SREE VIDYANIKETHAN ENGINEERING COLLEGE
(AUTONOMOUS)
Sree Sainath Nagar, Tirupati

Department of Electrical and Electronics Engineering

Supporting Document for 1.1.3

Courses having focus on

Employability/ Entrepreneurship/ skill Development

Program: M.Tech.- Electrical Power Systems

Regulations : SVEC-16

The Courses (with course outcomes) under SVEC-16 Regulations which focus on ***employability/ entrepreneurship/ skill development*** are highlighted with the following colours.

Skill

Employability

Entrepreneurship

M. Tech. I-Semester

16MT10701: ADVANCED CONTROL SYSTEMS

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	4	--	--	4

PRE-REQUISITES: Control Systems at UG level.

COURSE DESCRIPTION:
Advanced concepts of controllability, observability; Analysis of non-linear systems; Lyapunov stability; design of controllers and observers; optimal control concepts.

COURSE OUTCOMES: On successful completion of the course, student will be able to

CO1. demonstrate knowledge in canonical forms, principle of duality, controllability, observability, effect of feedback, stability of nonlinear control systems and the concept of optimal control.
CO2. apply/analyse describing function, Phase-Plane methods and Lyapunov's stability criterion for stability analysis of non-linear systems.
CO3. solve problems in the area of non-linear systems.
CO4. initiate research in stability and optimal control systems applied to various real-time applications.
CO5. use modern techniques in the design and study of controllers, observers for stability of non-linear systems.

DETAILED SYLLABUS:

UNIT - I: CONTROLLABILITY AND OBSERVABILITY (10 Periods)
Review of state variable techniques – Concept of controllability and observability for Continuous Time Systems. Principle of Duality. Controllability and Observability of state models in Jordan canonical form and other canonical forms – effect of state feedback on controllability and observability.

UNIT - II: ANALYSIS OF NON-LINEAR SYSTEMS (12 Periods)
Introduction to non-linear systems, types of physical non-linearities, characteristics of non-linearities, properties of non-linear systems. Describing functions, derivation of describing functions for: dead zone, saturation, backlash, relay with dead zone and hysteresis. Stability analysis of non-linear systems through describing functions. Phase-plane analysis, singular points, isocline method, delta method.

UNIT - III: STABILITY ANALYSIS (12 Periods)
Stability in the sense of Lyapunov, Lyapunov' stability theorems, definiteness, Sylvester criterion, stability analysis by lyapunov second method, lyapunov functions, Krasovoskii method, variable gradient method.

UNIT - IV: CONTROLLERS AND OBSERVERS DESIGN (07 Periods)
Design of state feedback control through pole placement - full order observer and reduced order observer, state regulator problem.

UNIT - V: OPTIMAL CONTROL **(11 Periods)**

Introduction to optimal control - formulation of optimal control problems - calculus of variations, minimization of functional of single function, Euler Lagrange equation, constrained minimization, minimum principle, control variable inequality constraints.

Total Periods: 52

TEXT BOOKS:

1. M. Gopal, *Modern Control System Theory*, 2nd edition, New Age International Publishers, 1996.
2. Katsuhiko Ogata, *Modern Control Engineering*, 5th edition, Prentice Hall of India, 2010.
3. A. Nagoor kani. *Advanced control theory*, 2nd edition, RBA publications, 2004.

REFERENCE BOOKS:

1. I.J. Nagrath and M.Gopal, *Control Systems Engineering*, New Age International (P) Ltd. 2007.
2. M. Gopal, *Digital Control and State Variable Methods*, Tata Mc Graw-Hill Companies, 1997.

M. Tech. I-Semester

16MT10702: HIGH VOLTAGE ENGINEERING

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	4	--	--	4

PRE-REQUISITES: Engineering Mathematics, Electromagnetic fields and Electrical Circuits at UG level.

COURSE DESCRIPTION:
Breakdown mechanisms in solids, liquids, gases and composite dielectrics materials; conventional methods of generation and measurement of high DC, AC, impulse voltages and currents; determine the ability of an electrical apparatus to meet guaranteed test procedures and standards.

COURSE OUTCOMES: On successful completion of the course, student will be able to

CO1. demonstrate knowledge on
- behavior of various insulation materials,
- generation of high voltage and currents,
- measuring techniques for high voltage and currents,
- testing of various electrical apparatus,
- overvoltage phenomena and protection against them.

CO2. analyze the
- behavior of insulation materials,
- circuits for generation and measurement of high voltages,
- testing circuits for testing of high voltage equipment.

CO3. evaluate various high voltage generation, measuring and testing parameters of high voltage circuits.

CO4. initiate research skills in design of
- new methods of generation of high voltages,
- measuring and testing circuits for high voltage systems,
- composite insulation systems to improve the dielectric strength.

DETAILED SYLLABUS:

UNIT - I: BREAKDOWN PHENOMENA **(12 Periods)**

Introduction to HV technology, need for generating high voltages in laboratory, Industrial applications of high voltage**.** Classification of HV insulating media. Properties of important HV insulating media under each category. Gaseous dielectrics, Ionization: primary and secondary ionization processes. Criteria for gaseous insulation breakdown based on Townsend's theory. Limitations of Townsend's theory. Streamer's theory breakdown in non-uniform fields. Corona discharges. Breakdown in electro negative gases. Paschen's law and its significance. Time lags of Breakdown. Breakdown in solid dielectrics: Intrinsic Breakdown, avalanche breakdown, thermal breakdown, and electro mechanic breakdown. Breakdown of liquid dielectrics: Suspended particle theory, electronic Breakdown, cavity breakdown (bubble's theory), electro convection breakdown.

UNIT - II: GENERATION OF HIGH VOLTAGE AC AND DC & GENERATION OF IMPULSE VOLTAGE AND CURRENT (12 Periods)

GENERATION OF HIGH VOLTAGE AC AND DC: HVAC-HV transformer; Need for cascade connection and working of transformers units connected in cascade. Series resonant circuit - principle of operation and advantages. Tesla coil. HVDC- voltage doubler circuit, cock croft- Walton type high voltage DC set, Van de Graaff generator. Calculation of high voltage regulation, ripple and optimum number of stages for minimum voltage drop.

GENERATION OF IMPULSE VOLTAGE AND CURRENT: Introduction to standard lightning and switching impulse voltages. Analysis of single stage impulse generator -expression for Output impulse voltage. Multistage impulse generator working of Marx impulse. Rating of impulse generator. Components of multistage impulse generator. Triggering of impulse generator by three electrode gap arrangement. Trigatron gap and oscillograph time sweep circuits. Generation of switching impulse voltage. Generation of high impulse current

UNIT - III: MEASUREMENT OF HIGH VOLTAGES (10 Periods)

Electrostatic voltmeter - principle, construction and limitation. Chubb and Fortescue method for HV AC measurement. Generating voltmeter - Principle, construction. Series resistance micro ammeter for HVDC measurements. Standard sphere gap measurements of HVAC, HVDC and impulse voltages; Factors affecting the measurements. Potential dividers-resistance dividers capacitance dividers mixed RC potential dividers. Measurement of high impulse currents -Rogowsky coil and Magnetic Links.

UNIT - IV: NON-DESTRUCTIVE INSULATION TESTING TECHNIQUES (09 Periods)

Dielectric loss and loss angle measurements using Schering Bridge, Transformer ratio Arms Bridge. Need for discharge detection and PD measurements aspects. Factors affecting the discharge detection. PD equivalent model, PD measuring circuits, straight and balanced detectors, Location and estimation of PD in power apparatus, PD measurement by non-electrical methods, Calibration of PD detectors.

UNIT - V: HIGH VOLTAGE TESTS ON ELECTRICAL APPARATUS (12 Periods)

Need for testing standards, Standards for porcelain / Glass insulator, Polymeric insulators Classification of porcelain / glass , Polymeric insulators ; insulator tests- Tests for cap and pin porcelain/ Glass insulators, Polymeric insulators. High voltage AC testing methods, power frequency tests- Over voltage tests on insulators, Isolators, Circuit Breakers and power cables. Impulse Testing: Impulse testing of transformers – Surge diverters and other apparatus. Contamination flashover phenomena – Contamination Severity, Artificial contamination tests.

Total Periods: 55

TEXT BOOKS:

1. M. S. Naidu and V. Kamaraju, *High Voltage Engineering*, 4th edition, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2008.
2. E. Kuffel, W.S. Zaengl and J. Kuffel, *High Voltage Engineering: Fundamentals*, 2nd edition, Newnes, Elsevier Press, 2000.
3. C.L.Wadhwa, *High Voltage Engineering*, New Age Science, 2010.

REFERENCE BOOKS:

1. Mazen Abdel-Salam, Hussein Anis, Ahdab El-Morshedy, Roshdy Radwan, *High Voltage Engineering Theory and Practice,* 2nd edition, Revised & Expanded, Marcel-Dekker Publishers (Special Indian Edn.), 2000.
2. T J Gallagher and A J Pearmain, *High voltage: measurement, testing, and design*. John Wiley & Sons, 1983.

M. Tech. I-Semester

16MT10703: POWER ELECTRONIC CONVERTERS

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	4	--	--	4

PRE-REQUISITES: Power Electronics at UG level

COURSE DESCRIPTION:
Power semiconductor devices; Characteristics of power switching devices; Gate and base drive circuits; Multipulse controlled rectifiers; Power factor improvement techniques; Voltage source converters; Current source converters; Switching mode regulators; Resonant converters; Voltage control of single phase and three phase inverters; Multilevel inverters.

COURSE OUTCOMES: On successful completion of the course, student will be able to

CO1. demonstrate knowledge on
- operation and performance of power electronic converters,
- control strategies of power devices and converters.

CO2. analyze the performance of multi pulse AC/DC converters and DC/DC converters.

CO3. evaluate the power converter modules for various operating / control parameters.

CO4. initiate research in designing appropriate power converter schemes to meet/solve the industrial requirements/problems.

DETAILED SYLLABUS:

UNIT - I: POWER DEVICES AND THEIR CONTROL (11 Periods)
Overview of power semiconductor devices-reverse recovery characteristics of power diodes, switching characteristics of Power MOSFET and IGBT. Basic construction and switching characteristics of GTO and IGCT.
Characteristics of power switching devices- control characteristics, ideal and practical characteristics, specifications of switches. Gate drive circuits for SCR, MOSFET, IGBT and base drive circuits for power BJT.

