A18

M.Tech. (POWER SYSTEMS)

M.Tech. Amended R18 [A18] CBCS Curriculum

VNR VIGNANA JYOTHI INSTITUTE OF ENGINEERING AND TECHNOLOGY

An Autonomous, ISO 9001:2015 & QS I-Gauge Diamond Rated Institute, Accredited by NAAC with 'A++' Grade
NBA Accreditation for B.Tech. CE, EEE, ME, ECE, CSE, EIE, IT Programmes
Approved by AICTE, New Delhi, Affiliated to JNTUH, NIRF 135th Rank in Engineering Category
Recognized as "College with Potential for Excellence" by UGC
Vignana Jyothi Nagar, Pragathi Nagar, Nizampet (S.O), Hyderabad – 500 090, TS, India.
Telephone No: 040-2304 2758/59/60, Fax: 040-23042761
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VISION OF THE INSTITUTE

To be a World Class University providing value-based education, conducting interdisciplinary research in cutting edge technologies leading to sustainable development of the nation

MISSION OF THE INSTITUTE

- To produce technically competent and socially responsible engineers, managers and entrepreneurs, who will be future ready.

- To involve students and faculty in innovative research projects linked with industry, academic and research institutions in India and abroad.

- To use modern pedagogy for improving the teaching-learning process.

DEPARTMENT OF

ELECTRICAL AND ELECTRONICS ENGINEERING

VISION OF THE DEPARTMENT

To excel in Education, Technology and Research in Electrical and Electronics Engineering leading to sustainable socioeconomic development of the nation.

MISSION OF THE DEPARTMENT

- Excellent teaching- learning environment imbibed with professional ethics and social responsibility in promoting quality education.
- Promoting research through industry collaborations and innovative projects.

M.TECH.
(POWER SYSTEMS)

M.TECH. (PS)

PROGRAM EDUCATIONAL OBJECTIVES

PEO-I: Proficient in applying sustainable and comprehensive technologies to analyse, formulate and provide solutions for real time problems in diversified fields.

PEO-II: Solve complex technical problems using emerging technologies and tools.

PEO-III: Demonstrate interdisciplinary skills and build hands on models for testing and research.

PEO-IV: Develop professional ethics, strong communication skills, knowledge of social impacts and leadership qualities.

PEO-V: Engage in lifelong learning for a successful professional career.

M.TECH. (PS)

PROGRAM OUTCOMES

PO-1: Ability to independently carry out research /investigation and development work to solve practical problems.

PO-2: Ability to write and present a substantial technical report/document.

PO-3: An ability to demonstrate a degree of mastery over the area as per the specialization of the program.

PO-4: Design and conduct experiments, to analyse the power system models and interpret the data.

PO-5: Function on multidisciplinary technological issues assimilating power system advancements.

PO-6: Use the techniques, skills, and modern engineering simulation tools necessary for the design and development of power system technologies and engage in lifelong learning.

VNR VIGNANA JYOTHI INSTITUTE OF ENGINEERING AND TECHNOLOGY, HYDERABAD
M.TECH. I YEAR COURSE STRUCTURE AND SYLLABUS

(POWER SYSTEMS)

I SEMESTER **A18**

Course Type	Course Code	Name of the Course	L	T	P	Credits
Professional Core-I	A18PC1PS01	Power System Analysis	3	0	0	3
Professional Core-II	A18PC1PS02	Power System Dynamics	3	0	0	3
Professional Core-III	A18PC1PS03	Power System Restructuring	3	0	0	3
Professional Elective-I	A18PE1PS01	Renewable Energy Systems	3	0	0	3
	A18PE1PS02	Power System Transients				
	A18PE1PL01	Advanced Micro-Controller Based Systems				
Professional Elective -II	A18PE1PS03	Electrical Power Distribution System	3	0	0	3
	A18PE1PS04	SCADA System and Applications				
	A18PE1PL03	Artificial Intelligence Techniques				
Professional Core Lab-I	A18PC2PS01	Power System Analysis Laboratory	0	0	3	1.5
Professional Core Lab-II	A18PC2PS02	Power System Practice Laboratory	0	0	3	1.5
Project	A18PW4PS01	Technical Seminar	0	0	4	2
Audit	A18AU5CS01	Research Methodology and IPR	2	0	0	0
Total			**17**	**0**	**10**	**20**

VNR VIGNANA JYOTHI INSTITUTE OF ENGINEERING AND TECHNOLOGY, HYDERABAD
M.TECH. I YEAR COURSE STRUCTURE AND SYLLABUS

(POWER SYSTEMS)

II SEMESTER **A18**

Course Type	Course Code	Name of the Course	L	T	P	Credits
Professional Core-IV	A18PC1PS04	Digital Protection of Power System	3	0	0	3
Professional Core-V	A18PC1PS05	Power Quality	3	0	0	3
Professional Core-VI	A18PC1PS06	Flexible AC Transmission Systems	3	0	0	3
Professional Elective-III	A18PE1PS05	Voltage Stability	3	0	0	3
	A18PE1PS06	Power System Reliability				
	A18PE1PL05	Electric Hybrid Vehicles				
Professional Elective -IV	A18PE1PS07	EHV AC Transmission	3	0	0	3
	A18PE1PS08	Smart Grids				
	A18PC1PL06	Advanced Control Systems				
Professional Core Lab-III	A18PC2PS03	FACTS Laboratory	0	0	3	1.5
Professional Core Lab-IV	A18PC2PS04	Power System Dynamics Laboratory	0	0	3	1.5
Project	A18PW4PS02	Mini-Project	0	0	4	2
Audit	A18AU5EN01	English for Academic and Research Writing	2	0	0	0
Total			**17**	**0**	**10**	**20**

VNR VIGNANA JYOTHI INSTITUTE OF ENGINEERING AND TECHNOLOGY, HYDERABAD
M.TECH. II YEAR COURSE STRUCTURE AND SYLLABUS

(POWER SYSTEMS)

III SEMESTER **A18**

Course Type	Course Code	Name of the Course	L	T	P	Credits
Professional Elective-V	A18PE1PS09	Energy Auditing Conservation and Management	3	0	0	3
	A18PE1PL08	Energy Storage Technologies				
	A18PE1PL09	HVDC Transmission				
Open Elective	A18OE1CN01	Business Analytics	3	0	0	3
	A18OE1AM01	Industrial Safety				
	A18OE1AM02	Operations Research				
	A18OE1AM03	Composite Materials				
	A18OE1PS01	Waste to Energy				
Project	A18PW4PS03	Project Part - I	0	0	16	8
Total			**6**	**0**	**16**	**14**

IV SEMESTER **A18**

Course Type	Course Code	Name of the Course	L	T	P	Credits
Project	A18PW4PS04	Project Part - II	0	0	28	14
Total			**0**	**0**	**28**	**14**

VNR VIGNANA JYOTHI INSTITUTE OF ENGINEERING AND TECHNOLOGY

M.Tech. I Semester (PS)	**L**	**T/P**	**C**
	3	**0**	**3**

(A18PC1PS01) POWER SYSTEM ANALYSIS

COURSE PRE-REQUISITES: Fundamentals in Power Systems

COURSE OBJECTIVES:
- To evaluate the network matrices and study various methods of load flows and their advantages and disadvantages
- To analyze various types of faults in power system
- To understand power system security concepts and study the methods to rank the contingencies
- To learn network reduction techniques to obtain the power system equivalent network
- To understand need for power system state estimation and study various types of measurements used in state estimation

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Calculate impedance and admittance matrices of a given power system network
CO-2: Evaluate state variables at various nodes in the power system network using different load flow techniques.
CO-3: Calculate fault currents for various types of faults in power system and rank various contingencies according to their severity
CO-4: Determine the equivalent network for a given power system
CO-5: Estimate the bus voltage phasors given various quantities viz. power flow, voltages, taps, CB status etc.

UNIT-I:
Admittance and Impedance Matrix Calculations: Introduction, branch and node admittances, determination of bus admittance matrix, triangular factorization, bus admittance and impedance matrices, Thevenin's theorem and Zbus, modification of an existing Zbus, direct determination of Zbus, calculation of Zbus elements from Ybus.

UNIT-II:
Load Flows: Introduction, Gauss-Seidel method, Newton-Raphson Method, Decoupled method, Fast decoupled method, comparison between load flow methods, DC load flow.

UNIT-III:
Fault Analysis:
Symmetrical Faults: Introduction, Fault calculations using Zbus, Fault calculations using Zbus equivalent circuits.
Unsymmetrical Faults: Introduction, Symmetrical components, Sequence circuits of various components in power system (transmission lines, transformers and synchronous machines), Various types of unsymmetrical fault calculations-Single line to ground fault, line to line fault and double line to ground fault.

UNIT-IV:
Security Analysis: Introduction, Factors affecting power system security, Contingency analysis: Detection of network problems, Overview of security analysis, Linear sensitivity factors - Generator shift distribution factor and Line outage distribution factor, A.C power flow methods, Contingency selection using overload performance index and 1P1Q method.

UNIT-V:

Power System Equivalents: Introduction, Gaussian elimination method, Kron's reduction method, analysis of single contingencies, analysis of multiple contingencies, system reduction for contingency and fault studies- Ward equivalent circuit.

UNIT-VI:

State Estimation: Introduction, Measurement Classifications-actual, virtual, pseudo and quasi measurements, Method of least squares (WLS method), Statistics, errors and estimates, Test for bad data, Power System State Estimation.

TEXT-BOOKS:

1. Power System Analysis, J. J. Grainger & W. D. Stevenson, McGraw Hill, 2003
2. Power Generation, Operation and Control, A. J. Wood, John Wiley, 1994

REFERENCES:

1. Power System Analysis, A. R. Bergen & Vijay Vital, Pearson, 2000
2. Computer Aided Power System Analysis, G. L. Kusic, Prentice Hall India, 1986

VNR VIGNANA JYOTHI INSTITUTE OF ENGINEERING AND TECHNOLOGY

M.Tech. I Semester (PS)	**L**	**T/P**	**C**
	3	**0**	**3**

(A18PC1PS02) POWER SYSTEM DYNAMICS

COURSE PRE-REQUISITES: Electrical Power Systems, Electrical Machines, Power System Analysis

COURSE OBJECTIVES:
- To study of system dynamics and its physical interpretation
- To develop mathematical models for synchronous machine
- To develop the excitation, PSS and load models
- To study small signal and transient power system stability

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Understand the modelling of synchronous machine in detail
CO-2: Development of transient models of synchronous machine for stability studies
CO-3: Development of models for excitation systems and power system stabilizers (PSS)
CO-4: Understand the power system small signal and transient stability problem

UNIT-I:
Synchronous Machine Modelling: Review of magnetic circuit equations coupled circuits flux linkage equations, physical description of synchronous machine, rotating magnetic field, stator and rotor mmf wave shapes. Mathematical description of a synchronous machine, stator and rotor circuits of synchronous machine. Necessary assumptions for modelling, basic equations of synchronous machine, variation of performance with rotor position, self-inductances, variation of self-inductance and mutual inductance between stator windings. Mutual inductance between stator and rotor circuit equations and stator and rotor flux linkage equations.

UNIT-II:
Park's Transformation and DQ Equivalent Circuits: dqo transformation and transformation of Stator Phase quantities to direct and quadrature axis quantities. Modified Park's transformation and choice of controls for power invariant transformation and the relation between electrical power and torque. Physical interpretation of dqo transformation. Per unit representation, pu stator and rotor voltage equations and per unit electromagnetic torque d-axis and q-axis equivalent circuits.

UNIT-III:
Steady State and Transient Models: Phasor representation of voltages and currents unloaded machine equations and steady state equivalent circuit, active and reactive power expressions. Loaded machine and expressions for load angle, direct and quadrature axis voltages and currents, and relation between active power and torque, steady state phasor diagram – numerical problem. 3-Ph SC on machine terminals and elimination of D.C. offset in short circuit current magnetic saturation – OCC, SCC and SCR and representation of saturation in stability studies. Simple sub transient, transient and steady state models and phasor diagram for transient conditions.

UNIT-IV:
Modelling of Prime Movers and Excitation Systems: Functional block diagram of power generation and control system, modelling of turbines- hydraulic turbine-model of governors for hydraulic turbine-block diagram and steam turbine model.
Modelling of Excitation Systems: Commonly used D.C and A.C excitation system block diagrams. IEEE type-I excitation system block diagram.

UNIT-V:
Introduction to Stability Studies:
Classification of Power System Stability: Small signal stability, Transient Stability, mid-term and long-term stability. Swing equation, Inertia constant H and typical values of H, power angle curve and swing curve. Block diagram representation of swing equation for stability studies.
The stability Phenomenon: Synchronising and damping torques nature of small disturbance response with constant filed voltage and excitation control-swing curves.
Transient Stability: Swing curves for large disturbances for different cases: first swing stability, equal area criterion.

