

# SREE VIDYANIKETHAN ENGINEERING COLLEGE

(Autonomous)

DEPARTMENT OF EEE

COURSE STRUCTURE for M.Tech. (ELECTRICAL POWER SYSTEMS)

## I – SEMESTER

Subject Code	Subject	L	T	P	Credits	Max. Marks		
						Internal	External	Total
10MT10101	Advanced Control Systems	4	-	-	4	40	60	100
10MT10102	EHVAC Transmission	4	-	-	4	40	60	100
10MT10103	Microprocessors & Microcontrollers	4	-	-	4	40	60	100
10MT10104	Power System Control & Stability	4	-	-	4	40	60	100
10MT10105	Reactive Power Compensation & Management	4	-	-	4	40	60	100
<b>Elective - I</b>								
10MT10106	Advanced Digital Signal Processing	4	-	-	4	40	60	100
10MT10107	Neural Networks & Fuzzy Systems	4	-	-	4	40	60	100
10MT10108	Power Quality	4	-	-	4	40	60	100
<b>Laboratory</b>								
10MT10109	Power Systems & Relays lab	-	-	3	2	25	50	75
<b>Total</b>		<b>24</b>	<b>-</b>	<b>3</b>	<b>26</b>	<b>265</b>	<b>410</b>	<b>675</b>

## II – SEMESTER

Subject Code	Subject	L	T	P	Credits	Max. Marks		
						Internal	External	Total
10MT20101	Economic Operation & Control of Power System	4	-	-	4	40	60	100
10MT20102	FACTS Controllers	4	-	-	4	40	60	100
10MT20103	HVDC Transmission	4	-	-	4	40	60	100
10MT20104	Power System Reliability	4	-	-	4	40	60	100
10MT20105	Static and Digital Protection of Power System	4	-	-	4	40	60	100
<b>Elective - II</b>								
10MT20106	Energy Audit, Conservation & Management	4	-	-	4	40	60	100
10MT20107	Power System Dynamics and Stability	4	-	-	4	40	60	100
10MT20108	Restructured Power System	4	-	-	4	40	60	100
10MT20109	Industrial Visit	-	-	-	2	50	-	50
<b>Laboratory</b>								
10MT20110	Computer Applications in Power Systems lab	-	-	3	2	25	50	75
<b>Total</b>		<b>24</b>	<b>-</b>	<b>3</b>	<b>28</b>	<b>315</b>	<b>410</b>	<b>725</b>

## III - SEMESTER

Subject Code	Course	Periods per Week			Credits	Internal	External	Total
		L	T	P				
10MT30101	Project Work Phase-I	-	-	-	4	50	-	50
<b>Total</b>		<b>-</b>	<b>-</b>	<b>-</b>	<b>4</b>	<b>50</b>	<b>-</b>	<b>50</b>

## IV – SEMESTER

Subject Code	Course	Periods per Week			Credits	Internal	External	Total
		L	T	P				
10MT40101	Project Work Phase-II	-	-	-	12	50	100	150
<b>Total</b>		<b>-</b>	<b>-</b>	<b>-</b>	<b>12</b>	<b>50</b>	<b>100</b>	<b>150</b>

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### **(10MT10101) ADVANCED CONTROL SYSTEMS**

**UNIT-I: Design of Compensators & Controllers by Time Domain Approach**  
Control System Design by the root locus method-lead, lag and lag-lead compensation, PI, PD, PID Controllers design procedures and examples.

**UNIT-II: Design of Compensators & Controllers by Frequency Response Approach**

Control System Design by frequency response approach-lead, lag lag-lead compensation, PI, PD, PID Controllers – design procedures and examples.

**UNIT-III: Controllability & Observability**

General concept of Controllability - General concept of Observability - Controllability tests for Continuous – Time Invariant systems - Observability tests for Continuous - Time Invariant systems - Controllability and Observability of state model in Jordan Canonical form - Controllability and Observability Canonical forms of State model

**UNIT-IV: Non-Linear Systems-I**

Introduction – Non Linear Systems – Types of Non – Linearities – Saturation – Dead – Zone – Backlash – Jump Phenomenon etc; - Singular Points – Introduction to Linearization of nonlinear systems, properties of Non Linear Systems – Describing function – describing function analysis of nonlinear systems- Stability analysis of Non – Linear systems through describing functions

**UNIT-V: Non-Linear Systems-II**

Introduction to phase – plane analysis, Method of Isoclines for Constructing Trajectories, singular points, phase – plane analysis of nonlinear control systems.

**UNIT-VI: Stability Analysis**

Stability in the sense of Lyapunov, Lyapunov's stability and Lyapunov's instability theorems – Stability Analysis of the Linear Continuous time invariant systems by Lyapunov second method – Generation of Lyapunov functions – Variable gradient method – Krasooviski's method.

**UNIT-VII: State Feedback Controllers & Observers**

State Feedback Controller design through Pole Assignment – state observers

**UNIT-VIII: Optimal Control Theory**

Introduction to optimal control – Formulation of optimal control problems – calculus of variations – fundamental concepts, functional, variation of functional – fundamental theorem of Calculus of variations – boundary

conditions – constrained minimization – formulation using Hamiltonian method  
– Linear quadratic regulator

**TEXT BOOKS:**

1. M. Gopal, *Modern Control System Theory*, New Age International, 1984
2. Donald E. Kirk, *Optimal control Theory - An Introduction*, Dover Publications, New York, 1998
3. A. Nagoor Kani, *Advanced Control Theory*, 2<sup>nd</sup> Edition, RBA Publications.