UNIT - II: MULTIPULSE CONTROLLED RECTIFIERS (11 Periods)
Six pulse SCR rectifiers – Semi and full converters, operation with different firing angles, effect of line inductance, power factor and THD.
Twelve pulse SCR rectifiers - idealized 12 pulse rectifier operation, effect of line and leakage inductance, power factor and THD. 18 and 24 pulse SCR rectifiers, operation.
Single phase series converters. Power factor improvement- extinction angle control, symmetric angle control, PWM control-single and three phase control.

UNIT - III: VOLTAGE SOURCE AND CURRENT SOURCE CONVERTERS (09 Periods)
Self-commutated voltage source converters (VSC)-basic principles. Single phase full wave VSC- one phase leg circuit operation, voltage harmonics. Three phase full wave VSC-operation of a phase leg through four quadrants.
Current source converters-types, operation of thyristor based converter and current stiff converter.

UNIT - IV: ANALYSIS OF DC-DC AND RESONANT CONVERTERS (13 Periods)

Voltage commutated chopper. Current commutated chopper. Switch mode regulators – buck, boost, buck-boost and Cuk regulators, condition for continuous inductor current and capacitor voltage - design of LC filter, comparison of regulators. Multi-output boost converters – advantages, applications, numerical problems. Resonant converters- concept of ZVS and ZCS, principle of operation, analysis of M-type and L-type converters.

UNIT - V: PWM AND MULTI LEVEL INVERTERS (11 Periods)

Voltage control of single phase inverters – single, multiple, sinusoidal, modified sinusoidal pulse width modulation, phase displacement control. Advanced PWM techniques-trapezoidal, staircase, stepped, harmonic injection, delta modulations. Voltage control of three phase inverter-sinusoidal PWM, 60 degree PWM, third harmonic PWM, space vector modulation. Harmonic reduction. Multilevel inverters-types-diode clamped, flying capacitor, cascaded- operation, features, applications.

Total Periods: 55

TEXT BOOKS:

1. Muhammad H. Rashid, *Power Electronics circuits, devices and applications*, 3rd edition, Prentice Hall publications, 2009.
2. Ned Mohan, Tore M. Undeland and William P. Robbin, *Power Electronics: Converters, Application and Design*, 3rd edition, John Wiley and sons Inc., New York, 2009.

REFERENCE BOOKS:

1. Bin Wu, *High power converters and AC Drives*, John Wiley and Sons, 2006.
2. P.C Sen., *Modern Power Electronics*, 1st edition, Wheeler publishing Co, 1998.
3. Naran G. Hingorani, Laszlo Gyugyi, *Understanding FACTS*, IEEE Press., Standard Publishers Distributors, Delhi, 2001.

M. Tech. I-Semester

16MT10704: POWER SYSTEM SECURITY AND STATE ESTIMATION

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	4	--	--	4

PRE-REQUISITES: Engineering mathematics, numerical methods, fundamental of power system, Power system operation and Control and Power system Analysis at UG level

COURSE DESCRIPTION:
Power system network matrices; Balanced and unbalanced short circuit analysis; AC and DC Load flow studies; Power system security; Methods of power system state estimation

COURSE OUTCOMES: On successful completion of the course, student will be able to

CO1. demonstrate in-depth knowledge on
- formation of power system network matrices,
- load flow solutions and fault analysis for various operating conditions,
- state estimation and security analysis of power systems,
- Energy Management System (EMS) and control center.

CO2. analyze state and security aspects of power system network for various operational issues and contingencies.

CO3. develop skills in evaluating the state and security of power system network.

CO4. initiate research in developing algorithms to investigate the state & security of power system network and design appropriate control strategy to meet the required specifications.

DETAILED SYLLABUS:

UNIT - I: POWER SYSTEM NETWORK MATRICES (09 Periods)

Formation of bus admittance matrices by direct inspection method – Algorithm for formation of Bus impedance matrix: addition of a branch and addition of a link, removal element in Bus impedance matrix – simple problems. $\prod$-representation of off-nominal tap transformers.

UNIT - II: FAULT ANALYSIS (11 Periods)

Short circuit studies – introduction, short circuit calculations using $Z_{bus,}$ Z_f^{abc}, Y_f^{abc}, Z_f^{012} and Y_f^{012} matrices for various faults. Analysis of balanced and unbalanced three phase faults – simple problems.

UNIT - III: POWER SYSTEM SECURITY - I (12 Periods)

Review of power flow methods *(qualitative treatment only),* DC power flow method -simple problems. Introduction to power system security, factors influencing power system security. Introduction to contingency analysis

UNIT - IV: POWER SYSTEM SECURITY - II (09 Periods)

Contingency analysis: Detection of Network problems, linear sensitivity factors, AC power flow methods, Contingency selection, concentric relaxation, bounding – simple problems.

UNIT - V: STATE ESTIMATION IN POWER SYSTEM (14 Periods)

Power system state estimation, EMS center, data acquisition, Methods of state estimation – method of least squares, orthogonal matrix, properties, Givens rotation, orthogonal decomposition - Hessian matrix, Treatment of bad data – applications to power system state estimation – simple problems

Total Periods: 55

TEXT BOOKS:

1. Allen J.Wood and Wollenberg B.F., *Power Generation Operation and control* John Wiley & Sons, 2nd edition, 2006.
2. Venkatesh, B.V. Manikandan, S. Charles Raja and A.Srinivasan, *Electrical power systems analysis, security, and deregulation*, PHI Learning private limited, Delhi, 2014.

REFERENCE BOOKS:

1. Nagrath I.J. and Kothari D.P., *Modern Power System Analysis*, TMH, New Delhi, 2004.
2. T. K. Nagasarkar and M.S. Sukija, *Electrical Power Analysis*, OXFORD University press, 2nd edition, New Delhi, 2009.

M. Tech. I-Semester

16MT10705: REACTIVE POWER COMPENSATION AND MANAGEMENT

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	4	--	--	4

PRE-REQUISITES: Power Systems at UG level

COURSE DESCRIPTION:

Reactive Power compensation: Ideal compensator; Line and load compensation ; Compensating devices; Reactive power coordination; Quality of power supply; Distribution side management; Reactive power management in domestic and industrial sectors.

COURSE OUTCOMES: On successful completion of the course, student will be able to

CO1. demonstrate knowledge on

- concepts of reactive power compensation,
- different methods of reactive power compensation,
- load patterns and loss reduction methods in distribution lines.

CO2. analyze different types of reactive power compensation methods

CO3. develop skills in evaluating size and location of compensator to improve power system profile.

CO4. initiate research in reactive power management for commercial and industrial applications.

CO5. follow standards and practices for maintaining quality of power.

DETAILED SYLLABUS:

UNIT - I: REACTIVE POWER COMPENSATION (10 Periods)

Need for Reactive Power compensation – reactive power characteristics. Ideal compensator, practical compensation – power factor correction and voltage regulation. Load compensator as a voltage regulator, phase balancing and power factor correction of unsymmetrical loads – examples.

UNIT - II: REACTIVE POWER COMPENSATION IN TRANSMISSION SYSTEMS (12 Periods)

Steady state Reactive power compensation – Uncompensated line, Types of compensation, Passive shunt, series and dynamic shunt compensation – examples.

Transient state Reactive power compensation – Characteristic time periods. Passive shunt compensation. Static compensations–series capacitor compensation, compensation using synchronous condensers - examples

UNIT - III: REACTIVE POWER COORDINATION AND PLANNING (11 Periods)

Reactive power coordination: Objectives, Mathematical modeling, Operation planning, transmission benefits. Basic concepts of quality of power supply: Disturbances, steady – state variations, effects of under voltages, frequency, Harmonics, radio frequency and electromagnetic interferences, IEEE /IEC standards.

Reactive power planning: Objectives, Economics Planning capacitor placement and retrofitting of capacitor banks.

UNIT - IV: REACTIVE POWER MANAGEMENT (12 Periods)

KVAR requirements for domestic appliances: Purpose of using capacitors, selection of capacitors, deciding factors. Types of available capacitors – characteristics and limitations, Control of capacitors.

Demand side management: Load patterns, basic methods load shaping, power tariffs, KVAR based tariffs penalties for voltage flickers and Harmonic voltage levels - System losses, loss reduction methods - examples.

UNIT -V: REACTIVE POWER MANAGEMENT IN INDUSTRIAL SECTORS

(10 Periods)

Typical layout of traction systems–reactive power control requirements. Distribution transformers, Electric arc furnaces, textile and plastic industries, furnace transformer, filter requirements, remedial measures, and power factor of an arc furnace, role of capacitors in wind mill generator, minimum capacitance required for excitation.

Total Periods: 55

TEXT BOOKS:

1. T.J.E.Miller, *Reactive power control in Electric power systems*, John Wiley and Sons, 1982.
2. D.M. Tagare, *Reactive power Management*, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2004

REFERENCE BOOK:

1. Wolfgang Hofmann, Jurgen Schlabbach, Wolfgang Just, *Reactive power compensation: A Practical Guide,* Willey, April, 2012.

M. Tech. I-Semester

16MT10706: EHVAC TRANSMISSION

(Professional Elective - 1)

Int. Marks	Ext. Marks	Total marks	L	T	P	C
40	60	100	4	--	--	4

PRE-REQUISITES: Transmission of electric power, Distribution of Electric Power and Power System Analysis at UG level.

COURSE DESCRIPTION:
Transmission Line Trends and Preliminaries, Voltage Gradients of Conductors, Corona Effects, Electrostatic Fields, Power-Frequency Voltage Control and Over Voltages.

COURSE OUTCOMES: On successful completion of the course, student will be able to
CO1. demonstrate knowledge on
- EHVAC conductor parameters, configurations, electrical and mechanical aspects,
- corona interference, effects and relevant parameters in EHVAC systems,
- electrostatic field interference and effects,
- voltage control methods in EHVAC system.

CO2. analyze
- various electrical parameters of conductor with various configurations,
- various parameters of corona phenomenon in EHVAC system.

