

**GODAVARI INSTITUTE OF ENGINEERING & TECHNOLOGY**  
(AUTONOMOUS)

Approved by AICTE, Accredited by NBA & NAAC 'A' Grade, Recognized under 2(f) and 12(b) of UGC, Permanently Affiliated to JNTUK, Kakinada.

**DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING**  
2 Years M.Tech. (Power Systems (High Voltage Engineering)) Course Structure : (2014-15)

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w.e.f. Academic Year : 2014-2015

**I YEAR**

**I SEMESTER**

S. No.	Subject codes	Subject	Periods per week			C	Scheme of Examination Maximum Marks		
			L	T	P		Int.	Ext.	Total
1	14221101	Generation and Measurements of High Voltages	3	1	-	3	40	60	100
2	14221102	Dielectrics and Insulation Engineering	3	1	-	3	40	60	100
3	14221103	High Voltage Direct Current Transmission	3	1	-	3	40	60	100
4	14221104	Power System Operation and Control	3	1	-	3	40	60	100
5	14221161 (a)	(Elective-I) Break Down Phenomenon in Electrical Insulation (Gases, Liquids, Solids And Vacuum)	3	1	-	3	40	60	100
	14221161 (b)	Smart Grid							
	14221161 (c)	Advanced Digital Signal Processing							
	14221161 (d)	Artificial Intelligence Techniques							
6	14221162 (a)	(Elective-II) High Voltage Power Apparatus and Diagnostics	3	1	-	3	40	60	100
	14221162 (b)	Collision Phenomena in Plasma Science							
	14221162 (c)	Advanced Electro Magnetic Fields							
7	14221111	High Voltage Laboratory	--	--	3	2	40	60	100
		<b>Total</b>	<b>18</b>	<b>6</b>	<b>3</b>	<b>20</b>	<b>280</b>	<b>420</b>	<b>700</b>

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**I YEAR**

**II SEMESTER**

S. No.	Subject codes	Subject	Periods per week			C	Scheme of Examination Maximum Marks		
			L	T	P		Int.	Ext.	Total
1	14221201	High Voltage Testing Techniques	3	1	-	3	40	60	100
2	14221202	High Voltage Alternating Current Transmission	3	1	-	3	40	60	100
3	14221203	Surge Phenomenon and Insulation Co-ordination	3	1	-	3	40	60	100
4	14221204	Advanced Power System Protection	3	1	-	3	40	60	100
5	14221263 (a)	(ELECTIVE-III) Partial Discharges in High Voltage Equipment	3	1	-	3	40	60	100
	14221263 (b)	High Voltage Systems Using Electromagnetic Transients Program Analysis							
	14221263 (c)	Pulse Power Engineering							
6	14221264(a)	(ELECTIVE-IV) Reactive Power Compensation & Management	3	1	-	3	40	60	100
	14221264 (b)	Power System Deregulation							
	14221264 (c)	Flexible Alternating Current Transmission Systems							
7	14221211	Simulation Laboratory	--	--	3	2	40	60	100
		<b>Total</b>	<b>18</b>	<b>6</b>	<b>3</b>	<b>20</b>	<b>280</b>	<b>420</b>	<b>700</b>

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w.e.f. Academic Year : 2014-2015

**II YEAR**

**I SEMESTER**

S. No.	Subject codes	Subject	Periods per week			C	Scheme of Examination Maximum Marks		
			L	T	P		Int.	Ext.	Total
1	14221381	Seminar - I	-	-	-	2	-	-	-
2	14221341	Project Work - I	-	-	-	18	-	-	-
		<b>Total</b>	-	-	-	<b>20</b>	-	-	-

**II YEAR**

**II SEMESTER**

S. No.	Subject codes	Subject	Periods per week			C	Scheme of Examination Maximum Marks		
			L	T	P		Int.	Ext.	Total
1	14221781	Seminar - II	-	-	-	2	-	-	-
2	14221741	Project work - II	-	-	-	18	-	-	-
		<b>Total</b>	-	-	-	<b>20</b>	-	-	-

<b>Regulation</b>	<b>GR - 14 ( M.Tech.)</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Course/ Code</b>	<b>GENERATION AND MEASUREMENTS OF HIGH VOLTAGES / 14221101</b>	<b>3</b>	<b>1</b>	<b>0</b>	<b>3</b>
<b>Teaching</b>	<b>Total contact hours - 60</b>				

## **Unit-I**

**Electrostatic fields and field stress control:** Electric fields in homogeneous Isotropic materials and in multi dielectric media-Simple configurations-field stress control. Methods of computing electrostatic fields-conductive analogues-Impedance networks Numerical techniques-finite difference method-finite element method and charge simulation method

## **Unit-II**

**Generation of High AC & DC Voltages:** Direct Voltages: AC to DC conversion methods electrostatic generators-Cascaded Voltage Multipliers. Alternating Voltages: Testing transformers-Resonant circuits and their applications, Tesla coil.

## **Unit-III**

**Generation of Impulse Voltages:** Impulse voltage specifications-Impulse generations circuits-Operation, construction and design of Impulse generators-Generation of switching and long duration impulses. Impulse Currents : Generation of High impulse currents and high current pulses.

## **Unit-IV**

**Measurement of High AC & DC Voltages:** Measurement of High D.C. Voltages: Series resistance meters, voltage dividers and generating voltmeters. Measurement of High A.C. Voltages: Series impedance meters electrostatic voltmeters potential transformers and CVTS-voltage dividers and their applications.

## **Unit -V**

**Measurement of Peak Voltages:** Sphere gaps, uniform field gaps, rod gaps. Chubb-Fortesque methods. Passive and active rectifier circuits for voltage dividers. Measurement of Impulse Voltages: Voltage dividers and impulse measuring systems-generalized voltage measuring circuits-transfer characteristics of measuring circuits-L.V. Arms for voltage dividers-compensated dividers. Measurement of Impulse Currents: Resistive shunts-current transformers-Hall Generators and Faraday generators and their applications-Impulse Oscilloscopes.

## **Course Outcomes**

After completion of this course, a successful student will be able to:

- CO-1.** Understand numerical computation of electrostatic problems.
- CO-2.** Understand the techniques of generation of high AC, DC and transient voltages.
- CO-3.** Measure high AC, DC and transient voltages.
- CO-4.** Measure high AC, DC and transient currents.

## **Text Books**

1. High Voltage Engineering , E.Kuffel and W.S.Zaengl. Pergaman press Oxford, 1984.
2. High Voltage Engineering, .S.Naidu and V.Kamaraju, Mc Graw-Hill Books Co., New Delhi, 2nd edition, 1995

## **Reference Books**

1. High Voltage Technology,LL Alston, Oxford University Press 1968.
2. High Voltage Measuring Techniques – A. Schwab MIT Press, Cambridge,USA, 1972. Relevant I.S. and IEC Specifications

<b>Regulation</b>	<b>GR - 14 ( M.Tech.)</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Course/ Code</b>	<b>DIELECTRICS AND INSULATION ENGINEERING / 14221102</b>	<b>3</b>	<b>1</b>	<b>0</b>	<b>3</b>
<b>Teaching</b>	<b>Total contact hours - 60</b>				

## **Unit-I**

**Dielectrics and Insulating Materials:** Review of Dielectric Phenomenon : Complex permittivity – Polarization - Relaxation and resonant models. Solid, Liquid and Gaseous insulating materials-Physical, Thermal & Electrical properties-Classification of Insulating Materials

## **Unit-II**

**Solid Insulating Materials:** Organic Fiber materials Ceramics & Synthetic polymers and their applications. Liquid Insulating Materials : Insulating oils, their properties and applications. Gaseous Insulating Materials : Air and SF6- applications in electrical apparatus.