**REFERENCES:**

1. Kuo, *Automatic Control Systems*, 7<sup>th</sup> Edition, Printice Hall of India
2. Ogata. K, *Modern Control Engineering*, 4<sup>th</sup> Edition, Prentice Hall, 1997

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### **(10MT10102) EHVAC TRANSMISSION**

#### **UNIT–I: Transmission Line Trends**

E.H.V.A.C. Transmission line trends and preliminary aspect standard transmission voltages – Estimation at line and ground parameters

#### **UNIT–II: Calculation of Line & 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–III: Electrostatic Fields of EHV Lines and its adverse effects**

Electrostatic field and voltage gradients – calculations of electrostatic field of AC lines – effect high electrostatic field on biological organisms and human beings surface voltage gradients and maximum gradients of actual transmission lines – voltage gradients on sub conductor

#### **UNIT–IV: Measurement of Electrostatic Fields**

Electrostatic induction in un-energized lines – measurements of field and voltage gradients for three phase single and double circuit lines – un-energized lines.

#### **UNIT–V: Power Frequency Voltage control and over voltages in EHV lines**

No load voltage – charging currents at power frequency - voltage control – shunt and series compensation – static VAR compensation.

#### **UNIT–VI: Corona Effects – I: Power Loss and Audible Noise**

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–VII: Corona Effects – II: Audible Noise measurement and Radio interference**

Measurements of audio noise radio interference due to Corona RF properties of radio noise – frequency spectrum of RI fields – Measurements of RI and RIV.

#### **UNIT–VIII: Design of EHV Lines and EHV Cables**

Design of EHV lines based on steady state and transient limits. EHV cables and their characteristics.

**TEXT BOOKS:**

1. Rakosh Das Begamudre, *Extra High Voltage AC Transmission Engineering*, 3<sup>rd</sup> Edition, New Age International Pvt. Ltd.

**REFERENCES:**

1. Edison Electric Institution (GEC), *EHV Transmission line reference Book*, Edison House, 1986
2. S. Rao, *EHVAC, HVDC Transmission and Distribution Engineering*, Khanna Publications, 2001

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### **(10MT10103) MICROPROCESSORS AND MICROCONTROLLERS**

#### **UNIT-I: Intel 8086/8088**

Architecture, its register organization, Pin diagram, Minimum and Maximum Mode System and Timings, Machine language instruction formats, Addressing modes, Timing Diagram

#### **UNIT-II: ALP Programming of 8086**

Assembly Language Programming with an assembler, Assembler Directives, Instruction set, Procedures & Macros

#### **UNIT-III: Peripherals & Their Interfacing**

Memory Interfacing (DRAM), PPI- Modes of operation of 8255, Programmed I/O, Interrupt Driven I/O, interfacing to ADC & DAC, Stepper Motor Interfacing

#### **UNIT-IV: Special Purpose of Programmable Peripheral Devices and their Interfacing:**

Programmable Interrupt Controller 8259A, Programmable Communication Interface 8251 -USART and their interfacing.

#### **UNIT-V: Advanced Processors**

Architectural features of 80186, 80286, 80386, 80486 Processors & their memory management, Introduction to Pentium & Pentium Pro Processors their features, RISC Vs CISC Processors.

#### **UNIT-VI: Microcontrollers**

Introduction to Intel 8-bit and 16-bit Microcontrollers, 8051-Architecture, memory organization, Addressing modes.

#### **UNIT-VII: Hardware Description of 8051**

Instruction formats, Instruction set, Interrupt structure and interrupt priorities, Port structures and Operation, Timers & Counter functions - Different modes of operation and programming Examples.

#### **UNIT-VIII: 8051 Interfacing and Industrial Applications**

Interfacing of LED's & Relay's, Keyboard Interfacing, Interfacing Seven Segment Display, ADC & DAC Interfacing

**TEXT BOOKS:**

1. Douglas V. Hall, *Microprocessors and Interfacing - Programming and Hardware*, Tata McGraw-Hill Publishing Company Limited, New Delhi
2. Barry b Brey, *The Intel Microprocessors - Architecture, Programming and interfacing*, Printice Hall of India Pvt. Ltd., New Delhi
3. Kenneth J Ayala, *The 8051 Microcontroller Architecture, Programming & Applications*, Thomson Publishers.

**REFERENCES:**

1. A K Ray & K M Bhurchandi, *Advanced Microprocessors and Peripherals – Architecture, Programming and Interfacing*, TMH Publishing Company, New Delhi
2. Muhammad Ali Mazidi, *The 8051 Microcontroller and Embedded Systems*, Pearson Education

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### **(10MT10104) POWER SYSTEM CONTROL & STABILITY**

#### **UNIT-I: The Elementary Mathematical Model**

A Classical model of one machine connected to an infinite bus – Classical model of multi-machine system – Problems – Effect of the excitation system on Transient stability.

#### **UNIT-II: System Response to small Disturbances**

The unregulated synchronous Machine – Effect of small changes of speed – modes of oscillation of an unregulated Multimachine system – regulated synchronous machine – voltage regulator with one time lag – Governor with one time lag – Problems.

#### **UNIT-III: Dynamic Stability**

Concept of Dynamic stability – state space model of one machine system connected to infinite bus – effect of excitation on Dynamic stability – examination of dynamic stability by Routh's criterion

#### **UNIT-IV: Power system stabilizers**

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

#### **UNIT-V: Excitation systems**

Excitation system response – Non-continuously regulated systems – continuously regulated systems – Excitation system compensation – state space description of the excitation system- simplified linear model – effect of excitation on generator power limits.

#### **UNIT-VI: Types of Excitation systems**

Type –2 system: rotating rectifier system, Type-3 system: Static with terminal potential and current supplies - Type –4 system: non – continuous acting - Block diagram representation – state space modeling equations of these types.

#### **UNIT-VII: Stability Analysis using direct method of Lyapunov**

Review of Lyapunov's stability theorems of non-linear 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.