CO3. demonstrate skills in evaluation of various parameters of EHV lines
CO4. initiate research in designing strategies to minimize adverse effects of EHVAC system.

DETAILED SYLLABUS:

UNIT - I: TRANSMISSION LINE TRENDS AND PRELIMINARIES (13 Periods)
Role of EHV AC transmission. Power handling capacity and line loss, costs of transmission lines and equipment. Mechanical considerations in line performance – numerical problems.
Line and Ground parameters:
Calculation of resistance of conductors. Properties of bundled conductors - bundle spacing, bundle radius and geometric mean radius of bundle. Inductance of EHV line configurations – Inductance of two conductors, multi-conductor lines and bundled conductor lines. Line Capacitance calculation - sequence inductances and capacitances – modes of propagation – Resistance and inductance of ground return – numerical problems.

UNIT - II: VOLTAGE GRADIENTS OF CONDUCTORS (12 Periods)
Electrostatics, field of sphere gap, field of line changes and their properties, charge - potential relations for multi-conductors. Surface voltage gradient on conductors - distribution of voltage gradient on sub conductors of bundle - numerical problems.

UNIT - III: CORONA EFFECTS (14 Periods)
Power loss: corona loss formulae, charge-voltage (Q-V) diagram.
Audible Noise (AN): Generation, characteristics, limits and measurements of AN, relation between 1-phase and 3-phase AN levels – numerical problems.

Radio Interference (RI): Corona pulses - generation, properties and frequency spectrum. Limits for radio interference fields. Lateral profiles of RI and modes of propagation, excitation function, measurement of RI, RIV and excitation functions – numerical problems.

UNIT - IV: ELECTROSTATIC FIELDS (10 Periods)

Electrostatic field: calculation of electrostatic field of EHV lines, effect on humans, animals and plants - electrostatic induction in un-energized circuit of Single circuit and double-circuit lines – meters and measurement of electrostatic fields– numerical problems.

UNIT - V: POWER-FREQUENCY VOLTAGE CONTROL AND OVERVOLTAGES (10 Periods)

No-load voltage conditions and charging currents, voltage control – synchronous condenser, shunt and series compensation. Static VAR compensation – Numerical problems.

Total Periods: 59

TEXT BOOK:

1. Rakosh Das Begamudre, *Extra High Voltage AC Transmission Engineering*, 3rd edition, New Age International Pvt. Ltd, 2009.

REFERENCE BOOKS:

1. S. Rao, *EHVAC, HVDC Transmission and Distribution Engineering*, 3rd edition, Khanna Publications, 2001.
2. General Electric Company (GEC), Project EHV, *EHV Transmission line reference Book*, Edison House, 1968.

M. Tech. I-Semester

16MT10707: MICROCONTROLLERS AND APPLICATIONS

(Professional Elective - 1)

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	4	--	--	4

PRE-REQUISITES: Digital logic design, Microprocessors and Microcontrollers at UG level

COURSE DESCRIPTION:
8051 Microcontroller: Architecture, Programming and Interfacing; PIC Microcontrollers: Architecture, features, programming and Interfacing

COURSE OUTCOMES: On successful completion of the course, student will be able to

CO1. demonstrate knowledge on architecture and salient features of 8051 and PIC microcontrollers.
CO2. critically analyze a microcontroller and develop a suitable interface for interfacing and control operations.
CO3. develop skills in evaluating stand-alone systems and develop programs for interfacing and control.
CO4. undertake research by identifying a suitable microcontroller for solving complex electrical engineering problems.
CO5. use modern tools like PROTEUS, MPLAB, SCILAB, PIC 'C' Compiler etc., for the design, analysis and implementation of the system.

DETAILED SYLLABUS:

UNIT - I: 8051 MICROCONTROLLER (12 Periods)
Overview of 8051 microcontrollers. 8051/8052 – architecture and features. Memory – internal / external Program, Data memory and their interfacing. Data memory – Register Bank, Bit addressable space, scratch pad area. Special Function Registers (SFRs). Instruction set – Data transfer, Arithmetic, logical, branch control instructions. Addressing modes. Timers – Mode - 0, 1, 2 and 3 operations, TMOD, TCON. Timer applications – wave generation, Device control operations.

UNIT-II: 8051 INTERFACING (10 Periods)
Basics of serial communication – RS232, MAX232, Baud rate. Serial port programming - SCON, SMOD, SBUF, PCON. Interrupts – IE, TCON, IP. Applications using interrupts of 8051/8052 – wave generation. Device control operations. Interfacing – ADC, DAC, DC motor key board and PWM.

UNNIT-III: PIC MICROCONTROLLERS (11 Periods)
CISC vs RISC. Harvard Vs Von Neumann architectures. PIC16F87XA architecture and features. PIC16 Memory organization – program memory, data memory. PIC Register file – General purpose registers and SFRs.
Introduction to PIC Assembly Programming, PIC Data Format and Directives.PIC programming tools. Instruction set – data transfer, arithmetic, logical, bit manipulation, branch Instructions. I/O Port Programming. Addressing modes – Immediate, Direct and Register indirect addressing Modes. Macros and Modules. PIC programming using MPLAB and PIC 'C' Compiler.

UNIT–IV: SERIAL, INTERRUPT, I/O PORTS AND TIMER PROGRAMMING (11 Periods)

I/O ports – Port A, TRISA, Port B, TRISB, Port C TRISC. Timer - 0, 1, 2 modules. Compare mode, capture mode. PIC Serial Port programming, PIC Interrupts, Programming Timer Interrupts, Programming the Serial Communication Interrupts, Port-B - Change Interrupt, Interrupt Priority in the PIC.

UNIT–V: PIC INTERFACING (11 Periods)

ADC Characteristics, ADC Programming in the PIC, DAC Interfacing, Sensor Interfacing and Signal Conditioning, Standard and Enhanced CCP Modules, Compare Mode Programming, Capture Mode Programming, PWM Programming, ECCP Programming, Relays and Opto-isolators, Stepper Motor Interfacing, DC Motor Interfacing and PWM, PWM Motor Control with CCP, DC Motor Control with ECCP.

Total Periods: 55

TEXT BOOKS:

1. Muhammad Ali Mazidi, Janice Gillispie Mazidi, Rolin D. McKinlay, *The 8051 Microcontroller and Embedded Systems using Assembly and C*, 2nd edition, Pearson education, 2009.
2. John B. Peatman, *Design with PIC Microcontrollers*, Pearson education, 2009.

REFERENCE BOOKS:

1. PIC16F87XA manual.
2. Muhammad Ali Mazidi, Rolin D. McKinlay, Danny Causey, *PIC Microcontroller and Embedded Systems using assembly and C for PIC 18*, Pearson Prentice Hall, 2008.
3. John B. Peatman, *Embedded design with the PIC18F452 Microcontroller volume 1*, Prentice Hall, 2003.

M. Tech. I-Semester

16MT10708: POWER SYSTEM RELIABILITY

(Professional Elective - I)

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	4	-	-	4

PRE-REQUISITES: Probability and Statistics at UG level

COURSE DESCRIPTION:
Fundamentals of Reliability Engineering; Evaluation of Power system operating capacity reserve; Evaluation of Frequency and Duration Techniques; Reliability Analysis of Interconnected Systems; Power Distribution System Reliability Analysis

COURSE OUTCOMES: On successful completion of the course, student will be able to

CO1. demonstrate knowledge on
- conceptual algorithms for planning, security and reliable operation of power system,
- system risks during normal and adverse weather conditions.

CO2. analyze complex power system network structures for computation of reliability indices.

CO3. evaluate the reliability of power system network using reliability indices.

CO4. initiate research in developing various algorithms for determining the power system network reliability for various operating scenarios.

DETAILED SYLLABUS:

UNIT – I: FUNDAMENTALS OF RELIABILITY ENGINEERING (13 Periods)
Probability Concept, Random variables, Probability Density and Distribution functions – Probability Distributions: time dependent and independent, Mean, SD, Variance. Reliability function, Hazard rate, types of Failures, Bath Tub Curve and Reliability cost and worth.
Network and Markov Modeling: redundant and non-redundant configuration – complex systems – conditional probability approach, Decomposition Method, cut-set, tie-set approaches – Standby redundant systems – Event trees. Markov chain – Markov Process, STPM, LSP – one, two and three component repairable models.

UNIT – II: EVALUATION OF GENERATING CAPACITY RESERVE (10 Periods)
Introduction – Generation system model – determination of capacity outage probability table – Identical units – Non-Identical units – Determination of transitional rates – deterministic and probabilistic criteria – Sequential addition method – Recursive relation for unit addition, unit removal - LOLP, LOLE, EIR.

UNIT – III: EVALUATION OF FREQUENCY AND DURATION TECHNIQUES (10 Periods)
Frequency and duration concepts – Two components repairable model (with & without identical components) – Evaluation of cumulative probability and cumulative frequency by using recursive relation – Equivalent transition rates – nonequivalent transition rates.
System risk indices: Daily load model – Two level representation of daily load modeling – evaluation of probabilities, transitional rates.

UNIT – IV: RELIABILITY ANALYSIS OF INTERCONNECTED SYSTEMS (12 Periods)

Introduction – probability array method in two interconnected systems – evaluation techniques – equivalent assisting approach – factors affecting interconnections, effect of tie capacities, tie lines. Weather effects on transmission lines – common mode failures – circuit breaker model – Preventive maintenance.

UNIT – V: DISTRIBUTION SYSTEM RELIABILITY ANALYSIS (10 Periods)

Distribution system reliability system analysis – Basic indices – Customer oriented indices – Load and energy indices – Active and Passive failures – open circuit & short circuit failures – Problems.

Total Periods: 55

TEXT BOOKS:

1. Roy Billinton and Ronald N Allan, *Reliability Evaluation of Power System*s, 2nd edition, Springer, New York, 1996.
2. J. Endrenyi, *Reliability Modeling in Electric Power Systems*, 1st edition, A Wiley-Interscience Publication, John Willey and Sons, US, 1979.

REFERENCE BOOKS:

1. Roy Billinton and Ronald N Allan, *Reliability Evaluation of Engineering Systems - Concepts and Techniques*, 2nd edition, Springer, New York, 2013.
2. Charles E. Ebeling, *An Introduction to Reliability and Maintainability Engineering*, Tata McGraw Hill, India, 2004.

