) - Corona pulses generation, properties, limits – Frequency spectrum – Modes of propagation – Excitation function – Measurement of RI, RIV and excitation functions **-** Examples.

UNIT – IV: Electro Static Field & Traveling Wave Theory:

Electrostatic field: calculation of electrostatic field of EHV/AC lines – Effect on humans, animals and plants – Electrostatic induction in unenergised circuit of double - circuit line – Electromagnetic interference - Examples. Traveling wave expression and solution - Source of excitation - Terminal conditions - Open circuited and short circuited end - Reflection and refraction coefficients - Lumped parameters of distributed lines - Generalized constants - No load voltage conditions and charging current.

UNIT –V: Voltage Control:

Power circle diagram and its use – Voltage control using synchronous condensers – Cascade connection of shunt and series compensation – Sub synchronous resonance in series capacitor – Compensated lines – Static VAR compensating system.

COURSE OUTCOMES:

The students will have knowledge on the following concepts:

- The necessity of EHV AC transmission, choice of voltage for transmission, line losses and power handling capability.
- Corona, Radio Interference & its effects with the EHVAC transmission system.
- Calculating the field effect & travelling wave of EHVAC lines.
- Various voltage control methods adopted in the Transmission system.

TEXT BOOKS:

1. R.D. Begamudre, EHVAC Transmission Engineering, New Age International (p) Ltd.
2. S. Rao, EHVAC and DC Transmission, Khanna Publishers, Delhi

REFERENCE BOOKS:

1. K.R.Padiyar - HVDC Power Transmission Systems : Technology & System Interactions,New age International (P) Ltd.
2. Kuffel,Zangle,Kuffle – High Voltage Engineering,Newnes Publications.
3. M.S.Naidu & V.Kamaraju – High Voltage Engineering,TMH Publications.

I M.TECH II SEMESTER

FACTS CONTROLLERS (17D07209)

L T P C
4 0 0 4

COURSE OBJECTIVES:

This course enables the students to

- The basic concepts, different types and applications of FACTS controllers in power transmission.
- To deal with the objectives of shunt and series compensation.
- The working principle, structure and control of UPFC.
- The operation, structure and control of IPFC.

UNIT-I: Facts Concepts,VSI and CSI

Transmission interconnections power flow in an AC system, loading capability limits, Dynamic stability considerations, importance of controllable parameters basic types of FACTS controllers, benefits from FACTS controllers. Single phase three phase full wave bridge converters transformer connections for 12 pulse 24 and 48 pulse operation. Three level voltage source converter, pulse width modulation converter, basic concept of current source Converters, and comparison of current source converters with voltage source converters.

UNIT – II: Shunt Compensation

Objectives of shunt compensation - Methods of controllable var generation - variable impedance type static var generators - switching converter type var generators - hybrid var generators – Comparison of SVC and STATCOM.

UNIT – III: Series Compensation

Objectives of series compensation – GTO Thyristor Controlled Series Capacitor (GCSC) - Thyristor Switched Series Capacitor (TSSC) - Thyristor Controlled Series Capacitor (TCSC) - Control schemes for TCSC, TSSC and TCSC.

UNIT- IV: Unified Power Flow Controller (UPFC)

Introduction - The Unified Power Flow Controller **-** Basic Operating Principles - Conventional Transmission Control Capabilities - Independent Real and Reactive Power Flow Control - Control Structure - Basic Control System for P and Q Control - Hybrid Arrangements: UPFC With a Phase Shifting Transformer.

UNIT – V: Interline Power Flow controller (IPFC)

Introduction, basic operating principle and characteristics of IPFC, control structure, practical and application considerations, generalized and multifunctional fact controllers

COURSE OUTCOMES:

The students will have knowledge on the following concepts

- The various control techniques for the purpose of identifying the scope and for selection of specific FACTS controllers.
- The different types of controllable var generation and variable impedance techniques.
- Design simple converters using FACTS controllers.
- The operation of Unified Power Controller and Hybrid Arrangements.

TEXT BOOKS:

1. Understanding FACTS – Concepts and technology of Flexible AC Transmission systems, Narain G. Hingorani, Laszlo Gyugyi, IEEE Press, WILEY, 1st Edition, 2000, Reprint 2015.
2. FACTS Controllers in Power Transmission and Distribution, Padiyar K.R., New Age International Publishers, 1st Edition, 2007.

REFERENCE BOOKS:

1.Flexible AC Transmission Systems: Modelling and Control, Xiao – Ping Zhang, Christian Rehtanz, Bikash Pal, Springer, 2012, First Indian Reprint, 2015.

2. FACTS – Modelling and Simulation in Power Networks, Enrigue Acha, Claudio R. Fuerte – Esquival, Huge Ambriz – perez, Cesar Angeles – Camacho, WILEY India Private Ltd., 2004, Reprint 2012.

I M.TECH II SEMESTER

POWER SYSTEMS SIMULATION LAB –II (17D07210)

L	T	P	C
0	0	3	2

COURSE OBJECTIVES:

This course enables the students to:

- To have hands on experience on various system studies and different techniques Used for system planning software packages.
- To perform the dynamic analysis of power system.
- Programming and simulation of Z Bus formation , Economic Load Dispatch by considering transmission losses using Matlab.

List of experiments:-

1. Z Bus formation using Matlab.
2. Reliability analysis of distribution systems.
3. Simulation of faults through power system fault analysis.
4. Voltage stability assessment in distribution systems.
5. Economic Load Dispatch using Matlab by considering transmission losses
6. Transient stability analysis through single machine.
7. Transient stability analysis through multi machine system.

Analysis of FACTS devices in power system

8. SVC
9. TCSC
10. Analysis of dynamic stability using Mi Power
11. Network reduction using Mi Power
12. Relay coordination using Mi Power for Phase to earth over current relay
13. Line and cable parameters calculation using Mi Power

COURSE OUTCOMES:

The students will have ability to:

- Apply knowledge of mathematics, science, and engineering.
- Design and conduct experiments, as well as to analyze and interpret results.
- Understand the impact of engineering solutions in a global perspective.
- Acquire skills of using computer packages MATLAB coding and SIMULINK in power system studies.
- Acquire skills of using Mi power software for power system studies.

REFERENCE BOOKS:

- MATLAB DeMYSTiFieD A SELF TECHING GUIDE By David McMahon(Tata Mc Graw Hill)

I M.TECH II SEMESTER

POWER CONVERTERS AND ENERGY LAB (17D07211)

L	T	P	C
0	0	3	2

COURSE OBJECTIVES:

- To know the knowledge on I-V and P-V curves of Solar Panel using P-V Emulator.
- To understand different connections of solar panel
- To analyse the Performance of frequency drop characteristics of Induction generator at different loading conditions .
- To simulate the different types of of converters.

List of experiments:-

1) Draw the I-V and P-V curves of Solar Panel using P-V Emulator
2) Series Connection of Solar Panel
3) Parallel Connection of Solar Panel
4) Study of Sun tracking System
5) Charging Characteristics of a battery
6) Discharging Characteristics of a battery
7) P,V,& F Measurement of output of wind generator
8) Impact of load and wind speed on power output and its quality
9) Performance of frequency drop characteristics of Induction generator at different loading conditions
10) Design of DC-AC Convertors for different types of variable AC loads through Simulink

Design and Simulation of following Convertors

1) Buck-Boost Converter
2) Push-Pull Converter
3) Forward Converter
4) Half Bridge Converter
5) Full Bridge Converter
6) Fly Back Converter

COURSE OUTCOMES:

The students will have knowledge on the following concepts:

- The characteristics of battery and Measurement of output Power, voltage frequency of wind generator.
- The frequency drop characteristics of Induction generator at different loading conditions
- Simulate different types of converters.

Reference Books:

1. Pressman A.I, Switching Power Supply Design, McGraw Hill, 2nd edition, 1999.
2. Renewable and Efficient Electric Power systems: Gilbert M. Masters, John Wiley & Sons, Inc., Publication

M.Tech COURSE STRUCTURE – R21 - ELECTRICAL POWER SYSTEMS

Semester-I

S.No.	Course Code	Course Name	L-T-P	Credits
1		Economic Operation of Power Systems	3-0-0	**3**
2		Advanced Power System Protection	3-0-0	**3**
3		**Program Elective I:** i) Modelling and Analysis of HVDC Systems ii) Modern Control Theory iii) Solar & Wind Energy Conversion Systems	3-0-0	**3**
4		**Program Elective II:** i) Reliability Engineering and Applications to Power Systems ii) Power System Optimization iii) Electric Vehicle Engineering	3-0-0	**3**
5		Power Systems Protection Lab	0-0-4	**2**
6		Power Systems Simulation Lab	0-0-4	**2**
7		Research Methodology and IPR	2 -0-0	**2**
8		**Audit Course – I** Research Paper Writing Skills	2-0-0	**0**
			Total Credits :	**18**

Semester-II

S.No.	Course Code	Course Name	L-T-P	Credits
1		Power System Stability and Control	3-0-0	**3**
2		FACTS Controllers	3-0-0	**3**
3		**Program Elective III:** i) Energy Auditing, Conservation & Management ii) Smart Grid Technologies iii) EHVAC Transmission systems	3-0-0	**3**
4		**Program Elective IV:** i) Restructured power systems ii) Power Quality iii) Reactive power Compensation & Management	3-0-0	**3**
5		Renewable Energy Lab	0-0-4	**2**
6		FACTS Devices Simulation Lab	0-0-4	**2**
7		Technical Seminar	0 -0-4	**2**
8		**Audit Course – II** Personality Development Through Life Enlightenment Skills	2-0-0	**0**
			Total Credits :	**18**

Semester-III

S.No.	Course Code	Course Name	L-T-P	Credits
1		**Program Elective V:** i) Distributed Generation and Micro grid Control ii) Power System Automation iii) Intelligent Control Techniques	3-0-0	**3**
2		**Open Elective:** i) Energy from Waste ii) Cost Management of Engineering Projects iii) Internet of Things (IoT)	3-0-0	**3**
3		Dissertation Phase -I	0-0-20	**10**
4		Co-curricular Activities		**2**
			Total Credits :	**18**

Semester-IV

S.No.	Course Code	Course Name	L-T-P	Credits
1		Dissertation Phase -II	0-0-32	16
			Total Credits :	**16**

JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS) PULIVENDULA

ECONOMIC OPERATION OF POWER SYSTEMS

I Year M.Tech (EPS) – 1st Semester

L	T	P	C
3	0	0	3

Course Objectives: Students will be able to

- Understand economic load scheduling problem and unit commitment problem.
- Understand hydro-thermal scheduling problem.
- Understand load frequency control (LFC)
- Understand the optimal power flow (OPF) problem.

UNIT-I: ECONOMIC LOAD SCHEDULING **10 Hrs**

Characteristics of Steam Turbine, Variations in steam unit characteristics, Economic dispatch with piecewise linear cost functions, Lambda Iterative method, LP method, Economic dispatch under composite generation production cost function, Base point and Participation factors, Thermal system Dispatching with Network losses.

Learning Outcomes:

At the end of this unit, the student will be able to

- Analyzes the characteristics of steam turbine **L4**
- Learn about Economic dispatch of thermal units with various methods. **L2**

UNIT-II: UNIT COMMITMENT **10 Hrs**

Unit Commitment – Definition – Constraints in Unit Commitment–Unit Commitment solution methods –Priority–List Methods – Dynamic Programming Solution.

Learning Outcomes:

At the end of this unit, the student will be able to

- Understands what unit commitment is. **L2**
- Understand about various unit commitment methods. **L2**

Unit-III: HYDRO THERMAL SCHEDULING **10 Hrs**

Characteristics of Hydroelectric units, Introduction to Hydrothermal coordination, Long-Range and Short-Range Hydro-Scheduling, Hydroelectric plant models, Hydrothermal scheduling with storage limitations, Dynamic programming solution to hydrothermal scheduling

Learning Outcomes:

At the end of this unit, the student will be able to

- Undrstands the characteristics of hydroelectric units **L2**
- Knows the sheduling of the hydrothermal units. **L2**

UNIT – IV: LOAD FREQUENCY CONTROL **10 Hrs**

Control of generation – models of power system elements – single area and two area block diagrams– generation control with PID controllers – implementation of Automatic Generation control (AGC) –AGC features.

Learning Outcomes:
At the end of this unit, the student will be able to

- Understands the load frequency control of single area and double area PS. **L2**
- Implement the AGC features to power system. **L4**

UNIT – V: OPTIMAL POWER FLOW **10 Hrs**

Introduction to Optimal power flow problem, OPF calculations combining economic dispatch and power flow, OPF using DC power flow, Algorithms for solution of the ACOPF, Optimal Reactive Power Dispatch.