## **Unit-III**

**Breakdown phenomenon in gaseous and vacuum insulation:** Insulation and decay processes-transition from self sustained discharges to breakdown-Townsend and streamer discharge paschen's law penning effect-Time lags-Surge breakdown voltage-Breakdown an non uniform fields-Vacuum insulation and vacuum breakdown.

## **Unit-IV**

**Breakdown Phenomenon in Liquid and Solid Insulation :** pure and commercial liquids-suspended particle and bubble theories-stressed oil volume theory-Breakdown in solid insulation Intrinsic breakdown-Treeing and tracking phenomenon-Thermal breakdown—Breakdown in composite dielectrics.

## **Unit-V**

**Insulation Engineering :** Insulation design for power cables, capacitors, bushings, switchgear, Transformers and rotating machines-resents trends.

## **Course Outcomes**

After completion of this course, a successful student will be able to:

- CO-1.** Learn Properties of insulating materials.
- CO-2.** Know Electrical breakdown in gas and vacuum insulation.
- CO-3.** Know Electrical breakdown in liquid and solid insulation.
- CO-4.** Know Insulation design in electrical power apparatus

## **Reference Books**

1. High Voltage Engineering – by E.Kuffel and W.S. Zaegnl Pergamon press, Oxford, 1984.
2. High Voltage Engineering – by M.S.Naidu and V.Kamaraju, Tata Mc Graw-Hill Books Co., New Delhi, 2nd edition, 1995.
3. Electrical Engineering Materials – B. Tareev, M.I.R. Publications, MOSCOW.
4. Physics of Dielectrics - B. Tareev, M.I.R. Publications, MOSCOW
5. High Voltage Technology - LL Alston, Oxford University Press 1968.
6. Insulation Engineering- by Arora ,John Wiley & Sons
7. Insulating Materials-by Dekker,S.Chanda & Co
8. Dielectrics and waves-by vonhipple,John Wiley & Sons

<b>Regulation</b>	<b>GR - 14 ( M.Tech.)</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Course/ Code</b>	<b>HIGH VOLTAGE DIRECT CURRENT TRANSMISSION / 14221103</b>	<b>3</b>	<b>1</b>	<b>0</b>	<b>3</b>
<b>Teaching</b>	<b>Total contact hours - 60</b>				

## **Unit-I**

**Limitation of EHV AC Transmission :** Advantages of HVDC Technical economical reliability aspects. H.V.D.C. Transmission: General considerations, Power Handling Capabilities of HVDC Lines, Basic Conversion principles, static converter configuration. Types of HVDC links-Apparatus and its purpose.

## **Unit-II**

**Static Power Converters :** 6-pulse bridge circuit and 12-pulse converters, converter station and Terminal equipment, commutation process, Rectifier and inverter operation, equivalent circuit for converter – special features of converter transformers. Comparison of the perform of diametrical connection with 6-pulse bridge circuit

## **Unit-III**

**Control of HVDC Converters and systems :** constant current, constant extinction angle and constant Ignition angle control. Individual phase control and equidistant firing angle control, DC power flow control. Factors responsible for generation of Harmonics voltage and current harmonics effect of variation of  $\alpha$  and  $\mu$ . Filters Harmonic elimination

## **Unit-IV**

**Interaction between HV AC and DC systems:** Voltage interaction, Harmonic instability problems and DC power modulation. Development of DC circuit Breakers, Multi-terminal DC links and systems; series, parallel and series parallel systems, their operation and control.

## **Unit –V**

**Transient over voltages in HV DC systems :** Over voltages due to disturbances on DC side, over voltages due to DC and AC side line faults. Converter faults and protection in HVDC Systems: Converter faults, over current protection - valve group, and DC line protection, circuit breakers. Over voltage protection of converters, surge arresters.

## **Course Outcomes**

After completion of this course, a successful student will be able to:

- CO-1.** Understand the various schemes of HVDC transmission.
- CO-2.** Understand the basic HVDC transmission equipment.
- CO-3.** Understand the control of HVDC systems.
- CO-4.** Understand the interaction between HVAC and HVDC system.
- CO-5.** Understand the various protection schemes of HVDC engineering.

## **Reference Books**

1. High Voltage Direct current Transmission, K.R.Padiyar Wiley Eastern Ltd., New Delhi – 1992.
2. Direct current Transmission, E.W. Kimbark, Wiley Inter Science – New York.
3. H.V.D.C.Transmission, J.Arillaga Peter Peregrinus Ltd., London UK 1983
4. Power Transmission by Direct Current, E.Uhlman ,Springer Verlag, Berlin Helberg – 1985.
5. HVDC Transmission-S Kamakshaih and V Kamaraju MG hill.

<b>Regulation</b>	<b>GR - 14 ( M.Tech.)</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Course/ Code</b>	<b>POWER SYSTEM OPERATION AND CONTROL / 14221104</b>	<b>3</b>	<b>1</b>	<b>0</b>	<b>3</b>
<b>Teaching</b>	<b>Total contact hours - 60</b>				

## **Unit-I**

**Unit commitment problem and optimal power flow solution** : **Unit commitment** : Constraints in UCP,UC solutions. Methods-priority list method, introduction to Dynamic programming Approach.

## **Unit-II**

**Load Frequency Control-I** : Necessity of keeping frequency constant. Definition of control area, single area control, Block diagram representation of an isolated Power System, Steady State analysis, Dynamic response-Uncontrolled case. Proportional plus Integral control of single area and its block diagram representation, steady state response, load frequency control and Economic dispatch control.

## **Unit-III**

**Load Frequency Control-II** : **Load frequency control of 2-area system** : uncontrolled case and controlled case, tie-line bias control. Optimal two-area LF control-steady state representation, performance Index and optimal parameter adjustment.

## **Unit-IV**

**Generation with limited Energy supply** : Take-or-pay fuel supply contract, composite generation production cost function. Solution by gradient search techniques, Hard limits and slack variables, Fuel scheduling by linear programming.

## **Unit-V**

**Interchange Evaluation and Power Pools Economy Interchange**: Economy interchange Evaluation, Interchange Evaluation with unit commitment, Multiple Interchange contracts. After-the-fact production costing, Transmission Losses in transaction Evaluation, other types of Interchange, power pools.

## **Course Outcomes**

After completion of this course, a successful student will be able to:

- CO-1.** Determine the unit commitment problem for economic load dispatch.
- CO-2.** Get the knowledge of load frequency control of single area and two area systems
- CO-3.** Know the effect of generation with limited energy supply.
- CO-4.** Determine the interchange evaluation in interconnected power systems.

## **Reference Books**

1. Modern Power System Analysis - by I.J.Nagrath & D.P.Kothari, Tata Mc Graw-Hill Publishing Company Ltd, 2nd edition.
2. Power system operation and control PSR Murthy B.S publication.
3. Power Generation, Operation and Control - by A.J.Wood and B.F.Wollenberg, John Wiley & Sons Inc. 1984.
4. Electrical Energy Systems Theory - by O.I.Elgerd, Tata Mc Graw-Hill Publishing Company Ltd, 2nd edition.
5. Reactive Power Control in Electric Systems - by TJE Miller, John Wiley & Sons.

Regulation	GR - 14 ( M.Tech.)	L	T	P	C
Course/ Code	BREAK DOWN PHENOMENON IN ELECTRICAL INSULATION (GASES, LIQUIDS, SOLIDS AND VACUUM) / 14221161 (a )	3	1	0	3
Teaching	Total contact hours - 60				

## Unit-I

**Fundamentals of Electrical Breakdown Phenomena in Gases:** Review of gas laws-mean free path of a particle-velocity distribution of swarm of molecules-Expression for mean free path ( $\lambda$ )-Distribution of free paths-Bohr's model of an atom. Calculation of radius of Bohr's orbit Energy of an electron-Ionization energy of an atom calculation of frequency of emitted radiation.