#### **UNIT-VIII: Introduction to Voltage stability**

What is voltage stability – Factors affecting voltage instability and collapse – Comparison of Angle and voltage stability – Analysis of voltage instability and

collapse – Integrated analysis of voltage and Angle stability – Control of voltage instability.

**TEXT BOOKS:**

1. P.M. Anderson, A.A. Fouad, *Power System Control and Stability*, IOWA State University Press, 1<sup>st</sup> Edition, Galgotia Publications, Vol. – I & II.
2. M.A. Pai, *Power System Stability – Analysis by the direct method of Lyapunov*, North Holland Publishing Company, Newyork, 1981.

**REFERENCES:**

1. K.R. Padiyar, *Power System Dynamics (Stability & Control)*, 2<sup>nd</sup> Edition, B.S. Publications.
2. Prabha Kundur, Neal J. Balu, Mark G. Lauby, *Power system stability and control*, 2<sup>nd</sup> Edition, McGraw-Hill.

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### **(10MT10105) REACTIVE POWER COMPENSATION AND MANAGEMENT**

#### **UNIT-I: Theory of Load Compensation**

Objectives and specifications – 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: Steady–state reactive power compensation in transmission system:**

Uncompensated line – types of compensation – Passive shunt and series and dynamic shunt compensation – examples

#### **UNIT-III: Transient state reactive power compensation in transmission systems:**

Characteristic time periods – passive shunt compensation – static compensations - series capacitor compensation – compensation using synchronous condensers – examples

#### **UNIT-IV: Reactive power coordination and Quality in Supply**

Objective – Mathematical modeling – Operation planning – transmission benefits – Basic concepts of quality of power supply – disturbances- steady – state variations – effects of under voltages – frequency – Harmonics, radio frequency and electromagnetic interferences

#### **UNIT-V: Demand side management:**

Load patterns – basic methods load shaping – power tariffs- KVAR based tariffs penalties for voltage flickers and Harmonic voltage levels

#### **UNIT-VI: Distribution side Reactive power Management**

System losses –loss reduction methods – examples – Reactive power planning – objectives – Economics Planning capacitor placement – retrofitting of capacitor banks

#### **UNIT-VII: User side reactive power management**

KVAR requirements for domestic appliances – Purpose of using capacitors – selection of capacitors – deciding factors – types of available capacitor, characteristics and Limitations

#### **UNIT-VIII: Reactive power management in Industries**

Typical layout of traction systems – reactive power control requirements – distribution transformers- Electric arc furnaces –textile and plastic industries- furnaces transformer –filter requirements – remedial measures –power factor of an arc furnace

**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, 2004.

**REFERENCE:**

1. Peter W. Sauer, *Applied Mathematics for Restructured Electric Power systems*.

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### **(10MT10106) ADVANCED DIGITAL SIGNAL PROCESSING** **(Elective-I)**

#### **UNIT-I: Sampling**

Sampling theorem – Graphical and analytical proof for Band Limited Signals, impulse sampling, Natural and Flat top Sampling, Re-construction of signal from its samples, effect of under sampling – Aliasing.

#### **UNIT-II: Introduction To Digital Signal Processing**

Discrete time signals & sequences, linear shift invariant systems, stability and causality. Linear constant coefficient difference equations. Frequency domain representation of discrete time signals and systems.

#### **UNIT-III: Discrete Fourier Series**

Properties of discrete Fourier series, DFS representation of periodic sequences.  
**Discrete Fourier Transforms:** Properties of DFT, linear convolution of sequences using DFT, Computation of DFT.

#### **UNIT-IV: Fast Fourier Transforms**

Fast Fourier transforms (FFT) - Radix-2 decimation in time and decimation in frequency FFT Algorithms, Inverse FFT and FFT for composite N

#### **UNIT-V: Z-Transforms**

Concept of Z- Transform of a discrete sequence. Region of convergence in Z-Transform, constraints on ROC for various classes of signals, Inverse Z-transform, properties of Z-transforms. Relation between Z-transform and DFS. Applications of Z – transforms.

**Realization Of Digital Filters:** solution of difference equations of digital filters, Block diagram representation of linear constant-coefficient difference equations, Basic structures of IIR systems, Transposed forms, Basic structures of FIR systems, System function.

#### **UNIT-VI: IIR Digital Filters**

Analog filter approximations – Butter worth and Chebyshev, Design of IIR Digital filters from analog filters, Design Examples: Analog-Digital transformations

#### **UNIT-VII: FIR Digital Filters**

Characteristics of FIR Digital Filters, frequency response. Design of FIR Digital Filters using Window Techniques, Frequency Sampling technique, Comparison of IIR & FIR filters.

## **UNIT-VIII: Multirate Digital Signal Processing**

Decimation, interpolation, sampling rate conversion, Implementation of sampling rate conversion.

### **TEXT BOOKS:**

1. B.P. Lathi, *Signals, Systems & Communications*, BS Publications, 2003.
2. John G.Proakis, Dimitris G. Manolakis, *Digital Signal Processing, Principles, Algorithms, and Applications*, Pearson Education / PHI, 2007.
3. A.V.Oppenheim and R.W. Schaffer, *Discrete Time Signal Processing*, PHI

### **REFERENCES:**

1. A.V. Oppenheim, A.S. Willsky and S.H. Nawab, *Signals and Systems*, 2<sup>nd</sup> Edition, PHI.
2. Andreas Antoniou, *Digital Signal Processing*, TATA Mc Graw Hill, 2006
3. MH Hayes, *Digital Signal Processing*, Schaum's Outlines, TATA Mc-Graw Hill, 2007.
4. C. Britton Rorabaugh, *DSP Primer*, Tata Mc Graw Hill, 2005.
5. Robert J. Schilling, Sandra L. Harris, *Fundamentals of Digital Signal Processing using MATLAB*, Thomson, 2007.
6. Alan V. Oppenheim, Ronald W. Schafer, *Digital Signal Processing*, PHI, 2006

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### **(10MT10107) NEURAL NETWORKS & FUZZY SYSTEMS (Elective-I)**

#### **UNIT-I: Introduction and Essentials of Artificial Neural Networks**

Introduction, Humans and Computers, Organization of the Brain, Biological Neuron, Biological and Artificial Neuron Models, Characteristics of ANN, McCulloch-Pitts Model, Types of Neuron Activation Function, ANN Architectures, Neural Dynamics (Activation and Synaptic), Learning Strategy (Supervised, Unsupervised, Reinforcement), Learning Rules - Potential Applications of ANN.