Learning Outcomes:
At the end of this unit, the student will be able to

- Understands what is OPF **L2**
- Learn about the OPF with DC and AC methods. **L2**

Text Books:

1.Olle l. Elgerd, "Electric Energy Systems Theory an Introduction", TMH, 2nd Edition, 1983

2. J.J. Grainger &W.D.Stevenson, "Power system analysis", McGraw Hill, 2003.

Reference Books:

1. Allen J. Wood, Bruce F. Wollenberg, Gerald B. Sheblé-Power Generation, Operation and Control-Wiley-Interscience (2013)

2. NPTEL Course, Prof. S. N. Singh, Power System Operation and Control, https://www.youtube.com/playlist?list=PL4BFB13CCDB954BCF

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

- Distinguish between economic load dispatch and unit commitment problem **L2**
- Solve economic load scheduling (with and without network losses) and unit commitment problem **L2**
- Solve hydro-thermal scheduling problem **L3**
- Analyzes the single area and two area systems for frequency deviation **L4**
- Solve the OPF problem using ac and dc load flow methods **L3**

JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS) PULIVENDULA

ADVANCED POWER SYSTEM PROTECTION

I Year M.Tech (EPS) – 1st Semester

L	T	P	C
3	0	0	3

Course Objectives: Student can be able to know

- To know construction of static relays
- To understand the operation of amplitude and phase comparators
- To comprehend the concepts of Static over current, static differential and static distance relays.
- To understand multi-input comparators and concept of power swings on the distance relays.
- To know the operation of microprocessor based protective relays.

UNIT – 1: INTRODUCTION TO STATIC RELAYS & COMPARATORS 10Hrs

Introduction to Static relays - Basic construction of Static relays – Level detectors – Replica Impedance-Mixing circuits-General equation for two input phase and Amplitude Comparators – their types - DualitybetweenAmplitudeandPhaseComparator.Conicsectioncharacteristics– ThreeinputAmplitudeComparator – Hybrid comparator – Switched distance schemes – Poly phase distance schemes-Phase fault scheme –Three phase scheme–Combined and Ground fault scheme.

Learning Outcomes:

At the end of this unit, the student will be able to

- Define the Basic construction of Static relays **L1**
- Explain the Level detectors – Replica Impedance-Mixing circuits **L2**

UNIT – II: STATIC RELAYS 10Hrs

Introduction-Instantaneous over current relay – Time over current relays - Basic principles-Definite time and Inverse definite time over current relays, directional over current relays. StaticDifferentialRelays-Analysis of static differential relays–static relay schemes-Dual bias transformer differential protection – Harmonic restraint relay.

Learning Outcomes:

At the end of this unit, the student will be able to

- Repeat the - Basic principles-Definite time and Inverse definite time over current relays, **L1**
- Explain the Static Differential Relays **L2**

UNIT – III: DISTANCE RELAYS AND POWERSWINGS 10Hrs

Static Distance Relays- Static Impedance –reactance - MHO and Angle Impedance relay sampling comparator – Realization of reactance and MHO relay using a sampling comparator.

Effect of power swings on the performance of Distance relays- Power swing analysis – Principle of out of step tripping and blocking relays–Effect of line length and source impedance on distance relays.

Learning Outcomes:

At the end of this unit, the student will be able to

- Define the Static Impedance –reactance - MHO and Angle Impedance relays **L1**

- Generalize the Realization of reactance and MHO relay using a sampling comparator **L2**

UNIT – IV: MICROPROCESSOR BASED PROTECTIVE RELAYS **10Hrs**

Over current relays – Impedance relays – Directional relay – Reactance relay (Block diagram and flow chart approach only).Generalized mathematical expression for distance relays-Measurement of resistance and reactance–MHO and offset MHO relays–Realization of MHO characteristics–Realization of Offset MHO characteristics (Block diagram and flow chart approach only) Basic principle of Digital computer relaying.

Learning Outcomes:

At the end of this unit, the student will be able to

- Reproduce the Impedance relays – Directional relay **L1**
- Identify the Generalized mathematical expression for distance relays. **L2**

UNIT – V: NUMERICAL RELAYS: **10Hrs**

Advantages of Numerical Relays-Numerical network-Digital Signal processing–Estimation of Phasors – Full Cycle Fourier Algorithm – Half Cycle Fourier Algorithm- practical considerations for selection of Algorithm–Discrete Fourier Transform

Learning Outcomes:

At the end of this unit, the student will be able to

- Define the Numerical network-Digital Signal processing. **L1**
- Explain the Full Cycle Fourier Algorithm – Half Cycle Fourier Algorithm. **L2**

Text Books:

1. T.S. Madhava Rao, Power system Protection static relay, 2 nd Edition, Tata McGrawHill Publishing Company limited 2004.

2. Badri Ram and D.N. Vishwakarma, Power system Protection and Switchgear, 2 nd Edition, Tata McGraw Hill Publication Company limited, 2013.

Reference Books:

1. Bhavesh Bhalja, R. P. Maheshwari, N. G. Chothani, Protection and Switchgear, Oxford University Press, 2nd edition, New Delhi, India, 2018

2. Oza, B. A., N. C. Nair, R. P. Mehta, et al., Power System Protection & Switchgear, Tata McGraw Hill, New Delhi, 2010.

Course Outcomes:

After completing the course, the student should be able to do the following:

- Define the construction of static relay and identify the advantages of static relay over electromagnetic relay. **L1**
- Explain the operation of rectifier bridge comparators, instantaneous comparators, phase comparators, multi input comparators, static differential and distance relays **L2**
- Instruct the instantaneous, definite time and inverse definite minimum time over current relays. **L3**
- Distinguish the concept of power swings on distance relays and to identify the microprocessor based protective relays and their operation **L4**
- Implement the Full Cycle Fourier Algorithm – Half Cycle Fourier Algorithm. **L5**

JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS) PULIVENDULA

MODELLING AND ANALYSIS OF HVDC TRANSMISSION SYSTEMS (PE-I)

I Year M.Tech (EPS) – 1st Semester	L	T	P	C
	3	0	0	3

Course Objectives:

- State HVDC systems
- Understand the concept, planning of DC power transmission.
- Implement HVDC converters to the system
- Compare modeling of Power Flow analysis of AC/DC Systems
- Design digital dynamic simulation of converters and DC systems.

UNIT-I HVDC CONVERTERS AND SYSTEM CONTROL **10 Hrs**

Analysis of HVDC Converters: Pulse number – choice of converter configuration – simplified analysis of Graetz circuit – converter bridge characteristics.
Converter and HVDC system control: Principles of DC link control – converter control characteristics – system control hierarchy – firing angle control – current and extinction angle control – starting and stopping of DC link power control.

Learning Outcomes:

At the end of this unit, the student will be able to

- Understand converter bridge characteristics **L2**
- Understand HVDC system control **L2**

UNIT-II MODELING FOR POWER FLOW ANALYSIS OF AC/DC SYSTEMS **10 Hrs**

Modeling of HVDC Components: HVDC Converter model, Converter control, Modeling of DC network, Modeling of AC Networks.

Learning Outcomes:

At the end of this unit, the student will be able to

- Compare the power flow analysis of A.C/D.C systems **L4**
- Represent solution of A.C/D.C power flow **L2**

UNIT-III TRANSIENT AND DYNAMIC STABILITY ANALYSIS **10 Hrs**

Transient stability Analysis – Converter model – Converter control models – DC network models – solution methodology – Direct methods for stability Evaluation. Dynamic Stability and power modulation: Power modulation for damping low frequency oscillations – Basic principles – practical consideration in the application of power modulation controllers – Gamma or reactive power modulation – power modulation in MTDC system – voltage stability in AC/DC system

Learning Outcomes:

At the end of this unit, the student will be able to

- Apply direct methods for stability evaluation **L3**
- Understand the power modulation in MTDC system **L2**

UNIT-IV HARMONIC AND TORSIONAL INTERACTIONS **10 Hrs**

Harmonic and Torsional Interactions: Harmonic Interactions, Torsion Interactions – Torsional interactions with in HVDC systems – counter measures to torsion interactions with DC systems.

Simulation of HVDC systems: System simulation – philosophy & Tools – HVDC system simulation – modeling of HVDC systems Digital dynamic simulation.

Learning Outcomes:

At the end of this unit, the student will be able to

- Analyze harmonic and torsional interactions **L4**
- Develop modeling of HVDC systems and digital dynamic simulation **L5**

UNIT-V MODELING OF HVDC SYSTEMS **10 Hrs**

Digital dynamic simulation of converters and DC systems: Valve model, Gate pulse generation – generation of control voltage – transformer model – converter model – transient simulation of DC and AC systems.

Learning Outcomes:

At the end of this unit, the student will be able to

- Understand digital dynamic simulation of converters and D.C systems **L2**
- Develop transient simulation of D.C and A.C systems **L5**

Text Books:

1. K.R. Padiyar, HVDC Power Transmission Systems – Technology & System Interactions, New Age International Publishers, 2017.

2. S Kamakshaiah and V Kamaraju, HVDC Transmission, Tata Mc Graw Hill, New Delhi, 2011.

Course Outcomes:

At the end of this Course the student will be able to

- Identify the electrical requirements for HVDC lines. **L1**
- Understand the different modes of operation for six pulse & twelve pulse converter unit in the context of HVDC system. **L2**
- Apply the knowledge of HVDC transmission in Power networks. **L3**
- Analyze the modeling of A.C/D.C systems **L4**
- Implement transformer model, converter model of HVDC systems **L5**

JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS) PULIVENDULA

MODERN CONTROL THEORY (PE- 1)

I Year M.Tech (EPS) – 1st Semester	**L**	**T**	**P**	**C**
	3	**0**	**0**	**3**

Course Objectives:

- To evaluate the solution of state equation and state transition matrix
- To design controllers, access the design through the constraint specifications, and decide whether the initial design is acceptable or can be improved by iterating.
- To design full order observer using Ackermann's formula
- To simulate state equation using MATLAB/ SIMULINK program.
- To identify the solution of a system using Lyapunov stability

UNIT – 1 **10 Hrs**

Introductory matrix algebra and linear vector space. State space representation of systems. Linearization of a non- linear System. Solution of state equations. Evaluation of State Transition Matrix (STM)

Learning Outcomes:

At the end of this unit, the student will be able to

- Understand State space representation of a system **L1**
- Evaluate State Transition Matrix for a system **L4**

UNIT – II **10 Hrs**

Similarity transformation and invariance of system properties due to similarity transformations. Minimal realization of SISO, SIMO, MISO transfer functions. Discretization of a continuous time state space model. Conversion of state space model to transfer function model using Fadeeva algorithm. Fundamental theorem of feedback control - Controllability and Controllable canonical form - Pole assignment by state feedback using Ackermann's formula – Eigen structure assignment problem.

Learning Outcomes:

At the end of this unit, the student will be able to

- Convert state space model to transfer function model **L4**
- Understand the concept of Pole assignment using Ackermann's formula **L2**

UNIT – III **10 Hrs**

Linear Quadratic Regulator (LQR) problem and solution of algebraic Riccati equation using Eigen value and Eigen vector methods, iterative method. Controller design using output feedback.

Observability and observable canonical form - Design of full order observer using Ackermann's formula, Bass Gura algorithm. Duality between controllability and observability - Full order Observer based controller design. Reduced order observer design.

Learning Outcomes:

At the end of this unit, the student will be able to

- Determine Eigen values and Eigen vectors **L3**
- Understand Linear Quadratic Regulator problem **L2**

UNIT – IV **10 Hrs**

Introduction – Non Linear Systems - Types of Non-Linearities – Saturation – Dead-Zone - Backlash – Jump Phenomenon etc; Linearization of nonlinear systems, Singular Points and its types– Describing function–describing function of different types of nonlinear elements, – Stability analysis of Non-Linear systems through describing functions. Introduction to phase-plane analysis, Method of Isoclines for Constructing Trajectories, Stability analysis of nonlinear systems based on phase-plane method.

Learning Outcomes:

At the end of this unit, the student will be able to

- Implement basic principles and techniques in designing Non-linear control systems. **L5**
- Understand the concet of Controllability and Observability **L2**

UNIT – V **10 Hrs**

Internal stability of a system. Stability in the sense of Lyapunov, asymptotic stability of linear time invariant continuous and discrete time systems. Solution of Lyapunov type equation. Model decomposition and decoupling by state feedback. Disturbance rejection, sensitivity and complementary sensitivity functions.

Learning Outcomes:

At the end of this unit, the student will be able to

- Analyze the concept of Lyapunov stability theorems **L3**
- Understand sensitivity and complementary sensitivity functions **L2**

Text Books:

1. K. Ogata, Modern Control Engineering, Prentice Hall, India 1997
2. T. Kailath, T., Linear Systems, Perntice Hall, Englewood Cliffs, NJ, 1980.
3. N. K. Sinha, Control Systems, New Age International, 3rd edition, 2005.
4. K. Ogata, Modern Control Engineering, Prentice Hall, India 1997

Reference Books:

1. Panos J Antsaklis, and Anthony N. Michel, Linear Systems, New - age international (P) LTD. Publishers, 2009.
2. John J D‘Azzo and C. H. Houpis , -Linear Control System Analysis and Design conventional and Modern‖, McGraw - Hill Book Company, 1988.
3. B.N. Dutta, Numerical Methods for linear Control Systems - , Elsevier Publication, 2007
4. C.T.Chen Linear System Theory and Design - PHI, India, 1984.

Course Outcomes:

At the end of this Course the student will be able to

- Test the controllability and observability of a given system **L4**
- Analyze Linearization of a non linear system **L3**
- Design Pole assignment by state feedback using Ackermann‘s formula **L5**
- Identify the Lyapunov stability of a system. **L2**
- Design of Model decomposition and decoupling of system by state feedback. **L5**

JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS) PULIVENDULA

SOLAR and WIND ENERGY CONVERSION SYSTEMS (PE-I)

I Year M.Tech (EPS) – 1st Semester	**L**	**T**	**P**	**C**
	3	**0**	**0**	**3**

Course Objectives:

- To introduce photovoltaic systems and principle of wind turbines
- To deal with various technologies of solar PV cells
- To understand details about manufacture, sizing and operating techniques in solar energy conversion systems.
- Understand the concepts of fixed speed and variable speed, wind energy conversion systems.
- To have knowledge of design considerations and analyze grid integration issues.