UNIT-VI:
SMIB System:
SSS of SMIB System: State space representation of classical generator model connected to Infinite Bus and its block diagram representation. Undamped natural frequency and damping ratio expressions: Block diagram with constant field voltage, effect of field flux linkage variation on system stability. Phillips Heffron model, block diagram representation with exciter and AVR and effect of AVR on synchronising and damping torque components.
Power System Stabilizer: structure and tuning of Power System Stabilizer (PSS), block diagram with AVR and PSS.

TEXT BOOKS:
1. Power System Stability and Control, P. Kundur, McGraw Hill Inc., 1994
2. Power System Dynamics Stability and Control, K. R. Padiyar, BS Publications, 2006

REFERENCES:
1. Power System Dynamics and Stability, J. Machowski, J. Bialek& J. R. W. Bumby, John Wiley & Sons, 1997
2. Power System Stability Vol. I & III, E. W. Kimbark, John Wiley & Sons, 2002
3. Advanced Power System Analysis and Dynamics, L. P. Singh, New Age International, 2006
4. Power System Control and Stability, P. M. Anderson & A. A. Fouad, Galgotia, 1981

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M.Tech. I Semester (PS)	**L**	**T/P**	**C**
	3	**0**	**3**

(A18PC1PS03) POWER SYSTEM RESTRUCTURING

COURSE PRE-REQUISITES: Power System Operation and Control, Power System Analysis

COURSE OBJECTIVES:
- To introduce the restructuring of power industry and market models
- To get knowledge on fundamental concepts of congestion management
- To analyse the concepts of Transmission pricing and LMP
- To illustrate about various power sectors in India and risk hedging functionalities

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Identify the economic aspects and need of regulation and deregulation
CO-2: Describe the Technical issues and services provided in Deregulated Power Industry
CO-3: Analyse the concepts of Transmission pricing and LMP
CO-4: Explain existing electricity markets like PJM and OPF models
CO-5: Illustrate the ancillary services, Reform initiatives and open access issues

UNIT-I:
Fundamentals of Restructuring: Introduction: Motivation – Benefits - Reasons – Structure - Restructuring process - Different entities - Role of ISO – PJM ISO - Models of Competition: Monopoly, Purchasing agency, wholesale competition, Retail Competition - contractual restructuring models: Poolco, Bilateral and Hybrid - Power Exchange, Comparison of various market models - Issues involved in deregulation - Fundamentals of Economics: Modeling the Consumers, Modeling the producers, Market equilibrium – pareto efficiency.

UNIT-II:
Transmission Congestion Management: Introduction: Definition of Congestion, reasons for transfer capability limitation, Effects of congestion management - features of congestion management – Classification of congestion management methods: Non – market methods – Market methods – OPF based Congestion management-- Inter zonal and Intra zonal congestion management – Price area congestion management – Capacity alleviation method - Congestion Pricing methods.

UNIT-III:
Calculation of ATC: Structure of OASIS: Functions and Architecture – Implementation- Types of information available in OASIS and information requirements -Transfer Capability on OASIS - Definitions, Transfer Capability issues, ATC Calculation – TTC Calculation – TRM Calculation – CBM Calculation - methods of determination of ATC - ATC calculation considering the effect of contingency analysis.

UNIT-IV:
Transmission Pricing: Introduction – Principles – Classification - methods of transmission pricing – Rolled In pricing paradigm - Marginal transmission pricing paradigm – Composite pricing paradigm – comparison of different paradigms – Debate Issues - Fundamentals of Locational Marginal Pricing – LMP formulation and Implementation using ACOPF – Lossless and Loss DCOPF model - PJM LMP model.

UNIT-V:
Ancillary Service Management: Introduction – Functions – Classification – Load generation balancing related services: Frequency regulation – Spinning reserve services – Voltage control and reactive power support devices - Sources of reactive power and their

comparison - Issues – Black start capability service - How to obtain ancillary service – Co-optimization of energy and reserve services.

UNIT-VI:

Reforms in Indian Power Sector: Introduction – objectives of power sector reforms - Framework of Indian power sector – Reform initiatives - Availability based tariff – Electricity act 2003 – Open access issues - Reforms in the near future - Risk hedging functionality: Risk classification – Definition of hedging – sources of electricity market risks – factors contributing to counterparty risk and its managing.

TEXT BOOKS:

1. Restructured Electrical Power Systems: Operation, Trading and Volatility, Mohammad Shahidehpour, Muwaffaq Alomoush, Marcel Dekker, 2001
2. Power System Restructuring and Deregulation, Loi Lei Lai, Wiley India
3. Fundamentals of Power System Economics, Daniel Kirschen and Goranstrbac, John Wiley & Sons Ltd., 2004

REFERENCES:

1. Operation of Restructured Power Systems, Kankar Bhattacharya, Jaap E. Daadler, Math H. J. Boolen, Kluwer Academic Pub., 2001
2. Making Competition Work in Electricity, Sally Hunt, John Willey and Sons Inc., 2002
3. Understanding Electric Utilities and De-Regulation, Lorrin Philipson and H. Lee Willis, CRC Press, 2006
4. NPTEL Course-Restructured Power Systems, A. R. Abhyankar, S. A. Khaparde
   Available: http://nptel.iitm.ac.in/courses/108101005

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M.Tech. I Semester (PS)	**L**	**T/P**	**C**
	3	**0**	**3**

(A18PE1PS01) RENEWABLE ENERGY SYSTEMS

COURSE PRE-REQUISITES: Power Systems, Switchgear Protection, Power Electronics

COURSE OBJECTIVES:
- To learn various renewable energy sources
- To gain understanding of integrated operation of renewable energy sources
- To understand Power Electronics Interface with the Grid

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Gain Knowledge about renewable energy
CO-2: Understand the working of distributed generation system in autonomous / grid connected modes
CO-3: Know the Impact of Distributed Generation on Power System

UNIT-I:
Distributed Generation: Introduction- Distributed vs Central Station Generation, Reasons for DG, Technical Impacts of DG, DG Technologies, Economic Impact of DG, Barriers to DG Development, Renewable Sources of Energy, Renewable Energy Economics, Interconnection, Recommendations and Guidelines for DG Planning

UNIT-II:
Sustainable Energy Sources: Introduction to Solar Energy, Wind Energy, Hydro Energy, Tidal Energy, Wave Energy, Geothermal Energy, Biomass, Fuel Cells. Combined Heat and Power Status, Options for Space Heating, Properties, Variation in Production with Time, Correlation between CHP and Consumption

UNIT-III:
Grid Integration with Renewable Energy Sources: Direct Machine Coupling with the Grid , Full Power Electronics Coupling with the Grid, Partial Power Electronics Coupling to the Grid, Distributed Power Electronics Interface, Impact of the Type of Interface on the Power System, Local Control of Distributed Generation.

UNIT-IV:
Power Quality Issues in Grid: Impact of Distributed Generation on the Power System, Changes Taking Place, Impact of the Changes, Hosting Capacity Approach, Power Quality Issues: Voltage Quality, Current Quality, Multiple Generator Tripping. Voltage Quality and Design of Distributed Generation: Normal Operation, Variations, Normal Events, Abnormal Events. Hosting Capacity Approach for Events, Increasing the Hosting Capacity

UNIT-V:
Distributed Generators Protection: Over current Protection for Upstream and Downstream Faults, Fuse–Recloser Coordination, Inverse-Time Over current Protection, Calculating the Fault Currents, Calculating the Hosting Capacity, Bus bar Protection, Excessive Fault Current Protection, and Generator Protection.

UNIT-VI:
Economics of Distributed Generation: Introduction-Estimating the cost of distributed versus centralized energy generation, The financial viability of individual DG systems, The social costs and benefits of DG penetration, The overall economic, environmental and social impacts of DG penetration, Case Studies.

TEXT BOOKS:

1. Renewable Energy Sources and Emerging Technologies, Ranjan Rakesh, Kothari D. P., Singal K. C, 2nd Ed. Prentice Hall of India, 2011
2. Integration of Distributed Generation in the Power System, Math H. Bollen, Fainan Hassan, Wiley–IEEE Press, 2011

REFERENCES:

1. Distributed Generation: Induction and Permanent Magnet Generators, Loi Lei Lai, Tze Fun Chan, Wiley-IEEE Press, 2007
2. Photovoltaic System Engineering, Roger A. Messenger, Jerry Ventre, 3rd Ed., 2010
3. Wind Energy Explained: Theory Design and Application, James F. Manwell, Jon G. McGowan, Anthony L. Rogers, 2nd Ed., John Wiley and Sons, 2010
4. The Economics of Distributed Energy Generation: A Literature Review, Grant Allan, Igor Eromenko, Michelle Gilmartin, Ivana Kockar, Peter McGregor, Renewable and Sustainable Energy Reviews, Volume 42, February 2015, Pages 543-556

VNR VIGNANA JYOTHI INSTITUTE OF ENGINEERING AND TECHNOLOGY

M.Tech. I Semester (PS)	**L**	**T/P**	**C**
	3	**0**	**3**

(A18PE1PS02) POWER SYSTEM TRANSIENTS

COURSE PRE-REQUISITES: Power Systems, High Voltage Engineering

COURSE OBJECTIVES:
- To learn the reasons for occurrence of transients in a power system
- To understand the change in parameters like voltage & frequency during transients
- To know about the lightning phenomenon and its effect on power system

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Get the knowledge of various transients that could occur in power system and their mathematical formulation
CO-2: Design various protective devices in power system for protecting equipment and personnel
CO-3: Coordinating the insulation of various equipment's in power system
CO-4: Model the power system for transient analysis

UNIT-I:
Analysis of Electrical Transients: Review and importance of study of transients Fundamental circuit analysis of electrical transients, Laplace Transform method of solving simple Switching transients, Damping circuits-Abnormal switching transients, Three-phase circuits and transients, Computation of power system transients.

UNIT-II:
Overvoltages and Protection: Lightning, switching and temporary over voltages, Lightning, Physical phenomena of lightning, Protective devices, Protection of system against over voltages, lightning arresters, substation earthling

UNIT-III:
Transients in Power Systems: Interaction between lightning and power system, Influence of tower footing resistance and Earth Resistance - closing and re-closing of lines, line dropping, load rejection – over voltages induced by faults.

UNIT-IV:
Travelling Waves on Transmission Lines: Switching HVDC line, travelling waves on transmission line, Circuits with distributed Parameters Wave Equation, Reflection, Refraction, Behavior of Travelling waves at the line terminations, Lattice Diagrams – Attenuation and Distortion, Multi-conductor system, and Velocity wave.

UNIT-V:
Insulation Co-ordination: Principle of insulation co-ordination in Air Insulated substation (AIS) and Gas Insulated Substation (GIS), Co-ordination between insulation and protection level, Statistical approach.

UNIT-VI:
Computation of Power System Transients: Principle of digital computation – Matrix method of solution, Modal analysis- Z transform- Computation using EMTP.

TEXT BOOKS:
1. Electrical Transients in Power System, Allan Greenwood, Wiley & Sons Inc. New York, 1991
2. Electromagnetic Transients in Power System, Pritindra Chowdhari, John Wiley and Sons Inc., 1996

3. Transient in Power Systems, Harold A. Peterson, McGraw Hill, 1966

REFERENCES:

1. IEEE Guide for safety in AC substation grounding IEEE Standard 80-2000
2. Very Fast Transient Phenomena Associated with Gasinsulated System, Working Group 33/13-09, CIGRE, 33-13, pp. 1-2, 1988
3. Extra High Voltage AC Transmission Engineering, Rakosh Das Begamudre, Second Edition, Newage International (P) Ltd., New Delhi, 1990

VNR VIGNANA JYOTHI INSTITUTE OF ENGINEERING AND TECHNOLOGY

M.Tech. I Semester (PS)	**L**	**T/P**	**C**
	3	**0**	**3**

(A18PE1PL01) ADVANCED MICRO-CONTROLLER BASED SYSTEMS

COURSE PRE-REQUISITES: Microprocessors and Micro-controllers

COURSE OBJECTIVES:
- To understand the architecture of advance microcontrollers
- To understand the applications of these controllers
- To get some introduction to FPGA

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Learn how to program a processor in assembly language and develop an advanced processor-based system
CO-2: Learn the configuration by using different peripherals in a digital system
CO-3: Compile and debug a Program
CO-4: Generate an executable file and use it

UNIT-I:
Structure of Basic Computer: Basic Computer Organization. - Main parts of a computer system –Instruction codes-Computer register-Computer instructions-Timing and control-instruction cycle-Accumulator based processes-Architecture-Memory-Types of memory-two basic memory operations- Organization-I/O Organization

UNIT-II:
Overview and Architecture of 8051: Micro-Controllers-Intel 8051 Architecture-Instruction Sets-Addressing modes- Registers Organization, Memory Organization. - Stack & Subroutine- I/O Ports- Serial Communication. Timers, Interrupts

UNIT-III:
8051- Microcontrollers Instruction Set and Assembly Language Programming in Real Time Control: Data transfer instructions – Data and Bit-manipulation instructions – Arithmetic instructions – Instructions for Logical operations – Program flow control instructions – Interrupt control flow. Intel 8051 – Basic Assembly language programming
Timer, serial port and Interrupts programming: Programming 8051 timers/counters, 8051 serial port programming, programming timer interrupts, programming External hardware interrupts, programming serial communication interrupts.