M. Tech. I-Semester

16MT10709: SOLAR AND WIND ENERGY CONVERSION SYSTEMS

(Professional Elective - I)

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	4	--	--	4

PRE-REQUISITES: Power Electronics and Non-Conventional Energy Resources at UG level

COURSE DESCRIPTION:
Non-Conventional energy resources; Wind and Solar energy systems: design and operation; Power Conditioning Schemes for Solar and Wind Energy systems; Impact of power quality problems.

COURSE OUTCOMES: On successful completion of the course, student will be able to

CO1. demonstrate knowledge on various renewable energy sources.

CO2. analyze

- various operational aspects of renewable energy sources,
- various power quality and conditioning issues while integrating renewable energy sources.

CO3. develop skills in estimating wind & solar power generation and other parameters.

CO4. initiate research in designing of wind and solar power systems.

DETAILED SYLLABUS:

UNIT – I: INTRODUCTION TO RENEWABLE ENERGY SYSTEMS (10 Periods)
Renewable Energy systems, Environmental aspects of electric energy conversion: impacts of renewable energy generation on environment - Qualitative study of different renewable energy resources: Solar, wind, ocean, Biomass and Fuel cell. Renewable energy resources available in India.

UNIT – II: DESIGN AND OPERATION OF WIND POWER SYSTEM (11 Periods)
Wind Power System: Components, Turbine Rating, Electrical Load Matching, Variable-Speed operation, system design features, Maximum Power Operation, System Control Requirements, Speed Control, Rate Control and Environmental Aspects. Wind Energy Conversion Systems and their Classification.

UNIT – III: DESIGN AND OPERATION OF PV SYSTEM (14 Periods)
Solar Photovoltaic Power System: The PV Cell, Module and Array, Equivalent Electrical Circuit, Open Circuit Voltage and Short Circuit Current, I-V and P-V Curves, Array Design, Peak Power Point Operation, PV System Components.
Solar Thermal System: Energy Collection, Synchronous Generator, Equivalent Electrical circuit, Excitation Methods, Electrical Power Output, Transient Stability Limit, Commercial Power Plants. Introduction to Electric vehicles: operation and design of Electric Vehicles.

UNIT – IV: POWER CONDITIONING SCHEMES FOR SOLAR AND WIND ENERGY SYSTEMS (12 Periods)
Switching devices for solar energy conversion: DC power conditioning converters, maximum power point tracking algorithms, AC Power conditioners, Line commutated inverters, synchronized operation with grid supply, Harmonic reduction.

Wind energy Conversion system (WECS): Performance of Induction generators for WECS, Self-Excited Induction Generator (SEIG) for isolated power generators. Controllable DC power from SEIGs, system performance, Grid related problems, generator control, AC voltage controllers, Harmonic reduction and Power factor improvement.

UNIT – V: POWER QUALITY ISSUES IN INTEGRATION OF RENEWABLE ENERGY RESOURCES (09 Periods)

Stand alone and Grid connected systems, Power Quality issues, Impact of power quality problems on DG, Mitigation of power quality problems, role of custom power devices in Distributed Generation.

Total Periods: 56

TEXT BOOKS:

1. Mukund. R. Patel, *Wind and Solar Power Systems*, CRC Press, 1999.
2. G.D. Rai, *Non - Conventional Energy Resources*, Khanna Publishers, 2002.

REFERENCE BOOKS:

1. V. Daniel Hunt, *Wind power: a handbook on wind energy conversion systems,* Van Nostrand Reinhold Co., 1981.
2. Arindam Ghosh, Gerard Ledwich, *Power Quality Enhancement Using Custom Power Devices*, Springer, 2002.
3. Roger C. Dugan, Mark F. McGranaghan, Surya Santoso and H. Wayne Beaty, *Electrical Power Systems Quality*, 2nd edition, TATA McGraw Hill, 2008.

M. Tech. I-Semester

16MT10731: HIGH VOLTAGE ENGINEERING LAB

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
50	50	100	--	--	4	2

PRE-REQUISITES: High Voltage Engineering and Electrical Measurements at UG level.

COURSE DESCRIPTION:
To conduct experiments on Breakdown mechanisms in dielectrics materials; Generation & measurement of high DC, AC, impulse voltages and currents and testing high voltage electrical apparatus.

COURSE OUTCOMES: On successful completion of the course, student will be able to

CO1. demonstrate knowledge on
- behavior of various insulation materials,
- generation of high voltage and currents,
- measuring techniques for high voltage and currents,
- testing of various electrical apparatus.

CO2. analyze the behavior of insulation systems, circuits for high voltage generation, measurement and testing.

CO3. evaluate various parameters of high voltage generating, measuring and testing circuits.

CO4. initiate research to design a suitable setup for measuring and testing of High Voltage.

CO5. follow the IEC standards and safety measures for efficient operation and testing of high voltage equipment.

CO6. function effectively as an individual and as a member in a team

CO7. prepare laboratory report that clearly communicates the experimental information.

CO8. practice professional code of ethics.

LIST OF EXPERIMENTS:

Conduct any **TEN** experiments from the following

1. Generation and characteristics of Lightning Impulse Voltages.
2. Generation of High DC voltage using voltage doubler circuit.
3. Spark over characteristics of gaseous, liquid and solid insulation under uniform and non-uniform fields.
4. Measurement of HVAC and HVDC.
5. Breakdown strength of transformer oil using oil-testing unit.
6. Determination of the Flashover Characteristics of Insulators.
7. Determination of 50% Critical Impulse Flash-Over Voltages on the 11 kV type Insulator with Positive Impulse and Negative Impulse.
8. Determination of String Efficiency of Suspension Type Insulator.
9. Measurement of Capacitance and loss tangent.
10. Measurement of Earth and insulation resistance.
11. Partial discharge measurement in high voltage apparatus.
12. Calibration of meters by using Sphere Gap, Rod Gap and Point Gap method.

M. Tech. I-Semester

16MT10732: POWER SYSTEMS SIMULATION-I LAB

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
50	50	100	--	--	4	2

PRE-REQUISITES:
Power system operation and control, Power system analysis, Power quality, Power electronics and Control Systems at UG and PG level.

COURSE DESCRIPTION:
Modelling, simulation and analyze operation, control of power system Networks and Power electronics converters.

COURSE OUTCOMES: On successful completion of the course, student will be able to

CO1. demonstrate knowledge on various problems in electrical engineering through modern tools and simulate the methods to mitigate using software packages in field of power system and power electronics.
CO2. analyze the simulated observations of power system networks, power electronic circuits and their behavior through theoretical perspective.
CO3. evaluate various parameters of the power systems/power electronic circuits
CO4. interpret the observations of network/circuits and design a suitable control strategy to meet the required specifications.
CO5. select and apply modern software tools for solving problems in the existing power system.
CO6. function effectively as an individual and as a member in a team
CO7. prepare laboratory report that clearly communicates the experimental information.
CO8. practice the professional code of ethics.

LIST OF EXPERIMENTS:

Conduct any **TEN experiments** from the following using **MATLAB/ SIMULINK**

1. Formation of bus admittance matrix.
2. Formation of Bus Impedance matrix.
3. Load flow studies.
4. Contingency analysis.
5. Available Transfer Capabilities computation.
6. Fault analysis using Bus impedance matrix.
7. Weighted Least Square linear and nonlinear state estimation.
8. Analysis of various controller and observers for power system applications.
9. Three phase fully controlled Rectifier.
10. Three phase inverter with PWM controller.
11. Buck and Boost converter for power system applications.
12. Resonant converter for power system applications.

M. Tech. I-Semester

16MT13808: RESEARCH METHODOLOGY

(Common to all M. Tech. Programs)
(Audit Course)

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
-	-	-	-	2	-	-

PRE-REQUISITES:

COURSE DESCRIPTION:
Overview of Research, research problem and design, various research designs, data collection methods, statistical methods for research, importance of research reports and its types

COURSE OUTCOMES: On successful completion of the course, student will be able to

CO1. demonstrate knowledge on
- research design and conducting good research,
- various data collection methods,
- statistical methods in research,
- report writing techniques.

CO2. analyze various research design issues for conducting research in core or allied areas

CO3. formulate solutions for engineering problems by conducting research effectively in the core or allied areas

CO4. carryout literature survey and apply good research methodologies for the development of scientific/technological knowledge in one or more domains of engineering.

CO5. select and apply appropriate techniques and tools to complex engineering activities in their respective fields

CO6. write effective research reports.

CO7. develop attitude for lifelong learning to do research

CO8. develop professional code of conduct and ethics of research.

DETAILED SYLLABUS:

UNIT - I: INTRODUCTION TO RESEARCH METHODOLOGY (05 Periods)
Objectives and Motivation of Research, Types of Research, Research Approaches, Research Process, Criteria of good Research, Defining and Formulating the Research Problem, Problem Selection, Necessity of Defining the Problem, Techniques involved in Defining a Problem.

UNIT - II: RESEARCH PROBLEM DESIGN AND DATA COLLECTION METHODS (07 Periods)
Features of Good Design, Research Design Concepts, Different Research Designs, Different Methods of Data Collection, Data preparation: Processing Operations, Types of Analysis.

UNIT - III: STATISTICS IN RESEARCH (06 Periods)
Review of Statistical Techniques - Mean, Median, Mode, Geometric and Harmonic Mean, Standard Deviation, Measure of Asymmetry, ANOVA, Regression analysis.

UNIT - IV: HYPOTHESIS TESTING (07 Periods)

Normal Distribution, Properties of Normal Distribution, Basic Concepts of Testing of Hypothesis, Hypothesis Testing Procedure, Hypothesis Testing: t-Distribution, Chi-Square Test as a Test of Goodness of Fit.

UNIT - V: INTERPRETATION AND REPORT WRITING (03 Periods)

Interpretation – Techniques and Precautions, Report Writing – Significance, Stages, Layout, Types of reports, Precautions in Writing Reports.

Total Periods: 28

TEXT BOOK:

1. C.R. Kothari, *Research Methodology: Methods and Techniques*, New Age International Publishers, New Delhi, 2nd revised edition, 2004.