UNIT – 1: SOLAR & WIND FUNDAMENTALS **10 Hrs**

Need for sustainable energy sources –solar radiation – the sun and earth movement – angle of sunrays on solar collectors – sun tracking – estimating solar radiation – measurement of solar radiation.Types of wind energy conversion devices – definition - solidity, tip speed ratio, power coefficient, wind turbine ratings and specifications - aerodynamics of wind rotors - design of the wind turbine rotor

Learning Outcomes:

At the end of this unit, the student will be able to

- Learn about Need for sustainable energy sources L1
- Learn about Types of wind energy conversion devices L2

UNIT – II: SOLAR PHOTOVOLTAIC MODULES **10 Hrs**

Solar PV Modules from solar cells – model of a solar cell, effect of series and shunt resistance on efficiency, effect of solar radiation on efficiency - series and parallel connection of cells – mismatch in module – mismatch in series connection – hot spots in the module , bypass diode – mismatching in parallel diode – design and structure of PV modules – number of solar cells in a module, wattage of modules, fabrication of PV module – PV module power output.

Learning Outcomes:

At the end of this unit, the student will be able to

- Understand and estimate Solar PV Modules from solar cells L1
- Understand - series and parallel connection of cells L2

UNIT – III PV SYSTEM DESIGN AND APPLICATIONS **10 Hrs**

Introduction to solar PV systems – standalone PV system configuration – design methodology of PV systems – design of PV powered DC fan without battery, standalone system with DC load using MPPT, design of PV powered DC pump, design of standalone system with battery and AC/DC load – wire sizing in PV system – precise sizing of PV systems – Hybrid PV systems – grid connected PV systems.

Learning Outcomes:

At the end of this unit, the student will be able to

- Understand the standalone PV system configuration L1
- Distinguish between design of standalone system with battery and AC/DC load L2

UNIT – IV: WIND TURBINE CONTROL SYSTEMS & SITE ANALYSIS **10 Hrs**

Wind Turbine - Torque speed characteristics - Pitch angle control – stall control – power electronic control – Yaw control – Control strategy – Wind speed measurements – Wind speed statistics – Site and turbine selection. Constant voltage & constant frequency-single output system –double output system with current converter & voltage source inverter – equivalent circuits – reactive power and harmonics - reactive power compensation – variable voltage, variable frequency – the self-excitation process – circuit model for the self-excited induction generator – analysis of steady state operation – the excitation requirement – effect of a wind generator on the network

Learning Outcomes:

At the end of this unit, the student will be able to

- Understand Wind Turbine - Torque speed characteristics L1
- Distinguish between - single output system –double output system with current converter L2

UNIT – V: : WIND GENERATION WITH VARIABLE SPEED TURBINES AND APPLICATIONS **10 Hrs**

Classification of schemes – operating area – induction generators – doubly fed induction generator – wound field synchronous generator – the permanent magnet generator – Merits and limitations of wind energy conversion systems – application in hybrid energy systems – diesel generator and photovoltaic systems – wind photovoltaic systems

Learning Outcomes:

At the end of this unit, the student will be able to

- Understand doubly fed induction generator L1
- Understand application in hybrid energy systems – diesel generator and photovoltaic systems – wind photovoltaic systems L2

Text Books:

1. "Solar Photovoltaics Fundamentals, Technologies and Applications" by Chetan singh solanki, PHI publications..
2. S.N.Bhadra, D.Kastha, S.Banerjee, " wind electrical systems" Oxford University Press

Reference Books:

1. Solar Energy Fundamentals and applications by H.P. Garg, J. Prakash , Tata McGraw- Hillpublishers Ist edition
2. S.Rao & B.B.Parulekar, "Energy Technology", 4th edition, Khanna publishers, 2005
3. "Renewable Energy sources & Conversion Technology" by N.K.Bansal, Manfred Kleemann,Michael Meliss. Tata Mcgraw Hill Publishers

At the end of this Course the student will be able to

- Understand the basic concepts of solar and wind L1
- Identify the factors affecting of solar and wind L2
- Analyze converters are used in solar and wind L3
- Estimate the generation of solar and wind energy . L4
- Understand the basic concepts of solar and wind L5

JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS) PULIVENDULA

RELIABILITY ENGINEERING AND APPLICATION TO POWER SYSTEMS (PE – II)

I Year M.Tech (EPS) – 1st Semester	**L**	**T**	**P**	**C**
	3	**0**	**0**	**3**

Course Objectives:

- The Basic concepts, rules for combining probabilities of events, failure density and distribution functions.
- Evaluation of network Reliability / Unreliability and types of redundancies.
- Evaluation of network Reliability / Unreliability using conditional probability method.
- Expected value and standard deviation of Exponential distribution and Measures of reliability.
- Evaluation of Limiting State Probabilities of one, two component repairable models.

UNIT – 1: Basics of Probability Theory, Distribution & Network Modelling 9 Hrs

Basic Probability Theory – Rules for Combining Probabilities of Events – Bernoulli's Trials – Probability Density and Distribution Functions – Binomial Distribution – Expected Value and Standard Deviation of Binomial Distribution – Analysis of Series, Parallel, Series-Parallel Networks – Complex Networks – Decomposition Method.

Learning Outcomes:

At the end of this unit, the student will be able to

- To know about basic rules for probabilities of events **L1**
- Get detailed information about Probability of failure density and distribution Functions and obtain the expected value and standard deviation for binomial distribution. **L2**
- How to find the Probability of success and failures of network using different approaches for series-parallel configurations. **L1**
- To find reliability / unreliability of complex systems using different methods **L2**

UNIT – II: Reliability Functions 9 Hrs

Reliability Functions F(T), F(T), R(T), H(T) and Their Relationships – Exponential Distribution

– Expected Value and Standard Deviation of Exponential Distribution – Bath Tub Curve – Reliability Analysis of Series Parallel Networks Using Exponential Distribution – Reliability Measures MTTF, MTTR, MTBF.

Learning Outcomes:

At the end of this unit, the student will be able to

- Understand the concepts of time domain functions and relationship between them. and obtain the expected value and standard deviation for exponential distribution. **L1**
- To obtain probabilistic measures for fully redundant and partially redundant configurations **L3**

UNIT – III: Markov Modelling And Frequency & Duration Techniques 9 Hrs

Basic concepts – Reliability functions f(t), Q(t), R(t), h(t) – Relationship between these

functions – Bath tub curve – Exponential failure density and distribution functions - Expected value and standard deviation of Exponential distribution – Measures of reliability – MTTF, MTTR, MTBF – Evaluation of network reliability / Unreliability of simple Series, Parallel, Series-Parallel systems -
Partially redundant systems - Evaluation of reliability measure – MTTF for series and parallel systems – Examples.

Learning Outcomes:

At the end of this unit, the student will be able to

- Understand the concepts of Stochastic Transitional Probability Matrix, Limiting State Probability **L1**
- Understand the concept of Frequency balance approach. And To distinguish between Markov chains and Markov processes **L2**

UNIT – IV: Applications To Power Systems -I **9 Hrs**

Generation System Reliability Analysis: Reliability Model of a Generation System– Recursive Relation for Unit Addition and Removal – Load Modeling - Merging of Generation Load Model- Evaluation of Transition Rates for Merged State Model – Cumulative Probability, Cumulative Frequency of Failure Evaluation – LOLP, LOLE, LOEE.

Learning Outcomes:

At the end of this unit, the student will be able to

- Understand the concepts of recursive relation for evaluation of equivalent transitional rates. **L1**
- To know about computation of basic probability indices for series, parallel configurations **L2**

UNIT – V: Applications To Power Systems - II **9 Hrs**

Basic Techniques - Radial Networks – Evaluation of Basic Reliability Indices, Performance Indices – Load Point and System Reliability Indices – Customer Oriented, Loss and Energy Oriented Indices -Examples single feeder - parallel configuration RDS – Network reduction technique – cut set approaches – weather effects – repairable and non – repairable effects modeling and evaluation of basic probability indices.

Learning Outcomes:

At the end of this unit, the student will be able to

- Design the reliability composite systems and distribution systems for finding reliability indices. **L3**

Text Books:

1. Reliability Evaluation of Engineering Systems by Roy Billinton and Ronald N. Allan, Reprinted in India B. S. Publications, 2007.
2. Reliability Engineering by E. Balagurusamy, Tata McGraw Hill, 2003.

Reference Books:

1. Introduction to Reliability Engineering by E. E. Lewis by Wiley Publications.
2. Reliability and Maintainability Engineering by Charles E. Ebeling, Tata McGraw Hill, 2000.
3. Reliability and Safety Engineering by Ajit Kumar Verma, Srividya Ajit and Durga Rao Karanki, Springer, Second Edition, 2016. System Reliability Theory Marvin Rausand and Arnljot Hoyland, Wiley Publications.

Course Outcomes:

At the end of this Course the student will be able to

• Understand the concepts for combining Probabilities of events, Bernoulli's trial, and Binomial distribution.	**L1**
• Network Reliability/Unreliability using conditional probability, path and cutset based approach, complete event tree and reduced event tree methods.	**L2**
• Understanding Reliability functions and to develop relationship between these functions, expected value and standard deviation of Exponential distribution and measures of reliabilities.	**L3**
• Analyze the time dependent reliability evaluation of single component repairable model, frequency and duration concepts, Frequency balance approach.	**L4**
• `Recursive relation for evaluation of equivalent transitional rates, cumulative probability and cumulative frequency and 'n' component repairable model.	**L5**

JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS) PULIVENDULA

POWER SYSTEM OPTIMIZATION (PE – II)

I Year M.Tech (EPS) – 1st Semester	L	T	P	C
	3	0	0	3

Course Objectives:

- Understand the fundamental concepts of Optimization Techniques.
- Analyze the importance of optimizations in real life scenarios.
- Apply the concepts of various classical and modern methods for constrained and unconstrained problems in both single and multivariable.
- Design the algorithms for different optimizations techniques

UNIT – 1: Fundamentals of Particle Swarm Optimization (PSO) Techniques 9 Hrs

Introduction – Basics of Particle Swarm Optimization – Background of PSO – Original PSO – Variation of PSO – Discrete PSO – PSO for MINLPs – Constriction Factor Approach (CFA) – Hybrid PSO (HPSO) – Lbest Model – Adaptive PSO (APSO) Evolutionary PSO (EPSO) – Applications.

Learning Outcomes:

At the end of this unit, the student will be able to

- Understand the concept of optimality criteria for various type of optimization problems. **L2**

UNIT – II: Fundamentals of Ant Colony Search Algorithms 9 Hrs

Introduction – Ant Colony Search Algorithm – Behavior of Real Ants – Ant Colony Algorithms – The Ant System – The Ant Colony System – The Max-Min Ant System – Major Characteristics of Ant Colony Search Algorithm – Distributed Computation: Avoid Premature Convergence – Positive Feedback: Rapid Discovery of Good Solution – Use of Greedy Search and Constructive Heuristic Information: Find Acceptable Solutions in the Early Stage of the Process.

Learning Outcomes:

At the end of this unit, the student will be able to

- Analyze the concept of different optimization techniques in real world applications. **L3**

UNIT – III: Fundamentals of Tabu Search 9 Hrs

Introduction – Overview of the Tabu Search Approach – Problem Formulation – Coding and Representation – Neighborhood Structure – Characterization of the Neighborhood – Functions and Strategies in Tabu Search – Recency- Based Tabu Search – Basic Tabu Search Algorithm – Candidate List Strategies – Tabu tenure – Aspiration Criteria – The Use of Long Term Memory in Tabu Search – Frequency-Based Memory – Intensification – Diversification – Other TS Strategies – Path Relinking – Strategic Oscillation – Applications of Tabu Search.

Learning Outcomes:

At the end of this unit, the student will be able to

- Solve various constrained and unconstrained problems in single variable as well as multivariable. **L2**

UNIT – IV: Application to power systems 9 Hrs

Introduction to power system applications – Model identifications – Dynamic load modeling – Short term load forecasting – Distribution system applications – Network reconfiguration for loss reduction – Optimal protection and switching devices placements – Examples.

Learning Outcomes:

At the end of this unit, the student will be able to

- Design the methods of optimization for real life situation. **L4**

UNIT – V: Power system controls **9 Hrs**

Introduction – Power system controls: Particle Swarm Technique – Problem formulation of VVC – State variables – Problem formulation – Expansion of PSO for MINLP – Voltage security assessment – VVC using PSO – Treatment of state variables – VVC algorithm using PSO – Numerical Examples – IEEE 14 Bus system.

Learning Outcomes:

At the end of this unit, the student will be able to

- Design the methods of Minimization of losses in IEEE 14 Bus System **L4**

Text Books:

1. Kwang Y. Lee and Mohamed A. El- Sharkawi "Modern Heuristic Optimization Techniques Theory and Applications to Power Systems", A John Wiley & Sons. INC. Publication.
2. D. P. Kothari and J. S. Dhillon, "Power System Optimization", Second Edition - PHI Learning Private Limited, 2011.

Reference Books:

1. Jizhong Zhu , "Optimization of power system operation", IEEE Press, John *Wiley* & Sons, Inc., *Publication, 2009*.
2. Joshua adam Taylor, "Convex optimization of power systems'', Cambridge University Press, 2015.