UNIT-IV:
Overview and Architecture of PIC 16F877: PIC 16F877- Architecture –Program memory organization –Data memory organization-register files map-special function register-Addressing Modes-Timers–capture /compare/ PWM modules- Programming. Interfacing Memory/ I/O Devices, Serial I/Oand data communication

UNIT-V:
Outline of DSP Processor and FPGA: Digital Signal Processor (DSP) - Architecture – CPU Register-Addressing modes- Assembly language instructions- Timers –serial port- - Programming, Introduction to FPGA- Basic concepts-digital design and FPGA'S- FPGA based system design-Hardware description languages.

UNIT-VI:
Interfacing to 8051: A/D interface and D/A Converter interface, Stepper Motor Interface, DC Motor interface -Key Board Interfacing, -LCD Interfacing

TEXT BOOKS:

1. Microcomputer Architecture and Programming, John F. Wakerly, John Wiley and Sons, 1981
2. The 8051 Microcontroller, Kenneth J. Ayala, Cengage Learning, 2004
3. The PIC Microcontroller: Your Personal Introductory Course, John Morton, Elsevier, 2005

REFERENCES:

1. Microprocessor Architecture, Programming and Applications with the 8085, Ramesh S. Gaonker, Penram International Publishing (India), 1994
2. Advanced PIC Microcontroller Projects in C: from USB to RTOS with the PIC18F Series, Dogan Ibrahim, Elsevier, 2008
3. Microchip Datasheets for PIC16F877
4. TMS320C3x User's Guide
5. FPGA Based System Design, Wayne Wolf

VNR VIGNANA JYOTHI INSTITUTE OF ENGINEERING AND TECHNOLOGY

M.Tech. I Semester (PS)	**L**	**T/P**	**C**
	3	**0**	**3**

(A18PE1PS03) ELECTICAL POWER DISTRIBUTION SYSTEMS

COURSE PRE-REQUISITES: Power Systems, Electrical Distribution Systems

COURSE OBJECTIVES:
- To learn about power distribution system
- To analyze the protective devices and coordination
- To know the functions and maintenance of Distribution Automation

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Acquire knowledge of power distribution system
CO-2: Study of Distribution automation and its application in practice
CO-3: Calculate voltage drop and loss
CO-4: Optimization and maintenance of EPDS

UNIT–I:
Distribution Feeders and Substations: Introduction to distribution systems- Design considerations of distribution feeders: Radial and Loop types of primary feeders, voltage levels, feeder-loading. Design practices of the secondary distribution system. Location of substations: Rating of a distribution substation, service area with primary feeders. Benefits derived through optimal location of substations.

UNIT–II:
Distribution Automation: Distribution of Power, Power Loads, Short-term Load Forecasting, Long-term Load Forecasting. Definitions in Distribution Automation, Need for Distribution Automation, Objectives, functions and Benefits of Distribution Automation. Restoration / Reconfiguration of Distribution Network, Different Methods and Constraints, Power Factor Correction, Advantages of Distribution Management System (DMS).

UNIT-III:
Capacitive Compensation for Power Factor Control: Different types of power capacitors, shunt and series capacitors, effect of shunt capacitors (fixed and switched) power factor correction, capacitor location. Economic justification. Procedure to determine the best capacitor location. Voltage Control: Equipment for voltage control, effect of series capacitors, effect of AVB/AVR, line drop compensation.

UNIT-IV:
Protective Devices and Coordination: Objectives of distribution system protection, types of common faults and procedure for fault calculation. Protective Devices: Principle of operation of fuses, circuit reclosers, line sectionalizers and circuit breakers. Coordination of protective devices: General coordination procedure.

UNIT–V:
Optimization of Distribution Systems: Calculation of Optimum Number of Switches, Capacitors, Optimum Switching Device Placement in Radial Distribution Systems, Sectionalizing Switches – Types, Benefits, Bellman's Optimality Principle, Reliability Indices of Distribution System, Energy efficiency in electrical distribution & Monitoring.

UNIT–VI:
Maintenance of Distribution Systems: Maintenance of Automated Distribution Systems, Difficulties in Implementing Distribution Automation in actual practice, Urban/Rural Distribution, Need based Energy Management, AI techniques applied to Distribution

Automation–Overview of General Techniques, GA and its implementation to Distribution Automation.

TEXT BOOKS:

1. Electric Power Distribution, A. S. Pabla, Fourth Edition, Tata McGraw Hill Publishing Co. Ltd.
2. A Text Book of Electrical Power Distribution Automation, M. K. Khedkar, G. M. Dhole, University Science Press, New Delhi
3. Electrical Power Distribution Engineering, Turan Gonen, CRC Press, Third Edition

REFERENCES:

1. Electrical Distribution Engineering, Anthony J. Panseni, CRC Press
2. Electric Power Distribution, Automation, Protection & Control, James Momoh, CRC Press

VNR VIGNANA JYOTHI INSTITUTE OF ENGINEERING AND TECHNOLOGY

M.Tech. I Semester (PS)	**L**	**T/P**	**C**
	3	**0**	**3**

(A18PE1PS04) SCADA SYSTEMS AND APPLICATIONS

COURSE PRE-REQUISITES: Basic Power Systems, Power Distribution Systems

COURSE OBJECTIVES:
- To understand what is meant by SCADA and its functions
- To know SCADA communication
- To get an insight into its application

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Describe the basic tasks of Supervisory Control Systems (SCADA) as well as their typical applications in transmission & distribution sectors and various industries etc.
CO-2: Acquire knowledge about SCADA architecture, various advantages and disadvantages of each system
CO-3: Comprehend about SCADA Protocols. IEC 60870, DNP3, ICCP etc.
CO-4: Learn about SCADA system components: remote terminal units, PLCs, intelligent electronic devices, HMI systems, SCADA server

UNIT- I:
Introduction to SCADA:
SCADA systems: Components of SCADA Systems & Applications in various industries, SCADA in Power Systems: Advantages, Basic functions& Application functions, Power System field, Types of data& signals in power system, Flow of data from field to SCADA control center, Open System-Need and advantages, Building blocks of SCADA Systems.

UNIT-II:
SCADA RTU & IED Components:
RTU- Block diagram, Sub systems- Communication, Logical, Termination, Power supply, HMI; Advanced RTU Functionalities of the logic subsystem.
IED- Functional block diagram, Hardware and software Architecture, Advanced functionalities, Communication subsystem; Data concentrators and merging units.

UNIT-III:
SCADA MS & HMI Components:
MS- Major functions of basic SCADA software, Hardware components and their main functions, Block diagrams of small, medium, large Master Stations; Global Positioning Systems (GPS), MS performance.
HMI- Components, functionalities, HMI Intelligent alarm filtering and suppression techniques, Classification of SCADA Systems:-Single master- single remote, Single master-multiple RTU, Multiple master- multiple RTUs, Single master- multiple sub master- multiple remote.

UNIT-IV:
SCADA Communication: SCADA communication- Requirements, Topologies, Smart grid communication infrastructure; SCADA Data communication - Techniques, Components, Transmission of Digital Signals and their Modes, Error detection techniques, Media Access Control techniques.

UNIT-V:
SCADA Architecture & Protocols:
SCADA Communication Protocol Architectures: OSI seven layer model, enhanced performance architecture (EPA) model, Transmission Control Protocol (TCP)/ Internet Protocol (IP) model.

SCADA And Smart Grid Protocols: Mod bus, International Electro Technical Commission (IEC 60870), Distributed Network Protocol 3 (DNP3), Inter-Control Center Protocol (ICCP), Ethernet, IEC 61850, IEEE C37.118 Synchrophasor standard, Zig bee & its devices, Wi-Fi, Guided (wired)& Unguided (wireless)media.

UNIT-VI:

SCADA Case Studies & Implementation: Security and challenges for SCADA and smart grid communication, SCADA Case Studies, Laboratory model- Overview of SCADA Hardware Laboratory, Laboratory software relational diagram, Programmable Logic Controller (PLC)-PLC used as RTU, Basic rules of Ladder Logic, Different instructions.

TEXT BOOKS:

1. Power System SCADA and Smart Grids, Mini S. Thomas, John D. McDonald, CRC Press, Taylor and Francis, 2015
2. SCADA-Supervisory Control and Data Acquisition, Stuart A. Boyer, Instrumentation Systems and Automation Society

REFERENCES:

1. Practical SCADA for Industry, David Bailey, Edwin Wright, Newnes, 2003
2. Designing SCADA Application Software: A Practical Approach, Stuart G. McCrady

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M.Tech. I Semester (PS)	**L**	**T/P**	**C**
	3	**0**	**3**

(A18PE1PL03) ARTIFICIAL INTELLIGENCE TECHNIQUES

COURSE PRE-REQUISITES: Control Systems, Power Systems, Electrical Drives

COURSE OBJECTIVES:
- To locate soft commanding methodologies, such as artificial neural networks, Fuzzy logic and genetic Algorithms
- To observe the concepts of feed forward neural networks and about feedback neural networks
- To practice the concept of fuzziness involved in various systems and comprehensive knowledge of fuzzy logic control and to design the fuzzy control
- To analyze genetic algorithm, genetic operations and genetic mutations

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Quote the feed forward neural networks and learning and understanding of feedback neural networks
CO-2: Generalize fuzziness involved in various systems and fuzzy set theory
CO-3: Examine genetic algorithm and applications in electrical engineering
CO-4: Understand concept of hybrid AI techniques

UNIT-I:
Artificial Neural Networks: Introduction to AI, biological foundation to intelligent systems. Artificial Neural Network: architecture, learning process, learning rules. Training algorithms: LMS algorithm, Back-propagation algorithm.
Radial basis network-covers theorem generalized radial basis function networks, estimation of regularization parameter.

UNIT-II:
Fuzzy Logic: Introduction – Fuzzy versus crisp – Fuzzy sets - Membership function – Basic Fuzzy set operations – Properties of Fuzzy sets –Operations on Fuzzy relations – Min Max operations - Fuzzification, Membership value assignment, development of rule base and decision-making system, De-fuzzification to crisp sets, De-fuzzification methods.

UNIT-III:
Genetic Algorithm: 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 - Problems on optimization-Algorithm.

UNIT-IV:
Neuro-Fuzzy Systems: Fuzzy associative memories; Fuzzy rule generation using neural net approaches, Fuzzy neural networks; adaptive neuro-fuzzy inference systems (ANFIS); neuro-fuzzy control.

UNIT-V:
System Identification Using Neural and Fuzzy Systems: System/process identification using neural networks, system identification using fuzzy models: Mamdani Model, Takagi-Sugeno model.

UNIT-VI:

Applications of AI Techniques: Control and Process Monitoring, fault diagnosis and load forecasting, Function Approximation, – Load flow studies – Economic load dispatch – Load frequency control –Single area system and two area system – Position and speed control of DC and AC Motors.

TEXT BOOKS:

1. An Introduction to ANN, J. M. Zurada, Jaico Publishing House
2. Neural Networks, Simon Haykins, Prentice Hall
3. Neural Networks, Fuzzy Logic & Genetic Algorithms, S. Rajasekaran and G.A.V. Pai, PHI, New Delhi, 2003

REFERENCES:

1. Neural Network & Fuzzy System, Bart Kosko, Prentice Hall, 1992
2. Neural Computing Theory & Practice, P.D. Wasserman, Van Nostrand Reinhold, New York,1989
3. Fuzzy Sets, Uncertainty and Information, G. J. Klir and T.A. Folger, PHI, 1994
4. Genetic Algorithms, D. E. Goldberg, Addison Wesley, 1999
5. Neural Networks, Satish Kumar, Tata McGraw-Hill

VNR VIGNANA JYOTHI INSTITUTE OF ENGINEERING AND TECHNOLOGY

M.Tech. I Semester (PS)	**L**	**T/P**	**C**
	0	**3**	**1.5**

(A18PC2PS01) POWER SYSTEM ANALYSIS LABORATORY

COURSE PRE-REQUISITES: Power System Analysis

COURSE OBJECTIVES:
- To develop computer programs to perform load flow studies of transmission and distribution systems
- To design Simulink model for short circuit analysis
- To develop computer program to evaluate transient stability of power system
- To plan the optimal scheduling of generators

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Evaluate node voltages in transmission and distribution systems.
CO-2: Evaluate various types of fault currents in a power system.
CO-3: Analyze the stability of a power system.
CO-4: Perform optimal scheduling of generators.

LIST OF EXPERIMENTS:

1. Formation of Z_{bus} using Z_{bus} building algorithm
2. Load flow analysis using Gauss-Seidel method
3. Load flow analysis using Newton-Raphson method
4. Short circuit analysis in a power system
5. Transient stability analysis for single machine connected to infinite bus using Point by Point method
6. Evaluation of generating system reliability
7. Evaluation of distribution system reliability
8. Contingency analysis
9. Economic load dispatch
10. Distribution system load flow analysis

Note: The above experiments are to be simulated using suitable simulation software.