## Unit-II

**Ionization Its Gases:** Methods of ionization in gases-Ionization by collision-types of inelastic collisions, collision cross sections. Behavior of charged particles in a gas in electric fields of low (E/P)-drift velocity -mobility conditions for low (E/P). Electrical Breakdown in Uniform Fields: Voltage-current relationship is gaseous gap (small gaps)-condition for high (E/P)-Townsend's first Ionization coefficient ( $\alpha$ ) - ( $\alpha/p$ ) is a function of (E/P)-Experimental determination of ( $\alpha$ ) –Penning effect.

## Unit-III

**Self-sustained discharge:**  $\beta$ -process and its limitations cathode process –methods of liberating secondary electrons –Townsend's second ionization coefficient - $\gamma$  -process . Condition for electric spark breakdown. Secondary emission by gas produced photons – Meta stables-Role of solid contaminants. Electron Attachment, electronegative gases (SF<sub>6</sub> etc). Measurement of  $\gamma$ - Paschen's law –expression for Minimum Breakdown voltage and minimum (P<sub>min</sub>) - limitations of Paschen's law. Breakdown of long gaps: Streamer Mechanism- Explanation for positive streamer. Estimation of space charge fields (E<sub>s</sub>) - Anode directed streamer - comparison between Townsend and streamer mechanism. Breakdown in non-uniform fields –corona discharges - difference between DC and AC corona. Effect of polarity on break down of point-plane gaps.

## Unit-IV

**Breakdown in Solids and Liquid Insulations:** Types of Breakdown: Intrinsic Breakdown – Electronic Breakdown – Streamer Breakdown – Electromechanical Breakdown –Thermal Breakdown -treeing and tracking. Electro – Chemical Breakdown – BD due to thermal discharges. Breakdown in liquids dielectrics: Pure and commercial liquids – Breakdown tests – Pre-breakdown currents and breakdown in pure liquids – breakdown in commercial liquids –Suspended particle theory, cavitations and bubble mechanism. Thermal breakdown – Stressed oil – Volume Theory.

## Unit-V

**Breakdown in Vacuum Insulation:** Pre-Breakdown currents – Steady currents –Micro discharges-Factors affecting the Breakdown . like electrode separation - electrode conditioning - electrode material –Surface condition surface contamination - electrode area and configurations –effect of electrode temperature –frequency of applied voltage – pressure - recovery strength of vacuum gap. Practical Exchange theory –electron beam Hypothesis – Clump mechanism- transition in breakdown mechanisms – criteria for B.D - effect of solids dielectrics in vacuum and liquids.

## **Course Outcomes**

After completion of this course, a successful student will be able to:

- CO-1.** Understand the fundamental process of conduction in gases.
- CO-2.** Understand ionization and breakdown phenomena in gases.
- CO-3.** Understand breakdown phenomena in liquid and solid dielectrics.
- CO-4.** Understand breakdown phenomena in vacuum.

## **Reference Books**

1. Fundamentals of gaseous ionization and plasma electronics by Izam Nassar
2. High voltage & electrical insulation by Ravindra Arora , john willy and sons.
3. High voltage technology –Alston Ll -Oxford Press.

<b>Regulation</b>	<b>GR - 14 ( M.Tech.)</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Course/ Code</b>	<b>SMART GRID / 14221161 (b )</b>	<b>3</b>	<b>1</b>	<b>0</b>	<b>3</b>
<b>Teaching</b>	<b>Total contact hours - 60</b>				

## **Unit-I**

**Introduction to Smart Grid:** Evolution of Electric Grid, Concept of Smart Grid, Definitions, Need of Smart Grid, Functions of Smart Grid, Opportunities & Barriers of Smart Grid, Difference between conventional & smart grid, Concept of Resilient & Self Healing Grid, Present development & International policies on Smart Grid. Case study of Smart Grid.

## **Unit-II**

**Smart Grid Technologies: Part 1:** Introduction to Smart Meters, Real Time Prizing, Smart Appliances, Automatic Meter Reading(AMR), Outage Management System(OMS), Plug in Hybrid Electric Vehicles(PHEV), Vehicle to Grid, Smart Sensors, Home & Building Automation, Phase Shifting Transformers.

## **Unit-III**

**Smart Grid Technologies: Part 2:** Smart Substations, Substation Automation, Feeder Automation. Geographic Information System(GIS), Intelligent Electronic Devices(IED) & their application for monitoring & protection, Smart storage like Battery, SMES, Pumped Hydro, Compressed Air Energy Storage, Wide Area Measurement System(WAMS), Phase Measurement Unit(PMU).

## **Unit-IV**

**Microgrids and Distributed Energy Resources:** Concept of microgrid, need & applications of microgrid, formation of microgrid, Issues of interconnection, protection & control of microgrid. Plastic & Organic solar cells, Thin film solar cells, Variable speed wind generators, fuelcells, microturbines, Captive power plants, Integration of renewable energy sources.

## **Unit-V**

**Power Quality Management in Smart Grid:** Power Quality & EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid, Web based Power Quality monitoring, Power Quality Audit.

**Information and Communication Technology for Smart Grid:** Advanced Metering Infrastructure (AMI), Home Area Network (HAN), Neighborhood Area Network (NAN), Wide Area Network (WAN).

## Course Outcomes

After completion of this course, a successful student will be able to:

- CO-1.** Understand smart grids and analyse the smart grid policies and developments in smart grids.
- CO-2.** Develop concepts of smart grid technologies in hybrid electrical vehicles etc.
- CO-3.** Understand smart substations, feeder automation, GIS etc.
- CO-4.** Analyse micro grids and distributed generation systems.
- CO-5.** Analyse the effect of power quality in smart grid and to understand latest developments in ICT for smart grid.

## Text Books

1. Integration of Green and Renewable Energy in Electric Power Systems, Ali Keyhani, Mohammad N. Marwali, Min Dai, Wiley
2. The Smart Grid: Enabling Energy Efficiency and Demand Response ,Clark W. Gellings,CRC Press Grid: Technology and Applications ,Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama,—Smart”, Wiley
3. Smart Grids,Jean Claude Sabonnadière, Nouredine Hadjsaïd, Wiley Blackwell 19
4. Smart Power: Climate Changes, the Smart Grid, and the Future of Electric Utilities Peter S. Fox Penner, Island Press; 1 edition 8 Jun 2010.
5. Microgrids and Active Distribution Networks Institution of Engineering and Technology,S. Chowdhury, S. P. Chowdhury, P. Crossley, —, 30 Jun 2009.
6. Smart Grids (Power Engineering),Stuart Borlase,CRC Press

## Reference Books

1. The Advanced Smart Grid: Edge Power Driving Sustainability: 1,Andres Carvallo, John Cooper, Artech House Publishers July 2011
2. Control and Automation of Electric Power Distribution Systems (Power Engineering),James Northcote, Green, Robert G. Wilson, CRC Press
3. Substation Automation (Power Electronics and Power Systems).Mladen Kezunovic, Mark G. Adamiak, Alexander P. Apostolov, Jeffrey George Gilbert, Springer
4. Electrical Power System Quality ,R. C. Dugan, Mark F. McGranahan, Surya Santoso, H. Wayne Beaty, 2nd Edition, McGraw Hill Publication
5. Communication and Networking in Smart Grids , Yang Xiao, CRC Press

<b>Regulation</b>	<b>GR - 14 ( M.Tech.)</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Course/ Code</b>	<b>ADVANCED DIGITAL SIGNAL PROCESSING / 14221161 (c)</b>	<b>3</b>	<b>1</b>	<b>0</b>	<b>3</b>
<b>Teaching</b>	<b>Total contact hours - 60</b>				

## **Unit-I**

**Digital Filter Structure:** Block diagram representation-Equivalent Structures-FIR and IIR digital filter Structures All pass Filters-tunable IIR Digital Filters-IIR tapped cascaded Lattice Structures-FIR cascaded Lattice structures-Parallel-Digital Sine-cosine generator-Computational complexity of digital filter structures.