Course Outcomes:

At the end of this Course the student will be able to

- Understand the concept of optimality criteria for various type of optimization problems. **L1**
- Analyze the concept of different optimization techniques in real world applications. **L2**
- Solve various constrained and unconstrained problems in single variable as well as multivariable. **L3**
- Design the methods of optimization for real life situation. **L4**
- Design the methods of Minimization of losses in IEEE 14 Bus System **L5**

JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS) PULIVENDULA

ELECTRIC VEHICLE ENGINEERING (PE – II)

I Year M.Tech (EPS) – 1st Semester	L	T	P	C
	3	0	0	3

Course Objectives:

- To understand and differentiate between Conventional Vehicle and Electric Vehicles, electro mobility and environmental issues of EVs.
- To remember and understand various configurations in parameters of EV system and dynamic aspects of EV.
- To analyze fuel cell technologies in EV and HEV systems.
- To analyze the battery charging and controls required of EVs.

UNIT – I Introduction to EV Systems and Parameters **10 Hrs**

Past, Present and Future of EV - EV Concept- EV Technology- State-of-the Art of EVs- EV configuration- EV system- Fixed and Variable gearing- Single and multiple motor drive- In-wheel drives- EV parameters: Weight, size, force and energy, performance parameters.

Learning Outcomes:

At the end of this unit, the student will be able to

- Learn about EV Technology **L1**
- Learn about different EV parameters **L2**

UNIT-II EV and Energy Sources **10 Hrs**

Electro mobility and the environment- History of Electric power trains- Carbon emissions from fuels- Green houses and pollutants- Comparison of conventional, battery, hybrid and fuel cell electric systems.

Learning Outcomes:

At the end of this unit, the student will be able to

- Understand and estimate the Electric power trains **L1**
- Understand hybrid and fuel cell electric systems **L2**

UNIT-III EV Propulsion and Dynamics **10 Hrs**

Choice of electric propulsion system- Block diagram- Concept of EV Motors- Single and multi motor configurations- Fixed and variable geared transmission- In-wheel motor configuration- Classification- Electric motors used in current vehicle applications- Recent EV Motors- Vehicle load factors- Vehicle acceleration.

Learning Outcomes:

At the end of this unit, the student will be able to

- Understand the Concept of EV Motors **L1**
- Distinguish between Single and multi motor configurations **L2**

UNIT-IV Fuel Cells **10 Hrs**

Introduction of fuel cells- Basic operation- Model- Voltage, power and efficiency- Power plant system – Characteristics- Sizing - Example of fuel cell electric vehicle.

Introduction to HEV- Brake specific fuel consumption- Comparison of Series-Parallel hybrid systems- Examples.

Learning Outcomes:
At the end of this unit, the student will be able to

- Understand the fuel cells **L1**
- Distinguish between Series-Parallel hybrid systems **L2**

UNIT-V Battery Charging and Control **10 Hrs**

Battery charging: Basic requirements- Charger architecture- Charger functions- Wireless charging- Power factor correction.

Control: Introduction- Modeling of electro mechanical system- Feedback controller design approach- PI controllers designing- Torque-loop, Speed control loop compensation- Acceleration of battery electric vehicle.

Learning Outcomes:
At the end of this unit, the student will be able to

- Understand the Wireless charging **L1**
- Understand Torque-loop, Speed control loop compensation **L2**

Text Books:

1. C.C Chan, K.T Chau: Modern Electric Vehicle Technology, Oxford University Press Inc., New York 2001.
2. Ali Emadi, “Advanced Elelctric Drive Vehicles”, CRC Press, 2017.
3. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, “Modern Elelctric, Hybrid Elelctric and Fuel Cell Vehicles: Fundamentals, Theory and Design”, CRC Press, 2004.
4. James Larminie, John Lowry, “Electric Vehicle Technology Explained”, Wiley, 2003.

Reference Books:

1. Electric and Hybrid Vehicles Design Fundamentals, Iqbal Husain, CRC Press 2005.
2. Ali Emadi, Advanced Electric Drive Vehicles, CRC Press, 2015.

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

- To understand and differentiate between Conventional Vehicle and Electric Vehicles, electro mobility and environmental issues of EVs. **L1**
- To remember and understand various configurations in parameters of EV system and dynamic aspects of EV. **L2**
- To analyze fuel cell technologies in EV and HEV systems. **L3**
- To analyze the battery charging and controls required of EV **L4**
- `Understand the fuel cells **L5**

JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS) PULIVENDULA

POWER SYSTEM PROTECTION LAB

I Year M.Tech (EPS) – 1st Semester	**L**	**T**	**P**	**C**
	0	**0**	**4**	**2**

Course Objectives:

To make the student learn about:

- Understand the experiments ensuring the safety of equipment and personnel.
- Analyze the power system data fault studies.
- Interpret the experimental results and correlating them with the practical power system.
- Design the relays for power system protection purpose.

List of Experiments

1. Characteristics of Static/Numeric Over Current Relay
2. Characteristics of Static Negative Sequence Relay
3. Characteristics of Static/Numeric Over Voltage Relay
4. Characteristics of Static/Numeric Percentage Biased Differential Relay
5. Testing of Buchholz relay
6. Testing of Frequency Relay.
7. Testing of Reverse Power Relay.
8. Testing of Earth fault Relay
9. Equivalent Circuit of a Three Winding Transformer
10. Determination of Sub transient Reactance of a Salient Pole Machine
11. Determination of Sequence Impedances of a Cylindrical Rotor Synchronous Machine
12. Fault Analysis
    i) LG Fault ii) LL Fault iii) LLG Fault iv) LLLG Fault
13. Equivalent Circuit of a Three Winding Transformer
14. Separation of No Load losses of a Three Phase Squirrel Cage Induction Motor
15. Power Angle Characteristics of a Salient Pole Synchronous Machine

Note: From the above list minimum 10 experiments are to be conducted .

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

- Understand Load balancing using compensators. Understand the concept of different experiments.
- Analyze the data for and compute the data to obtain results.
- Apply the computational results to solve the original power system problems.
- Have the capability to develop advanced relays to identify various faults.

JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS) PULIVENDULA

POWER SYSTEMS SIMULATION LAB

I Year M.Tech (EPS) – 1st Semester	**L**	**T**	**P**	**C**
	0	**0**	**4**	**2**

Course Objectives:

To make the student learn about:

- Understand how to write the coding in simulation
- Analyze the data related to load flows, economic dispatch problem and transient stability analysis.
- Apply the computational results in real life power system problems.
- Have the capabilities to develop new software's to optimize the results.

List of Experiments

1. Y - Bus Formation
2. Gauss – Seidel Load Flow Analysis
3. Fast Decoupled Load Flow Analysis
4. Fast Decoupled Load Flow Analysis for Distribution Systems
5. Point by Point Method
6. Computation of Available Transfer Capabilities.
7. Contingency analysis.
8. State estimation using Weighted Least Square, linear and non-linear methods.
9. Simulation of power quality problems (Sag/Swell, interruption, transients, harmonics, flickers etc.)
10. Harmonic analysis and Single tuned filter design to mitigate harmonics.
11. Harmonic analysis and Double tuned filter design to mitigate harmonics.
12. Develop Program for Unit Commitment Problem using Forward Dynamic Programming Method.
13. Develop Program for Economic Load Dispacth Problem using Lambda Iterative Method.

Note: From the above list minimum 10 experiments are to be conducted using suitable software.

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

- Understand the coding in simulation
- Analyze the power system data for load-flow and stability studies.
- Apply computational methods for large scale power system studies.
- Develop software for power system industry to solve various issues

JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS) PULIVENDULA

RESEARCH METHODOLOGY & IPR

I Year M.Tech (EPS) – 1st Semester	L	T	P	C
	2	0	0	2

Course Objectives:

- To understand the research problem
- To know the literature studies, plagiarism and ethics
- To get the knowledge about technical writing
- To analyze the nature of intellectual property rights and new developments
- To know the patent rights

UNIT – 1: RESEARCH FORMULATION AND DESIGN **11 Hrs**

Motivation and objectives – Research methods vs. Methodology. Types of research – Descriptive
vs. Analytical, Applied vs. Fundamental, Quantitative vs. Qualitative, Conceptual vs. Empirical, concept of applied and basic research process, criteria of good research.
Defining and formulating the research problem, selecting the problem, necessity of defining the problem, importance of literature review in defining a problem, literature review-primary and secondary sources, reviews, monograph, patents, research databases, web as a source, searching
the web, critical literature review, identifying gap areas from literature and research database, development of working hypothesis.

UNIT – II : DATA COLLECTION AND ANALYSIS **10 Hrs**

Accepts of method validation, observation and collection of data, methods of data collection, sampling methods, data processing and analysis strategies and tools,data analysis with statically
Package (Sigma STAT,SPSS for student t-test, ANOVA, etc.), hypothesis testing.

UNIT – III : INTERPRETATION AND REPORT WRITING **8 Hrs**

Meaning of Interpretation, Technique of Interpretation, Precaution in Interpretation, Significance
of Report Writing, Different Steps in Writing Report, Layout of the Research Report, Types of Reports, Oral Presentation, Mechanics of Writing a Research Report, Precautions for Writing Research Reports, Conclusions.

UNIT – IV : RESEARCH ETHICS, IPR AND SCHOLARY PUBLISHING **8 Hrs**

Ethics-ethical issues, ethical committees (human & animal); IPR- intellectual property rights and patent law, commercialization, copy right, royalty, trade related aspects of intellectual property rights (TRIPS); scholarly publishing- IMRAD concept and design of research paper, Citation and acknowledgement, plagiarism, reproducibility and accountability.

UNIT – V **8 Hrs**

Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information
and databases. Geographical Indications. New Developments in IPR: Administration of Patent

System.
New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge
Case Studies, IPR and IITs.

Text Books:

1. Stuart Melville and Wayne Goddard, “Research methodology: an introduction for science & engineering students’”
2. Kothari, C.R., 1990. Research Methodology: Methods and Techniques. New Age International. 418p.

Reference Books:

1. Sinha, S.C. and Dhiman, A.K., 2002. Research Methodology, Ess Ess Publications. 2 volumes.
2. Carlos, C.M., 2000. Intellectual property rights, the WTO and developing countries: the TRIPS agreement and policy options. Zed Books, New York.
3. T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand, 2008

Course Outcomes:

At the end of this Course the student will be able to

• Understand research problem formulation.	**L4**
• Analyze research related information	**L3**
• Follow research ethics	**L5**
• Understand that today’s world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.	**L2**
• Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.	**L5**

JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS) PULIVENDULA

RESEARCH PAPER WRITING SKILLS
(Audit Course - I)

I Year M.Tech (EPS) – 1st Semester

L	T	P	C
2	0	0	0

Course Objectives:

- Understand that how to improve your writing skills and level of readability
- Learn about what to write in each section
- Understand the skills needed when writing a Title Ensure the good quality of paper at very first-time submission

UNIT – 1: **8 Hrs**

Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness

UNIT – II : **8 Hrs**

Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticizing, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts. Introduction

UNIT – III : **8 Hrs**

Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check.

UNIT – IV : **8 Hrs**

key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature

UNIT – V **8 Hrs**

skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions. useful phrases, how to ensure paper is as good as it could possibly be the first- time submission

Text Books:

1. Goldbort R (2006) Writing for Science
2. Day R (2006) How to Write and Publish a Scientific Paper

Reference Books:

1. Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM. Highman'sbook.

2. Adrian Wallwork, English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011

JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS) PULIVENDULA

POWER SYSTEM STABILITY & CONTROL

I Year MTECH (EPS)- 2nd Semester

L	T	P	C
3	0	0	3

Course Objectives:

- Understand about linear and nonlinear models of multi-machine power systems.
- Analyze various types of stability properties of power systems.
- Identify power system models from dynamic data and simulate excitation mechanisms in synchronous machines.
- Design excitation systems and their state space model equations for further stability applications.
- Understand about Voltage and Angle stability

UNIT-I: The Elementary Mathematical Model **10 Hrs**

Introduction to equal area criteria – Power Angle curve of a Synchronous Machine – Model of single machine connected to an infinite bus – Model of multimachine system – Problems – Classical Stability Study of multimachine system – Effect of the excitation system on Transient stability.

Learning Outcomes:

At the end of this unit, the student will be able to

- Learn about model of single and machine system connected to the infinite bus bar **L1**
- Learn about stability of multi machine system **L2**

UNIT – II: System Response to Small Disturbances and Dynamic Stability **10 Hrs**

The unregulated synchronous Machine – Modes of oscillation of an unregulated multimachine system – Regulated synchronous machine – Voltage regulator with one time lag – Governor with one time lag – Problems - Concept of Dynamic stability – State-space model of single machine system connected to infinite bus – Effect of excitation on Dynamic stability – Examination of dynamic stability by Routh-Hurwitz criterions.

Learning Outcomes:

At the end of this unit, the student will be able to

- Understand behavior of unregulated synchronous machine **L1**
- Understand Voltage and Governor regulator with one time lag **L2**
- Understand the concept of Dynamic stsbility **L3**
- Understand the R-H criterian for dynamic stability **L4**

UNIT – III: Power System Stabilizers **10 Hrs**

Introduction to supplementary stabilizing signals – Block diagram of the linear system – Approximate model of the complete exciter – Generator system – Lead compensation – Stability analysis using eigen value approach.