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M.Tech. I Semester (PS)	**L**	**T/P**	**C**
	0	**3**	**1.5**

(A18PC2PS02) POWER SYSTEM PRACTICE LABORATORY

COURSE PRE-REQUISITES: Power System Analysis and Power System Protection

COURSE OBJECTIVES:
- To find equivalent circuit of 3-winding transformer
- To outline sub-transient reactance of a salient polo synchronous machine
- To test the characteristics of OC, UV/OV, negative sequence relays

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Draw the equivalent circuit of 3-winding transformer
CO-2: Review sequence impedances of salient pole synchronous machine and 3-ph transformer
CO-3: Analyze the characteristics of OC, UV/OV, negative sequence relays

LIST OF EXPERIMENTS:

1. Determination of Sequence Impedances of a Cylindrical Rotor Synchronous Machine
2. Determination of Equivalent circuit of a Three winding Transformer
3. Determination of Sequence Impedances of Three Phase Transformer
4. Characteristics of IDMT Electromagnetic Over Current Relay
5. Differential protection on Single Phase Transformer
6. Characteristics of Microprocessor based Over Voltage / Under Voltage Relay
7. Determination of string efficiency of a suspension string insulator
8. Performance and Testing of Generator Protection System
9. Performance and Testing of Transformer Protection System
10. Performance and Testing of Transmission Line Model

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M.Tech. I Semester (PS)	**L**	**T/P**	**C**
	0	**4**	**2**

(A18PW4PS01) TECHNICAL SEMINAR

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Identify a research topic related to advanced/state-of-the-art technologies
CO-2: Collect the literature and comprehend/analyze critically the technological advancements
CO-3: Engage in effective oral communication through presentation of seminar
CO-4: Engage in effective written communication through report

COURSE OUTLINE:

- A student shall present a seminar on a technical topic during I semester of the M.Tech. programme.
- A student, under the supervision of a faculty member, shall collect literature on a technical topic of his / her choice, critically review the literature and submit it to the Seminar Review Committee (SRC) in a prescribed report form.
- The SRC shall consist of Head of the Department, faculty supervisor and a senior faculty member of the specialization / department.
- Student shall make an oral presentation before the SRC after clearing the plagiarism check.
- Prior to the submission of seminar report to the SRC, its soft copy shall be submitted to the PG Coordinator for PLAGIARISM check.
- The report shall be accepted for submission to the SRC only upon meeting the prescribed similarity index.

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M.Tech. I Semester (PS)	**L**	**T/P**	**C**
	2	**0**	**0**

(A18AU5CS01) RESEARCH METHODOLOGY AND IPR

COURSE PRE-REQUISITES: None

COURSE OBJECTIVES:
- To introduce the characteristics of a good research problem
- To choose appropriate approaches of investigation of solutions for research problem
- To familiarize with basic Intellectual Property Rights
- To understand different Patent Rights

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Understand research problem formulation, analyze research related information and follow research ethics
CO-2: Realize the importance of ideas, concept, and creativity in the present-day context
CO-3: Recognize that when IPR would take such important place in growth of individuals and nation, it is needless to emphasize the need of information about IPR to be promoted among students in general and engineering in particular
CO-4: Appreciate IPR protection which leads to creation of new and better products, and in turn brings about, economic growth and social benefits

UNIT-I:
Introduction: Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem.
Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, necessary instrumentations.

UNIT-II:
Literature Survey: Effective literature studies approaches, analysis. Plagiarism, Research ethics.

UNIT-III:
Effective Technical Writing: How to write report, Paper. Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

UNIT-IV:
Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of
Patenting and Development: technological research, innovation, patenting, development.
International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

UNIT-V:
Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

UNIT-VI:
New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR.

TEXT BOOKS:
1. Research Methodology: An Introduction for Science & Engineering Students, Stuart Melville and Wayne Goddard

2. Research Methodology: An Introduction, Wayne Goddard and Stuart Melville
3. Resisting Intellectual Property, Halbert, Taylor & Francis Ltd ,2007

REFERENCES:

1. Research Methodology: A Step-by-Step Guide for Beginners, Ranjit Kumar, 2nd Edition
2. Research Methodology: Methods and Techniques, C. R. Kothari and Gaurav Garg, New Age International Publishers
3. Intellectual Property in New Technological Age, Robert P. Merges, Peter S. Menell, Mark A. Lemley, 2016
4. Intellectual Property Rights Under WTO, T. Ramappa, S. Chand, 2008

VNR VIGNANA JYOTHI INSTITUTE OF ENGINEERING AND TECHNOLOGY

M.Tech. II Semester (PS)	**L**	**T/P**	**C**
	3	**0**	**3**

(A18PC1PS04) DIGITAL PROTECTION OF POWER SYSTEM

COURSE PRE-REQUISITES: Power System Protection, Switch Gear Protection

COURSE OBJECTIVES:
- To study numerical relays
- To develop mathematical approach towards protection
- To study algorithms for numerical protection

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Learn the importance of Digital Relays
CO-2: Apply Mathematical approach towards protection
CO-3: Learn to develop various Protection algorithms

UNIT-I:
Basic Elements of Digital Protection: Introduction, Basic components of digital Protection: Signal conditioning sub system: transducers, surge protection, analog filtering, analog multiplexers, Conversion subsystem: the sampling theorem, signal aliasing error, sample and hold circuits, Digital multiplexing, Digital to Analog and Analog to Digital conversions, Digital relay sub system, Digital relay as a unit, Performance and characteristics of digital protection.

UNIT-II:
Mathematical Background to Protection Algorithms: Finite difference techniques, Interpolation Formulae-Forward Interpolation, Backward Interpolation, Central difference interpolation Numerical differentiation, Curve fitting and smoothing-Least square method, smoothing Fourier analysis-Fourier series, Fourier Transform, Walsh function analysis, Relation between Fourier and Walsh Coefficients

UNIT-III:
Sinusoidal, Fourier Analysis and Walsh Function-Based Algorithms: Sinusoidal wave: Derivative methods-sample and first, First and second, Sample Techniques-Two sample, Three sample
Fourier analysis: full cycle window, fractional cycle window, Fourier Transform based algorithm,
Walsh function: Basic Principle, Development of basic algorithm, Algorithm for walsh function determination, Estimation of amplitude and phase angle of fundamental components, Determination of walsh coefficients for pure sinusoidal waves.

UNIT-IV:
Least Squares, Differential Equation Based Techniques: Least Squares:-Integral LSQ Fit, Power series LSQ Fit, Multi variable series LSQ Technique, Determination of measured impedance estimates
Differential equation**:** Representation of transmission lines with capacitance neglected, Differential equation protection with selected limits, Simultaneous differential equation techniques.

UNIT-V:
Travelling Wave Based Protection and Schemes: Travelling wave-based protection: Transmission line as a distributed component, super imposed quantities and their properties, Bergeron's equations, discriminate functions
Travelling wave-based protection Schemes: Bergeron's equation based, Ultra high speed polarity comparison, Ultra high speed wave differential, discriminate function based, Super imposed component trajectory based.

UNIT-VI:

Digital Differential Protection and Schemes: Digital Differential Protection of Power Transformer: Principles of transformer protection, FIR filter- based algorithms, Least squares curve fitting based algorithms, Fourier based algorithm, Flux restrained current differential relay, Basic hard ware of microprocessor-based transformer protection,

Digital line differential Protection: current based differential schemes, composite voltage and current based protection scheme, Recent Advances in Digital Protection of Power Systems

TEXT BOOKS:

1. Digital Protection of Power Systems, A. T. Johns and S. K. Salman, IEEE Press,1999
2. Computer Relaying for Power Systems, A. G. Phadke and J. S. Thorp, Wiley/Research Studies Press, 2009

REFERENCES:

1. Digital Power System Protection, S. R. Bhide, PHI Learning Pvt. Ltd., 2014
2. Numerical Distance Protection, Gerhard Zeigler, Siemens Publicis Corporate Publishing, 2006

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M.Tech. II Semester (PS)	**L**	**T/P**	**C**
	3	**0**	**3**

(A18PC1PS05) POWER QUALITY

COURSE PRE-REQUISITES: Analysis of Power Electronic Converters, Power Systems

COURSE OBJECTIVES:
- To get the knowledge on Power quality problems and standards
- To get awareness on devices introducing harmonics and mitigation methods
- To describe modeling of components in industrial power systems
- To get the concept of grounding & wiring problems

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Acquire knowledge on power quality issues and standards
CO-2: Model and analyze the harmonic introducing devices and effects on system equipment and loads
CO-3: Analyze the control techniques to APFC based on static VAR compensators
CO-4: Analyze the series and shunt active power filtering techniques for harmonics and effects of grounding

UNIT- I:
Introduction to Power Quality: Overview of power quality phenomena-classification of power quality Issues- Voltage, Sag, Swell, Surges, Harmonics, over voltages, spikes, Voltage fluctuations, Transients and Interruptions. Power quality measures and Standards Power acceptability curves- IEEE guidelines, EMC standards and recommended practices.

UNIT II:
Voltage Sags and Pq In Industrial Power Systems: Voltage Sag – Characterization - Single Phase: Voltage sag – definition, causes of voltage sag, voltage sag magnitude, monitoring. Voltage sag calculation in non-radial systems, meshed systems- voltage sag duration. Three Phase: Three phase faults, phase angle jumps, magnitude and phase angle jumps for three phase unbalanced sags. Modelling of networks and components under non-sinusoidal conditions-transmission and distribution systems- shunt capacitors- transformers-electric machines -loads that cause power quality problems.

UNIT III:
Interruptions and PQ Issues In Drives: Short interruptions – definition, origin of short interruptions and monitoring of short interruptions. Long Interruptions– Definition – Difference between failures, outage, Interruptions – causes of Long Interruptions – Origin of Interruptions.
Voltage sag – equipment behavior of Power electronic loads, induction motors, synchronous motors, computers, consumer electronics, adjustable speed AC drives and its operation. Mitigation of PQ problems in AC Drives, adjustable speed DC drives.

UNIT-IV:
Harmonics: Harmonics, Harmonics indices, Inter harmonics, Notching – Voltage vs Current distortion – Harmonics vs Transients – Sources and effects of harmonic distortion – System response characteristics – total harmonic distortion- RMS value of a harmonic waveform, Principles of controlling harmonics – Standards and limitation – important harmonic introducing devices-SMPS-Three phase power converters-harmonic distortion of fluorescent lamps-effect of power system harmonics on power system equipment and loads.

UNIT-V:
Harmonic Mitigation and Grounding: Passive compensation and passive filters, active filtering – shunt, series and hybrid Filters and their control and d-q domain control of three phase

shunt active filters. Uninterruptible power supplies- series active power filtering techniques for harmonic cancellation and isolation. Grounding and wiring-introduction-NEC grounding requirements-reasons for grounding- typical grounding and wiring problems and solutions.

UNIT VI:

PQ Improvement and Custom Power Devices: Overview of mitigation methods – from fault to trip, reducing the number of faults, reducing the fault clearing time, installing mitigation equipment, improving equipment immunity, different events and mitigation methods. Voltage source converter, series voltage controller: Dynamic Voltage Restorer, shunt controller: DSTATCOM, combined shunt and series controller: UPQC.

TEXT BOOKS:

1. Understanding Power Quality Problems, Math H. J. Bollen, IEEE Press
2. Electrical Power Systems Quality, Roger C. Durgan, Mark F. McGranaghan and H.Wayne Beaty, Tata McGraw-Hill, 2nd Edition, New York, 2008
3. Power Quality – Problems and Mitigation Techniques, Bhim Singh, Ambarish Chandra, Kamal Al-Haddad, Wiley Publication

REFERENCES:

1. Power Quality in Electrical Systems, Alexander kusko and Mark M.Thompson McGraw Hill Publication
2. Power Quality, Sankaran C, CRC Press, 2002
3. Distribution Reliability and Power Quality, T. A. Sort, Taylor & Francis
4. Electric Power Quality, G.T. Heydt, 2nd Edition, Stars in a Circle Publication, 1994
5. Power Quality Enhancement Using Custom Power Devices, A. Ghosh, G. Ledwich, Kluwer Academic, 2002

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M.Tech. II Semester (PS)	**L**	**T/P**	**C**
	3	**0**	**3**

(A18PC1PS06) FLEXIBLE ACTRANSMISSION SYSTEMS

COURSE PRE-REQUISITES: Power Electronics, Power Systems, Reactive Power Control

COURSE OBJECTIVES:
- To learn the active and reactive power flow control in power system
- To understand the need for static compensators
- To develop the different control strategies used for compensation
- To understand the need of custom power devices and applications

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Acquire knowledge of reactive power control in power systems
CO-2: Compensation Schemes at Transmission and Distribution level in Power Systems
CO-3: Learn various Static VAR controllers working and applications
CO-4: Understand the modeling and control of Static VAR controllers
CO-5: Understand the working and applications of custom power devices

UNIT-I:
Introduction to FACTS Controllers: Transmission inter connections, power and Reactive power flow control in AC transmission system, loading capability limits, constraints of maximum transmission loading and dynamic stability considerations. Uncompensated and compensated lines, relative importance of controllable parameters. Classification of FACTS controller based on type of connection, relative importance of different types of controllers and benefits of FACTS technology.