## **Unit-II**

**Digital filter design:** Preliminary considerations-Bilinear transformation method of IIR filter design-design of Low pass high pass-Band pass, and Band stop- IIR digital filters-Spectral transformations of IIR filters, FIR filter design-based on Windowed Fourier series- design of FIR digital filters with least – mean- Square-error-constrained Least-square design of FIR digital filters.

## **Unit-III**

**DSP algorithm implementation:** Computation of the discrete Fourier transform- Number representation-Arithmetic operations-handling of overflow-Tunable digital filters-function approximation.

## **Unit-IV**

**Analysis of finite Word length effects:** The Quantization process and errors- Quantization of fixed - point and floating -point Numbers-Analysis of coefficient Quantization effects - Analysis of Arithmetic Round-off errors, Dynamic range scaling-signal- to- noise ratio in Low -order IIR filters-Low- Sensitivity Digital filters-Reduction of Product round-off errors using error feedback-Limit cycles in IIR digital filters- Round-off errors in FFT Algorithms.

## **Unit-V**

**Power Spectrum Estimation:** Estimation of spectra from Finite Duration Observations signals – Non-parametric methods for power spectrum Estimation – parametric method for power spectrum Estimation, Estimation of spectral form-Finite duration observation of signals-Non-parametric methods for power spectrum estimation-Walsh methods-Blackman & torchy method.

## **Course Outcomes**

After completion of this course, a successful student will be able to:

- CO-1.** Describe structure of digital filters.
- CO-2.** Design digital filters with different techniques.
- CO-3.** Understand the implementation aspects of signal processing algorithms.
- CO-4.** Know the effect of finite word length in signal processing.
- CO-5.** Analyze different power spectrum estimation techniques

## **Reference Books**

1. Digital signal processing-sanjit K. Mitra-TMH second edition
2. Discrete Time Signal Processing – Alan V.Oppenheim, Ronald W.Shafer - PHI-1996 1st edition-9th reprint
3. Digital Signal Processing principles, algorithms and Applications – John G.Proakis -PHI –3rd edition-2002
4. Digital Signal Processing – S.Salivahanan, A.Vallavaraj, C. Gnanapriya – TMH - 2nd reprint-2001
5. Theory and Applications of Digital Signal Proceesing-LourensR. Rebinar & Bernold
6. Digital Filter Analysis and Design-Auntonian-TMH5. Theory and Applications of Digital Signal Proceesing

<b>Regulation</b>	<b>GR - 14 ( M.Tech.)</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Course/ Code</b>	<b>ARTIFICIAL INTELLIGENCE TECHNIQUES / 14221161 (d )</b>	<b>3</b>	<b>1</b>	<b>0</b>	<b>3</b>
<b>Teaching</b>	<b>Total contact hours - 60</b>				

## **Unit-I**

**Introduction to Neural Networks:** Introduction, Humans and Computers, Biological Neural Networks, Historical development of neural network, Terminology and Topology, Biological and artificial neuron models, Basic learning laws.

## **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 and applications of the Perceptron model, Generalized delta learning rule, Feedforward recall and error back propagation training-Radial basis function algorithms-Hope field networks

## **Unit-III**

**Genetic algorithms & Modelling:** Introduction-encoding-fitness function-reproduction operators-genetic operators-cross over and mutation-generational cycle-convergence of genetic algorithm.

## **Unit -IV**

**Classical and Fuzzy Sets** **Introduction to classical sets :** properties, operations and relations; Fuzzy sets, membership, Uncertainty, operations, properties, fuzzy relations, cardinalities, membership functions. Fuzzy Logic System Components-Fuzzification, Membership value assignment, development of rule base and decision making system, defuzzification to crisp sets, defuzzification methods.

## **Unit-V**

**Application of AI Techniques:** Load forecasting-load flow studies-economic load dispatch-load frequency control-reactive power control-speed control of dc and ac motors.

## **Course Outcomes**

After completion of this course, a successful student will be able to:

- CO-1.** Understand neural networks and analyze different types of neural networks.
- CO-2.** Design training algorithms for neural networks.
- CO-3.** Develop algorithms using genetic algorithm for optimization.
- CO-4.** Analyze and design fuzzy logic systems.
- CO-5.** Apply AI Techniques in electrical engineering.

## **Text Books**

1. Neural Networks, Fuzzy logic, Genetic algorithms: synthesis and applications by Rajasekharan and Rai PHI Publication.
2. Introduction to Artificial Neural Systems - Jacek M. Zuarda, Jaico Publishing House, 1997.

<b>Regulation</b>	<b>GR - 14 ( M.Tech.)</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Course/ Code</b>	<b>HIGH VOLTAGE POWER APPARATUS AND DIAGNOSTICS / 14221162 (a )</b>	<b>3</b>	<b>1</b>	<b>0</b>	<b>3</b>
<b>Teaching</b>	<b>Total contact hours - 60</b>				

## **Unit-I**

Introduction to power transformer, important components of power transformer, winding configuration, various types of insulation material, LV and HV bushings, cooling of winding. Reasons of failure of transformer, short circuit, overvoltage due to switching operation, inadequate clearances between various windings, over-voltage due to lightning impulse, over voltage due to fault, high level of partial discharges, inappropriate design, over fluxing.

## **Unit-II**

Tan delta, capacitance in transformer winding, method of measurement of tan delta and capacitance in transformer ,Tan delta ,resistivity and capacitance of transformer oil, bushing capacitance ,tan delta and resistivity, on-site measurement, analysis to detect ageing and likely failure

## **Unit-III**

Moisture in transformer oil and paper, ageing effect of paper, insulation resistance, Method of measurement of polarization, polarization value, method of moisture reduction, winding resistance, Influence with regard to life of transformer. Partial Discharges in transformer, causes of partial discharges, concept of partial discharges, acoustic method of measurement of partial discharges, discharges in oil, discharges in paper, method of reduction of partial discharges, analysis and detection of partial discharge sites within transformer volume.

## **Unit-IV**

Degree of polymerization (DP) of transformer paper, effect of DP on life of transformer, effect of transformer temperature on degree of polymerization, furfural content in oil insulation, inter – relationship between degree of polymerization and furfural content , method of measurement of tan delta and capacitance in transformer, method of measurement of tan delta and capacitance in transformer bushing , reduction of degree of polymerization in transformer paper. Dissolved gas analysis in transformer oil, various gas product in transformer oil, tolerable level of gases in transformer on load , detection of important gases in transformer, causes of various gases, likely reason of gases with reference to high temperature and partial discharges.

## **Unit-V**

Fourier Transform and frequency response analysis of transformer winding, concept of Fourier Transformer with regard to configuration of winding, low, medium and high frequency comparison of frequency response of LV , HV and tapping winding, concept of winding movement on the basis of frequency comparison, turn failure.

## **Course Outcomes**

After completion of this course, a successful student will be able to:

- CO-1.** learn power transformer, types of insulation material.
- CO-2.** measure tan delta and capacitance of transformer oil.
- CO-3.** know the concept of moisture in transformer oil and paper and partial discharges.
- CO-4.** know degree of polymerization.
- CO-5.** know concept of Fourier Transformer and frequency response analysis of transformer winding.

## **Text Books**

1. Transformer, Bharat Heavy Electricals Limited (Bhopal), Second edition 2003, First Edition 1987 Tata Mc.Graw-hill Publishing Company Ltd. Mc.Graw –Hill office Page 1- 602.

## **Reference books**

1. Seminar on fault finding and life assessment of power transformers Proceedings 25- 26 April2008 New Delhi, Organized by Central Board of Irrigation and Power, New Delhi in association with Omicron India.