Learning Outcomes:

At the end of this unit, the student will be able to

- Understand the supplementary stabilizing signals **L1**
- Understand the approximate model of the complete exciter **L2**
- Understand the lead compensation and stability analysis using eigen value approach **L3**

UNIT – IV: Excitation Systems 10 Hrs

Introduction to excitation systems – Non-continuously, Continuously regulated systems – Excitation system compensation – State-space description of the excitation system – Simplified linear model – Effect of excitation on generator power limits. Type-2, Type-3 and Type-4 excitation systems and their state-space modeling equations.

Learning Outcomes:

At the end of this unit, the student will be able to

- Understand the Non – continuous and continuous excitation systems **L1**
- Understand the state space model for excitation systems **L2**
- Understand the various types of excitation systems **L3**

UNIT – V: Stability Analysis 10 Hrs

Review of Lyapunov's stability of non-linear systems using energy concept – Method based on first concept – Method based on first integrals – Zubov's method – Popov's method – Lyapunov function for single machine connected to infinite bus – Voltage stability – Factors affecting voltage instability and collapse – Comparison of Angle and Voltage stability – Analysis of voltage instability and collapse – Control of voltage instability.

Learning Outcomes:

At the end of this unit, the student will be able to

- Understand the Stability analysis of Non linear systems **L1**
- Understand the various Non linear stability methods **L2**
- Understand the Voltage and Angle stability analysis **L3**

Text Books:

1. Vijay Vittal, James D. McCalley, Paul M. Anderson "Power System Control and Stability", Jhon Willey and Sons, 2019.
2. Prabha Kundur, "Power System Control and Stability", McGraw Hill Education India, 2008.

Reference Books:

1. Dr Jan Machowski, Dr Janusz W. Bialek, Dr Jim Bumby · "Power System Dyanmics: Stability and Control", Jhon willey and Sons, 2nd Edition, 2011.
2. M.A.Pai, Power System Stability-Analysis by the direct method of Lyapunov, North Holland Publishing Company, New York, 1981.
3. L.P. Singh , "Advanced Power System Analysis and Dynamics", New Age International, 2006.

JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS) PULIVENDULA

FACTS CONTROLLERS

I Year MTECH (EPS)- 2nd Semester

L	T	P	C
3	0	0	3

Course Objectives:

To make the student learn about:

- To know the basic definitions and different types of Facts controllers and their uses.
- To know about the voltage source converter operation and different modulation techniques with comparison.
- To deal with the objectives of shunt and series compensation..
- To enhance the transient stability and power oscillation damping by SVC and STATCOM.
- The working principle, structure and control of UPFC.
- The operation, structure and control of IPFC.

UNIT – I: FACTS CONCEPTS, VSI AND CSI **10 Hrs**

Transmission interconnections power flow in an AC system, loading capability limits, Dynamic stability considerations, importance of controllable parameters basic types of FACTS controllers, benefits from FACTS controllers. Single phase three phase full wave bridge converters transformer connections for 12 pulse 24 and 48 pulse operation. Three level voltage source converter, pulse width modulation converter, basic concept of current source Converters, and comparison of current source converters with voltage source converters.

Learning Outcomes:

At the end of this unit, the student will be able to

- To learn about basic definitions and power flow in AC systems **L1**
- To know about the different types of Facts controllers and their uses. **L2**

UNIT – II: SHUNT COMPENSATION 10 Hrs

Objectives of shunt compensation - Methods of controllable var generation - variable impedance type static var generators - switching converter type var generators - hybrid var generators – Comparison of SVC and STATCOM.

Learning Outcomes:

At the end of this unit, the student will be able to

- To understand voltage source converters and Transformation connections **L1**
- To distinguish between SVC and STATCOM **L2**

UNIT – III: SERIES COMPENSATION **10 Hrs**

Objectives of series compensation–GTO Thyristor Controlled Series Capacitor (GCSC)-Thyristor Switched Series Capacitor (TSSC) - Thyristor Controlled Series Capacitor (TCSC) - Control schemes for TCSC, TSSC and TCSC.

Learning Outcomes:

At the end of this unit, the student will be able to

- To understand the objectives of series compensation. **L1**
- To understand the control method of GCSC,TSSC&TCSC. **L2**

UNIT – IV: UNIFIED POWER FLOW CONTROLLER (UPFC) 10 Hrs

Introduction - The Unified Power Flow Controller - Basic Operating Principles - Conventional Transmission Control Capabilities - Independent Real and Reactive Power Flow Control - Control Structure – Basic Control System for P and Q Control-Hybrid Arrangements: UPFC With a Phase Shifting Transformer.

Learning Outcomes:

At the end of this unit, the student will be able to

- To understand the UPFC **L1**
- To understand the control structure and Hybrid Arrangements **L2**

UNIT – V: INTER LINE POWER FLOW CONTROLLER (IPFC) 10 Hrs

Introduction, basic operating principle and characteristics of IPFC, control structure, practical and application considerations, generalized and multi functional fact controllers.

Learning Outcomes:

At the end of this unit, the student will be able to

- To know about IPFC. **L1**
- To understand the Multi functional facts controllers **L2**

Text Books:

1. Hingorani HGandGyugyi.L"Understanding FACTS-Concepts and Technology of Flexible AC Transmission Systems" NewYork,IEEE Press,2000.
2. Padiyar K.R," FACTS Controllers in Power Transmission and Distribution" New Age Int.Publishers,2007

Reference Books:

1. Zhang,Xiao-Ping, Rehtanz,Christian,Pal,Bikash"Flexible AC Transmission Systems: Modeling and Control",Springer,2012.
1. Yong-Hua Song, AllanJohns, "Flexible AC Transmission Systems", IET,1999.

Course Outcomes:

At the end of this Course the student will be able to

- Know the basic definitions and different types of Facts controllers and their uses. **L1**
- Know about the voltage source converter operation and different modulation Techniques with comparison. **L2**
- Improve the stability of power system by Shunt Compensation and Series Compensation with facts controllers. **L3**
- The operation of Unified Power Controller and Hybrid Arrangements. **L4**

JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS) PULIVENDULA

ENERGY AUDITING, CONSERVATION AND MANAGEMENT (PE-III)

I Year MTECH (EPS)- 2nd Semester

L	T	P	C
3	0	0	3

Course Objectives: This course enables the students to know

• The growing worldwide concern for conservation of energy has reawakened interest in ecologically
Sustainability, processes and sources of energy.

• The better ways to conserve the energy from energy audit concepts, Representations and energy
Conservation schemes.

• Management skills and communication of energy manager.

• Various operational problems and remedies of motor and electrical devices.

• Evaluation of life time of machine based on time value money and demand.

UNIT – 1: BASIC PRINCIPLES OF ENERGY AUDIT **10 Hrs**

Energy audit- definitions, concept , types of audit, energy index, cost index ,pie charts, Sankey diagrams, load profiles and Energy conservation schemes- Energy audit of industries- energy saving potential, energy audit of process industry, thermal power station, building energy audit.

Learning Outcomes:

At the end of this unit

- Student can understand the concepts of energy audit **L1**
- Student can learn process of energy audit **L2**

UNIT – II: ENERGY MANAGEMENT **10 Hrs**

Principles of energy management, organizing energy management program, initiating, planning, controlling,promoting, monitoring, reporting- Energy manger, Qualities and functions, language, Questionnaire – check list for top management.

Learning Outcomes:

At the end of this unit

- Student can able to learn the principles of energy management **L1**
- Student can understand the qualities and functions of energy manager **L2**

UNIT – III: ENERGY EFFICIENT MOTORS **10 Hrs**

Energy efficient motors , factors affecting efficiency, loss distribution , constructional details , characteristics -variable speed , variable duty cycle systems, RMS hp- voltage variation-voltage unbalance- over motoring- motor energy audit

Learning Outcomes:

At the end of this unit,

- Student can understand the internal and external problems of a motor **L1**
- Student can able to learn the making of normal motor in to energy efficient motor **L2**

UNIT – IV: POWER FACTOR IMPROVEMENT, LIGHTING AND ENERGY INSTRUMENTS **10 Hrs**

Power factor – methods of improvement, location of capacitors, Pf with non linear loads, effect of harmonics on power factor, power factor motor controllers - Good lighting system design and practice, lighting control ,lighting energy audit - Energy Instruments- wattmeter, data loggers, thermocouples, pyrometers, lux meters, tongue testers and application of PLC's

Learning Outcomes:

At the end of this unit

- Student can understand the importance of power factor ,lighting and energy instruments **L1**
- Student can learn the implementation of energy conservation schemes **L2**

UNIT – V: ECONOMIC ASPECTS AND ANALYSIS **10 Hrs**

Economics Analysis-Depreciation Methods, time value of money, rate of return , present worth method ,replacement analysis, life cycle costing analysis- Energy efficient motors- calculation of simple payback method, net present worth method- Power factor correction, lighting - Applications of life cycle costing analysis, return on investment.

Learning Outcomes:

At the end of this unit

- Student can understand the economic aspects and analysis **L1**
- Student can learn the how the economic analysis is related to energy aditing **L2**

Text Books:

1. Energy management by W.R. Murphy AND G. McKay Butter worth, Heinemann
2. publications.
3. Electrical Energy Utilization and Conservation by S.C.Tripathy(Tata Mc Graw Hill)

Reference Books:

1. Energy management by Paul o' Callaghan, Mc-graw Hill Book company-1st edition,1998
2. Energy efficient electric motors by John .C. Andreas, Marcel Dekker Inc Ltd-2nd edition, 1995
3. Energy management hand book by W.C. Turner, John wiley and sons
4. Energy management and good lighting practice: fuel efficiency- booklet12-EEO

Course Outcomes:

At the end of this Course the student will have the knowledge on

Current energy scenario and energy management	**L1**
Energy auditing	**L2**
conservation and economic analysis	**L3**
Systematic knowledge and skill about assessing the energy efficiency	**L4**
Systematic knowledge and skill about assessing the energy auditing and energy Management.	**L5**

JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS) PULIVENDULA

SMART ELECTRIC GRID TECHNOLOGIES (PE-III)

I Year MTECH (EPS)- 2nd Semester

L	T	P	C
3	0	0	3

Course Objectives:

- To learn about recent trends in grids as smart grid
- To understand about smart grid architecture and technologies
- To know about smart substations
- To learn about smart transmission systems
- To learn about smart distribution systems

UNIT – 1: INTRODUCTION TO SMART GRID **10 Hrs**

Working definitions of Smart Grid and Associated Concepts – Smart Grid Functions – Traditional Power Grid and Smart Grid – New Technologies for Smart Grid – Advantages – Indian Smart Grid – Key Challenges for Smart Grid Smart Grid Architecture: Components and Architecture of Smart Grid Design – Review of the proposed architectures for Smart Grid. The fundamental components of Smart Grid designs – Transmission Automation – Distribution Automation – Renewable Integration

Learning Outcomes:

At the end of this unit, the student will be able to

- To understand basic definitions and architecture of Smart grid **L1**
- To understand the need for integration of Renewable energy sources **L2**

UNIT – II: SMART METERS **9 Hrs**

Introduction to Smart Meters, Real Time Prizing, Smart Appliances, Automatic Meter Reading(AMR), Outage Management System(OMS), Plug in Hybrid Electric Vehicles(PHEV), Vehicle to Grid, Smart Sensors, Home & Building Automation, Smart Substations, Substation Automation, Feeder Automation .

Learning Outcomes:

At the end of this unit, the student will be able to

- To know about basic characteristic features of smart grid technologies **L1**
- To know about integration requirements, standards of renewable energy sources in Microgrids **L2**

UNIT – III: SMART SUBSTATIONS **9 Hrs**

Protection, Monitoring and control devices, sensors, SCADA, Master stations, Remote terminal unit, interoperability and IEC 61850, Process level, Bay level, Station level, Benefits, role of substations in smart grid, Volt/VAR control equipment inside substation

Learning Outcomes:

At the end of this unit, the student will be able to

- To know about protection, monitor and control devices in Smart substations **L1**
- To understand about Volt/VAR control equipment inside substation **L3**

UNIT – IV: SMART TRANSMISSION **10 Hrs**

Energy Management systems, History, current technology, EMS for the smart grid, Wide

Area Monitoring Systems (WAMS), protection & Control (WAMPC), needs in smart grid, Role of WAMPC smart grid, Drivers and benefits, Role of transmission systems in smart grid, Synchro Phasor Measurement Units (PMUs)

Learning Outcomes:

At the end of this unit, the student will be able to

- To know about Energy Management Systems in smart transmission systems **L1**
- To know about role of transmission systems in Smart grid **L2**

UNIT – V: Smart Distribution Systems **9 Hrs**

DMS, DSCADA, trends in DSCADA and control, current and advanced DMSs, Voltage fluctuations, effect of voltage on customer load, Drivers, objectives and benefits, voltage-VAR control, VAR control equipment on distribution feeders, implementation and optimization, FDIR - Fault Detection Isolation and Service restoration (FDIR),faults, objectives and benefits, equipment, implementation

Learning Outcomes:

At the end of this unit, the student will be able to

- To know about DSCADA in Smart Distribution Systems **L1**
- To understand about VAR control and equipment on distribution feeders **L2**

Text Books:

1. Stuart Borlase, Smart Grids - Infrastructure, Technology and Solutions, CRC Press,1e, 2013
2. Gil Masters, Renewable and Efficient Electric Power System, Wiley–IEEE Press, 2e,2013.