UNIT-II:
Objectives of Static Compensation: Objectives of Shunt compensation – midpoint voltage regulation, voltage instability precaution – importance of Transient Stability – Power Oscillation damping. Objectives of series compensation – Improvement of Transient Stability and Voltage Stability – Power Oscillation Damping – Methods of controllable var generation – variable impedance type static var generations, switching converter type var generations and hybrid var generations.

UNIT-III:
SVC and STATCOM: Static versus passive VAR compensator, Static shunt compensators: SVC and STATCOM - Operation and control of TCR, TSC, FC-TCR and TSC-TCR type SVCs and STATCOM - Compensator control. Comparison between SVC and STATCOM.

UNIT-IV:
Static Series Compensators: Variable impendence type FACTS controllers - GCSC, TSSC and TCSC and their control schemes. Switching converter type FACTS controllers: SSSC and its control. Static voltage and phase angle regulators – TCVR and TCPAR Operation and Control –Applications.

UNIT-V:
UPFC and IPFC: Unified Power Flow Controller: Circuit Arrangement, Operation and control of UPFC.
Basic Principle of P and Q control- Independent real and reactive power flow control- Applications. Introduction to interline power flow controller: basic operation and characteristics.

UNIT-VI:

Modelling and Control of FACTS Controllers: Modeling and analysis of FACTS Controllers – Internal control schemes of STATCOM-indirect output voltage control and direct output voltage control. Transfer function and dynamic response of STATCOM. Implementation of regulation slope for Static Var Generators (SVG's) – Control circuits implementations for Transient stability, power oscillation damping and VAR reserve control for SVG. Approximate models of SVC and STATCOM for power system study.

TEXT BOOKS:

1. Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems, N. G. Hingorani, L. Gyugyi, IEEE Press Book, Standard Publishers and Distributors, Delhi, 2001
2. FACTS Controllers in Power Transmission and Distribution, K. R. Padiyar, New Age International Publishers, 2007

REFERENCES:

1. Flexible AC Transmission Systems-Modeling and Control, X. P. Zhang, C. Rehtanz, B. Pal, Springer Verlag, Berlin, 2006
2. Static Reactive Power Compensation, T. J. E. Miller, John Wiley and Sons, New York, 1982
3. FACTS Controllers & Applications, K. S. Suresh Kumar, S. Ashok, E-book Edition, Nalanda Digital Library, NIT Calicut, 2003

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M.Tech. II Semester (PS)	**L**	**T/P**	**C**
	3	**0**	**3**

(A18PE1PS05) VOLTAGE STABILITY

COURSE PRE-REQUISITES: Power System Analysis, Power System Operation

COURSE OBJECTIVES:
- To analyze the concepts of Power System Stability, Security and Assessment methods
- To understand the Reactive Power Control in Generation/Transmission Interconnected Networks
- To assess the methods for Voltage Stability Indices(L,VCPI) and Graphical Methods P-V Q-V Curves-Analysis
- To improve the controlling and compensation methods of voltage stability

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Understand the significance of Q-control, PS load model, angle stability and voltage stability
CO-2: Analyze the graphical methods of evaluating voltage stability
CO-3: Analyze voltage stability indices (L-Index and VCPI)
CO-4: Understand the preventive methods of voltage collapse

UNIT–I:
Reactive Power Control: Concepts of power in A.C transmission systems, reactive loss characteristics, operation of transmission lines under NL and heavy load conditions. Voltage regulation relations with reactive power line – line loadability – governing effects on reactive power flow – system MVAr mismatch – constraints effects and practical aspects of reactive power flow problem.

UNIT–II:
Introduction to Voltage Stability: Definitions: Voltage Stability, Voltage Collapse, Voltage Security; Classification of Voltage Stability, different expressions and scenarios between reactive power and system stability.; Factors affecting Voltage collapse and instability; Previous cases of voltage collapse incidences.

UNIT–III:
Graphical Analysis of Voltage Stability: Comparison of Voltage and angular stability of the system; Graphical Methods describing voltage collapse phenomenon: P-V and Q-V curves; detailed description of voltage collapse phenomenon with the help of Q-V curves.

UNIT–IV:
Analysis of Voltage Stability: Analysis of voltage stability on SMLB system: Analytical treatment and analysis.
Voltage Stability Indices: L-Index and its expression, Voltage collapse proximity indicator - Determinant of Jacobin as proximity indicators- Voltage stability margin.

UNIT–V:
Power System Loads: Loads that influences voltage stability: Discharge lights, Induction Motor, Air-conditioning, heat pumps, electronic power supplies, OH lines and cables.
Reactive Power Compensation: Generation and Absorption of reactive power- Series and Shunt compensation- Synchronous condensers- SVCs- OLTCs - Booster Transformers.

UNIT–VI:
Voltage Stability Margin: Stability Margin: Compensated and un-compensated systems.
Voltage Security: Definition; Voltage security; Online monitoring of Voltage Stability; Methods

to improve voltage stability and its practical aspects.

TEXT BOOKS:

1. Power System Voltage Stability, C. W. Taylor, McGraw Hill, 1994
2. Performance, Operation and Control of EHV Power Transmission System, A. Chakrabarthy, D. P. Kotari and A. K. Mukopadyay, A.H. Wheeler Publishing, I Edition, 1995

REFERENCES:

1. Power System Dynamics: Stability and Control, K. R. Padiyar, 2nd Edition, B. S. Publications
2. Voltage Stability of Electric Power Systems, Thierry Van Cutsem, Costas Varnas, Springer-Verlag New York Inc.

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M.Tech. II Semester (PS)	**L**	**T/P**	**C**
	3	**0**	**3**

(A18PE1PS06) POWER SYSTEM RELIABILITY

COURSE PRE-REQUISITES: Mathematics, Power Systems-II, Distribution Systems, Power System Protection

COURSE OBJECTIVES:
- To identify the generation system model and recursive relation for capacitive model building
- To calculate the equivalent transitional rates, cumulative probability and cumulative frequency
- To classify the risk, system and load point reliability indices
- To evaluate the basic reliability indices

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Find loss of load and energy indices for generation systems model
CO-2: Describe merging of generation and load models
CO-3: Evaluate operating reserve, system and load point reliability indices
CO-4: Apply various indices for distribution systems

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 of encountering a state – Evaluation of equivalent transitional rates, cumulative probability and cumulative frequency of identical generating units using two component repairable model – 2- level daily load representation - merging of generation and load models – Examples.

UNIT-III:
Operating Reserve Evaluation: Basic concepts - risk indices – PJM methods — Modeling of rapid start and hot reserve units using STPM approach - security function approach.
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 in two component repairable System

UNIT-IV:
Inter Connected System Reliability Analysis: Probability array methods in two inter connected systems -Factors affecting the emergency assistance through the interconnections- Reliability evaluation in three interconnected systems.

UNIT-V:
Distribution System Reliability Analysis – I (Radial Configuration): Basic evaluation Techniques of Radial networks – Evaluation of Basic reliability indices and additional interruption indices– Examples.

UNIT-VI:
Distribution System Reliability Analysis - II (Parallel Configuration): Basic evaluation techniques –inclusion of bus bar failures, scheduled maintenance – temporary and transient failures – weather effects - inclusion of breaker failures.

Substations and Switching Stations: Effects of short-circuits and breaker operation – Open and Short-circuit failures – Active and Passive failures

TEXT BOOKS:

1. Reliability Evaluation of Power Systems, R. Billinton, R. N. Allan, BS Publications, 2007
2. Reliability Modeling in Electric Power Systems, J. Endrenyi, John Wiley and Sons, 1978

REFERENCES:

1. Reliability Engineering: Theory and Practice, Alessandro Birolini, Springer
2. System Reliability Concepts, V. Sankar, Himalaya Publishing House, 2015
3. An Introduction to Reliability and Maintainability Engineering, Charles Ebeling, TMH
4. Reliability Engineering, E. Balaguruswamy, TMH
5. Reliability Engineering, Elsayed A. Elsayed, Prentice Hall

VNR VIGNANA JYOTHI INSTITUTE OF ENGINEERING AND TECHNOLOGY

M.Tech. II Semester (PS)	**L**	**T/P**	**C**
	3	**0**	**3**

(A18PE1PL05) ELECTRIC HYBRID VEHICLES

COURSE PRE-REQUISITES: Electrical Machines

COURSE OBJECTIVES:
- To study the different drive train configurations of electric vehicles
- To propose the various propulsion and energy storage systems for EHVs
- To know the sizing of propulsion motors and other systems involved in EH vehicles
- To carry out different design case studies of EHv and BEVs

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Assess the performance, societal and environmental impact of EHVs having known their past history
CO-2: Implement various drive train topologies and control strategies in Electric and Hybrid vehicles
CO-3: Recommend, Design/Size and Control different electric propulsion units and other components of EHVs and BEVs
CO-4: Appropriately select the energy storage system and strategize its management in EHVs

UNIT-I:
Introduction to Hybrid Electric Vehicles: History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies. Conventional Vehicles: Basics of vehicle performance, Forces acting on a vehicle, vehicle power source (plant) characteristics, transmission characteristics: Manual, Hydro-dynamic and Continuously Variable Transmissions, mathematical model of vehicle.

UNIT-II:
Electric Drive-Trains: Advantages of Electric Vehicles (EVs), Basic concept of electric traction, introduction to various electric drive-train topologies (Configurations), Electric Vehicle Performance, power flow control in electric drive-train topologies, fuel efficiency analysis.

UNIT-III:
Hybrid Electric Drive-Trains: Basic architecture and concept of hybrid traction, patterns of power flow, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis

UNIT-IV:
Electric Propulsion Unit: Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, drive system efficiency.

UNIT-V:
Sizing the Drive System: Matching the electric machine and the internal combustion engine (ICE), Sizing of the propulsion motor, Sizing of engine-generator, Sizing the power electronics based on Switch Technology - Switching Frequency and Ripple capacitor design , selecting the energy storage technology, Supporting subsystems

UNIT-VI:
Energy Storage and Energy Management Strategies: Energy Storage Requirements in Hybrid and Electric Vehicles, batteries, Fuel cell and super conductor and Flywheel based Energy

storage Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy management strategies. Case Studies of design of a Hybrid Electric Vehicle (HEV) and Battery Electric Vehicle (BEV).

TEXT BOOKS:

1. Electric and Hybrid Vehicles: Design Fundamentals, Iqbal Hussein, CRC Press, 2010
2. Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, CRC Press, 2009
3. Electric Vehicle Technology Explained, James Larminie, John Lowry, Wiley, 2003

REFERENCES:

1. Hybrid Vehicle Propulsion, Jefferson C. M., Barnard and R. H., WIT Press, 2002
2. Hybrid, Electric and Fuel Cell Vehicles, Jack Erjavec and Jeff Arias, Cengage Learning, 2012
3. Electric Vehicles - The Benefits and Barriers, Seref Soylu, InTech Publishers, 2011
4. Alternative Fuel Technology – Electric, Hybrid and Fuel Cell Vehicles, Jack Erjavec and Jeff Arias, Cengage Learning Pvt. Ltd., 2007
5. Build Your Own Electric Vehicle, Seth Leitman, McGraw Hill, 2013

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M.Tech. II Semester (PS)	**L**	**T/P**	**C**
	3	**0**	**3**

(A18PE1PS07) EHV AC TRANSMISSION

COURSE PRE-REQUISITES: High Voltage Engineering, Transmission Line Theory

COURSE OBJECTIVES:
- To identify the different aspects of Extra High Voltage A.C and D.C Transmission design and analysis
- To understand the importance of modern developments of E.H.V and U.H.V transmission systems
- To demonstrate EHV ac transmission system components, protection and insulation level for over voltages

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: List the necessity of EHV AC transmission, choice of voltage for transmission, line losses and power handling capability
CO-2: Estimate the Statistical procedures for line designs, scientific and engineering principles in power systems
CO-3: Construct commercial transmission system

UNIT-I:
Modeling of EHV Lines: E.H.V.A.C. Transmission line trends and preliminary aspect standard transmission voltages – Estimation at line and ground parameters-Bundle conductor systems-Inductance and Capacitance of E.H.V. lines – positive, negative and zero sequence impedance – Line Parameters for Modes of Propagation.

UNIT-II:
Electrostatic Field and Voltage Gradients Estimation: Electrostatic field– calculations of electrostatic field of AC lines – 3 phase single circuit, double circuit lines and 6 phase AC lines - effect of high electrostatic field on biological organisms and human beings.
Voltage Gradients: surface voltage gradients and maximum gradients of actual transmission lines – voltage gradients on sub conductor.