REFERENCE BOOKS:

1. Ranjit Kumar, *Research Methodology: A step-by-step guide for beginners*, Sage South Asia, 3rd edition, 2011.
2. R. Panneerselvam, *Research Methodology*, PHI learning Pvt. Ltd., 2009.

M. Tech. II-Semester

16MT20701: FLEXIBLE AC TRANSMISSION SYSTEM

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	4	--	--	4

PRE-REQUISITES: Power Electronics and Power Systems at UG level and Power Electronic Converters and Reactive Power Compensation and management at I-Sem. of M.Tech. EPS

COURSE DESCRIPTION:
Need for Flexible AC transmission systems; objectives of shunt and series compensation, phase angle regulators; FACTS controllers: shunt, series and combined; Coordination of various FACTS controllers.

COURSE OUTCOMES: On successful completion of the course, student will be able to
CO1. demonstrate knowledge on

- compensation schemes for real and reactive power control,
- Static Shunt, Series and Shunt-Series compensation,
- FACTS devices.

CO2. analyze FACTS devices for the appropriate control operation.
CO3. evaluate feasibility of FACTS device and controllers for flexible operation of system.
CO4. initiate research to develop/design new FACTS controllers for reliable operation of power system.

DETAILED SYLLABUS:

UNIT - I: INTRODUCTION TO AC TRANSMISSION SYSTEMS (08 Periods)
Overview of interconnected power system. Power flow in AC systems, expression for real and reactive power flow between two nodes of a power system, controllable parameters. Power flow in parallel and meshed system. Overview of compensated transmission lines, shunt and series compensation. Conventional controllers for real and reactive power flows, merits and demerits.
FACTS: benefits, types of FACTS controllers.

UNIT - II: STATIC SHUNT COMPENSATION (12 Periods)
Expression for real and reactive power flow with mid-point voltage regulation. Variable impedance type static VAR generators, V-I characteristics and control schemes of TCR, TSR, TSC. Q_D-Q_O characteristic and control scheme of TSC-TCR. Switching converter type VAR generators: V-I characteristics and control schemes of STATCOM. Hybrid VAR generators: V-I characteristics of SVC and STATCOM, regulation of V-I slope. Applications of static shunt compensators: Voltage regulation, improvement in transient stability, prevention of voltage instability, power oscillation damping. Comparison of static shunt compensators.

UNIT - III: STATIC SERIES COMPENSATION (10 Periods)
Expression for real and reactive power flow with series line compensation. Variable impedance type series compensators: V-I characteristics and control schemes of GCSC, TSSC, TCSC, modes of operation. Sub-synchronous resonance. Switching converter type series compensator: V-I characteristics, internal and external control schemes of SSSC. Applications of static series compensators: improvement in transient stability, power oscillation damping. Comparison of static series compensators.

UNIT - IV: STATIC PHASE ANGLE REGULATORS AND COMBINED COMPENSATORS (12 Periods)

Power flow control by phase angle regulators: concept of voltage and phase angle regulation, operation and control of TCVR and TCPAR. Switching converter type phase angle regulators. Objectives of TCPAR: improvement of transient stability, power oscillation damping. UPFC: principle, expression for real and reactive power between two nodes of UPFC, independent real and reactive power flow control using UPFC, control schemes of UPFC, operating principle and characteristics of IPFC.

UNIT - V: CO-ORDINATION OF FACTS CONTROLLERS (12 Periods)

FACTS controller interactions: interaction between multiple SVC's, interaction between multiple TCSC's: SVC-TCSC interaction, co-ordination of multiple controllers using linear control techniques. Comparative evaluation of different FACTS controllers: performance comparison and cost comparison, Control coordination using Genetic Algorithm, Future direction of FACTS technology.

Total periods: 54

TEXT BOOKS:

1. Narain G. Hingorani, Laszlo Gyugyi, *Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems,* Wiley-IEEE Press, 2000.
2. R. Mohan Mathur and Rajiv K. Varma, *Thyristor based FACTS controllers for Electrical Transmission Systems,* Wiley-IEEE Press, 2002.

REFERENCE BOOKS:

1. Xiao-Ping Zhang, Christian Rehtanz, Bikash Pal, *Flexible AC Transmission Systems: Modelling and Control*, Springer Power Systems Series, 2012.
2. Timothy J. E. Miller, *Reactive Power Control in Electric Systems,* Wiley, 1982.

M. Tech. II-Semester

16MT20702: INTELLIGENT SYSTEMS

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	4	--	--	4

PRE-REQUISITES: Engineering Mathematics, Electrical Machines & Power Systems at UG level.

COURSE DESCRIPTION:
Neural Networks; Fuzzy Logic Systems; Genetic Algorithms; Hybrid Intelligent Systems; Swarm intelligence; Applications.

COURSE OUTCOMES: On successful completion of the course, student will be able to

CO1. demonstrate knowledge on soft computing techniques.
CO2. analyze complex engineering problems with intelligent techniques.
CO3. solve electrical engineering problems using intelligent systems.
CO4. initiate research related to applications of soft computing in the fields of electrical engineering and allied areas.
CO5. select and apply suitable intelligent techniques for engineering problems.

DETAILED SYLLABUS:

UNIT - I: NEURAL NETWORKS (11 Periods)
Neural network Architectures, Perceptron model, Learning strategies: Supervised Learning, Radial basis function network, Back propagation Network. Unsupervised Learning: Kohonen's SOM, Reinforced learning. Load forecasting using neural networks

UNIT - II: FUZZY LOGIC SYSTEMS (11 Periods)
Fuzzy sets: Relations & Operations, Membership functions, Fuzzification, Rule base, Inference Mechanism, Defuzzification and design of Fuzzy control system, Speed control of separately excited DC motor using fuzzy logic.

UNIT - III: GENETIC ALGORITHMS (10 Periods)
Introduction to evolutionary computation, Genetic algorithms (GA): Biological background, Traditional optimization and search techniques, Basic terminologies, Simple GA, Flow chart, Operators in GA, Encoding, selection, crossover, mutation, Constraints in GA, Fitness function, Advantages and limitations of GA, Economic load dispatch using GA.

UNIT - IV: HYBRID INTELLIGENT SYSTEMS (12 Periods)
Introduction to hybrid intelligent systems: Adaptive Neuro-Fuzzy Inference Systems, Architecture and Learning. Fuzzy GA systems: rules generation. ANN Learning Using GA: Optimization of weights, Load forecasting problem using Neuro-fuzzy approach.

UNIT - V: SWARM INTELLIGENCE (11 Periods)
Introduction to swarm intelligence, Swarm intelligence algorithms-Ant colony optimization: Biological and artificial ant colony systems, Applications of ant colony intelligence: Static & Dynamic combinatorial optimization problems, Algorithm of Ant colony system, Particle swarm optimization: The basic PSO method, characteristic features of PSO, PSO algorithm, Optimum parameter setting for the best performance of PSO, Comparison with other Evolutionary computing techniques, Engineering application of ANT colony intelligence in unit commitment problem

Total Periods: 55

TEXT BOOKS:

1. S.N. Sivanandam, S.N. Deepa, *Principles of Soft Computing*, Wiley–India Edition, 2008.
2. N.P. Padhy, *Artificial Intelligence and Intelligent Systems*, Oxford University press, 10th Reprint, 2011.

REFERENCE BOOKS:

1. Saroj Kaushik, *Artificial Intelligence*, Cengage Learning India Private Limited, Fifth Indian reprint, 2013.
2. J.S.R. Jang, C.T. Sun, E. Mizutani, *Neuro-fuzzy and Soft Computing: A Computational Approach to Learning and Machine Intelligence*, Pearson Education Taiwan Limited, 2004.
3. Fakhreddine O. karray, Clarence De Silva, *Soft computing and Intelligent systems Design, Theory, tools and applications*, Pearson Education Limited, 2009.

M. Tech. II-Semester

16MT20703: POWER SYSTEM STABILITY AND CONTROL

1nt. marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	4	--	--	4

PRE-REQUISITES: Electrical Machines, Control systems, Power system analysis, Power System operation and control at UG level and Advanced control systems and Power System Security and State Estimation at PG level.

COURSE DESCRIPTION:
Introduction to the synchronous machine classical model; state space models of synchronous machine; Methods of Excitation systems and modelling; Effect of excitation on stability; Analysis of Voltage stability

COURSE OUTCOMES: On successful completion of the course, student will be able to

CO1. demonstrate knowledge on

- various power system stability issues of a small and large power system networks,
- modeling of SMIB, multi-machine and excitation systems,
- voltage control and reactive power management concepts.

CO2. analyze the power system network for stability and control.

CO3. develop skills in evaluating power system stability.

CO4. initiate research to develop / design new control strategies or methodology for enhancing stability of power system.

DETAILED SYLLABUS:

UNIT - I: THE ELEMENTARY MATHEMATICAL MODEL (13 Periods)

A Classical model of one machine connected to infinite bus – Problems. System Response to small Disturbances: Types of problems studied, Block diagram of unregulated and regulated synchronous Machine, methods of studies – Effect of small changes of speed. Regulated synchronous machine – voltage regulator with one time lag – Governor with one time lag Classical model of multi-machine system – Modes of oscillation of unregulated Multi machine system – Problems

UNIT – II: THE SYNCHRONOUS MACHINE MODEL (10 Periods)

Introduction – Clarkes's and Park's Transformation – flux linkage equations, self and mutual inductances of stator and rotor, transformation of inductances, voltage equations. Formulations of state space model of one machine system connected to infinite bus, voltage, current equations.

UNIT – III: EXCITATION SYSTEMS (11 Periods)

Simplified view of excitation control, control configuration. Excitation system response -Non-continuously regulated systems, and continuously regulated systems. Excitation system compensation- state space description of the excitation system - simplified linear model only.

Types of Excitation systems: Type -1 system: Continuously acting regulator, Type - 2 system: rotating rectifier system, Type - 3 system: Static with terminal potential and current supplies, Type-4system: non–continuous acting - Block diagram representation – state space representation.