Reference Books:

1. A.G. Phadke and J.S. Thorp, Synchronized Phasor Measurements and theirApplications,
   Springer Edition, 2e, 2017.
2. T. Ackermann, Wind Power in Power Systems, Hoboken, NJ, USA, John Wiley, 2e,2012.

Course Outcomes:

At the end of this Course the student will be able to

- To be able to understand trends in Smart grids **L1**
- To understand the needs and roles of Smart substations **L2**
- To understand the needs and roles of Smart Transmission systems **L3**
- To understand the needs and roles of Smart Distribution systems **L4**
- `To distinguish between SCADA and DSCADA systems in practical working environment **L5**

JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS) PULIVENDULA

EHVAC TRANSMISSION (PE-III)

I Year MTECH (EPS)- 2nd Semester

L	T	P	C
3	0	0	3

Course Objectives:

- To understand the basic concepts of EHVAC
- To Identify the factors affecting AC-DC transmission
- To analyze travelling waves and the effects of corona like audible noise
- To estimate field intensity at any point in EHV system with the help of different computational method

UNIT – 1: PRELIMINARIES **10 Hrs**

Necessity of EHV AC transmission – Advantages and problems – Power handling capacity and line losses- Mechanical considerations – Resistance of conductors – Properties of bundled conductors – Bundle spacing and bundle radius - Examples

Learning Outcomes:

At the end of this unit, the student will be able to

- Learn about Necessity of EHV AC transmission L1
- Learn about Properties of bundled conductors L2

UNIT – II: LINE AND GROUND REACTIVE PARAMETERS **10 Hrs**

Line inductance and capacitances – Sequence inductances and capacitances – Modes of propagation – Ground return – Examples. Electrostatics – Field of sphere gap – Field of line changes and properties – Charge – potential relations for multi-conductors – Surface voltage gradient on conductors – Distribution of voltage gradient on sub-conductors of bundle – Examples.

Learning Outcomes:

At the end of this unit, the student will be able to

- Understand and estimate Line inductance and capacitances L1
- Understand potential relations for multi-conductor L2

UNIT – III CORONA EFFECTS **10 Hrs**

Power loss and audible noise (AN) – corona loss formulae – Charge voltage diagram – Generation, characteristics - Limits and measurements of AN – Relation between 1-phase and 3 -phase AN levels – Radio interference (RI) - Corona pulses generation, properties, limits – Frequency spectrum – Modes of propagation – Excitation function – Measurement of RI, RIV and excitation functions - Examples.

Learning Outcomes:

At the end of this unit, the student will be able to

- Understand the Relation between 1-phase and 3 -phase AN levels L1
- Distinguish between Measurement of RI, RIV and excitation functions L2

UNIT – IV: ELECTROSTATIC FIELD & TRAVELING WAVE THEORY **10 Hrs**

Electrostatic field: calculation of electrostatic field of EHV/AC lines – Effect on humans, animals and plants – Electrostatic induction in un-energized circuit of double - circuit line – Electromagnetic interference - Examples. Traveling wave expression and solution - Source of excitation - Terminal conditions - Open circuited and short circuited end - Reflection and refraction coefficients - Lumped parameters of distributed lines - Generalized constants - No load voltage conditions and charging current

Learning Outcomes:

At the end of this unit, the student will be able to

- Understand the calculation of electrostatic field of EHV/AC lines L1
- Distinguish between - Open circuited and short circuited end - Reflection and refraction coefficients L2

UNIT – V: : VOLTAGE CONTROL 10 Hrs

Power circle diagram and its use – Voltage control using synchronous condensers – Cascade connection of shunt and series compensation – Sub synchronous resonance in series capacitor – Compensated lines – Static VAR compensating system.

Learning Outcomes:

At the end of this unit, the student will be able to

- Understand Voltage control using synchronous condensers L1
- Understand Static VAR compensating system L2

Text Books:

1. Sanjay Kumar Sharma, "EHV-AC,HVDC Transmission and Distribution Engineering" Edition 2, 2016.
2. R. D. Begamudre, "EHVAC Transmission Engineering", New Age International (p) Ltd.2013.
3. M. G. Dwek, EHV Transmission, Elsevier Sc., 1991.

Reference Books:

1. R. Padiyar, HVDC Transmission Systems, Wiley Eastern Ltd., New Delhi , 1992.
2. J. Arrilaga, High Voltage Direct Current Transmission, peter pereginver Ltd.London, U.K., 1998.
3. E.W. Kimbark, Direct Current Transmission-vol.1, Wiley Inter science, New York , 1971

Course Outcomes:

At the end of this Course the student will be able to

- Understand the basic concepts of EHVAC L1
- Identify the factors affecting AC-DC transmission L2
- Analyze travelling waves and the effects of corona like audible noise L3
- Estimate field intensity at any point in EHV system with the help of different computational method. L4
- Understand the basic concepts of EHVAC L5

JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS) PULIVENDULA

RESTRUCTURED POWER SYSTEMS (PE-IV)

I Year MTECH (EPS)- 2nd Semester

L	T	P	C
3	0	0	3

Course Objectives: Students will be able to

- Understand basic concepts of the restructuring of power industry and market models.
- Analyze about the fundamental concepts of congestion management, Transfer Capability issues and ancillary service management.
- Apply the transmission cost allocation methods to evaluate the cost.
- Develop the operational planning activities in different competitive environment

UNIT – 1: KEY ISSUES IN ELECTRIC UTILITIES **10 Hrs**

Introduction – Restructuring models – Independent System Operator (ISO) – Power Exchange – Market operations – Market Power – Standard cost – Transmission Pricing – Congestion Pricing – Management of Inter zonal/Intra zonal Congestion.

Learning Outcomes:

At the end of this unit, the student will be able to

- Learn about restructuring models,ISO **L2**
- Knows how to manage the Intra&Inter zonal congestional problem. **L2**

UNIT – II: OPENACCESS SAME-TIME INFORMATION SYSTEM (OASIS) &MARKETPOWER **10 Hrs**

Structure of OASIS – Posting of Information – Transfer capability on OASIS – Market Power: Introduction – Different types of market Power – Mitigation of Market Power – Examples

Learning Outcomes:

At the end of this unit, the student will be able to

- Understands what is OASIS **L2**
- Apply the market power techniques in RPS. **L3**

UNIT – III: AVAILABLE TRANSFER CAPABILITY (ATC) &ELECTRICITY PRICING **10 Hrs**

Transfer Capability Issues – ATC – TTC – TRM – CBM Calculations – Calculation of ATC based on power flow – Electricity Pricing: Introduction – Electricity Price Volatility Electricity Price Indexes – Challenges to Electricity Pricing – Construction of Forward Price Curves – Short-time Price Forecasting.

Learning Outcomes:

At the end of this unit, the student will be able to

- Understands the transfer capability issues. **L2**
- Understands the electric pricing,indexes and challenges. **L2**

UNIT – IV: POWER SYSTEM OPERATION IN COMPETITIVE ENVIRONMENT 10 Hrs

Introduction – Operational Planning Activities of ISO – The ISO in Pool Markets – The ISO in Bilateral Markets – Operational Planning Activities of a GENCO

Learning Outcomes:

At the end of this unit, the student will be able to

- Understands operational planning activities of ISO in pool & bilateral. **L2**
- Understands the operational planning activities of GENCO in POOL& Bilateral **L2**

UNIT – V: TRANSMISSION COST ALLOCATION METHODS &ANCILLARYSERVICES MANAGEMENT 10 Hrs

Introduction – Transmission Cost Allocation Methods: Postage Stamp Rate Method – Contract Path Method – MW-Mile Method – Unused Transmission Capacity Method – MVA-Mile method – Comparison of cost allocation methods – Ancillary Services Management: Introduction – Reactive Power as an Ancillary Service, a Review – Synchronous Generators as Ancillary Service Providers.

Learning Outcomes:

At the end of this unit, the student will be able to

- Apply the various transmission cost allocation methods. **L3**
- Unferstands the Ancillary services. **L2**

Text Books:

1. Kankar Bhattacharya, Math H.J. Boller and JaapE.Daalder, Operation of Restructured Power System, Kulwer Academic Publishers, 2001.
2. Mohammad Shahidehpour and Muwaffaq Alomoush, Restructured Electrical PowerSystems, Marcel Dekker, Inc., 2001.

Reference Books:

1. Loi Lei Lai, Power System Restructuring and Deregulation, John Wiley & Sons Ltd.,England, 2001.

Course Outcomes:

At the end of this Course the student will be able to

1. Understand the differences between the conventional power system operation and the restructured one and basics concepts of market power, electricity pricing and competitive environment. **L2**
2. Analyze the concepts of Independent System Operator (ISO) and Open Access Same-Time Information System (OASIS). **L4**
3. Apply the methods to find Available Transfer Capability (ATC) and to allocate the Transmission cost. **L3**
4. Develops power markets and market architectural aspects and short time Price forecasting **L3**

JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS) PULIVENDULA

POWER QUALITY (PE-IV)

I Year MTECH (EPS)- 2nd Semester

L	T	P	C
3	0	0	3

Course Objectives:
To make the student learn about:

- To learn about voltage disturbances and power transients that is occurring in power systems
- To know about voltage sag and transient over voltages for quality of power supply
- To understand about harmonics and their mitigation
- To study about different power quality measuring and monitoring concepts.
- To know about long duration voltage variations

UNIT – 1 POWER QUALITY ISSUES **10 Hrs**

Power quality, voltage quality, The power quality Evaluation procedure, Terms and Definitions, Transients, Long-duration voltage variations, short-duration voltage variations, voltage imbalance, wave form distortion, voltage fluctuation, power frequency variations, power quality terms CBEMA and ITI curves.

Learning Outcomes:
At the end of this unit, the student will be able to

- To learn about various issues of power quality **L1**
- To know about the evaluation procedure of power quality issues **L2**

UNIT – II: VOLTAGE SAGS AND TRANSIENT OVER VOLTAGES **10 Hrs**

Sources of sags and interruptions, Estimating voltage sag performance, fundamental principles of protection, solutions at the end-use level, Motor-starting sags and utility system fault-clearing issues, sources of over voltages, principles of over voltage protection, devices for over voltage protection, utility capacitor-switching transients, utility system lightning protection.

Learning Outcomes:
At the end of this unit, the student will be able to

- To understand what is meant by voltage sag **L1**
- To know about voltage sag performance estimations **L2**

UNIT – III: FUNDAMENTALS OF HARMONICS **10 Hrs**

Harmonic sources from commercial and industrial loads, locating harmonic sources, Power system response characteristics, Harmonics Vs transients, Effect of harmonics, harmonic distortion, voltage and current distortion, harmonic indices, inter harmonics, resonance, harmonic distortion evaluation, devices for controlling harmonic distortion, passive and active filters, IEEE and IEC Standards.

Learning Outcomes:
At the end of this unit, the student will be able to

- To understand about effects of harmonics **L1**
- To distinguish between voltage and current harmonics **L2**

UNIT – IV: LONG-DURATION VOLTAGE VARIATIONS **10 Hrs**

Principles of regulating the voltage, Devices for voltage regulation, utility voltage regulator Application, capacitors for voltage regulation, End user capacitor applications, flicker.

Learning Outcomes:

At the end of this unit, the student will be able to

- To know about principles of regulating the voltages **L1**
- To understand about the necessity of power electronic devices for voltage regulation **L2**

UNIT – V: POWER QUALITY BENCH MARKING AND MONITORING **10 Hrs**

Benchmarking process, RMS Voltage variation Indices, Harmonic indices Power Quality Contracts, Monitoring considerations, power quality measurement equipment, Power quality Monitoring Standards

Learning Outcomes:

At the end of this unit, the student will be able to

- To know about what is meant by bench marking in power quality issues **L1**
- To identify and able to compute voltage variation indices **L2**

Text Books:

1. Electrical Power Systems Quality by Roger C. Dugan, Mark F.McGranaghan, Surya Santoso, H.Wayne Beaty, 2nd Edition, TMH Education Pvt. Ltd, 2012
2. Power quality by C. Sankaran, CRC Press, 2017

Reference Books:

1. Electrical systems quality Assessment by J. Arrillaga, N.R. Watson, S. Chen, John Wiley & Sons, 2000.
2. Understanding Power quality problems by Math H. J. Bollen, Wiley-IEEE Press, 2000

Course Outcomes:

At the end of this Course the student will be able to

- To get knowledge about different power quality issues and to mitigate them **L1**
- Analyze voltage disturbances and power transients that are occurring in power systems. **L2**
- Understand the concept of harmonics in the system and their effect on different power system equipment. **L3**
- Able to understand the principles of regulation of long duration voltage variations **L4**
- To get knowledge about different power quality measuring and monitoring concepts **L5**

JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS) PULIVENDULA

REACTIVE POWER COMPENSATION & MANAGEMENT (PE-IV)

I Year MTECH (EPS)- 2nd Semester

L	T	P	C
3	0	0	3

Course Objectives:

- To identify the necessity of reactive power compensation
- To describe load compensation and various types of reactive power compensation in transmission systems
- To illustrate reactive power coordination system
- To characterize distribution side and utility side reactive power management.

UNIT – I LOAD COMPENSATION **10 Hrs**

Objectives and specifications – Reactive power characteristics – Inductive and capacitive approximate biasing – Load compensator as a voltage regulator – Phase balancing and power factor correction of unsymmetrical loads - Examples.