UNIT- III:
Power Frequency Voltage Control: Calculation of Electrostatic induction in un-energized D/C lines – measurement of field for three phase double circuit un-energized lines. Power Frequency Voltage control and over-voltages in EHV lines: No load voltage condition and charging current – cascade connection of components - shunt and series compensation – static VAR compensation.

UNIT-IV:
Corona: Corona in E.H.V. lines – Corona loss formulae- attention of traveling waves due to Corona – Audio noise due to Corona, its generation, characteristic and limits.

UNIT-V:
Electro Magnetic Interference: Measurements of audio noise radio interference due to Corona - properties of radio noise – frequency spectrum of RI fields – Measurements of RI and RIV.

UNIT-VI:
Design Aspects of EHV Lines: Design of EHV lines based on steady state and transient limits - EHV cables and their characteristics

TEXT BOOKS:

1. EHVAC Transmission Engineering, R. D. Begamudre, 3rd Edition, New Age International
2. HVDC Power Transmission Systems, K. R. Padiyar, 2nd Revised Edition New Age International, 2012

REFERENCES:

1. EHVAC and HVDC Transmission Engineering Practice, S. Rao, Khanna Publishers
2. High Voltage Direct Current Transmission, Arrillaga J. 2nd Edition (London) Peter Peregrines, IEEE, 1998
3. FACTS Controllers in Power Transmission and Distribution, Padiyar K. R., New Age International, 2007
4. Understanding FACTS-Concepts and Technology of Flexible AC Transmission Systems, Hingorani H. G. and Gyugyi L., IEEE Press, 2000

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M.Tech. II Semester (PS)	**L**	**T/P**	**C**
	3	**0**	**3**

(A18PE1PS08) SMART GRIDS

COURSE PRE-REQUISITES: Electrical Distribution Systems, Power Systems

COURSE OBJECTIVES:
- To understand concept of smart grid and its advantages over conventional grid
- To know smart metering techniques
- To learn wide area measurement techniques
- To understand the problems associated with integration of distributed generation & it's solution through smart grid

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Appreciate the difference between smart grid & conventional grid
CO-2: Apply smart metering concepts to industrial and commercial installations
CO-3: Formulate solutions in the areas of smart substations, distributed generation and wide Area measurements
CO-4: Come up with smart grid solutions using modern communication technologies

UNIT-I:
Introduction to Smart Grid: Introduction, Evolution of Electric Grid, Smart Grid Concept, Need of Smart Grid, Features-Characteristics- Key Drivers of the Smart Grid, Functions of Smart Grid, Opportunities of Smart Grid, Challenges in Implementation of Smart Grid, Technical Challenges for Development of Smart Grid in India, Smart Grid Benefits, Scope of Smart Grid, Difference between Conventional and Smart Grid, Concept of Resilient, Resilience of Smart Grid Functions, Self-Healing Grid, Smart Grid Implementation, Present Development and International policies in Smart Grid ,

UNIT-II:
Smart Grid Technologies: Introduction, Smart Substation-Technology-Drivers, Classifications of Substations, Elements of Substation, Objectives of Smart Substation, Functions of Smart Substation, Sub-Station Automation: Key Drivers - Benefits – Functions. Feeder Automation, Applications of Feeder Automation, Energy Management System (EMS), System Design, Mechanism of Smart Energy System Outage Management, Plug in Hybrid Electric Vehicles (PHEV). Vehicle to grid.

UNIT-III:
Phasor Measurement Unit: Concept of Phasor Measurement Phasor Measurement Unit (PMU)-Features -Fundamentals, The Global Positioning Satellite (GPS) Systems, Synchrophasor Definition and Measurements, Applications of PMUs in Power Systems, Outlook of PMUs, Main strategy of PMU placement Based on Power Systems Intrinsic Characteristics, The Comparisons between SCADA system and PMUs System, Intelligent Electronic Devices-Functions-Advantages, , Wide Area Monitoring, Wide Area Monitoring Protection and Control (WAMPAC) System

UNIT-IV:
Micro-Grid: Concept of Micro grid, need & applications of Micro grid, Formation of micro grid, Inter connection, protection and control of micro grid, Plastic & Organic Solar cells, Thin film solar cells, Variable speed Wind generators, Fuel cells, micro turbines, Captive power plants, Integration of Renewable Energy Sources, Smart Storages, Battery, SMES, Pumped hydro, Compressed air storage.

UNIT-V:

Power Quality in Smart Grid: Introduction, Power Quality, Electromagnetic Compatibility (EMC), Relation Between Voltage Quality and EMC, Field Experiences with Smart Grid Technology, Voltage Quality Planning Levels, Power Quality Standard, Power Quality Issues of Grid Connected Renewable Energy Sources, Causes Of Low Power Quality, Issues ,Challenges and Solutions of RES-Grid Integration, , Power Quality Conditioner (PQC)-Principle – Control Circuit- Series Compensation Control Circuit, Power Quality Monitoring-Considerations, Permanent Power Quality Monitoring Equipment.

UNIT-VI:

Smart Meters and Advanced Metering: Introduction, Smart Meter, The Smart Grid and Smart Meter Systems, Smart Meter-Technologies-Benefits, Advanced Metering Infrastructure (AMI)-Technologies-Protocols- Benefits-Standards-Initiatives- Developments

Local Area Network (LAN)-Objectives-Technologies, Home Area Network (HAN)-Components- Technologies, Wide Area Network (WAN), Types of Connection in WAN, WAN Devices, Broadband Over Power Lines (BPL)-Features-Working, IP based Protocol, Need of Internet Protocol, Goals of IP, IP Based Networks, Cloud Computing, Cyber Security for Smart Grid, Need of Secure Smart Grid, Objectives and Requirements of Cyber Security, Network Security Threats in the Smart Grid

TEXT BOOKS:

1. Smart Grid Fundamentals of Design and Analysis, James Momoh, First Edition
2. Introduction to the Smart Grid Concepts, Technologies and Evolution, S. K. Salman, IET Library, 2017

REFERENCES:

1. Smart Grid Technology, Harsh Tanwar, Bhavishya Mittal, Bhawana Chouhan, Genius Publications
2. Smart-Grid-Handbook: For Regulators & Policy Makers, Indian Smart Grid Forum, 2017

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M.Tech. II Semester (PS)	**L**	**T/P**	**C**
	3	**0**	**3**

(A18PC1PL06) ADVANCED CONTROL SYSTEMS

COURSE PRE-REQUISITES: Control Systems, Linear Control Systems, Digital Control Systems

COURSE OBJECTIVES:
- To cater the knowledge of basic and modern control system for the real time analysis and design of control systems
- To provide adequate knowledge of nonlinear systems
- To analyze the concept of stability of nonlinear systems and categorization
- To provide comprehensive knowledge of optimal control and modern control

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Apply the knowledge of basic and modern control system for the real time analysis and design of control systems
CO-2: Understand the concepts of state variables analysis
CO-3: Analyze the concept of stability of nonlinear systems and optimal control
CO-4: Analyze the concepts of optimal control and modern control

UNIT-I:
State Space Representation: State Space Representation of physical systems, Transfer function to state space representation, Phase variable form, Canonical Forms – Controllable Canonical Form, Observable Canonical Form, Jordan Canonical Form, State space to Transfer function-State diagram Representation.

UNIT-II:
State Transition Matrix, Controllability and Observability: Solution of State Equation, State Transition Matrix; Tests for controllability and observability for continuous time systems – Time varying case, time invariant case, Principle of Duality, Controllability and observability form and other canonical forms.

UNIT-III:
Nonlinear Systems & Phase-Plane Analysis: Introduction to nonlinear systems, Properties of nonlinear systems, Types of nonlinearities, Introduction to phase-plane analysis, Isocline Method, singular points- Stable, Unstable Nodes, Saddle Point.

UNIT-IV:
Stability Analysis: Stability in the sense of Lyapunov, Lyapunov's stability and Lypanov's instability theorems. Direct method of Lypanov for the Linear and Nonlinear continuous time autonomous systems, Variable gradient method.

UNIT-V:
Modal Control & Calculus of Variations: Effect of state feedback on controllability and observability, Design of State Feedback Control through Pole placement. Full order observer and reduced order observer.
Minimization of functional of single function, Constrained minimization - Minimum principle. Control variable inequality constraints. Control and state variable inequality constraints. Euler Lagrange Equation.

UNIT-VI:
Optimal Control: Formulation of optimal control problem, Minimum time, Minimum energy, minimum fuel problems. State regulator problem. Output regulator problem. Tracking problem, Continuous-Time Linear Regulators.

TEXT BOOKS:

1. Modern Control System Theory, M. Gopal, 2nd Edition, New Age International Publishers, 1996
2. Advanced Control Systems, A. Nagoor Khani, 2nd Edition, RBA Publications, 2014

REFERENCES:

1. Modern Control Engineering, K. Ogata, 3rd Edition, Prentice Hall of India, 1998
2. Control Systems Engineering, I. J. Nagarath and M. Gopal, New Age International (P) Ltd.
3. Digital Control and State Variable Methods, M. Gopal, Tata McGraw-Hill Companies, 1997

VNR VIGNANA JYOTHI INSTITUTE OF ENGINEERING AND TECHNOLOGY

M.Tech. II Semester (PS)	**L**	**T/P**	**C**
	0	**3**	**1.5**

(A18PC2PS03) FACTS LABORATORY

COURSE PRE-REQUISITES: Power Electronics and Flexible AC Transmission Systems

COURSE OBJECTIVES:
- To study different types of compensators
- To develop various models of compensators
- To apply Power electronics to various systems

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Analyze various types of variable Impedance type FACTS Controllers
CO-2: Analyze converter based FACTS Controllers
CO-3: Modelling and simulation of transmission lines and Controllers
CO-4: Transient stability and voltage stability Improvement of Power Systems using FACTS controllers

LIST OF EXPERIMENTS:

1. Modeling and simulation of medium and long transmission lines
2. Study and simulation of Thyristor Controlled Reactor with its waveform
3. Modeling and simulation of FC-TCR type SVC
4. Modeling and simulation of TSC-TCR type SVC
5. Simulation of PWM based VSC
6. Simulation of three level voltage sourced converter
7. Modeling and Simulation of TCSC Controllers
8. Voltage stability Improvement of large-scale power system using FACTS Controllers
9. Transient stability improvement of large-scale power system using FACTS Controllers
10. A static synchronous compensator used for mid-point voltage regulation on a transmission line

Note: The above experiments are to be simulated using suitable simulation software

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M.Tech. II Semester (PS)	**L**	**T/P**	**C**
	0	**3**	**1.5**

(A18PC2PS04) POWER SYSTEM DYNAMICS LABORATORY

COURSE PRE-REQUISITES: Power System Dynamics

COURSE OBJECTIVES:
- To study of AVR and PSS models
- To develop mathematical approach for stability
- To study of dynamic coherence

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Study the Load frequency control of single and two area systems
CO-2: Small signal and transient stability analysis of SMIB System and Interconnected systems
CO-3: Analysis of SMLB system and self-excited Synchronous Generator
CO-4: Study of AVR and PSS on system stability and stability analysis

LIST OF EXPERIMENTS:

1. Load frequency control of single area power system using simulation
2. Load frequency control of two area power system using simulation
3. Steady state stability analysis of a SMIB test system using root locus technique
4. Dynamic stability study of SMIB test system using time response of simplified model
5. Transient stability study of SMIB test system using dynamic simulation
6. Study of Steady state voltage stability of SMLB test system using simulation
7. Simulation and study of self-excited synchronous generator
8. Study of transient stability of interconnected power system using fault analysis
9. Steady state and Transient Models of 3-Phase Synchronous Machine
10. Simulation of AVR/PSS Models

Note: The above experiments are to be simulated using suitable simulation software

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M.Tech. II Semester (PS)	**L**	**T/P**	**C**
	0	**4**	**2**

(A18PW4PS02) MINI-PROJECT

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Understand the formulated industry / technical / societal problems
CO-2: Analyze and / or develop models for providing solution to industry / technical / societal problems
CO-3: Interpret and arrive at conclusions from the project carried out
CO-4: Demonstrate effective communication skills through oral presentation
CO-5: Engage in effective written communication through project report

COURSE OUTLINE:

- A student shall undergo a mini-project during II semester of the M.Tech. programme.
- A student, under the supervision of a faculty member, shall collect literature on an allotted project topic of his / her choice, critically review the literature, carry out the mini-project, submit it to the department in a prescribed report form.
- Evaluation of the mini-project shall be done by a Project Review Committee (PRC) consisting of the Head of the Department, faculty supervisor and a senior faculty member of the specialization / department.
- Prior to the submission of mini-project report to the PRC, its soft copy shall be submitted to the PG Coordinator for PLAGIARISM check.
- The mini-project report shall be accepted for submission to the PRC only upon meeting the prescribed similarity index.