#### **UNIT-II: Feed Forward Neural Networks**

Introduction, Perceptron Models: Discrete, Continuous and Multi-Category, Training Algorithms: Discrete and Continuous Perceptron Networks, Perceptron Convergence theorem, Limitations of the Perceptron Model, Applications.

#### **Multilayer Feed Forward Neural Networks**

Credit Assignment Problem, Generalized Delta Rule, Derivation of Backpropagation (BP) Training, Summary of Backpropagation Algorithm, Kolmogorov Theorem, Learning Difficulties and Improvements.

#### **UNIT-III: Associative Memories**

Paradigms of Associative Memory, Pattern Mathematics, Hebbian Learning, General Concepts of Associative Memory (Associative Matrix, Association Rules, Hamming Distance, The Linear Associator, Matrix Memories, Content Addressable Memory), Bidirectional Associative Memory (BAM) Architecture, BAM Training Algorithms: Storage and Recall Algorithm, BAM Energy Function, Proof of BAM Stability Theorem.

Architecture of Hopfield Network: Discrete and Continuous versions, Storage and Recall Algorithm, Stability Analysis, Capacity of the Hopfield Network.

#### **UNIT-IV: Self-Organizing Maps (SOM) & Adaptive Resonance Theory (ART)**

Introduction, Competitive Learning, Vector Quantization, Self-Organized Learning Networks, Kohonen Networks, Training Algorithms, Linear Vector Quantization, Stability- Plasticity Dilemma, Feed forward competition, Feedback Competition, ART1, ART2, Applications.

#### **UNIT-V: Classical & Fuzzy Sets**

Introduction to classical sets – properties, Operations and relations; Fuzzy sets, Membership, Uncertainty, Operations, Properties, fuzzy relations, cardinalities, membership functions.

#### **UNIT-VI: Fuzzy Logic System Components**

Fuzzy logic controller -Fuzzification, Membership Value assignment, fuzzy rule base-choice of variables- derivation of rules and decision making system,

Defuzzification to crisp sets - Defuzzification methods, Mamdani and sugeno fuzzy systems.

### **Unit-VII: Neuro Fuzzy Control**

Fuzzy associative memories –Fuzzy and neural function estimators – FAM system Architecture – Comparison of Fuzzy and Neural systems-Adaptive neuro, Adaptive Fuzzy, Adaptive Neuro-Fuzzy interface systems- Neuro controller

### **Unit-VIII: Applications**

**Neural network applications:** Process identification, Control and Process Monitoring, Fault diagnosis and Load forecasting.

**Fuzzy logic applications:** Fuzzy logic control for a temperature process and Fuzzy classification.

### **TEXT BOOKS:**

1. S.Rajasekaran and G.A.Vijayalakshmi Pai, *Neural Networks, Fuzzy logic, Genetic algorithms: synthesis and applications*, PHI, 2009.
2. S.N Sivanandam, S. Sumathi & S N Deepa, *Introduction to Neural Networks using MATLAB 6.0*, Tata Mc Graw Hill.
3. Timothy J. Ross, *Fuzzy logic with engineering applications*, 2<sup>nd</sup> Edition, Wiley Indian Edition
4. Bart Kosko, *Networks & Fuzzy Systems*, Prentice Hall India Pvt., Ltd.,

### **REFERENCES:**

1. James A Freeman and Davis Skapura, *Neural Networks*, Pearson, 2002
2. Simon Hykins, *Neural Networks*, 2<sup>nd</sup> Edition, Pearson Education.
3. J M Zurada, *Introduction to Artificial Neural Networks*, Jaico Publishing House, Delhi
4. YegnaNarayana, *Artificial Neural Networks*, Prentice Hall India Pvt., Ltd.,

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### **(10MT10108) POWER QUALITY** **(Elective-I)**

#### **UNIT-I: Introduction**

Introduction of the Power Quality (PQ) problem, Terms used in PQ: Voltage, Sag, Swell, Surges, Harmonics, over voltages, spikes, Voltage fluctuations, Transients, Interruption, overview of power quality phenomenon, Remedies to improve power quality, power quality monitoring

#### **UNIT-II: Long Interruptions**

Interruptions – Definition – Difference between failure, outage, Interruptions – causes of Long Interruptions – Origin of Interruptions – Limits for the Interruption frequency – Limits for the interruption duration – costs of Interruption – Overview of Reliability evaluation to power quality, comparison of observations and reliability evaluation.

#### **UNIT-III: Short Interruptions**

Short interruptions – definition, origin of short interruptions, basic principle, fuse saving, voltage magnitude events due to re-closing, voltage during the interruption, monitoring of short interruptions, difference between medium and low voltage systems. Multiple events, single phase tripping – voltage and current during fault period, voltage and current at post fault period, stochastic prediction of short interruptions.