UNIT – IV: EFFECT OF EXCITATION ON STABILITY (10 Periods)

Introduction – effect of excitation on generator power limits – effect of the excitation system on transient stability, effect of excitation on dynamic stability – examination of dynamic stability by routh's criterion. Block diagram of the linear generator with exciter, supplementary stabilizing signals, approximate model of the complete exciter-generator system, Lead compensation

UNIT – V: VOLTAGE STABILITY ANALYSIS (11 Periods)

Voltage stability – Factors affecting voltage instability and collapse – Comparison of Angle and voltage stability – Analysis of voltage in stability collapse – Control of voltage instability.

Review of Lyapunov's stability theorems of non-liner systems using energy concept – Method based on first concept – Method based on first integrals – Quadratic forms – Variable gradient method – Zubov's method – Popov's method, Lyapunov function for single machine connected to infinite bus.

Total Periods: 55

TEXT BOOKS:

1. P. M. Anderson, A. A. Fouad, *Power System Control and Stability*, 2nd edition, IEEE Press, 2003.
2. K. R. Padiyar, *Power System Dynamics Stability & Control*, 2nd edition, B.S.Publications, Hyderabad, India, 2008.

REFERENCE BOOKS:

1. Prabha Kundur, Neal J. Balu, Mark G. Lauby, *Power System Stability and Control*, 2nd edition, McGraw-Hill, 1994.
2. M. A. Pai, *Power System Stability: Analysis by the direct method of Lyapunov*, North Holland Publishing Company, Newyork, 1981.

M. Tech. (EPS), II-Semester

16MT20704: RESTRUCTURED POWER SYSTEM

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	4	--	--	4

PRE-REQUISITES: Power system operation and control, FACTS and Reactive Power Compensation and Management at UG level.

COURSE DESCRIPTION:
Features of Restructured Power systems; Market models; Information and transmission services; Electricity pricing and forecasting; Ancillary services management.

COURSE OUTCOMES: On successful completion of the course, student will be able to

CO1. demonstrate knowledge on:
- operation of deregulated electricity market,
- key issues of electricity market models and their functionalities in different scenarios,
- electricity pricing, forecasting methods and ancillary service management in competitive market.

CO2. analyze market models to provide power exchange among various entities of deregulated power system.

CO3. solve market models, evaluating transmission losses and to regulate congestion in tie-lines for reliable operation in the competitive premise

CO4. design and develop various forecasting methods for pricing, planning and operation of deregulated power systems.

DETAILED SYLLABUS:

UNIT - I: OVERVIEW OF KEY ISSUES IN ELECTRIC UTILITIES (10 Periods)

Introduction: Deregulation, need for deregulation, Advantages of deregulation in power system. Restructuring Models: PoolCo Model, Bilateral Model, Hybrid Model: independent system operator (ISO), Role of ISO. Power exchange, market operations, market power, standard cost, transmission pricing, congestion pricing, management of congestion.

UNIT - II: MARKET MODELS IN RESTRICTED POWER SYSTEMS (10 Periods)

Introduction: Market models based on contractual arrangements: Monopoly model, Single buyer model, Wholesale competition model, Retail competition model. Comparison of various market models. Market architecture: Day-ahead and Hour-Ahead Markets, Block forwards Market, Transmission Congestion Contracts (TCCs), and Ancillary service market.

UNIT - III: OASIS: OPEN ACCESS SAME-TIME INFORMATION SYSTEM (11 Periods)

Structure of OASIS: Functionality and Architecture of OASIS, information requirement of OASIS, Transfer Capability on OASIS: Definitions, Transfer Capability Issues, ATC Calculation, TTC Calculation, TRM Calculation, CBM Calculation. Transmission Services, Methodologies to Calculate ATC.

UNIT - IV: ELECTRICITY PRICING - VOLATILITY, RISK AND FORECASTING

(12 Periods)

Electricity pricing: introduction, electricity price volatility, electricity price indexes. Challenges to Electricity Pricing: Pricing Models, Reliable Forward Curves. Construction of Forward Price Curves: Time frame for Price Curves, Types of Forward Price Curves: Short-term Price Forecasting, Factors Impacting Electricity Price, Forecasting Methods, Analyzing Forecasting Errors.

UNIT - V: ANCILLARY SERVICES MANAGEMENT **(12 Periods)**

Introduction: Types of ancillary services, Classification of ancillary services, Load-generation balancing related services: Frequency regulation, Load following, Spinning reserve services. Voltage control and reactive power support services: Generators, Synchronous condensers, Capacitors and inductors, SVCs, STATCOMs- Black start capability service.

Total Periods: 55

TEXT BOOKS:

1. Kankan Bhattacharya, Math H.J. Buller, Jalap E. Daladier, *Operation of Restructured Power System*, Kluwer Academic Publisher, 2001.
2. Mohammad Shahidehpour, and Muwaffaq Alomoush, - *Restructured Electrical Power Systems – Operation, Trading and Volatility,* Marcel Dekker, Inc. 2001.

REFERENCE BOOK:

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

M. Tech. II-Semester

16MT20705: STATIC AND DIGITAL PROTECTION OF POWER SYSTEMS

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	4	--	--	4

PRE-REQUISITES: Switchgear and Protection, Microprocessors and Microcontrollers at UG level.

COURSE DESCRIPTION:
Fundamentals of static and digital relays; Amplitude and Phase Comparators; characteristics of Static over current and differential relays; Static Distance relays; Numerical relays.

COURSE OUTCOMES: On successful completion of the course, student will be able to

CO1. demonstrate knowledge on
- digital and numerical relays,
- operation of static and microprocessor based relays.

CO2. analyze different power system protection schemes.

CO3. evaluate various protection schemes for power system components.

CO4. initiate research related to design and application of appropriate digital relays in the fields of electrical engineering.

DETAILED SYLLABUS:

UNIT – I: INTRODUCTION TO STATIC AND DIGITAL RELAYS (10 Periods)
Static Relays - basic construction and advantages. Level detectors, Replica impedance, Mixing circuits, Phase and Amplitude Comparators – General equation for two input phase and amplitude comparators, Duality between Phase and Amplitude Comparators.
Numerical Relays: Block diagram of typical Numerical Relay – Advantages and Disadvantages.

UNIT – II: COMPARATORS (13 Periods)
Amplitude comparators: Circulating current type, opposed voltage type rectifier bridge comparators – Direct and Instantaneous comparators.
Phase comparators: Coincidence circuit type - block spike phase comparator, techniques to measure the period of coincidence – Integrating type – Rectifier and vector product type phase comparators.
Multi–Input comparators: Conic section characteristics – Three input amplitude comparator – Hybrid comparator.

UNIT – III: STATIC OVER CURRENTAND DIFFERENTIAL RELAYS (11 Periods)
Static over current relays: Introduction, Instantaneous over current relay – Time over current relays. Basic principles – Definite time, Inverse Definite time and Directional over current relays.
Static Differential Relays: Analysis of Static differential relays – static relay schemes – Duo bias transformer differential protection – Harmonic restraint relay.

UNIT – IV: STATIC DISTANCE RELAYS (10 Periods)
Static impedance, Reactance, MHO and angle impedance relays – sampling comparator – realization of reactance and MHO relays using a sampling comparator.

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

UNIT – V: MICROPROCESSOR BASED PROTECTIVE RELAYS (11 Periods)

Microprocessor based over current relays, Impedance relay, Directional relay, Reactance relay. Generalized mathematical expression for distance relays, measurement of resistance and reactance, MHO and offset-MHO relays –Realization of MHO characteristics, realization of offset MHO characteristics – Microprocessor Implementation of Digital distance relaying algorithms – Mann-Morrison technique, Differential equation technique.

Total Periods: 55

TEXT BOOKS:

1. T.S. Madhava Rao, *Power system Protection - Static relays with Microprocessor Applications*, 2nd edition, Tata McGraw Hill Publishing Company limited, 2008.
2. Badri Ram and D. N. Vishwakarma, *Power system Protection and Switchgear*, 2nd edition, Tata McGraw Hill Publication Company limited 2013.

REFERENCE BOOK:

1. Bhuvanesh A Oza, Nirmal Kumar C Nair, Rashesh P Mehta, Vijay H Makwana, *Power system protection and switchgear*, Tata McGraw Hill Education Private Limited, 2010.

M. Tech. II-Semester

16MT20706: ENERGY AUDITING, CONSERVATION AND MANAGEMENT

(Professional Elective - 2)

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	4	--	--	4

PRE-REQUISITES: Generation of Electric Power and Managerial Economics and Financial Analysis at UG level.

COURSE DESCRIPTION:
Basic Principles of Energy Audit; Energy Management; Energy Efficient Motors and Lighting; Energy Instruments; Computation of Economic Aspects and Analysis.

COURSE OUTCOMES: On successful completion of the course, student will be able to

CO1. demonstrate knowledge on energy conservation and management.

CO2. analyze the economic aspects of energy management.

CO3. evaluate and practice various auditing schemes for domestic and industrial systems.

CO4. design and apply various energy instruments for energy auditing and lighting systems.

DETAILED SYLLABUS:

UNIT - I: BASIC PRINCIPLES OF ENERGY AUDIT (09 Periods)
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 (10 Periods)
Principles of energy management, organizing energy management program, initiating, planning, controlling, promoting, monitoring, reporting. Energy manger, Qualities and functions, language, Questionnaire - check list for top management.

UNIT - III: ENERGY EFFICIENT MOTORS AND LIGHTING (14 Periods)
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 – PF correction- motor energy audit.
Good lighting system design and practice, lighting control, lighting energy audit

UNIT - IV: ENERGY INSTRUMENTS (11 Periods)
Energy Instruments watt meter, data loggers, thermocouples, pyrometers, lux meters, tongue testers, application of PLC. Design of Energy instruments

UNIT - V: COMPUTATION OF ECONOMIC ASPECTS AND ANALYSIS (12 Periods)
Economics Analysis-Depreciation Methods, time value of money, rate of return, present worth method, replacement analysis, life cycle costing analysis - Calculation of simple payback method, net present worth method - Applications of life cycle costing analysis, return on investment.

Total Periods: 56

TEXT BOOKS:

1. W. Raymond Murphy & Gordon Mckay, *Energy Management,* Butterworths, 1982.
2. Umesh Rathore, *Energy management*, 1st edition, Kataria & Sons, New Delhi 2014.