<b>Regulation</b>	<b>GR - 14 ( M.Tech.)</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Course/ Code</b>	<b>COLLISION PHENOMENA IN PLASMA SCIENCE / 14221162 (b )</b>	<b>3</b>	<b>1</b>	<b>0</b>	<b>3</b>
<b>Teaching</b>	<b>Total contact hours - 60</b>				

## **Unit-I**

Ionization, Deionization and Electron Emission :Ionization and plasma conductivity, Production of charged particles, Ionization by cosmic rays, Thermal ionization. The free path, excited states, metastable states. Diffusion, Recombination, Negative ions. Photoelectric emission, Thermionic emission, Field emission.

## **Unit-II**

Behavior of charged particles in a gas in electric fields of low E/P and high E/P, Definition and significance of mobility, Forces between ions and molecules, Diffusion under low fields, Electron drift velocity.

## **Unit-III**

What is high E/P?, Coefficient of ionization by electron collision, evaluation of , electron avalanche, effect of the cathode, Ionization coefficient in alternating fields. The Self-Sustaining Discharge Breakdown Mechanisms: Ionization by positive-ion collision, Cathode processes, space-charge field of an avalanche. Critical avalanche size.

## **Unit-IV**

Townsend mechanism and its limitations, Streamer formation. The transition between the breakdown mechanisms, The effect of electron attachment. Partial Breakdown and Breakdown Under Alternating Fields: Electron current, positive-ion current, total current, characteristic time, effect of space charge, Anode coronas, Cathode coronas.

## **Unit-V**

The Glow and Plasma: General description, The cathode zone, Negative glow and Faraday dark space, positive column, Anode region, other effects. Definition of plasma, Debye length, scope of known plasmas, Plasma oscillations, high-temperature plasmas, Plasma diagnostics.

## **Course Outcomes**

After completion of this course, a successful student will be able to:

- CO-1.** Understand the collision phenomena in different materials.
- CO-2.** Know Transition from Streamer to Townsend mechanisms of breakdown.
- CO-3.** Understand Electric glow discharge and plasma glow discharge.

## **Reference Books**

1. Fundamentals of Gaseous Ionization And Plasma Electronics by Essam Nasser, John Willey & Sons, Printed in America, 1971

<b>Regulation</b>	<b>GR - 14 ( M.Tech.)</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Course/ Code</b>	<b>ADVANCED ELECTRO MAGNETIC FIELDS / 14221162 (c)</b>	<b>3</b>	<b>1</b>	<b>0</b>	<b>3</b>
<b>Teaching</b>	<b>Total contact hours - 60</b>				

## **Unit-I**

**Electrostatics:** Electrostatic Fields – Coulomb’s Law – Electric Field Intensity (EFI) – EFI due to a line and a surface charge – Work done in moving a point charge in an electrostatic field – Electric Potential – Properties of potential function – Potential gradient – Gauss’s law – Application of Gauss’s Law – Maxwell’s first law,  $\text{div } (\mathbf{D}) = \rho$  – Laplace’s and Poisson’s equations – Solution of Laplace’s equation in one variable

## **Unit-II**

**Electric fields-1:** Introduction, Analytical calculation of space-charge-free fields, simple geometries, transmission conductors to ground, fields in multielectric media, experimental analogs for space-space-charge-free fields, electrolytic tank, semi conducting paper analog, resistive-mesh analog.

## **Unit-III**

**Electric fields-2:** Analytical Calculations Of Fields With Space Charges, Numerical Computation of Fields With Space Charges, Finite Element Technique, Finite Element Technique Combined With The Method Of Characteristics, Charge-Simulation Technique Combined With The Method Of Residues, Electric Stress Control And Optimization, Electric Stress Control, Electric Stress Optimization

## **Unit-IV**

**Conductors & Dielectrics :** Behavior of conductors in an electric field – Conductors and Insulators – Electric field inside a dielectric material – polarization – Dielectric – Conductor and Dielectric – Dielectric boundary conditions – Energy stored and energy density in a static electric field – Current density – conduction and Convection current densities – Ohm’s law in point form – Equation of continuity

## **Unit-V**

**Force in Magnetic fields & Time Varying Fields:** Magnetic force - Moving charges in a Magnetic field – Lorentz force equation, a differential current loop as a magnetic dipole ,Time varying fields – Faraday’s laws of electromagnetic induction – Its integral and point forms ,Statically and Dynamically induced EMFs -Modification of Maxwell’s equations for time varying fields – Displacement current.

## **Course Outcomes**

After completion of this course, a successful student will be able to:

- CO-1.** know about analysis of electrostatic fields and properties of potential gradients.
- CO-2.** know about the dielectric boundary conditions and electric stress control and optimization and time varying fields.

## **Text Books**

- 1 Engineering Electromagnetics" by William H. Hayt & John. A. Buck McGraw-Hill Companies, 7th Editon.2005.
- 2 Electromagnetics" by J. D Kraus Mc.Graw-Hill Inc. 4th edition 1992.

## **Reference Books**

- 1 Field Theory , Gangadhar, Khanna Publishers.
- 2 Elements of Electromagnetic field theory , Sadiku, Oxford Publ.
- 3 Electromagnetics"by J P Tewari.
- 4 Introduction to E-Magnetics"by CR Paul and S.A. Nasar, McGraw-Hill Publications
- 5 Introduction to Electro Dynamics"by D J Griffiths, Prentice-Hall of India Pvt.Ltd, 2nd editon
- 6 Electromagnetics" by Plonsy and Collin
- 7 Engineering Electro magnetic" by Nathan Ida, Springer(India) Pvt. Ltd. 2nd Edition.

<b>Regulation</b>	<b>GR - 14 ( M.Tech.)</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Course/ Code</b>	<b>HIGH VOLTAGE LABORATORY/ 14221111</b>	<b>0</b>	<b>0</b>	<b>3</b>	<b>2</b>
<b>Teaching</b>	<b>Total contact hours - 45</b>				

Any 10 of the following experiments are to be conducted List of Experiments:

- 1 Milli volt drop test and Tong tester calibration
- 2 Breakdown characteristics of sphere-sphere gap
- 3 Measurement of Leakage current and breakdown voltage of pin insulator
- 4 Breakdown test of transformer oil
- 5 Breakdown characteristics of rod-rod gap
- 6 Measurement of Leakage current and insulation resistance of polypropylene scale
- 7 Measurement of Leakage current and insulation resistance of polypropylene rope
- 8 Breakdown characteristics of plane-rod-gap
- 9 Measurement of leakage current and breakdown voltage of suspension insulator
- 10 Breakdown characteristics of point-sphere gap
- 11 Measurement of tan delta and dielectric constant
- 12 Power frequency testing of HV transformer
- 13 Power frequency testing of HV Bushing
- 14 Power frequency testing of HV Cable

<b>Regulation</b>	<b>GR - 14 ( M.Tech.)</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Course/ Code</b>	<b>HIGH VOLTAGE TESTING TECHNIQUES / 14221201</b>	<b>3</b>	<b>1</b>	<b>0</b>	<b>3</b>
<b>Teaching</b>	<b>Total contact hours - 60</b>				

## **Unit-I**

**Non Destructive Testing Techniques :** Measurement of DC Resistivity– Dielectric loss and dielectric constant of insulating materials – Schering bridge method – Transformer ratio arm bridge for high voltage and high current applications – null detectors.

## **Unit-II**

**High Voltage Testing of Power Apparatus :** Need for testing standards – Standards for porcelain/Glass insulators-Classification of porcelain/glass insulator tests – Tests for cap and pin porcelain/Glass insulators.

## **Unit-III**

High voltage AC testing methods-Power frequency tests-Over voltagetests on insulators, Isolators, Circuit Breakers and power cables. Artificial Contamination Tests : Contamination flashover phenomena-Contamination Severity-Artificial contamination tests-Laboratory Testing versus in-Service Performance-Case study.