#### **UNIT-IV: Voltage sag – characterization:**

Voltage sag – definition, causes of voltage sag, voltage sag magnitude, and monitoring, theoretical calculation of voltage sag magnitude, voltage sag calculation in non-radial systems, meshed systems, and voltage sag duration. Three phase faults, phase angle jumps, magnitude and phase angle jumps for three phase unbalanced sags, load influence on voltage sags.

#### **UNIT-V: PQ considerations in Industrial Power Systems:**

Voltage sag – equipment behaviour of Power electronic loads, induction motors, synchronous motors, computers, consumer electronics, adjustable speed AC drives and its operation. Mitigation of AC Drives, adjustable speed DC drives and its operation, mitigation methods of DC drives.

#### **UNIT-VI: Mitigation of Interruptions and Voltage Sags:**

Overview of mitigation methods – from fault to trip, reducing the number of faults, reducing the fault clearing time changing the power system, installing mitigation equipment, improving equipment immunity, different events and mitigation methods. System equipment interface – voltage source converter, series voltage controller, shunt controller, combined shunt and series controller.

### **UNIT-VII: Fundamentals of Harmonics**

Harmonic Distortion – Voltage versus Current distortion – Harmonics versus Transients – Harmonic Indexes – Harmonic Sources from Commercial Loads – Harmonic Sources from industrial Loads – locating harmonic sources – System response characteristics – effects of harmonic distortion – inter harmonics.

### **UNIT-VIII: Power Quality Monitoring:**

Monitoring Considerations – Historical Perspective of Power Quality measuring Instruments – Power Quality measurement Equipment – Assessment of Power Quality Measurement Data – Application of Intelligent Systems – Power Quality Monitoring Standards.

### **TEXT BOOKS:**

1. Math H J Bollen, *Understanding Power Quality Problems*, IEEE Press.
2. C.Sankaran, *Power Quality*, CRC press

### **REFERENCE:**

1. Roger C. Dugan, Mark E. Mc. Granaghan, Surya Santosoh and H. Wayne Beaty, *Electrical Power Systems Quality*, 2<sup>nd</sup> Edition, TATA Mc Graw Hill.

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**(10MT10109) POWER SYSTEMS AND RELAYS LAB**

<b>S. No</b>	<b>Experiment Title</b>
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 Fault LL Fault
4.	Fault Analysis – II LLG Fault LLLG Fault
5.	Equivalent Circuit of a Three Winding Transformer.
6.	Separation of No-Load Losses of Three-Phase Squirrel Cage Induction Motor.
7.	Power Angle Characteristics of Salient Pole Synchronous Machine.
8.	Scott Connection.
9.	Characteristics of Over Current Relay
10.	Measurement of Dielectric strength of transformer oil using variable electrodes
11.	Characteristics of Over Voltage Relay.
12.	Characteristics of Percentage Biased Differential Relay.
13.	Testing of Frequency Relay
14.	Determination of Sequence components of Salient Pole Synchronous Machine.
15.	Testing of Reverse Power Relay

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**L T P C**

**II - Semester**

**4 - - 4**

### **(10MT20101) ECONOMIC OPERATION AND CONTROL OF POWER SYSTEM**

#### **UNIT-I: Economic Operation**

Economic operation- Load forecasting - Unit commitment – Economic dispatch problem of thermal units – Gradient method- Newton's method –Base point and participation factor method.

#### **UNIT-II: Unit Commitment and Solution Methods**

Optimal Unit Commitment, Constraints in unit commitment, Spinning reserve, Thermal Unit Constraints, Other constraints, Hydro constraints, Must Run, Fuel constraints, Unit commitment Solution methods: Priority-List methods, Dynamic Programming solution - Reliability considerations

#### **UNIT-III: Hydrothermal co-ordination**

Short-term hydrothermal scheduling problem - gradient approach – Hydro units in series - pumped storage hydro plants-hydro-scheduling using Dynamic programming and linear programming.

#### **UNIT-IV: Automatic generation control**

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

#### **UNIT-V: Interchange of Power & Energy**

Economic interchange between interconnected utilities – Inter utility energy evaluation – Power pools – Transmission effects and Issues: Limitations - Wheeling

#### **UNIT-VI: Power Flow problem & its solution**

Formulation of AC Power Flow – Solution Methods: Gauss Siedel, Newton Rhapson & Decoupled Power Flow methods - DC Power Flow Method

#### **UNIT-VII: Power system security**

Contingency analysis – linear sensitivity factors – AC power flow methods – contingency selection – concentric relaxation – bounding

#### **UNIT-VIII: Optimal Power Flow**

Gradient Method & Newton's Method – Linear Sensitivity Analysis – Linear Programming Methods - security constrained optimal power flow – Interior point Algorithm.

**TEXT BOOKS:**

1. Allen J.Wood and Wollenberg B.F., *Power Generation Operation and control*, 2<sup>nd</sup> Edition, John Wiley & Sons.
2. Nagrath, I.J. and Kothari D.P., *Modern Power System Analysis*, 3<sup>rd</sup> Edition, Tata McGraw-Hill, New Delhi.

**REFERENCE:**

1. D.P. Kothari & J.S. Dhillon, *Power System Optimization*, Printice Hall of India, 2004

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### **(10MT20102) FACTS CONTROLLERS**

#### **UNIT-I: FACTS Concepts**

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

#### **UNIT-II: Voltage Source Converters and Current Source Converters**

Transformer connections for 12 pulse 24 and 48 pulse operation, Three level voltage source converter, pulse width modulation converter, comparison of current source converters with voltage source converters.

#### **UNIT-III: Static Shunt Compensation**

Objectives of shunt compensation, mid point voltage regulation voltage instability prevention, improvement of transient stability, Power oscillation damping,

#### **UNIT-IV: Types of VAR Generators**

Methods of controllable VAR generation, variable impedance type static VAR generators switching converter type VAR generators hybrid VAR generators.