Learning Outcomes:

At the end of this unit, the student will be able to

- Learn about Reactive power characteristics **L1**
- Learn about Phase balancing and power factor correction of unsymmetrical loads **L2**

UNIT-II STEADY – STATE & TRANSIENT STATE REACTIVE **10 Hrs**

Uncompensated line – Types of compensation – Passive shunt and series and dynamic shunt compensation – Characteristic time periods – Passive shunt compensation – Static compensation- Series capacitor compensation – Compensation using synchronous condensers –Examples.

Learning Outcomes:

At the end of this unit, the student will be able to

- Understand Static compensation and Series capacitor compensation **L1**
- Understand Types of compensation **L2**

UNIT-III REACTIVE POWER COORDINATION & DEMAND SIDE MANAGEMENT **10 Hrs**

Objective – Mathematical modeling – Operation planning – Transmission benefits – Basic concepts of quality of power supply – Disturbances - Steady – state variations – Effects of under Voltages – Frequency – Harmonics, radio frequency and electromagnetic interferences. Load patterns – Basic methods - load shaping – Power tariffs - KVAR based tariffs - penalties for voltage flickers and Harmonic voltage levels.

Learning Outcomes:

At the end of this unit, the student will be able to

- Understand the Concept of quality of power supply **L1**
- Understand load sharing **L2**

UNIT-IV DISTRIBUTION & USER SIDE REACTIVE POWER MANAGEMENT 10 Hrs

System losses – Loss reduction methods – Examples – Reactive power planning – Objectives – Economics - Planning capacitor placement – Retrofitting of capacitor banks - KVAR requirements for domestic appliances – Purpose of using capacitors – Selection of capacitors – Deciding factors – Types of capacitors, characteristics and Limitations.

Learning Outcomes:

At the end of this unit, the student will be able to

- Understand the KVAR requirements for domestic appliances **L1**
- Understand Types of capacitors, characteristics and Limitations. **L2**

UNIT-V REACTIVE POWER MANAGEMENT IN ELECTRIC TRACTION SYSTEMS AND ARC FURNACES 10 Hrs

Typical layout of traction systems – Reactive power control requirements – Distribution transformers - Electric arc furnaces – Furnaces transformer – Filter requirements – Remedial measures – Power factor of an arc furnace.

Learning Outcomes:

At the end of this unit, the student will be able to

- Understand the Reactive power control requirements **L1**
- Understand Filter requirements – Remedial measures **L2**

Text Books:

1. T.J.E.Miller, “Reactive Power Control in Electric Systems”,JohnWileyandSons,2017.
2. D.M.Tagare,Reactivepower Management,TataMcGrawHill,2004.

Reference Books:

1. Dr. Hidaia alassouli, “Reactive Power Compensation”, Kindle Edition.2018.
2. Wolfgang Hofmann, Jurgen Schlabbach, Wolfgang Just “Reactive Power Compensation: A Practical Guide, April, 2012, Wiely publication

Course Outcomes:

At the end of this Course the student will be able to

- Understand the importance of load compensation in symmetrical as well as unsymmetrical loads **L1**
- Analyze various compensation methods in transmission lines **L2**
- Design model for reactive power coordination **L3**
- Distinguish demand side reactive power management & user side reactive power management **L4**
- Understand the Reactive power control requirements **L5**

JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS) PULIVENDULA

RENEWABLE ENERGY LAB

I Year MTECH (EPS)- 2nd Semester

L	T	P	C
0	0	4	2

List of Experiments

1. Draw the I-V and P-V curves of Solar Panel using PV Panel
2. Study of Series and Parallel connection of Solar Panels
3. Study of Sun tracking system
4. Maximum Power Point Tracking Charge Controllers
5. Inverter control for Solar PV based systems
6. Power, Voltage & Frequency Measurement of output of Wind Generator
7. Impact of load and wind speed on power output and its quality
8. Performance of frequency drop characteristics of induction generator at different loading condition
9. Charging and Discharging characteristics of Battery

Simulation Experiments

10. Modeling of PV Cell
11. Effect of temperature variation on Photovoltaic Array
12. Effect of Irradiation on a Photovoltaic Array
13. Design of solar PV boost converter using P&O MPPT technique

Note: From the above list minimum 10 experiments are to be conducted using suitable software.

JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS) PULIVENDULA

FACTS DEVICES & SIMULATION LAB

I Year MTECH (EPS)- 2nd Semester

L	T	P	C
0	0	4	2

Course Objectives:

To make the student learn about:

- Understand how to write the coding in MATLAB/Mipower
- Apply the SVC, STATCOM for voltage profile improvements & UPFC in power system networks.
- Analyze the data related to load flows incorporating SVC & STATCOM.
- Analyze operation of TCSC, STATCOM & SSSC for a transmission line fed by an ac supply.

List of Experiments

1. Voltage regulation using shunt and series compensation
2. Load balancing in power system network using compensators
3. Simulation of TCSC
4. Voltage profile improvement using SVC
5. Voltage profile improvement using STATCOM
6. Transient Stability enhancement using STATCOM.
7. Simulation of UPFC with mathematical models
8. Load flow incorporating SVC
9. Load flow incorporating STATCOM
10. Simulation of DVR
11. Transmission Line Characteristics (P vs δ, Q vs δ, P vs Distance, Q vs Distance and V vs Distance) with and without Compensation
12. Sizing- simulation and operation of TCR and FC-TCR for a transmission line fed by an ac supply and feeding
    (a) Resistive/inductive/capacitive load one at a time
    (b) A load which can have leading as well as lagging behavior
13. Sizing- simulation and operation of TCSC for a transmission line fed by an ac supply and feeding
    (a) Resistive/inductive/capacitive load one at a time
    (b) A load which can have leading as well as lagging behavior
14. Sizing- simulation and operation of STATCOM for a transmission line fed by an ac supply and feeding
    (a) Resistive/inductive/capacitive load one at a time
    (b) A load which can have leading as well as lagging behavior
15. Sizing- simulation and operation of SSSC for a transmission line fed by an ac supply and feeding
    (a) Resistive/inductive/capacitive load one at a time
    (b) A load which can have leading as well as lagging behavior

Note: From the above list minimum 10 experiments are to be conducted using suitable software.

References

1. Zhang,Xiao-Ping,Rehtanz,Christian,Pal,Bikash“Flexible AC Transmission Systems: Modeling and Control”,Springer,2012.
2. HingoraniHGandGyugyi.L“Understanding FACTS-Concepts and Technology of Flexible AC Transmission Systems” NewYork,IEEEPress,2000.

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

- Understand Load balancing using compensators.
- Apply load balancing using Compenasators.
- Analyse load flow incorporating SVC & STATCOM.
- Develop a Simulation model for STATCOM & UPFC.

JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS) PULIVENDULA

DISTRIBUTED GENERATION & MICROGRID CONTROL (PE-V)

II Year MTECH (EPS)- 1st Semester

L	T	P	C
3	0	0	3

Course Objectives:

- Able to know about the concept of distributed generation, distribution network & the concept of Microgrid, its configuration, advantages & limitations.
- Able to understand the basic concepts in combined heat and power, Wind energy conversionsystems, solar photovoltaic systems & other renewable energy sources.
- Able to analyze the impact of Microgrid & Active distribution network management system onvarious factors.
- Able to know the effect of SCADA & understand the concept of Power quality disturbances,improvement technologies & issues of premium power in DC integration.

UNIT – 1: INTRODUCTION TO DISTRIBUTED GENERATION AND MICROGRID CONCEPT **9 Hrs**

Introduction to distributed generation - Active distribution network - Concept of Microgrid - Microgrid configuration - Interconnection of Microgrids - Technical and economical advantages of Microgrid - Challenges and limitations of Microgrid development - Management and operational issues of a Microgrid - Dynamic interactions of Microgrid with main grid – low voltage DC grid.

Learning Outcomes:

At the end of this unit, the student will be able to

- To know about Concept of Microgrid **L1**
- Understand the concept of distributed generation, distribution network & the concept of Microgrid, its configuration, advantages & limitations. **L2**

UNIT – II: DISTRIBUTED ENERGY RESOURCES **9 Hrs**

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

Learning Outcomes:

At the end of this unit, the student will be able to

- Understand the basic concepts in combined heat and power, Wind energy conversion systems, solar photovoltaic systems & other renewable energy sources. **L2**
- To Design a Small-scale hydroelectric power generation **L3**

UNIT – III: MICROGRID AND ACTIVE DISTRIBUTION NETWORK MANAGEMENT SYSTEM **9 Hrs**

Introduction - Impact on heat utilization - Impact on process optimization - Impact on market - Impact on environment - Impact on distribution system - Impact on communication standards and protocols - Network management needs of Microgrid - Microsource controller - Central controller.

Learning Outcomes:
At the end of this unit, the student will be able to

- The impact of Microgrid & Active distribution network management system on various factors is known. **L3**
- Understand the concept of Microsource and Central Controller. **L2**

UNIT – IV: SCADA AND ACTIVE DISTRIBUTION NETWORKS **9 Hrs**

Introduction - Existing DNO SCADA systems - Control of DNO SCADA systems - SCADA in Microgrids - Human–machine interface (HMI) - Hardware components - Communication trends in SCADA - Distributed control system (DCS) - Sub-station communication standardization - SCADA communication and control architectures - Communication devices.

Learning Outcomes:
At the end of this unit, the student will be able to

- Understand the effect of SCADA & understand the concept of Power quality disturbances, improvement technologies & issues of premium power in DC integration. **L2**
- Understand the concepts of Distributed control systems **L2**

UNIT – V: IMPACT OF DG INTEGRATION ON POWER QUALITY AND RELIABILITY **9 Hrs**

Introduction - Power quality disturbances - Power quality sensitive customers - Power quality improvement technologies - Impact of DG integration - Issues of premium power in DG integration.

Learning Outcomes:
At the end of this unit, the student will be able to

- Define the power quality disturbances **L1**
- Understand the concept of power quality improvement technologies **L2**

Text Books:

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

Course Outcomes:

At the end of this Course the student will be able to

- Understand the concept of distributed generation, distribution network & the concept ofMicrogrid, its configuration, advantages & limitations. **L1**
- Understand the basic concepts in combined heat and power, Wind energy conversion systems,Solar photovoltaic systems & other renewable energy sources. **L2**
- The impact of Microgrid & Active distribution network management system on various factors isknown. **L3**
- Understand the effect of SCADA & understand the concept of Power quality disturbances,improvement technologies & issues of premium power in DC integration. **L4**

JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS) PULIVENDULA

POWER SYSTEM AUTOMATION (PE-V)

II Year MTECH (EPS)- 1st Semester

L	T	P	C
3	0	0	3

Course Objectives:

- Understand the basic concepts of deregulation, power system automation.
- Analyze about the energy control centers and applications of automation.
- Develop the models to control the system and energy control centers.
- To apply the techniques to solve the problems in deregulated system and automation.

UNIT – I POWER SYSTEM CONTROL AND DEREGULATION 10 Hrs

Introduction – Operation of power systems and modes – Organization and operator activities, Investment factor and control centre experiences – Deregulation – need for deregulation and Advantages of deregulation in power system – Restructuring Models PoolCo. Model – Bilateral Model and Hybrid Model – Independent system operator (ISO) – Role of ISO – Congestion Management.

Learning Outcomes:

At the end of this unit, the student will be able to

- Learn about Operation of power systems and modes **L1**
- Learn about Independent system operator **L2**

UNIT-II POWER SYSTEM AUTOMATION 10 Hrs

Evolution of automation systems – SCADA in Power system – Building blocks of SCADA system – Remote terminal unit – Intelligent electronic devices – Data concentrators and merging units – SCADA communication systems – Master station – Human-machine interface – Classification of SCADA systems.

Learning Outcomes:

At the end of this unit, the student will be able to

- Understand SCADA in Power system **L1**
- Understand Data concentrators and merging units **L2**

UNIT-III SUBSTATION AUTOMATION 10 Hrs

Substation automation – Conventional automation – New smart devices for substation automation – new integrated digital substation – Technical issues new digital simulation – Substation automation architectures – Substation automation applications functions – Benefits of data warehousing.

Learning Outcomes:

At the end of this unit, the student will be able to

- Understand the Substation automation and Conventional automation **L1**
- Understand Benefits of data warehousing. **L2**

UNIT-IV ENERGY CONTROL CENTERS 10 Hrs

Introduction – Energy control centers – EMS framework – Data acquisition and communication – Generation operation and management – Transmission operations –

Real time Study-mode Simulations – Post-event analysis and energy scheduling and accounting – Dispatcher training simulator – Smart transmission.

Learning Outcomes:

At the end of this unit, the student will be able to

- Understand the EMS framework and Data acquisition and communication **L1**
- Understand Post-event analysis and energy scheduling and accounting **L2**

UNIT-V DISTRIBUTION AUTOMATION SYSTEMS AND ARC FURNACES 10 Hrs

Introduction to Distribution automation – Customer, feeder and substation automation – Subsystems in a distribution control center – Distributed Management System (DMS) framework integration with subsystems – Advanced real-time DMS applications – Advanced analytical DMS applications – DMS coordination with other systems.

Learning Outcomes:

At the end of this unit, the student will be able to

- Understand the Distributed Management System **L1**
- Understand feeder and substation automation **L2**

Text Books:

1. M Shahidehpour, Muwaffaq Alomoush, Restructured electrical power systems operation, trading and volatility, CRC Press, 1st Edition, 2001.
2. Mini S Thomas and John D Mcdonald, Power System SCADA and Smart Grids, CRC Press, 1st Edition 2015.