## **Unit-IV**

**Impulse Testing :** Impulse testing of transformers-Surge diverters and other apparatus.

## **Unit-V**

**Partial Discharge Measurement :** PD equivalent model-PD currents-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. RIV Measurements: Radio Interference – RIV – Measurement of RI and RIV in laboratories and in field. Different test arrangements and their limitations.

## **Course Outcomes**

After completion of this course, a successful student will be able to:

- CO-1.** Understand different testing procedures on electrical Insulating materials, Insulation Systems, Power apparatus.
- CO-2.** Learn the different testing techniques adopted on electrical power apparatus.

## **Reference Books**

- 1 High Voltage Engineering – by E.KUFFEL and W.S.ZAENGL, Pergamon press, Oxford 1984.
- 2 High Voltage Engineering – by M.S.Naidu and V.Kamaraju, Tata Mc Graw Hill Publishing Company Limited, New Delhi – 2001.
- 3 Discharge Detection in H.V. Equipment – by KREUGER, F.H. Haywood London – 1964.
- 4 Outdoor Insulators – by Gorur & Cherney.
- 5 H.V. Testing Techniques Halfly.

<b>Regulation</b>	<b>GR - 14 ( M.Tech.)</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Course/ Code</b>	<b>HIGH VOLTAGE ALTERNATING CURRENT TRANSMISSION / 14221202</b>	<b>3</b>	<b>1</b>	<b>0</b>	<b>3</b>
<b>Teaching</b>	<b>Total contact hours - 60</b>				

### **Unit-I**

E.H.V. A.C. Transmission, line trends and preliminary aspects, standard transmission voltages – power handling capacities and line losses –mechanical aspects. Calculation of line resistance and inductance :resistance of conductors, temperature rise of conductor and current carrying capacity. Properties of bundled conductors and geometric mean radius of bundle, inductance of two conductor lines and multi conductor lines, Maxwell's coefficient matrix. Line capacitance calculation : capacitance of two conductor line, and capacitance of multi conductor lines, potential coefficients for bundled conductor lines, sequence inductances and capacitances and diagonalization.

### **Unit-II**

Calculation of electro static field of AC lines - Effect of high electrostatic field on biological organisms and human beings. Surface voltage Gradient on conductors, surface gradient on two conductor bundle and cosine law, maximum surface voltage gradient of bundle with more than 3 sub conductors, Mangolt formula.

### **Unit-III**

Corona : Corona in EHV lines – corona loss formulae – attenuation of traveling waves due to corona – Audio noise due to corona, its generation, characteristics and limits, measurement of audio noise.

### **Unit-IV**

Power Frequency voltage control : Problems at power frequency, generalized constants, No load voltage conditions and charging currents, voltage control using synchronous condenser, cascade connection of components : Shunt and series compensation, sub synchronous resonance in series – capacitor compensated lines.

### **Unit-V**

Static reactive compensating systems : Introduction, SVC schemes, Harmonics injected into network by TCR, design of filters for suppressing harmonics injected into the system.

## **Course Outcomes**

After completion of this course, a successful student will be able to:

- CO-1.** Calculate the transmission line parameters.
- CO-2.** Calculate the field effects on EHV and UHV AC lines.
- CO-3.** Determine the corona, RI and audible noise in EHV and UHV lines.
- CO-4.** Analyze voltage control in EHV and UHV transmission systems.

## **Reference Books**

- 1 Extra High Voltage AC Transmission Engineering – Rakesh Das Begamudre, Wiley Eastern Ltd., New Delhi – 1987.
- 2 EHV Transmission line reference book – Edison Electric Institute (GEC) 1986.

<b>Regulation</b>	<b>GR - 14 ( M.TECH.)</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Course/ Code</b>	<b>SURGE PHENOMENON AND INSULATION CO-ORDINATION / 14221203</b>	<b>3</b>	<b>1</b>	<b>0</b>	<b>3</b>
<b>Teaching</b>	<b>Total contact hours - 60</b>				

### **Unit-I**

Traveling Waves : Transmission line equation, attenuation and distortion point-Typical cases.  
Reflection of Traveling waves: Behaviors of waves at a transaction point-Typical cases. travelling waves on multiconductor systems.

### **Unit-II**

Successive Reflections : Reflection lattice, Effect of insulation capacitance. Standing waves and natural frequencies of transmission lines-Transient response of lines and systems with distributed parameters.

### **Unit-III**

Lightning Phenomena and over voltage in power systems. Mechanism of the lightning stroke – Mathematical model of the lightning stroke. Over voltages produced in power systems due to lightning – Over voltage due to faults in the system and switching surges. General principles of lightning protection – Tower – Footing resistance –Insulation withstand voltages and impulse flashover characteristics of protective gaps.

### **Unit-IV**

Surge Voltage distribution in transformer windings initial and final distribution characteristics : Protection of windings against over voltages. protection of transmission lines, transformers and rotating machines against over voltages. Use of rod gaps and lightning arresters protective characteristics. Selection of the lightning arresters.

### **Unit-V**

Insulation coordination lightning surge and switching surge characteristics of insulation structures. Geometric gap factors test procedures, correlation between insulation for protective levels. Protective devices Zno arresters,vale type-etc, protective tubes.

### **Course Outcomes**

After completion of this course, a successful student will be able to:

- CO-1.**Understand line concepts of travelling waves and their behavior in transmission systems.
- CO-2.**Understand lightning phenomena and over voltages in power systems.
- CO-3.**Understand the behavior of the transformer when surge voltages are induced in the windings.
- CO-4.**Understand the insulation coordination between different protecting and protective devices in the power system.

### **Reference Books**

- 1 Traveling waves of Transmission systems – by LV Bewley.
- 2 Insulation Co-ordination ELBS in H.V. Electrical Power, Systems by W.Diesendorf, Butter worth publications, London, 1974.
- 3 E.H.V. Transmission Engineering: Rakesh Das Begmudre Wielly Eastern Ltd., New Delhi, 1986.

<b>Regulation</b>	<b>GR - 14 ( M.TECH.)</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Course/ Code</b>	<b>ADVANCED POWER SYSTEM PROTECTION / 14221204</b>	<b>3</b>	<b>1</b>	<b>0</b>	<b>3</b>
<b>Teaching</b>	<b>Total contact hours - 60</b>				

## **Unit-I**

**Static Relays classification and Tools :** Comparison of Static with Electromagnetic Relays, Basic classification, Level detectors and Amplitude and phase Comparators – Duality – Basic Tools – Schmitt Trigger Circuit, Multivibrators, Square wave Generation – Polarity detector – Zero crossing detector – Thyristor and UJT Triggering Circuits. Phase sequence Filters – Speed and reliability of static relays.

## **Unit-II**

**Amplitude and Phase Comparators (2 Input) :** Generalized equations for Amplitude and Phase comparison – Derivation of different characteristics of relays – Rectifier Bridge circulating and opposed voltage type amplitude comparators – Averaging & phase splitting type amplitude comparators – Principle of sampling comparators.

**Phase Comparison :** Block Spike and phase Splitting Techniques – Transistor Integrating type, phase comparison, Rectifier Bridge Type Comparison – Vector product devices.

## **Unit-III**

**Static over current (OC) relays –** Instantaneous, Definite time, Inverse time OC Relays, static distance relays, static directional relays, static differential relays, measurement of sequence impedances in distance relays, multi input comparators, elliptic & hyperbolic characteristics, switched distance schemes, Impedance characteristics during Faults and Power Swings,

## **Unit-IV**

**Carrier plot protection scheme:** carrier current protection schemes, relative merits & demerits, carrier aided distance protection schemes, transfer schemes, blocking scheme and acceleration schemes. Differential relay Principle and characteristics, maloperation of differential relay, protection of transformers, protection of generators.