#### **UNIT-V: SVC and STATCOM**

The regulation and slope transfer function and dynamic performance, transient stability enhancement and power oscillation damping operating point control and summary of compensator control.

#### **UNIT-VI: Static Series Compensators**

Concept of series capacitive compensation, improvement of transient stability, power oscillation damping, Functional requirements. GTO thyristor controlled series capacitor (GSC), thyristor switched series capacitor (TSSC), and thyristor controlled series capacitor (TCSC) control schemes for GSC, TSSC and TCSC.

#### **UNIT-VII: Phase Angle Regulators**

Objectives of Voltage and Phase Angle Regulators, Approaches to Phase Angle Regulators (TCPARs) – Transient stability enhancement and Power Oscillation Damping.

#### **UNIT-VIII: Combined Compensators**

UPFC - Basic operating Principles, Conventional Transmission Control Capabilities, Independent Real and Reactive Power Flow Control, Control structure.

IPFC- Basic operating Principles, Control structure.

**TEXT BOOKS:**

1. Narain G. Hingorani, Laszlo Gyugyi, *Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems*, Wiley- IEEE Press, 1999.
2. R. Mohan Mathur and Rajiv k. varma, *Thyristor based FACTS controllers for Electrical Transmission Systems*, Wiley- IEEE Press, 2002.

**REFERENCES:**

1. Xiao-Ping, Rehtanz, Christian, Pal, Bikash, *Flexible AC Transmission Systems: Modeling and Control*, Springer, Power Systems Series, 2006.
2. Enrique Acha, Claudio R.Fuerte- Esquivel, Hugo Ambriz-perez, Casar Angeles-Camacho, *Modeling and Simulation in Power Networks*, Wiley - IEEE Press, 2004.

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### **(10MT20103) H.V.D.C. TRANSMISSION**

#### **UNIT-I: Introduction to HVDC Transmission**

H.V.DC Transmission: Role of HVAC and HVDC transmission, types of DC links, Power Handling Capabilities of HVDC lines, Basic Conversion principles, static converter configuration.

#### **UNIT-II: Static Power Converter Analysis**

Static Power Converters: 3 pulse, 6 pulse & 12 pulse converters, converter station and terminal equipment communication process, Rectifier and inverter operation, equivalent circuit for converter- special features of converter transformers.

#### **UNIT-III: Harmonics and Filters**

Generation of Harmonics in HVDC systems, methods of harmonics elimination, harmonic instability problems, Design of AC & DC filter

#### **UNIT-IV: Control of HVDC Converter and Systems**

Control of HVDC converter and systems: Principle of DC link control - constant current, constant extinction angle and constant ignition angle control. Individual phase control and equidistant firing angle control.

#### **UNIT-V: Active and Reactive Power Control**

DC power flow control – P.U. System for DC quantities-solution of AC-DC Power flow-Simultaneous method-Sequential method - sources of reactive power – reactive power control – DC power modulation.

#### **UNIT-VI: Multi – Terminal DC Link and Systems**

Multi-terminal DC link and systems; series, parallel and series parallel systems, their principle of operation and control.

#### **UNIT-VII: Voltage Interaction between HVAC and HVDC Systems**

Voltage interaction – Dynamic voltage regulation – causes for instability – remedies for instability problems.

#### **UNIT-VIII: Transient over Voltages, Faults and Protection**

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.

**TEXT BOOKS:**

1. K.R.Padiyar, *High Voltage Direct current Transmission*, Wiley Eastern Ltd.
2. J. Arillaga, *H.V.D.C. Transmission*, Peter Peregrinus Ltd., London UK, 1983
3. E. W. Kimbark, *Direct current Transmission*, John Wiley & sons, New York.

**REFERENCES:**

1. E.Uhlman, *Power Transmission by Direct Current* Springer Verlag, Berlin
2. S Rao, *EHVAC, HVDC Transmission & Distribution Engineering*, Khanna Publishers, 2001.

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### **(10MT20104) POWER SYSTEM RELIABILITY**

#### **UNIT–I: Basic Probability Theory**

Probability Concept, Elements of probability theory, Random variables (*Continuous, Discrete Variables*), Density function and Distribution functions. Mean, SD, Variance. Probability Distributions: Exponential Distribution, Binomial Distribution, Poisson distribution, Normal Distribution, Weibull Distribution, Log Normal Distribution.

#### **UNIT–II: Reliability Functions**

Definition of reliability, Component Reliability, Hazard rate, derivation of the Reliability function in terms of the hazard rate, Bath Tub Curve. MTTF, MTTR, MTBF, types of Failures (*early failures, chance failures and wear-out failures*). Reliability Block Diagrams, Series and Parallel configuration. Series-Parallel configuration, High level and low level redundancy

#### **UNIT–III: Network Modeling**

Reliability evaluation of Non - Series-Parallel configurations. Baye's Theorem Cut-set, Basic Cut-set, Tie-set and Basic Tie set, Minimal Cut-Set, Minimal Tie – set and Decomposition Methods. Deduction of the Minimal Cut sets from the Minimal paths-Stand by redundant Systems-Concept of redundancy, Perfect Switching, Imperfect Switching-Event trees

#### **UNIT–IV: Markov Modeling**

Introduction – Markov Process & Markov chain - STPM - Time Dependant probability - functions - Evaluating limiting state probabilities-Absorbing states - Markov process – one component repairable model -Two component repairable model - Three component repairable model.

#### **UNIT–V: Generation System Reliability Analysis**

Introduction – Generation system model - Identical units- determination of capacity outage probability table(COPT)- Determination of transitional rates - Non-Identical units- determination of capacity outage probability table - Reducing the states by Combining equal capacity states - Determination of transitional rates -Sequential addition method - Recursive relation for unit addition, unit removal - LOLP , LOLE determination .