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M.Tech. II Semester (PS)	**L**	**T/P**	**C**
	2	**0**	**0**

(A18AU5EN01) ENGLISH FOR ACADEMIC AND RESEARCH WRITING

COURSE OBJECTIVES:
- To understand the usage of appropriate vocabulary (Formal, Informal, Gender Insensitive etc.)
- To understand the features and processes of academic writing
- To identify the resources
- To understand standard documentation styles

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Use appropriate vocabulary (Formal, Informal, Slang, Gender Insensitive etc.)
CO-2: Employ processes of academic writing
CO-3: Identify the resources
CO-4: Understand standard documentation styles

UNIT- I:
Introduction to Research:
i. Identifying the topic
ii. Identifying Sources; Finding Sources
iii. Defining the broad area; Defining the specific area; Difference between a broad area and specific area
iv. Choosing a topic
v. Mechanics of Writing – Language, Tone, Style, Ethics

UNIT-II:
Referencing & Library Skills:
i. Literature Survey
ii. Writing Objectives
iii. Hypothesis
iv. Methodology
v. Prospects for Future Research

UNIT-III:
Academic Writing Skills:
i. Paraphrasing
ii. Summarizing
iii. Quoting
iv. Rewriting
v. Expansion

UNIT-IV:
Kinds of Academic Writing:
i. Essays
ii. Reports
iii. Reviews
iv. SOPs
v. Abstracts
vi. Proposals

UNIT-V:
Research Process:
i. Selection of Topic

ii. Formulation of Hypothesis
iii. Collection of Data
iv. Analysis of Data
v. Interpretation of Data
vi. Presentation of Data

UNIT-VI:

i. Title
ii. Abstract
iii. Introduction
iv. Literature Survey
v. Methodology
vi. Discussion
vii. Findings/Results
viii. Conclusion
ix. Documenting Sources

TEXT BOOKS:

1. Writing for Science, Goldbort R., Yale University Press (available on Google Books), 2006
2. Handbook of Writing for the Mathematical Sciences, Highman N., SIAM. Highman's Book, 1998

REFERENCES:

1. How to Write and Publish a Scientific Paper, Day R., Cambridge University Press, 2006
2. English for Writing Research Papers, Adrian Wall Work, Springer New York Dordrecht Heidelberg London, 2011
3. MLA Handbook for Research

VNR VIGNANA JYOTHI INSTITUTE OF ENGINEERING AND TECHNOLOGY

M.Tech. III Semester (PS)	**L**	**T/P**	**C**
	3	**0**	**3**

(A18PE1PS09) ENERGY AUDITING CONSERVATION AND MANAGEMENT

COURSE PRE-REQUISITES: Energy Systems and Power Systems

COURSE OBJECTIVES:
- To know the necessity of conservation of energy
- To generalize the methods of energy management
- To illustrate the factors to increase the efficiency of electrical equipment
- To detect the benefits of carrying out energy audits

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Tell energy audit of industries
CO-2: Predict management of energy systems
CO-3: Sequence the methods of improving efficiency of electric motor
CO-4: Analyze the power factor and to design a good illumination system
CO-5: Determine pay back periods for energy saving equipment

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 manager, 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: Power factor – methods of improvement, location of capacitors, p.f with nonlinear loads, effect of harmonics on power factor, power factor motor controllers.

UNIT-V:
Lighting and Energy Instruments: 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.
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.

UNIT VI:
Green Buildings: Barriers to green buildings, green building rating tools, material selection, operating energy, façade systems, ventilation systems, transportion, water treatment systems, water efficiency, building economics, Leed and IGBC codes.

TEXT BOOKS:

1. Energy Management, W. R. Murphy and G. Mckay, Butterworth-Heinemann Publications
2. Energy Management, Paul o' Callaghan, McGraw-Hill Book Company, 1st Edition, 1998
3. Sustainable Construction: Green Building Design and Delivery, Charles J. Kibert, John Wiley and Sons, Second Edition, 2008

REFERENCES:

1. Energy Efficient Electric Motors, John C. Andreas, Marcel Dekker Inc. Ltd., 2nd Edition, 1995
2. Energy Management Handbook, W. C. Turner, John Wiley and Sons
3. Energy Management and Good Lighting Practice: Fuel Efficiency Booklet, 12-EEO

VNR VIGNANA JYOTHI INSTITUTE OF ENGINEERING AND TECHNOLOGY

M.Tech. III Semester (PS)	**L**	**T/P**	**C**
	3	**0**	**3**

(A18PE1PL08) ENERGY STORAGE TECHNOLOGIES

COURSE PRE-REQUISITES: None

COURSE OBJECTIVES:
- To understand nonelectrical storage technologies available
- To understand Electro chemical secondary batteries characteristics
- To understand efficiency improvement techniques in storage systems
- To appreciate various applications of storage systems

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Learn Mechanical, Magnetic and Electrostatic storage systems
CO-2: Enumerate merits and demerits of various secondary batteries
CO-3: Study characteristics of Lead acid batteries
CO-4: Improve the efficiency of storage systems
CO-5: Apply knowledge on storage technologies in EV and Power systems

UNIT-I:
Non-electrical Storage Systems: Flywheel, Energy Relations, Flywheel System Components, Benefits of Flywheel over Battery, Superconducting Magnet Energy Storage, Compressed Air Energy storage, Overview Thermal Energy Storage.
Capacitor bank storage, Comparison of storage Technologies.

UNIT-II:
Electro Chemical Storage: History, General battery concepts- Types of Batteries- Primary, seconday- Battery Vs Cell, Nickel-Cadmium -Nickel-Metal Hydride, Nickel hydrogen, Lithium-Ion- Lithium-Polymer, Fuel cells.

UNIT –III:
Specifications and Characteristics: Domains of applications of Energy storage- Starter-Traction-stationary-mobile or nomadic, Review of storage requirements, Definitions of characteristics, Terminology of States, Battery Design, Battery Charging, Charge Regulators, Battery Management, General Equivalent Electrical Circuit, Performance Characteristics.

UNIT-IV:
Sealed-Lead Cells and Batteries: Discharge Characteristics, Charging-Importance-characteristics-charge acceptance-over charging, Types of charging- Constant voltage charging- Constant current charging- Taper charging-special charging- Charging power sources, storage, Testing, safety.

UNIT –V:
Electrical Energy Storage System Efficiency Improvement: Hybrid Electrical Energy storage– Design Considerations- Architecture- Charge management- components Modeling of Power Conversion, Reconfigurable EES Array Architecture, Cycle Efficiency and Capacity Utilization of EES Bank , General Bank Reconfiguration Architecture, Dynamic Reconfiguration Algorithm, Cycle Efficiency and Capacity Utilization Improvement .

UNIT–VI:

Storage Applications: Electric Vehicle application- Regenerative Brake- PV module assistance-Storage bank reconfiguration- Overall cost analysis, Energy storage in Transient regimes of Power system-Problem formulation-modeling- steady tate stability analysis with storage-storage Parameters to ensure transient stability, Battery rating calculations for standalone system.

TEXT BOOKS:

1. Energy Storage for Power Systems, A. Ter-Gazarian, Peter Peregrinus Ltd., 1994
2. Design and Management of Energy-Efficient Hybrid Electrical Energy Storage Systems, Younghyun Kim, Naehyuck Chang, Springer, 2014
3. Rechargeable Batteries Applications Handbook, EDN Series for Design Engineers, Elsevier

REFERENCES:

1. Lithium Batteries and Other Electrochemical Storage Systems, Christian Glaize, Sylvie Geniès
2. Wind and Solar Power Systems, Second Edition, Mukund R. Patel, CRC Press, 2006

VNR VIGNANA JYOTHI INSTITUTE OF ENGINEERING AND TECHNOLOGY

M.Tech. III Semester (PS)	**L**	**T/P**	**C**
	3	**0**	**3**

(A18PE1PL09) HVDC TRANSMISSION

COURSE PRE-REQUISITES: Power Electronics, Power Systems

COURSE OBJECTIVES:
- To comprehend the conversion principles of HVDC transmission
- To analyse 3, 6, 12 pulse converters, rectifier and inverter operations of HVDC converters
- To identify the different types of Harmonics and reduction by using filters
- To comprehend Interaction between HVAC and DC systems in various aspects
- To appreciate the reliable MTDC systems and protection of HVDC system

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Understand HVDC technology
CO-2: Apply the knowledge of modeling and analysis of HVDC system for inter-area power flow regulation
CO-3: Appreciate the reliable Multi terminal HVDC system
CO-4: Apply advanced protective schemes for HVDC systems against transient over voltages and over currents

UNIT-I:
HVDC Technology: Historical development in DC Transmission, Advantages & Disadvantages of DC Transmission over Ac Transmission, DC Transmission Systems: Mono-polar, bi-polar and homo-polar lines, back-to-back HVDC systems, Components of HDVC Transmission System, Main applications of DC Transmission.

UNIT-II:
HVDC Converters: Rectifier and Inverter operation Digital Simulation of converters, Control of HVDC converters and Systems, Individual phase control, Equidistant firing controls, higher level controls. Characteristics and non-characteristics harmonics filter design.

UNIT-III:
HVDC System Control: Constant current control, constant excitation angle control, VDCOL, constant ignition angle control, Individual phase control and equidistant pulse control; Valve blocking and by-passing; Starting, stopping and power flow reversal. Fault development and protection.

UNIT-IV:
MTDC Systems: Introduction-Potential applications of MTDC systems, Types of MTDC systems-Comparison, multi-terminal HVDC systems, control of MTDC systems. MTDC system - Case study - Interaction between AC-DC power systems over voltages on AC/DC side.

UNIT-V:
Power Flow Analysis in HVDC Systems: Introduction, Modeling of DC links, Modeling of HVDC systems - Basic model of the converter, converter equations, per unit system for DC quantities, DC Network equations, DC control equations, Representation for AC-DC power flow solution, representation for stability studies.

UNIT-VI:

Standards for Testing & Measurements in HVDC Systems: Introduction to relevant national and international standards-IEC, IEEE, CIGRE, safe clearances for HV, Study regulations for HV tests, Digital techniques in HV measurements.

TEXT BOOKS:

1. High Voltage Direct Transmission, J. Arrillaga, Peter Peregrinus Ltd. London, 1983
2. HVDC Power Transmission Systems, K. R. Padiyar, Wiley Eastern Ltd., 1990

REFERENCES:

1. Direct Current Transmission, E. W. Kimbark, Vol. I, Wiley Interscience, 1971
2. Power Transmission by Direct Current, Erich Uhlmann, B. S. Publications, 2004
3. EHVAC and HVDC Transmission Engg. Practice, Theory, Practice and Solved Problems, Felix A. Farret, M. S. Rao, Khanna Publishers, 1990

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M.Tech. III Semester (PS)	**L**	**T/P**	**C**
	3	**0**	**3**

(A18OE1CN01) BUSINESS ANALYTICS

COURSE OBJECTIVES:

- To understand the role of business analytics within an organization and to analyze data using statistical and data mining techniques and understand relationships between the underlying business processes of an organization
- To gain an understanding of how managers use business analytics to formulate and solve business problems and to support managerial decision making and to become familiar with processes needed to develop, report, and analyze business data
- To use decision-making tools/Operations research techniques and to manage business process using analytical and management tools
- To analyze and solve problems from different industries such as manufacturing, service, retail, software, banking and finance, sports, pharmaceutical, aerospace etc.

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Apply knowledge of data analytics
CO-2: Think critically in making decisions based on data and deep analytics
CO-3: Use technical skills in predicative and prescriptive modeling to support business decision-making
CO-4: Translate data into clear, actionable insights

UNIT-I:
Business Analytics: Overview of Business analytics, Scope of Business analytics, Business Analytics Process, Relationship of Business Analytics Process and organization, competitive advantages of Business Analytics.
Statistical Tools: Statistical Notation, Descriptive Statistical methods, Review of probability distribution and data modelling, sampling and estimation methods overview.

UNIT-II:
Trendiness and Regression Analysis: Modelling Relationships and Trends in Data, simple Linear Regression. Important Resources, Business Analytics Personnel, Data and models for Business analytics, problem solving, Visualizing and Exploring Data Business Analytics Technology.

UNIT-III:
Organization Structures of Business analytics, Team management, Management Issues, Designing Information Policy, Outsourcing, Ensuring Data Quality, Measuring contribution of Business analytics, Managing Changes.
Descriptive Analytics, predictive analytics, predicative Modelling, Predictive analytics analysis, Data Mining, Data Mining Methodologies, Prescriptive analytics and its step in the business analytics Process, Prescriptive Modelling, nonlinear Optimization.

UNIT-IV:
Forecasting Techniques: Qualitative and Judgmental Forecasting, Statistical Forecasting Models, Forecasting Models for Stationary Time Series, Forecasting Models for Time Series with a Linear Trend, Forecasting Time Series with Seasonality, Regression Forecasting with Casual Variables, Selecting Appropriate Forecasting Models.
Monte Carlo Simulation and Risk Analysis: Monte Carle Simulation Using Analytic Solver Platform, New-Product Development Model, Newsvendor Model, Overbooking Model, Cash Budget Model.