## **Unit-V**

**Numerical Protection:** Introduction , numerical relay, numerical relaying algorithms, mann-morrison technique, Differential equation technique, discrete fourier transform technique, rationalised harr transform technique, wavelet transform technique, numerical overcurrent protection , numerical distance protection , numerical differential protection.

## **Course Outcomes**

After completion of this course, a successful student will be able to:

- CO-1. Know the classifications and applications of static relays.
- CO-2. Understand the application of comparators.
- CO-3. Understand the static version of different types of relays.
- CO-4. Understand the numerical protection techniques.

## Reference Books

- 1 Power System Protection with Static Relays – by TSM Rao.
- 2 Protective Relaying Vol-II Warrington
- 3 Art & Science of Protective Relaying - C R Mason
- 4 Power System Stability Kimbark Vol-II
- 5 Power system protection & switchgear by Badri Ram & D N viswakarma.
- 6 Electrical Power System Protection –C.Christopoulos and A.Wright-Springer
- 7 Protection & Switchgear –Bhavesh Bhalaja,R.P Maheshwari, Nilesh G.Chothani-Oxford publisher

<b>Regulation</b>	<b>GR - 14 ( M.TECH.)</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Course/ Code</b>	<b>PARTIAL DISCHARGES IN HIGH VOLTAGE EQUIPMENT / 14221263 (a)</b>	<b>3</b>	<b>1</b>	<b>0</b>	<b>3</b>
<b>Teaching</b>	<b>Total contact hours - 60</b>				

### **Unit-I**

**Types of partial discharges and its occurrence and recurrence and magnitudes :** Definition of Partial discharges, inception of internal discharges, Inception of corona discharges.

### **Unit -II**

Discharges by electrical treeing. Discharges at AC Voltages, corona discharges, Discharges at D.C. Voltages, discharges at impulse voltages. Object of discharge detection, Quantities related to the magnitude of discharges, choice of PD as a measure for discharges.

### **Unit-III**

Electrical discharge detection & Detection circuits : Basic diagram, amplification of impulses, sensitivity, resolution, observation. Straight detection. Balanced detection, calibrators, Interferences, choice between straight detection & balance detection, common mode rejection.

### **Unit-IV**

Location of Partial discharges : Non-electric location, location by separation of electrodes, location with electrical probes. location by traveling waves, PD location in cables & switchgear by traveling waves. Evaluation of discharges : Recognition, mechanisms of deterioration, evaluation, specification.

### **Unit-V**

Detection in actual specimen : Detection in capacitors, cables, bushings. Transformers, machine insulation, Gas-insulated switchgear.

### **Course Outcomes**

After completion of this course, a successful student will be able to:

- CO-1.** Know Types of partial discharge that occurs in the insulation systems
- CO-2.** Understand Detection of discharges using different detection circuits.
- CO-3.** Understand Location of partial discharge in electrical apparatus and systems.

### **Reference Books**

- 1 Partial Discharges in HV Equipment by F..Kruguer, Butterworths & Co., Publications Ltd., 1989.
- 2 Partial Discharges in Electrical Power Apparatus. by Dieter Konig, Y. Narayana Rao- VDE-Verlag publisher.
- 3 Partial Discharges in Electrical Power Apparatus. by Dieter.

<b>Regulation</b>	<b>GR - 14 ( M.TECH.)</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Course/ Code</b>	<b>HIGH VOLTAGE SYSTEMS USING ELECTROMAGNETIC TRANSIENTS PROGRAM ANALYSIS / 14221263 (B)</b>	<b>3</b>	<b>1</b>	<b>0</b>	<b>3</b>
<b>Teaching</b>	<b>Total contact hours - 60</b>				

## **Unit-I**

**Definitions, objectives and background:** Introduction, Classification of electromagnetic transients, Transient simulators, Digital simulation -State variable analysis and Method of difference equations, Range of applications.

## **Unit- II**

**Analysis of continuous and discrete systems:** Continuous systems - State variable formulations, - Successive differentiation, - Controller canonical form, -Observer canonical form, -Diagonal canonical form, - Uniqueness of formulation , Time domain solution of state equations , Digital simulation of continuous systems, Discrete systems, Relationship of continuous and discrete domains.

## **Unit-III**

**State variable analysis:** Choice of state variables, Formation of the state equations - The transform method , The graph method, Solution procedure. Numerical integrator for linear parameters: Discretisation of  $R$ ,  $L$ ,  $C$  elements - Resistance, -Inductance, -Capacitance, -Components reduction, Dual Norton model of the transmission line, Network solution, Step Response for RL and RC loads.

## **Unit-IV**

**Numerical integrator for nonlinear parameters:** Non-linear or time varying parameters -Current source representation, -Compensation method , -Piecewise linear method. Transmission lines and cables:Bergeron's model - Multiconductor transmission lines , Frequencydependent transmission lines-Frequency to time domain transformation and Phase domain model , Overhead transmission line parameters-Bundled sub conductors and Earth wires , Underground cable parameters, 50 2013-14

## **Unit-V**

**Transformers:** Basic transformer model, Numerical implementation, Parameters derivation, Modeling of non-linearities , Advanced transformer models.

## **Course Outcomes**

After completion of this course, a successful student will be able to:

- CO-1.** Know about classification about electromagnetic transients
- CO-2.** Know about analysis of continuous and discrete systems
- CO-3.** Know about state variable analysis, numerical integrator for non-linear parameters

## **Text Books**

- 1 Power systems Electromagnetic Transients simulation-(IEEE Power and Energy series-39) – Arrillaga.J

## **Reference Books**

- 1 Electrical transients in Power Systems – Allan Greenwood John Wiley and Sons Inc.(1991)
- 2 EMTP in Power Systems P Chpvdhuri PHI (2004).

<b>Regulation</b>	<b>GR - 14 ( M.TECH.)</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Course/ Code</b>	<b>PULSE POWER ENGINEERING / 14221263 (c)</b>	<b>3</b>	<b>1</b>	<b>0</b>	<b>3</b>
<b>Teaching</b>	<b>Total contact hours - 60</b>				

## **Unit -I**

**Static and Dynamic Breakdown Strength of dielectric Materials** Introduction-Gases-static breakdown-pulsed breakdown-spark formation-liquids-basic electrical Process-steamer breakdown-practical considerations-solids-General observations-charge Transport, injection and Breakdown-statistical Interpretation of breakdown Strength Measurements.

## **Unit- II**

**Energy Storage** Pulse Discharge Capacitors-Marx Generators-classical Marx generators-LC Marx Generator-Basic Pulsed-Power Energy Transfer Stage-inductive energy storage-power and voltage multiplication-rotors and homo polar Generators.

## **Unit- III**

**Switches** Closing switches-gas switches-semi conductor closing switches-magnetic switches-summary-opening switches-fusesmechanical interrupters-superconducting opening switches-plasma opening switches-plasma flow switches-semiconductor opening switches.

## **Unit- IV**

**Pulse forming networks:** Transmission lines-terminations and junctions-transmission lines with losses-the finite transmission line as a circuit element-production of pulses with lossless transmission lines-RLC networks-circuit simulation with LEITER.

**Power and Voltage Adding:** Adding of Power-Voltage Adding-voltage adding by transit-time Isolation- voltage adding by Inductive Isolation-Blumlein Generators-Cumulative Pulse Lines

## **Unit- V**

**Examples of Pulsed-power Generators:** Single-pulse generators-KALIF-PBFA 2 and the Z-Machine-HERMES III

**Repetitive Generators:** RHEPP and Generators with opening switches

## **Course Outcomes**

After completion of this course, a successful student will be able to:

- CO-1.** Know Various energy storage devices, repetitive generators and cumulative pulse lines.
- CO-2.** Know Pulse forming networks and their applications.
- CO-3.** Know Pulse power generators.