#### **UNIT–VI: Frequency & Duration Techniques**

Frequency and duration concepts - Two components repairable model (with & without identical components) - Evaluation of cumulative probability & cumulative frequency - Equivalent transition rates – non equivalent transition rates.

### **UNIT–VII : Composite System Reliability Analysis**

Two level representation of daily load modeling - Merging of generation and load models – evaluation of probabilities, transitional rates-Decomposition method– Weather effects on transmission lines-circuit breaker model

### **UNIT–VIII: Distribution System Reliability Analysis (Parallel & Radial Configurations)**

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

#### **TEXT BOOKS:**

1. Roy Billinton and Ronald N Allen, *Reliability Evaluation of Engineering Systems*, Plenum press, New York and London (BS Publications Revised edition), 1996.
2. Roy Billinton and Ronald N Allen *Reliability Evaluation of Power Systems*, 2<sup>nd</sup> Edition, Plenum press, New York and London, (BS Publications Revised edition).
3. J. Endrenyi, *Reliability Modeling in Electric Power Systems*, 1<sup>st</sup> Edition, John Wiley & Sons.

#### **REFERENCES:**

1. Charles E. Ebeling, *An Introduction to Reliability and Maintainability Engineering*, TATA McGraw Hill, 2002
2. L. Srinath, *Reliability Engineering* TATA McGraw Hill.
3. A. Balaguru Swamy, *Reliability Engineering*, TATA Mc Graw Hill.

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### **(10MT20105) STATIC AND DIGITAL PROTECTION OF POWER SYSTEM**

#### **UNIT-I: Static Relays**

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

#### **UNIT-II: Comparators**

**Amplitude comparators:** Circulating current type and opposed voltage type rectifier bridge comparators – Direct and Instantaneous comparators

**Phase comparators:** coincidence circuit type block spike phase comparator, techniques to measure the period of coincidence – Integrating type – Rectifier and vector product type phase comparators.

#### **UNIT-III: Multi-input comparators**

Conic section characteristics – Three input amplitude comparator – Hybrid comparator – switched distance schemes – Polyphase distance schemes-Phase fault scheme –Three phase scheme – combined and ground fault scheme.

#### **UNIT-IV: Over Current and Differential Relays**

**Static over current relays:** Introduction-Instantaneous over current relay – Time over current relays-basic principles-Definite time and Inverse definite time over current relays.

**Static Differential Relays:** Analysis of static differential relays – static relay schemes –Duo bias transformer differential protection – Harmonic restraint relay.

#### **UNIT-V: Static distance Relays**

Static impedance – reactance - MHO and angle impedance relay sampling comparator–realization of reactance and MHO relay 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-VI: Microprocessor based protective relays-I**

Over current relays – impedance relays – directional relay – reactance relay (Block diagram and flow chart approach only)

#### **UNIT-VII: Microprocessor based protective relays-II**

Generalized mathematical expression for distance relays - measurement of resistance and reactance – MHO and offset MHO relays –Realization of MHO characteristics – Realization of offset MHO characteristics (Block diagram and flow chart approach only).

## **UNIT-VIII: Digital & Numerical Relays**

Basic principle of Digital computer relaying, Introduction to Numerical Relays – Advantages.

### **TEXT BOOKS:**

1. T.S. Madhava Rao, *Power system Protection static relay*, 2<sup>nd</sup> Edition, Tata McGraw Hill Publishing company limited.
2. Badri Ram and D.N. Vishwakarma, *Power system Protection and Switchgear*, 1<sup>st</sup> Edition, Tata McGraw Hill Publication company limited.

### **REFERENCE:**

1. Bhuvanesh A Oza, Nirmal Kumar C Nair et., al., *Power System Protection and Switchgear*, Tata McGraw Hill

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### **(10MT20106) ENERGY AUDITING, CONSERVATION & MANAGEMENT (Elective-II)**

#### **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-I**

Principles of energy management, organizing energy management program, initiating, planning, controlling, promoting, monitoring, reporting.

#### **UNIT-III: Energy management-II**

Energy manger, Qualities and functions, language, Questionnaire - check list for top management

#### **UNIT-IV: 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-V: Power Factor Improvement, Lighting**

Power factor – methods of improvement, location of capacitors, Pf with non linear loads, effect of harmonics on p.f., p.f motor controllers - Good lighting system design and practice, lighting control, lighting energy audit

#### **UNIT-VI: Energy Instruments**

Energy Instruments watt meter, data loggers, thermocouples, pyrometers, lux meters, tongue testers, application of PLC's

#### **UNIT-VII: 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

#### **UNIT-VIII: Computation of Economic Aspects**

Calculation of simple payback method, net present worth method - Power factor correction, lighting - Applications of life cycle costing analysis, return on investment.

**TEXT BOOKS:**

- 1) W.R. Murphy & G. McKay Butter worth, *Energy management*, Heinemann publications.
- 2) Paul o' Callaghan, *Energy Management*, 1<sup>st</sup> edition, McGraw Hill Book Company.
- 3) John C. Andreas, *Energy Efficient Electric Motors*, 2<sup>nd</sup> edition, Marcel Dekker Inc. Ltd.
- 4) W.C. Turner, *Energy management Hand Book*, John Wiley and sons

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### **(10MT20107) POWER SYSTEM DYNAMICS AND STABILITY (Elective-II)**

#### **UNIT-I: Classical Methods**

Introduction to the power system stability – Basic concepts and definitions – classification of stability – Synchronous Machine modeling – mathematical description of a synchronous machine – The DQO transformation – equivalent circuits for direct and quadrature axes – steady state analysis – electrical transient performance characteristics – equations of motion.