UNIT-V:

Decision Analysis: Formulating Decision Problems, Decision Strategies without Outcome Probabilities, Decision Trees, The Value of Information, Utility and Decision Making.

UNIT-VI:

Recent trends in Embedded and collaborative business intelligence, Visual data recovery, Data Storytelling and Data journalism.

TEXT BOOKS:

1. Business Analytics-Principles, Concepts, and Applications, Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, Pearson FT Press
2. Business Analytics, James Evans, Pearson Education
3. Business Analytics, Purba Halady Rao, PHI, 2013

REFERENCES:

1. Business Analytics for Managers: Taking Business Intelligence Beyond Reporting, Gert H. N. Laursen, Jesper Thorlund, 2nd Edition, Wiley Publications
2. Business Analytics: Data Analysis & Decision Making, S. Christian Albright, Wayne L. Winston 5th Edition, 2015
3. Business Intelligence Guidebook: From Data Integration to Analytics, Rick Sherman Elsevier, 2014

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M.Tech. III Semester (PS)	**L**	**T/P**	**C**
	3	**0**	**3**

(A18OE1AM01) INDUSTRIAL SAFETY

COURSE PRE-REQUISITES: Elements of Mechanical, Civil, Electrical and Industrial Engineering

COURSE OBJECTIVES:

- To achieve an understanding of principles, various functions and activities of safety management
- To communicate effectively information on Health safety and environment facilitating collaboration with experts across various disciplines so as to create and execute safe methodology in complex engineering activities
- To anticipate, recognize, and evaluate hazardous conditions and practices affecting people, property and the environment, develop and evaluate appropriate strategies designed to mitigate risk
- To develop professional and ethical attitude with awareness of current legal issues by rendering expertise to wide range of industries

COURSE OUTCOMES: After completion of the course, students should be able to

CO-1: Apply risk management principles to anticipate, identify, evaluate and control physical, chemical, biological and psychosocial hazards

CO-2: Communicate effectively on health and safety matters among the employees and with society at large

CO-3: Demonstrate the use of state-of-the-art occupational health and safety practices in controlling risks of complex engineering activities and understand their limitations

CO-4: Interpret and apply legislative / Legal requirements, industry standards, and best practices in accident prevention programmes in a variety of workplaces

UNIT-I:

Safety Management: Evaluation of modern safety concepts – Safety management functions – safety organization, safety department – safety committee, safety audit - performance measurements and motivation – employee participation in safety and productivity.

UNIT-II:

Operational Safety: Hot metal Operation – Boiler, pressure vessels – heat treatment shop - gas furnace operation-electroplating-hot bending pipes – Safety in welding and cutting. Cold-metal Operation- Safety in Machine shop-Cold bending and chamfering of pipes – metal cutting – shot blasting, grinding, painting – power press and other machines

UNIT-III:

Safety Measures: Layout design and material handling - Use of electricity – Management of toxic gases and chemicals – Industrial fires and prevention – Road safety– Safety of sewage disposal and cleaning – Control of environmental pollution – Managing emergencies in industrial hazards.

UNIT-IV:

Accident Prevention: Human side of safety – personal protective equipment – Causes and cost of accidents. Accident prevention programmes - Specific hazard control strategies - HAZOP – Training and development of employees – First Aid – Firefighting devices – Accident reporting investigation.

UNIT-V:

Safety, Health, Welfare & Laws: Safety and health standards – Industrial hygiene – occupational diseases prevention - Welfare facilities – History of legislations related to safety–

pressure vessel act- Indian boiler act- The environmental protection act – Electricity act - Explosive act.

UNIT-VI:

Safe Handling and Storage: Material Handling, Compressed Gas Cylinders, Corrosive Substances, Hydrocarbons, Waste Drums and Containers

TEXT BOOKS:

1. Safety Management, John V. Grimaldi and Rollin H. Simonds, All India Travellers Bookseller, New Delhi, 1989.
2. Safety Management in Industry, Krishnan N. V., Jaico Publishing House, 1996.

REFERENCES:

1. Occupational Safety Manual, BHEL
2. Industrial Safety and The Law, P. M. C. Nair Publisher's, Trivandrum
3. Managing Emergencies in Industries, Loss Prevention of India Ltd., Proceedings, 1999
4. Safety Security and Risk Management, U. K. Singh & J. M. Dewan, A. P. H. Publishing Company, New Delhi, 1996
5. Industrial Safety Management: Hazard Identification and Risk Control, L. M. Deshmukh, McGraw-Hill Education (India) Private Limited, 2005

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M.Tech. III Semester (PS)	**L**	**T/P**	**C**
	3	**0**	**3**

(A18OE1AM02) OPERATIONS RESEARCH

COURSE PRE-REQUISITES: Mathematics, Industrial Engineering

COURSE OBJECTIVES:
- To analyze linear programming models in practical and their practical use
- To apply the transportation, assignment and sequencing models and their solution methodology for solving problems
- To apply the theory of games, replacement, inventory and queuing models and their solution methodology for solving problems
- To evaluate the dynamic programming and simulation models

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Apply and solve the dynamic programming problems
CO-2: Apply the concept of non-linear programming
CO-3: Carry out sensitivity analysis
CO-4: Model the real world problem and simulate it

UNIT-I:
Introduction to Operations Research-Definitions of OR, Characteristics of OR, Scope of OR, Classification of Optimization Techniques, models in OR, General L.P Formulation, Graphical solution, Simplex Techniques.

UNIT-II:
Revised simplex method - duality theory - dual simplex method – sensitivity or post optimality analysis - parametric programming

UNIT-III:
Nonlinear programming problem - Kuhn-Tucker condition, min cost flow problem - max flow problem - CPM/PERT

UNIT-IV:
Scheduling and sequencing, Inventory models, deterministic inventory, models - Probabilistic inventory control models - Geometric Programming.

UNIT-V:
Waiting line Models, Single and Multi-channel Problems, Dynamic Programming, Game Theory, Simulation.

UNIT-VI:
Introduction to Genetic Algorithms, Operators, applications to engineering optimization, Problems.

TEXT BOOKS:
1. Operations Research, S. D. Sharma, Kedarnath Ramnath, Meerut, New Delhi
2. Engineering Optimization, S. S. Rao, New Age International Publications, 2014
3. Introduction to Genetic Algorithms, S. N. Sivanandam, Springer

REFERENCES:
1. Operations Research-An Introduction, H. A. Taha, PHI, 2008
2. Principles of Operations Research, H. M. Wagner, PHI, Delhi, 1982
3. Introduction to Optimization: Operations Research, J. C. Pant, Jain Brothers, Delhi, 2008

4. Operations Research, Hitler Liebermann McGraw-Hill Pub., 2009
5. Operations Research, Pannerselvam, Prentice Hall of India, 2010

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M.Tech. III Semester (PS)	**L**	**T/P**	**C**
	3	**0**	**3**

(A18OE1AM03) COMPOSITE MATERIALS

COURSE PRE-REQUISITES: Maths, Physics, Chemistry, Engineering Mechanics, Mechanics of Solids

COURSE OBJECTIVES:
- To understand composite materials and their properties, relationship between them and manufacturing methods
- To understand the principles of material science applied to composite materials
- To study the equations to analyze problems by making good assumptions and learn systematic engineering methods to solve practical composite mechanics problems

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Apply fundamental knowledge of mathematics to modeling and analysis of composite materials
CO-2: Understand the manufacturing methods of various composite materials
CO-3: Analyze the failure modes of composites

UNIT-I:
Introduction: Definition – Classification and characteristics of Composite materials. Advantages and application of composites. Functional requirements of reinforcement and matrix. Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.

UNIT-II:
Reinforcements: Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers. Properties and applications of whiskers, particle reinforcements.
Mechanical Behavior of Composites: Rule of mixtures, Inverse rule of mixtures. Isostrain and Isostress conditions.

UNIT-III:
Manufacturing of Metal Matrix Composites: Casting – Solid State diffusion technique, Cladding – Hot isostatic pressing. Properties and applications.
Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving. Properties and applications.

UNIT-IV:
Manufacturing of Polymer Matrix Composites: Preparation of Moulding compounds and prepregs – hand layup method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding. Properties and applications, Introduction to Machining of Composites.

UNIT-V:
Elastic Behavior of Laminate: Basic assumptions, Strain-displacement relations, Stress-strain relation of layer within a laminate, Force and moment resultant, General load–deformation relations, Analysis of different types of laminates

UNIT-VI:
Strength: Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure. Laminate first ply failure-insight

strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.

TEXT BOOKS:

1. Material Science and Technology, Vol. 13–Composites, R. W. Cahn – VCH, West Germany
2. Analysis and Performance of Fiber Composites, Third Edition, B. D. Agarwal, Wiley Publishers

REFERENCES:

1. Mechanics of Composite Materials, Second Edition. Robert M. Jones, Scripta Book Company
2. Materials Science and Engineering-An Introduction, W. D. Callister Jr., Adapted by R. Bala Subramaniam, John Wiley & Sons, NY, Indian Edition, 2007
3. Composite Materials, K. K. Chawla
4. Composite Materials Science and Applications, Deborah D. L. Chung
5. Composite Materials Design and Applications, Danial Gay, Suong V. Hoa and Stephen W. Tasi

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M.Tech. III Semester (PS)	**L**	**T/P**	**C**
	3	**0**	**3**

(A18OE1PS01) WASTE TO ENERGY

COURSE PRE-REQUISITES: None

COURSE OBJECTIVES:
- To create awareness in students of energy conservation
- To identify the use of different types of Bio waste energy resources
- To understand different types of bio waste energy conservations
- To detect different waste conversion into different forms of energy

COURSE OUTCOMES: After completion of the course, students should be able to
CO1: Find different types of energy from waste to produce electrical power
CO2: Estimate the use of bio waste to produce electrical energy
CO3: Understand different types of bio waste and its energy conversions
CO4: Analyze the bio waste utilization to avoid the environmental pollution

UNIT-I:
Introduction to Energy from Waste: Classification of waste as fuel, Agro based, Forest residue, Industrial waste, MSW (Municipal solid waste) – Conversion devices – Incinerators, Gasifiers, Digestors

UNIT-II:
Biomass Pyrolysis: Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

UNIT-III:
Biomass Gasification: 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: Biomass stoves – Improved chullahs, 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:
Biogas: 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.

UNIT-VI:
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. Biogas Technology-Transfer and Diffusion, M. M. EL-Halwagi, Elsevier Applied Science Publisher, New York, 1984
2. Introduction to Biomass Energy Conversions, Sergio Capareda

REFERENCES:

1. Non-Conventional Energy, Desai Ashok V., Wiley Eastern Ltd., 1990
2. Biogas Technology - A Practical Handbook, Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw-Hill Publishing Co. Ltd., 1983
3. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991
4. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996

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M.Tech. III Semester (PS)	**L**	**T/P**	**C**
	0	**16**	**8**

(A18PW4PS03) PROJECT PART-I

M.Tech. IV Semester (PS)	**L**	**T/P**	**C**
	0	**28**	**14**

(A18PW4PS04) PROJECT PART-II

COURSE OUTCOMES: After completion of the course, students should be able to
CO-1: Identify and formulate the problem (Industry/technical/societal)
CO-2: Analyze, design and develop a solution to industry/technical/societal problems
CO-3: Implement and execute the solution
CO-4: Demonstrate effective communication skills through oral presentation
CO-5: Engage in effective written communication through project report

COURSE OUTLINE:

- M.Tech. project work shall be for a minimum duration of 40 weeks spread over two semesters i.e., Project Part-I in III semester and Project Part-II in IV semester.
- A student shall be permitted to register for the major project after satisfying the attendance requirement in all the courses, i.e., theory and practical courses.
- Project reviews namely Project Review I and Project Review II in III semester and Project Review III and Project Pre-submission Seminar in IV semester shall be conducted during the course of Project work.
- A Project Review Committee (PRC) consisting of the Head of the Department as Chairperson and PG Coordinator, Project Supervisor and one senior faculty member of the Department offering the M. Tech. programme as members shall evaluate the progress of project work.
- In Project Review I, a student, in consultation with his Project Supervisor, shall present the title, objective and plan of action of his/her project work to the PRC for approval within four weeks from the commencement of III semester.
- A student can initiate the project work only after obtaining the approval of the PRC.
- The work on the project shall be initiated at the beginning of the III semester.
- Project Review II shall be conducted and evaluated at the end of the III semester.
- Project Review III shall be conducted during IV semester to examine the overall progress of the project work.
- A project pre-submission seminar shall be conducted to decide whether or not the project is eligible for final submission.
- After approval from the PRC, a soft copy of the thesis shall be submitted for PLAGIARISM check to the Examination Branch.
- At the end of IV semester upon fulfilling the above conditions, project viva-voce shall be conducted.
- A student shall submit project progress in prescribed report format during each of the project reviews.