REFERENCE BOOKS:

1. John C. Andreas, *Energy Efficient Electric Motors*, 2nd edition, Marcel Dekker Inc. Ltd, 1982.
2. Wayne C. Turner, Steve Doty, *Energy Management Hand Book*, 6th edition, CRC Press, 2006.
3. Paul W. O' Callaghan, *Energy Management*, 1st edition, McGraw Hill Book Company, 1993.

M. Tech. II-Semester

16MT20707: HIGH VOLTAGE DC TRANSMISSION

(Professional Elective - 2)

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	4	--	--	4

PRE-REQUISITES: Power Electronics and Power systems at UG level and Power Electronic converters at PG level

COURSE DESCRIPTION:
HVDC Transmission: Capabilities, Applications and planning; Analysis and control of power converter; Harmonics and Filters; Types of Multi-Terminal DC Systems and control; Faults and Protection.

COURSE OUTCOMES: On successful completion of the course, student will be able to

CO1. demonstrate knowledge on:

- HVDC transmission systems,
- operation of static converters and its control,
- different types of faults and protection schemes in HVDC systems.

CO2. analyze various static converters in HVDC systems, harmonics, filters and MTDC systems.

CO3. evaluate the performance of HVDC systems.

CO4. initiate research in designing filter circuits and control techniques for HVDC systems.

DETAILED SYLLABUS:

UNIT – I: INTRODUCTION TO HVDC TRANSMISSION (10 Periods)
HVDC Transmission– Comparison of HVAC and HVDC transmission, types of DC Links, power handling capabilities of HVDC lines, applications of HVDC Transmission, planning for HVDC transmission, modern trends in DC Transmission, basic conversion principles.

UNIT – II: STATIC POWER CONVERTOR ANALYSISIS AND CONTROL (12 Periods)
Static Power Converters: Static converter configuration- 6-pulse & 12-pulse converters, converter station and terminal equipment. Rectifier and inverter operation, converter bridge characteristics, equivalent circuit for converter.
Control of HVDC converter: Principle of DC link control – constant current, constant extinction angle and constant ignition angle control. Individual phase control and equidistant firing angle control.

UNIT – III: HARMONICS AND FILTERS (11 Periods)
Generation of harmonics in HVDC systems, methods of harmonics elimination, harmonic instability problems, Causes for instability, remedies for instability problems. Design of AC filters, single frequency tuned filter, Double frequency tuned filter, high pass filter, cost consideration of AC harmonic filter, DC filters.

UNIT – IV: MULTI-TERMINAL DC LINKS AND SYSTEMS (10 Periods)
Introduction – Potential applications of MTDC systems – Types of MTDC systems – series, parallel and series-parallel systems, their principle of operation and control - Protection of MTDC systems.

UNIT – V: FAULTS AND PROTECTION **(12 Periods)**

Over voltages due to disturbance on DC side, over voltages due to DC and AC side line faults – Converter faults, over current protection– Valve group and DC line protection. Over voltage protection of converters – Surge arresters.

Total Periods: 55

TEXT BOOKS:

1. K. R. Padiyar, *High Voltage Direct current Transmission*, New Age International (P) Ltd, Publishers, 2004.
2. S. Rao, *EHV-AC, HVDC Transmission & Distribution Engineering*, Khanna Publishers, 2006.

REFERENCE BOOKS:

1. E. Uhlman, *Power Transmission by Direct Current*, Springer Verlag, Berlin, 2000.
2. E. W. Kimbark, *Direct current Transmission*, John Wiely & sons, New York.
3. J. Arillaga, *HVDC Tranmission*, peter peregrilnus Ltd., London UK, 1983.

M. Tech. II-Semester

16MT20708: POWER QUALITY

(Professional Elective - 2)

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	4	--	--	4

PRE-REQUISITES: Distribution of Electric Power and Power Electronics at UG level

COURSE DESCRIPTION:
Power Quality concepts; harmonics and voltage regulation using conventional methods; power quality enhancement using custom power devices; power quality issues in distributed generation.

COURSE OUTCOMES: On successful completion of the course, student will be able to

CO1. demonstrate knowledge on
- various power quality issues and mitigation techniques,
- operational issues in distributed generation.

CO2. analyze
- harmonic distortion due to commercial and industrial loads,
- the suitability of various custom power devices.

CO3. evaluate various power quality indices.

CO4. initiate research to develop/design new schemes and techniques for power quality enhancement.

CO5. apply the appropriate principles and techniques for integration of distributed generation and utilities.

DETAILED SYLLABUS:

UNIT - I: FUNDAMENTALS OF POWER QUALITY (12 Periods)
Definition of power quality, classification of power quality issues, power quality standards, categories and characteristics of electromagnetic phenomena in power systems: impulsive and oscillatory transients, interruption, sag, swell, sustained interruption, under voltage, overvoltage and outage. Sources and causes of different power quality disturbances.

UNIT - II: HARMONICS & APPLIED HARMONICS (12 Periods)
Harmonic distortion, voltage vs current distortion, harmonics vs transients, power system qualities under non sinusoidal conditions, harmonic indices, harmonic sources from commercial loads, harmonic sources from industrial loads.
Applied harmonics**:** effects of harmonics, harmonic distortion evaluations, principles of controlling harmonics, devices for controlling harmonic distortion.

UNIT - III: VOLTAGE REGULATION USING CONVENTIONAL METHODS (08 Periods)
Principles of regulating the voltage, devices for voltage regulation: utility step-voltage regulators, ferro-resonant transformers, magnetic synthesizers, on-line UPS systems, motor-generator sets, static VAR compensators, shunt capacitors, series capacitors.

UNIT - IV: POWER QUALITY ENHANCEMENT USING CUSTOM POWER DEVICES (13 Periods)
Introduction to custom power devices: Network reconfiguring type: Solid State Current Limiter (SSCL), Solid State Breaker (SSB), Solid State Transfer Switch (SSTS).

Compensating type: Dynamic Voltage Restorer (DVR), Distribution STATCOM and Unified Power Quality Conditioner (UPQC): operation, realization and control of DVR, DSTATCOM and UPQC, load compensation. Power quality monitoring, Power quality monitoring standards.

UNIT - V: POWER QUALITY ISSUES IN DISTRIBUTED GENERATION (10 Periods)

DG Technologies, Perspectives on DG benefits- Interface to the Utility System - power quality issues affected by DG - Operating Conflicts: Utility fault-clearing, Reclosing, Interference with relaying, Voltage regulation issues, Islanding - siting DG.

Total Periods: 55

TEXT BOOKS:

1. Roger C. Dugan, Mark F. McGranaghan, Surya Santoso and H. Wayne Beaty, *Electrical Power Systems Quality*, 2nd edition, TATA Mc Graw Hill, 2010.
2. Arindam Ghosh, Gerard Ledwich, *Power Quality Enhancement Using Custom Power Devices*, Springer, 2002.

REFERENCE BOOKS:

1. Math H J Bollen, *Understanding Power Quality Problems: Voltage Sags and Interruptions*, Wiley, 2010.
2. C. Sankaran, *Power Quality*, CRC press, 2000.

M. Tech. II-Semester

16MT20709: SMART GRID TECHNOLOGY

(Professional Elective - 2)

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	4	--	--	4

PRE-REQUISITES: Power Systems at UG level

COURSE DESCRIPTION:
Concept of smart grid; various information and communication technologies for Smart Grid; Smart metering; Demand side integration; Energy management systems

COURSE OUTCOMES: On successful completion of the course, student will be able to

CO1. demonstrate knowledge on

- smart grid initiatives and technologies,
- information and communication technologies for the smart grid,
- sensing, measurement, control and automation.

CO2. demonstrate skills in analyzing fault levels and state of the system.

CO3. evaluate various information security protocols adhering the standards of smart grid.

CO4. initiate research on modern techniques for implementation in smart grid.

DETAILED SYLLABUS:

UNIT – I: SMART GRID **(07 Periods)**

smart grid introduction, ageing assets and lack of circuit capacity, thermal constraints, operational constraints, security of supply, national initiatives, early smart grid initiatives, active distribution networks, virtual power plant, other initiatives and demonstrations, overview of the technologies required for the smart grid.

UNIT – II: COMMUNICATION TECHNOLOGIES FOR THE SMART GRID (13 Periods)

Data Communications: Introduction, Dedicated and Shared Communication Channels, Switching Techniques, Circuit Switching, Message Switching, Packet Switching, Communication Channels, Wired Communication, Optical Fiber, Radio Communication, Cellular Mobile Communication, Layered Architecture and Protocols, the ISO/OSI Model, TCP/IP

Communication Technologies: IEEE 802 Series, Mobile Communications, Multi-Protocol Label Switching, Power line Communication, Standards for Information Exchange, Standards for Smart Metering, Modbus, DNP3, IEC 61850

UNIT – III: INFORMATION SECURITY FOR THE SMART GRID (11 Periods)

Introduction, Encryption and Decryption, Symmetric Key Encryption, Public Key Encryption, Authentication, Authentication Based on Shared Secret Key, Authentication Based on Key Distribution Center, Digital Signatures, Secret Key Signature, Public Key Signature, Message Digest, Cyber Security Standards, IEEE 1686: IEEE Standard for Substation Intelligent Electronic Devices(IEDs) Cyber Security Capabilities, IEC 62351: Power Systems Management and Association Information Exchange – Data and Communication Security.

UNIT – IV: SMART METERING AND DEMAND SIDE INTEGRATION (13 Periods)

Introduction, smart metering – evolution of electricity metering, key components of smart metering, smart meters: an overview of the hardware used – signal acquisition, signal conditioning, analogue to digital conversion, computation, input/output and communication. Communication infrastructure and protocols for smart metering - Home area network, Neighborhood Area Network, Data Concentrator, meter data management system, Protocols for communication. Demand Side Integration- Services Provided by DSI, Implementation of DSI, Hardware Support, Flexibility Delivered by Prosumers from the Demand Side, System Support from DSI.