## **Text Books**

- 1 Pulsed Power Engineering by Professor Dr. Hasjoachim Bluhm.
- 2 Explosive Pulsed Power -L. L. Altgilbers, J. Baird, B. Freeman, C. S. Lynch, and S. I. Shkuratov -Imperial College Press.
- 3 Advances in Pulsed Power Technology, Vol. 1 & 2, Plenum Press.
- 4 Pulsed Power Systems: Principles and Applications- Dr. Hasjoachim Bluhm-Springer.

<b>Regulation</b>	<b>GR - 14 ( M.TECH.)</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Course/ Code</b>	<b>REACTIVE POWER COMPENSATION &amp; MANAGEMENT / 14221264(a)</b>	<b>3</b>	<b>1</b>	<b>0</b>	<b>3</b>
<b>Teaching</b>	<b>Total contact hours - 60</b>				

## **Unit- I**

**Load Compensation** Objectives and specifications – reactive power characteristics – inductive and capacitive approximate biasing – Load compensator as a voltage regulator – phase balancing and power factor correction of unsymmetrical loads- examples.

## **Unit -II**

**Reactive power compensation in transmission system:** Steady state - Uncompensated line – types of compensation – Passive shunt and series and dynamic shunt compensation – examples  
Transient state - Characteristic time periods – passive shunt compensation – static compensations- series capacitor compensation –compensation using synchronous condensers – examples

## **Unit-III**

**Reactive power coordination:** 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-IV**

**Distribution side Reactive power Management:** System losses –loss reduction methods – examples – Reactive power planning – objectives – Economics Planning capacitor placement – retrofitting of capacitor banks

**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-V**

**Reactive power management in electric traction systems and arc**

**furnaces:** Typical layout of traction systems – reactive power control requirements – distribution transformers- Electric arc furnaces – basic operations- furnaces transformer –filter requirements – remedial measures –power factor of an arc furnace.

## **Course Outcomes**

After completion of this course, a successful student will be able to:

- CO-1.** Learn various load compensations.
- CO-2.** Obtain the mathematical model of reactive power compensating devices.
- CO-3.** Get application of reactive power compensation in electrical traction & arc furnaces.

## **Reference Books**

- 1 Reactive power control in Electric power systems by T.J.E.Miller, John Wiley and sons, 1982
- 2 Reactive power Management by D.M.Tagare,Tata McGraw Hill,2004

<b>Regulation</b>	<b>GR - 14 ( M.TECH.)</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Course/ Code</b>	<b>POWER SYSTEM DEREGULATION / 14221264(c)</b>	<b>3</b>	<b>1</b>	<b>0</b>	<b>3</b>
<b>Teaching</b>	<b>Total contact hours - 60</b>				

## **Unit-I**

Need and conditions for deregulation. Introduction of Market structure, Market Architecture, Spot market, forward markets and settlements. Review of Concepts marginal cost of generation, least-cost operation, incremental cost of generation. Power System Operation.

## **Unit-II**

Electricity sector structures and Ownership /management, the forms of Ownership and management. Different structure model like Monopoly model, Purchasing agency model, wholesale competition model, Retail competition model.

## **Unit-III**

Framework and methods for the analysis of Bilateral and pool markets, LMP based markets, auction models and price formation, price based unit commitment, country practices.

## **Unit-IV**

Transmission network and market power. Power wheeling transactions and marginal costing, transmission costing. Congestion management methods- market splitting, counter-trading; Effect of congestion on LMPs- country practices.

## **Unit -V**

Ancillary Services and System Security in Deregulation. Classifications and definitions, AS management in various markets- country practices. Technical, economic, & regulatory issues involved in the deregulation of the power industry.

## **Course Outcomes**

After completion of this course, a successful student will be able to:

- CO-1.**Understand of operation of deregulated electricity market systems
- CO-2.** Know Typical issues in electricity markets
- CO-3.** Analyze various types of electricity market operational and control issues

## **Reference Books**

- 1 Power System Economics: Designing markets for electricity - S. Stoft
- 2 Power generation, operation and control, -J. Wood and B. F. Wollenberg
- 3 Operation of restructured power systems - K. Bhattacharya, M.H.J. Bollen and J.E. Daalder
- 4 Market operations in electric power systems - M. Shahidehpour, H. Yamin and Z. Li
- 5 Fundamentals of power system economics - S. Kirschen and G. Strbac
- 6 Optimization principles: Practical Applications to the Operation and Markets of the Electric Power Industry - N. S. Rau
- 7 Competition and Choice in Electricity - Sally Hunt and Graham Shuttleworth

<b>Regulation</b>	<b>GR - 14 ( M.TECH.)</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Course/ Code</b>	<b>FLEXIBLE ALTERNATING CURRENT TRANSMISSION SYSTEMS / 14221264(c)</b>	<b>3</b>	<b>1</b>	<b>0</b>	<b>3</b>
<b>Teaching</b>	<b>Total contact hours - 60</b>				

## **Unit -I**

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

## **Unit-II**

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

## **Unit-III**

**Static shunt compensation :** Objectives of shunt compensation, midpoint voltage regulation, voltage instability prevention, improvement of transient stability, Power oscillation damping, methods of controllable var generation, variable impedance type static var generators, switching converter type var generators, hybrid var generators.

## **Unit-IV**

**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 compensation control.

## **Unit-V**

**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.

## **Course Outcomes**

After completion of this course, a successful student will be able to:

- CO-1. know the performance improvement of transmission system with FACTS.
- CO-2. get the knowledge of effect of static shunt and series compensation.
- CO-3. know the effect of UPFC.
- CO-4. determine an appropriate FACTS device for different types of applications.

## **Text Books**

- 1 Understanding FACTS Devices, N.G.Hingorani and L.Guygi, IEEE Press. Indian Edition is available:—Standard Publications
- 2 Flexible AC Transmission systems ,Sang.Y.H and John.A.T, IEEE Press (2006).
- 3 HVDC & FACTS Controllers: applications of static converters in power systems- Vijay K.Sood- Springer publishers

<b>Regulation</b>	<b>GR - 14 ( M.TECH.)</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Course/ Code</b>	<b>SIMULATION LABORATORY / 14221211</b>	<b>0</b>	<b>0</b>	<b>3</b>	<b>2</b>
<b>Teaching</b>	<b>Total contact hours - 45</b>				

**Any 10 of the following experiments are to be conducted.**

**List of Experiments:**

- 1 Y Bus formation for p systems with and without mutual coupling, by Singular transformation.
- 2 Y Bus formation for p systems with and without mutual coupling, by inspection method.
- 3 Determination of bus currents, bus power and line flow for a specified system voltage (Bus) Profile
- 4 Formation of Z-bus, using Z-bus building Algorithm without mutual.
- 5 ABCD parameters: Formation for symmetric II/I configuration. Verification of AD-BC=1 Determination of coefficient and regulation
- 6 Determination of power angle diagrams for salient and non-salient pole synchronous m/c s, reluctance power, excitation, emf and regulation.
- 7 To determine I) Swing curve II) critical clearing time for a single m/c connected to infinity bus through a pair of identical transmission lines, 3-phase fault on one of the lines for variation of inertia constant/lineparameters /fault location/clearing time/pre- fault electrical output.
- 8 Formation of Jacobian for a system not exceeding 4 buses \*(no PV buses) in polar coordinates
- 9 Write a program to perform load flow using Gauss- Seidel method (only p q bus)
- 10 To determine fault currents and voltages in a single transmission line systems with Star-delta transformers at a specified location for SLGF,DLGF.
- 11 Load flow analysis using Gauss- Siedel method for both pq and pv buses.
- 12 Load flow analysis using NR method for both pq and pv buses.
- 13 Fast decoupled flow method for both pq and pv buses.
- 14 Optimal Generator Scheduling for Thermal power plants.
- 15 Economic dispatch using lambda-iteration method