#### **UNIT-II: Synchronous Machine Control Methods**

Excitation systems – Requirement-Voltage and Speed Control overview-Exciter Models-Voltage Regulator models-Turbine Models-Speed Governor Models-Modeling of excitation systems.

#### **UNIT-III: Single Machine Dynamic Models**

Terminal Constraints-The Multi-Time Scale Model-Elimination of Stator/Network transients-The Two axis Model-The one Axis(Flux-Decay)Model-The Classical Model-Damping Torques-Synchronous Machine Saturation.

#### **UNIT-IV: Multi-Machine Dynamic Models**

The Synchronously Rotating Reference Frame-Network and R-L Load Constraints-Elimination of stator/network Transients-Generalization network and Load Dynamic Models-Multimachine Two axis Model-Multimachine flux decay Model-Multi machine Classical Model-Multimachine Damping Torques-Multimachine models with Saturation-Frequency during Transients-Angle References and an Infinite Bus.

#### **UNIT-V: Multi-Machine Simulation**

Differential Algebraic Model-Stator Algebraic Equations-Polar Form-Rectangular form-Alternate form of Stator algebraic Equations-Network Equations-Industry model-Simplification of the Two-Axis Model-Full model (Initial Conditions)-Numerical Solution: Power- Balance Form-SI method –PE Method

#### **UNIT-VI: Small Signal Stability**

Small – Signal Stability – fundamental concepts of stability of dynamic systems – Eigen properties of the state matrix – small signal stability of a single machine infinite bus system – effects of excitation system – power system stabilizer – system state matrix with amortisseurs – small signal stability of multi machine systems – special techniques for analysis of very large systems – characteristics small signal stability problems.

## **UNIT-VII: Load Modeling**

Power system loads – Basic load modeling concepts – modeling of Induction motors – Synchronous motor model – acquisition of load – model parameters.

## **Unit VIII: Energy Function Methods**

Physical and Mathematical aspects-Lyapunov's Method-Modeling Issues-Energy Function Formulation-Potential Energy Boundary Surface(PEBS)-The Boundary Controlling method(BCU)-Structure-Preserving Energy Functions.

### **TEXT BOOKS:**

1. Peter W. Sauer & M. A. Pai, *Power System Dynamics and Stability*, Pearson education, 2005
2. M.A. Pai, *Power System Stability Analysis by the direct method of Lyapunov*, North Holland Publishing Company, Newyork, 1981.

### **REFERENCES:**

1. K.R. Padiyar, *Power System Dynamics (Stability & Control)*, 2<sup>nd</sup> Edition, B.S. Publications.
2. Prabha Kundur, Neal J. Balu, Mark G. Lauby, *Power system stability and control*, 2<sup>nd</sup> Edition McGraw Hill.
3. P.M. Anderson, A.A. Fouad, *Power System Control and Stability Vol. – I & II*, 1<sup>st</sup> Edition, Galgotia Publications.

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### **(10MT20108) RESTRUCTURED POWER SYSTEM (Elective-II)**

#### **UNIT-I: Key Issues in Electric Utilities**

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

#### **UNIT-II: Open Access Same-time Information System (OASIS)**

Structure of OASIS - Posting of Information – Transfer capability on OASIS.

#### **UNIT-III: Available Transfer Capability (ATC)**

Transfer Capability Issues – ATC – TTC – TRM – CBM Calculations – Calculation of ATC based on power flow.

#### **UNIT-IV: Electricity Pricing**

Introduction – Electricity Price Volatility Electricity Price Indexes – Challenges to Electricity Pricing – Construction of Forward Price Curves – Short-time Price Forecasting.

#### **UNIT-V: Power System Operation in Competitive Environment**

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

#### **UNIT-VI: Market Power**

Introduction - Different types of market Power – Mitigation of Market Power - Examples.

#### **UNIT-VII: Transmission Congestion Management**

Introduction - Transmission Cost Allocation Methods : Postage Stamp Rate Method - Contract Path Method - MW-Mile Method – Unused Transmission Capacity Method - MVA-Mile method – Comparison of cost allocation methods.

#### **UNIT-VIII: Ancillary Services Management**

Introduction – Reactive Power as an Ancillary Service – a Review – Synchronous Generators as Ancillary Service Providers.

#### **REFERENCES:**

1. Kankar Bhattacharya, Math H.J. Boller and Jaap E.Daalder Kulwer, *Operation of Restructured Power System*, Academic Publishers, 2001.
2. Mohammad Shahidehpour and Muwaffaq Alomoush, *Restructured Electrical Power Systems*, Marcel Dekker Inc., 2001.
3. Loi Lei Lai, *Power System Restructuring and Deregulation*, John Wiley & Sons Ltd., England.

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**(10MT20110) COMPUTER APPLICATIONS IN POWER SYSTEM LAB**

1. PSPICE Simulation of Integrator and Differentiator circuits.
2. PSPICE Simulation of three phase full converter using RL and RLE loads.
3. PSPICE Simulation of single phase AC voltage controller using RL load
4. PSPICE Simulation of three phase inverter with PWM controller
5. PSPICE Simulation of resonant pulse commutation circuit
6. Y-Bus / Z-Bus formation using MATLAB
7. Gauss-Seidel load flow analysis using MATLAB
8. Newton Raphson method using MATLAB minimum of 6 bus system
9. Fast decoupled load flow analysis using MATLAB
10. Develop a program to solve swing equation by point by point method using MATLAB
11. Develop a Simulink model for a single area load frequency problem and simulate the same.
12. Develop a PID controller for two-area power system and simulate the same.
13. Stability analysis by using MATLAB
14. Analysis of short circuit studies by using MiPower
15. Transient stability analysis by using MiPower