UNIT – V: TRANSMISSION AND DISTRIBUTION MANAGEMENT SYSTEM (11 Periods)

Data Sources, Energy Management System, Wide Area Applications, Visualization Techniques, Data Sources and Associated External Systems, SCADA, Customer Information System, Modeling and Analysis Tools, Distribution System Modeling, Topology Analysis, Load Forecasting, Power Flow Analysis, Fault Calculations, State Estimation, Applications, System Monitoring, Operation, Management, Outage Management System, Energy Storage Technologies, Batteries, Flow Battery, Fuel Cell and Hydrogen Electrolyzer, Flywheels, Super conducting Magnetic Energy Storage Systems, Super capacitors, Energy storage for wind power, Agent-based control of electrical vehicle battery charging.

Total Periods: 55

TEXT BOOKS:

1. Janaka Ekanayake, Kithsiri Liyanage, JianzhongWu, Akihiko Yokoyama, Nick Jenkins, *Smart Grid Technology and Applications*, Wiley Publications, 2012.
2. James Momoh, *Smart Grid: Fundamentals of Design and Analysis*, Wiley, IEEE Press, 2012.
3. Bharat Modi, Anu Prakash, Yogesh Kumar, *Fundamentals of Smart Grid Technology*, S.K Kataria & Sons, 2015.

REFERENCE BOOKS:

1. Eric D. Knapp, Raj Samani, *Applied Cyber Security and the Smart Grid-Implementing Security Controls into the Modern Power Infrastructure*, Syngress Publishers, 2013.
2. Nouredine Hadjsaid, Jean-Claude Sabonnadiere, *Smart Grids*, Wiley Blackwell Publications.
3. Peter Fox-Penner, *Smart Power: Climate Changes, the Smart Grid, and the future of electric utilities*, Island Press, 1st edition, June 2010.

M. Tech. II-Semester

16MT20731: POWER SYSTEMS AND RELAYS LAB

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
50	50	100	--	--	4	2

PRE-REQUISITES: Electrical Machines and Power Systems at UG Level

COURSE DESCRIPTION:
Relay testing, fault analysis, determination of sequence reactances of power system components, dielectric strength of transformer oil and synchronous machine power angle characteristics.

OUTCOMES: On successful completion of the course, student will be able to

CO1. demonstrate knowledge in power system protection and testing of relays by combining existing and novel technology.
CO2. analyze protective schemes and testing methods in the field of power systems.
CO3. demonstrate skills in evaluating the power system network parameters and relay settings for appropriate protection.
CO4. initiate research to design/develop a suitable protection scheme for power system components / networks.
CO5. apply modern numerical and processor based relays for protection and relaying.
CO6. function effectively as an individual and as a member in a team
CO7. prepare laboratory report that clearly communicates the experimental information.
CO8. practice professional code of ethics

LIST OF EXPERIMENTS:

Conduct any **Twelve** Experiments from the following:

1. Determination of Sub-transient Reactance of Salient Pole Synchronous Machine.
2. Determination of Sequence Impedances of Cylindrical Rotor Synchronous Machine.
3. Fault Analysis
   i) LG and LL Faults
   ii) LLG and LLLG Faults
4. Measurement of Dielectric Strength of Transformer Oil Using Variable Electrodes.
5. Reactive power compensation using Tap changing transformer.
6. Power Angle Characteristic of Three-Phase Salient Pole Synchronous Machine.
7. Analysis of Long Transmission line.
8. Determination of Sequence Components of Salient Pole Synchronous Machine.
9. Scott Connection of Transformers.
10. Characteristics of Over Current Relay.
11. Characteristics of Over Voltage Relay.
12. Characteristics of Percentage Biased Differential Relay.
13. Testing of Frequency Relay.
14. Testing of Reverse Power Relay.

M. Tech. II-Semester

16MT20732: POWER SYSTEMS SIMULATION-II LAB

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
50	50	100	--	--	4	2

PRE-REQUISITES: Power system analysis, FACTS, Power system operation & control, Power quality and Switchgear and protection at UG and PG level.

COURSE DESCRIPTION:
Modelling, simulation and analyze operation and control of power system networks.

COURSE OUTCOMES: On successful completion of the course, student will be able to

CO1. demonstrate knowledge on various power system problems through modern tools and disseminate them using software packages in field of power system and power electronics.
CO2. analyze the simulated observations of power system networks, power electronic circuits and their behavior through theoretical perspective.
CO3. evaluate various parameters of the power systems
CO4. interpret the observations of power system network and design a suitable control strategy to meet the required specifications.
CO5. select and apply modern software tools for solving real time problems in the existing power system
CO6. function effectively as an individual and as a member in a team
CO7. prepare laboratory report that clearly communicates the experimental information.
CO8. practice professional code of ethics.

LIST OF EXPERIMENTS:

Conduct any **TEN** Experiments from the following using **MATLAB/PSCAD/MIPOWER**

1. Transient Response due to capacitor switching.
2. Transformer inrush currents measurement.
3. Load flow analysis.
4. Analysis of Short circuit studies with and with fault impedance.
5. Load frequency control problem for an interconnected power system.
6. Voltage stability analysis.
7. Stability analysis of SMIB.
8. Simulation of FACTS controllers.
9. Characteristics and Coordination of Relays.
10. Simulation of power quality problems (Sag/Swell, interruption, transients, harmonics, flickers etc.)
11. Harmonic analysis and tuned filter design to mitigate harmonics.
12. Demonstration of MATLAB tool boxes (Fuzzy, Neural, GA, PSO etc.) for power system applications.

M. Tech. II-Semester

16MT20733: SEMINAR

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
--	100	100	--	--	--	2

PRE-REQUISITES: --

COURSE DESCRIPTION:
Identification of seminar topic; literature survey; preparation of technical report and presentation.

COURSE OUTCOMES: On successful completion of the course, student will be able to

CO1. demonstrate capacity to identify an advanced topic for seminar in core and allied areas.
CO2. extract information pertinent to the topic through literature survey.
CO3. comprehend the extracted information through analysis and synthesis critically on the topic.
CO4. contribute to multidisciplinary scientific work in the field of Power systems.
CO5. manage time and resources effectively and efficiently.
CO6. plan, organize, prepare and present effective written and oral technical report on the topic.
CO7. engage in lifelong learning for development of technical competence in the field of Power Systems.
CO8. understand ethical responsibility towards environment and society in the field of Electrical engineering.
CO9. adapt to independent and reflective learning for sustainable professional growth in Electrical power systems.

M. Tech. II-Semester

16MT23810: INTELLECTUAL PROPERTY RIGHTS

(Common to all M. Tech. Programs)

(Audit Course)

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
-	-	-	-	2	-	-

PRE-REQUISITES: -

COURSE DESCRIPTION:
Introduction to Intellectual Property; Trade Marks; Law of Copy Rights; Law of Patents; Trade Secrets; Unfair Competition; New Development of Intellectual Property.

COURSE OUTCOMES: On successful completion of the course, student will be able to

CO1. demonstrate knowledge on
- Intellectual Property,
- Trade Marks & Secrets,
- Law of Copy Rights, Patents,
- New development of Intellectual Property.

CO2. analyze the different forms of infringement of intellectual property rights.

CO3. solve problems pertaining to Intellectual Property Rights.

CO4. stimulate research zeal for patenting of an idea or product.

CO5. write effective reports required for filing patents.

CO6. develop life-long learning capabilities.

CO7. develop awareness of the relevance and impact of IP Law on their academic and professional lives.

CO8. develop attitude for reflective learning.

DETAILED SYLLABUS:

UNIT - I: INTRODUCTION TO INTELLECTUAL PROPERTY (05 Periods)
Introduction, types of intellectual property, international organizations, agencies and treaties, importance of intellectual property rights.

UNIT - II: TRADE MARKS (05 Periods)
Purpose and function of trademarks, acquisition of trade mark rights, protectable matter, selecting and evaluating trade mark, trade mark registration processes.

UNIT - III: LAW OF COPY RIGHTS (06 Periods)
Fundamental of copy right law, originality of material, rights of reproduction, rights to perform the work publicly, copy right ownership issues, copy right registration, notice of copy right, international copy right law.
Law of patents: Foundation of patent law, patent searching process, ownership rights and transfer

UNIT - IV: TRADE SECRETS (06 Periods)
Trade secrete law, determination of trade secrete status, liability for misappropriations of trade secrets, protection for submission, trade secrete litigation.
Unfair competition: Misappropriation right of publicity, false advertising.

UNIT - V: NEW DEVELOPMENT OF INTELLECTUAL PROPERTY (06 Periods)

New developments in trade mark law; copy right law, patent law, intellectual property audits.

International overview on intellectual property, international - trade mark law, copy right law, international patent law, international development in trade secrets law.

Total Periods: 28

TEXT BOOKS:

1. Deborah, E. Bouchoux, *Intellectual property right*, cengage learning.
2. Prabuddha Ganguli, *Intellectual property right - Unleashing the knowledge economy*, Tata Mc Graw Hill Publishing Company Ltd.

M. Tech. III & IV-Semester

16MT30731 & 16MT40731: PROJECT WORK

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
200	200	400	--	--	--	28

PRE-REQUISITES: --

COURSE DESCRIPTION:
Identification of topic for the project work; Literature survey; Collection of preliminary data; Identification of implementation tools and methodologies; Performing critical study and analysis of the topic identified; Time and cost analysis; Implementation of the project work; Writing of thesis and presentation.

COURSE OUTCOMES: On successful completion of the course, the student will be able to

CO1. demonstrate capacity to identify an advanced topic for project work in core and allied areas.
CO2. analyze the problem and derive an optimal solution pertinent to the chosen topic.
CO3. solve engineering problems and provide a wide range of potential solutions.
CO4. comprehend extracted information through the literature survey for design and development of engineering problems pertinent to the chosen topic.
CO5. use the techniques, skills and modern engineering tools necessary for project work.
CO6. contribute to multidisciplinary scientific work in the field of Electrical power Systems.
CO7. execute the project effectively and efficiently considering economical and financial factors.
CO8. plan, prepare and present effective written and oral technical report on the topic.
CO9. engage in lifelong learning for development of technical competence in the field of Electrical power systems and allied fields.
CO10. understand ethical responsibility towards environment and society in the field of Electrical Engineering.
CO11. adapt to independent and reflective learning for sustainable professional growth.