Reference Books:

1. Torsten cegrell, Power systems control Technology, Prentice Hall, 1st Edition, 1986.
2. James Northcote-Green and Robert Wilson, Control and Automation of Electrical Power Distribution Systems, CRC Press, 1st Edition, 2013.

Course Outcomes:

At the end of this Course the student will be able to

- Understand the concepts of evolution of automation systems, SACADA, Congestion management. **L1**
- Analyze the techniques to resolve problems in energy control centers, data ware housing. **L2**
- Apply the techniques to get the optimum control in the system by using automation at the substation level and distribution level. **L3**
- Develop the real time case studies to solve the critical problems in power system automation. **L4**
- `Understand the Distributed Management System **L5**

JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS) PULIVENDULA

INTELLIGENT CONTROL TECHNIQUES (PE-V)

II Year MTECH (EPS)- 1st Semester

L	T	P	C
3	0	0	3

Course Objectives:

- Learn about basic concepts of AI
- Understand concepts of ANN and various learning algorithms
- Learn about Genetic Algorithm, ACO and Tabu search concepts
- Understand the concepts of Fuzzy
- Learn about Fuzzy logic controller and design using MATLAB

UNIT – I **10 Hrs**

Introduction to control techniques, need of intelligent control. Architecture for intelligent control. Symbolic reasoning system, rule - based systems, the AI approach. Knowledge representation. Expert systems. Data Pre - Processing: Scaling, Fourier transformation, principal - component analysis and wavelet transformations.

UNIT-II **10 Hrs**

Concept of Artificial Neural Networks and its basic mathematical model, McCulloch - Pitts neuron model, simple perceptron, Adaline and Madaline, Feed - forward Multilayer Perceptron. Learning and Training the neural network. Networks: Hopfield network, Self - organizing network and Recurrent network. Neural Network based controller, Case studies: Identification and control of linear and nonlinear dynamic systems using Matlab / Neural Network toolbox.

UNIT-III **10 Hrs**

Genetic Algorithm: Basic concept of Genetic algorithm and detail algorithmic steps, adjustment of free parameters. Solution of typical control problems using genetic algorithm. Concept on some other than GA search techniques like tabu search and ant - colony search techniques for solving optimization problems.

UNIT-IV **10 Hrs**

Introduction to crisp sets and fuzzy sets, basic fuzzy set operation and approximate reasoning. Introduction to Fuzzy logic modeling and control of a system. Fuzzification, inference and Defuzzification. Fuzzy knowledge and rule bases.

UNIT-V **10 Hrs**

Fuzzy modeling and control schemes for nonlinear systems. Self - organizing fuzzy logic control. Implementation of fuzzy logic controller using Matlab fuzzy - logic toolbox. Stability analysis of fuzzy control systems. Intelligent Control for SISO/MIMO Nonlinear Systems. Model Based Multivariable Fuzzy Controller.

Text Books:

1. Simon Haykins, Neural Networks: A comprehensive Foundation, Pearson Edition, 2003.
2. T.J.Ross, Fuzzy logic with Fuzzy Applications, Mc Graw Hill Inc, 1997.

Reference Books:

1. M.T.Hagan, H. B. Demuth and M. Beale, Neural Network Design, Indian reprint, 2008.
2. Fredric M.Ham and Ivica Kostanic, Principles of Neurocomputing for science and Engineering, McGraw Hill, 2001.

Course Outcomes:

At the end of this Course the student will be able to

- Learn about basic concepts of AI **L1**
- Understand concepts of ANN and various learning algorithms **L2**
- Learn about Genetic Algorithm, ACO and Tabu search concepts **L3**
- Understand the concepts of Fuzzy **L4**
- `Learn about Fuzzy logic controller and design using MATLAB **L5**

JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS) PULIVENDULA

ENERGY FROM WASTE (Open Elective)

II Year MTECH (EPS)- 1st Semester

L	T	P	C
3	0	0	3

Course Objectives:

- To understand the concept of waste to energy.
- To analyze technical and management principles for production of energy from waste.
- To apply the best available technologies for waste to energy.
- To develop the process for thermal conversion, bio-chemical and waste to energy conversion.

UNIT – 1: Introduction to Energy from Waste **9 Hrs**

Classification of waste as fuel – Agro based – Forest residue – Industrial waste – MSW – Conversion devices – Incinerators – Gasifiers – Digestors.

UNIT – II: Biomass Pyrolysis **9 Hrs**

Pyrolysis – Types – Slow fast – Manufacture of charcoal – Methods – Yields and application – Manufacture of pyrolytic oils and gases – Yields and applications.

UNIT – III: Biomass Gasification **9 Hrs**

Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

UNIT – IV: Biomass Combustion **9 Hrs**

Biomass stoves – Improved challahs – Types, Some exotic designs – Fixed bed combustors– Types – Inclined grate combustors – Fluidized bed combustors – Design – Construction and operation – Operation of all the above biomass combustors.

UNIT – V: Introduction to Biogas **9 Hrs**

Properties of biogas (Calorific value and composition) – Biogas plant technology and status – Bio energy system – Design and constructional features – Biomass resources and their classification – Biomass conversion processes – Thermo chemical conversion – Direct combustion – Biomass gasification – Pyrolysis and liquefaction – Biochemical conversion – anaerobic digestion Types of biogas Plants – Applications – Alcohol production from biomass – Bio diesel production – Urban waste to energy conversion – Biomass energy programme in India.

Text Books:

1. Non-Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.

2. Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II,Tata McGraw Hill Publishing Co. Ltd., 1983.

Course Outcomes:

At the end of this Course the student will be able to

- Understand the concept of waste to energy. **L1**
- Analyze technical and management principles for production of energy from waste. **L2**
- Apply the best available technologies for waste to energy. **L3**
- Develop the process for thermal conversion, bio-chemical and waste to energy conversion. **L4**

JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS) PULIVENDULA

COST MANAGEMENT OF ENGINEERING PROJECTS
(Open Elective)

II Year MTECH (EPS)- 1st Semester

L	T	P	C
3	0	0	3

Course Objectives:

- Understand the cost concepts, Project Management for planning to execution of projects.
- Enable them to comprehend the fundamentals of Project execution, Costing, Quantitative techniques.
- Apply the different methods to manage the projects, profit planning and cost.
- Develop the contemporary project management tools and methodologies in Indian context.

UNIT – 1: COST CONCEPTS **9 Hrs**

Introduction and Overview of the Strategic Cost Management Process Cost concepts in decision – making; Relevant cost – Differential cost Incremental cost and Opportunity cost – Objectives of a Costing System – Inventory valuation – Creation of a Database for operational control – Provision of data for Decision – Making.

UNIT – II: PROJECT MANAGEMENT **9 Hrs**

Project: meaning – Different types– Why to manage– Cost overruns centers – Various stages of project execution: conception to commissioning – Project execution as conglomeration of technical and nontechnical activities – Detailed Engineering activities – Pre-project execution main clearances and documents Project team: Role of each member – Importance Project site: Data required with significance – Project contracts – Types and contents. Project execution Project cost control – Bar charts and Network diagram – Project commissioning: mechanical and process.

UNIT – III: COST BEHAVIOR AND PROFIT PLANNING **9 Hrs**

Cost Behavior and Profit Planning Marginal Costing – Distinction between Marginal Costing and Absorption Costing – Break-even Analysis – Cost-Volume-Profit Analysis – Various decision – making problems – Standard Costing and Variance Analysis – Pricing strategies – Pareto Analysis – Target costing – Life Cycle Costing – Costing of service sector – Just-in-time approach – Material Requirement Planning – Enterprise Resource Planning – Total Quality Management and Theory of constraints.

UNIT – IV: COST MANAGEMENT **9 Hrs**

Activity-Based Cost Management – Bench Marking – Balanced Score Card and Value-Chain Analysis – Budgetary Control – Flexible Budgets – Performance budgets – Zero-based budgets. Measurement of Divisional profitability pricing decisions including transfer pricing.

UNIT – V: QUANTITATIVE TECHNIQUES **9 Hrs**

Quantitative techniques for cost management – Linear Programming – PERT/CPM – Transportation problems – Assignment problems – Simulation – Learning Curve Theory.

Text Books:

1. Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi.
2. Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting.

REFERENCE BOOKS:

1. Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher.
2. N.D. Vohra, Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd.

Course Outcomes:

At the end of this Course the student will be able to

• Understand the costing system, project characteristics and various stages of a project.	**L1**
• Analyze the learning and understand techniques for Project planning, scheduling and Execution Control.	**L2**
• Apply different techniques to solve the problems related to project and cost management.	**L3**
• Develop the management tools and quantitative techniques in order to obtain the profits.	**L4**

JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS) PULIVENDULA

Internet of Things (IoT)
(Open Elective)

II Year MTECH (EPS)- 1st Semester

L	T	P	C
3	0	0	3

Course Objectives:

- To assess the vision and introduction of IoT.
- To Understand IoT Market perspective.
- To Implement Data and Knowledge Management and use of Devices in IoT Technology.
- To Understand State of the Art - IoT Architecture.
- To classify Real World IoT Design Constraints, Industrial Automation in IoT.

UNIT -I: The IoT Networking Core:
Technologies involved in IOT Development:
Internet/Web and Networking Basics
OSI Model, Data transfer referred with OSI Model, IP Addressing, Point to Point Data Transfer, Point to Multi Point Data transfer & Network Topologies, Sub-netting, Network Topologies referred with Web, Introduction to Web Servers, and Introduction to Cloud Computing
Learning Outcomes:
At the end of this unit

- Students can Learn the definitions, topologies of IoT
- students can understand the working principles of Cloud Computing

UNIT -II: IoT Platform overview
Overview of IoT supported Hardware platforms such as: Raspberry pi, ARM Cortex Processors, Arduino and Intel Galileo boards. Network Fundamentals: Overview and working principle of Wired Networking equipment's – Router, Switches, Overview and working principle of Wireless Networking equipment's – Access Points, Hubs etc. Linux Network configuration Concepts: Networking configurations in Linux Accessing Hardware & Device Files interactions.

Learning Outcomes:
At the end of this unit

- Students can Learn the overview of IoT Platform
- students can understand the working of Wireless Networking equipment

UNIT -III: IoT Architecture:
History of IoT, M2M – Machine to Machine, Web of Things, IoT protocols.
Applications: Remote Monitoring & Sensing, Remote Controlling, Performance Analysis.
The Architecture The Layering concepts, IoT Communication Pattern, IoT protocol Architecture, The 6LoWPAN, Security aspects in IoT

Learning Outcomes:
At the end of this unit

- Students can Learn the IoT Architecture
- students can understand various applications

UNIT -IV: IOT Application Development:
Application Protocols MQTT, REST/HTTP, CoAP, MySQL
Back-end Application Designing
Apache for handling HTTP Requests, PHP & MySQL for data processing, MongoDBObject type Database, HTML, CSS & jQuery for UI Designing, JSON lib for dataprocessing, Security & Privacy during development, Application Development for mobile Platforms: Overview of Android / IOS App Development tools

Learning Outcomes:
At the end of this unit

- Students can Learn the Application Protocols
- Students can understand the working of Android / IOS App Development tools

UNIT -V: Case Study & advanced IoT Applications:
IoT applications in home, infrastructures, buildings, security, Industries, Home Appliances, other IoT electronic equipments. Use of Big Data and Visualization in IoT, Industry concepts.Sensors and sensor Node and interfacing using any Embedded target boards(Raspberry Pi / Intel Galileo/ARM Cortex/ Arduino)Note: Prior knowledge of basic Wireless & Networking, Wireless Sensor Networks, C Programming, Embedded OS is necessary to study this sub
Learning Outcomes:
At the end of this unit

- Students can Learn the various case studies
- students can understand advanced IoT Applications

Course Outcomes: Upon completion of this training, participants will be able to

- Understand the technology and standards relating to IoTs
- Understand the critical parts of the ICT ecosystem required to mainstream IoTs
- Acquire skills on developing their own national and enterprise level technical strategies

Text Books:

1. 6LoWPAN: The Wireless Embedded Internet, Zach Shelby, Carsten Bormann, Wiley, 2009.
2. Internet of Things: Converging Technologies for Smart Environments and Integrated Ecosystems, Dr. Ovidiu Vermesan, Dr. Peter Friess, River Publishers, 2013.
3. Interconnecting Smart Objects with IP: The Next Internet, Jean-Philippe Vasseur,Adam Dunkels, Morgan Kuffmann, 2010.

Reference Books:

1. The Internet of Things: From RFID to the Next-Generation Pervasive Networked Lu Yan, Yan Zhang, Laurence T. Yang, Huansheng Ning, 2008.
2. Internet of Things (A Hands-on-Approach) , Vijay Madisetti , Arshdeep Bahga, 2014.
3. Designing the Internet of Things , Adrian McEwen (Author), Hakim Cassimally, 2013.
4. Asoke K Talukder and Roopa R Yavagal, “Mobile Computing,” Tata McGraw Hill, 2010.
5. Computer Networks; By: Tanenbaum, Andrew S; Pearson Education Pte. Ltd., Delhi,4th Edition, 1981.
6. Data and Computer Communications; By: Stallings, William; Pearson Education Pte. Ltd., Delhi, 6th Edition, 1985.
7. F. Adelstein and S.K.S. Gupta, “Fundamentals of Mobile and Pervasive Computing,”McGraw Hill, 2009.
8. Cloud Computing Bible, Barrie Sosinsky, Wiley-India, 2010