ANNA UNIVERSITY, CHENNAI
UNIVERSITY DEPARTMENTS
REGULATIONS – 2015
CHOICE BASED CREDIT SYSTEM

M.E. HIGH VOLTAGE ENGINEERING

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs) :

I. To prepare the students for successful career in industry, research and teaching institutions
II. To provide strong foundation in basic science, mathematics and engineering necessary to formulate, solve and analyze electromagnetic field problems
III. To develop the ability to estimate and analyze overvoltages in power system
IV. To develop the ability to design and test High Voltage power apparatus
V. To provide an opportunity to students to work in multidisciplinary projects
VI. To promote student awareness for the lifelong learning and introduce them to the professional ethics

PROGRAMME OUTCOMES (POs):

On successful completion of the programme, the graduate would have attained the

1. Ability to acquire and apply knowledge of mathematics and electromagnetic fields in Electrical engineering
2. Ability to model and analyze power system and equipment for transient overvoltages using computational software
3. Ability to formulate, design, simulate, generate and measure High voltages and currents in the High Voltage laboratory
4. Ability to optimally design insulation scheme for power apparatus
5. Ability to conduct Dielectric tests as per national and international test standards
6. Ability to design and conduct experiments towards research
7. Ability to present technical subjects

Programme Educational Objectives	Programme Outcomes						
	PO1	PO2	PO3	PO4	PO5	PO6	PO7
I	✓	✓	✓	✓	✓	✓	✓
II	✓	✓					
III		✓			✓		
IV			✓	✓	✓	✓	
V	✓	✓				✓	
VI	✓			✓	✓	✓	✓

			PO1	PO2	PO3	PO4	PO5	PO6	PO7
YEAR 1	SEM 1	Applied Mathematics for Electrical Engineers	✓						
		High Voltage Generation and Measurement			✓				
		Insulation Technology				✓			
		Electrical Transients in Power System		✓					
		Electromagnetic Field Computation and Modelling	✓	✓					
		Elective I							
	SEM 2	High Voltage Testing Techniques			✓		✓		
		Insulation Design of High Voltage Power Apparatus		✓		✓			
		Principles of Electric Power Transmission		✓					
		Elective II							
		Elective III							
		Advanced High Voltage Laboratory			✓		✓	✓	
		Technical Seminar							✓
YEAR 2	SEM 3	Design of High Voltage Switchgear		✓			✓		
		Elective IV							
		Elective V							
		Project Work Phase I	✓	✓	✓	✓	✓	✓	✓
	SEM 4	Project Work Phase II	✓	✓	✓	✓	✓	✓	✓

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M.E. HIGH VOLTAGE ENGINEERING
CURRICULA AND SYLLABI I TO IV SEMESTERS

SEMESTER - I

S.No	Course Code	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	MA7156	Applied Mathematics for Electrical Engineers	FC	4	4	0	0	4
2.	HV7101	High Voltage Generation and Measurement	PC	5	3	0	2	4
3.	HV7102	Insulation Technology	PC	3	3	0	0	3
4.	HV7151	Electrical Transients in Power System	PC	3	3	0	0	3
5.	HV7152	Electromagnetic Field Computation and Modelling	PC	5	3	2	0	4
6.		Elective I	PE	3	3	0	0	3
			TOTAL	**23**	**19**	**2**	**2**	**21**

SEMESTER - II

S.No	Course Code	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	HV7201	High Voltage Testing Techniques	PC	3	3	0	0	3
2.	HV7202	Insulation Design of High Voltage Power Apparatus	PC	5	3	2	0	4
3.	HV7251	Principles of Electric Power Transmission	PC	3	3	0	0	3
4.		Elective II	PE	3	3	0	0	3
5.		Elective III	PE	3	3	0	0	3
PRACTICALS								
6.	HV7211	Advanced High Voltage Laboratory	PC	4	0	0	4	2
7.	HV7212	Technical Seminar	EEC	2	0	0	2	1
			TOTAL	**23**	**15**	**2**	**6**	**19**

SEMESTER - III

S.No	Course Code	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	HV7301	Design of High Voltage Switchgear	PC	3	3	0	0	3
2.		Elective IV	PE	3	3	0	0	3
3.		Elective V	PE	3	3	0	0	3
PRACTICALS								
4.	HV7311	Project Work Phase I	EEC	12	0	0	12	6
			TOTAL	**21**	**9**	**0**	**12**	**15**

SEMESTER - IV

Sl.No	Course Code	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
PRACTICALS								
1.	HV7411	Project Work Phase II	EEC	24	0	0	24	12
			TOTAL	**24**	**0**	**0**	**24**	**12**

TOTAL NO. OF CREDITS: 67

FOUNDATION COURSES (FC)

S.No	Course Code	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.		Applied Mathematics for Electrical Engineers	FC	4	4	0	0	4

PROFESSIONAL CORE (PC)

S.No	Course Code	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.		High Voltage Generation and Measurement	PC	5	3	0	2	4
2.		Insulation Technology	PC	3	3	0	0	3
3.		Electrical Transients in Power System	PC	3	3	0	0	3
4.		Electromagnetic Field Computation and Modelling	PC	5	3	2	0	4
5.		High Voltage Testing Techniques	PC	3	3	0	0	3
6.		Insulation Design of High Voltage Power Apparatus	PC	5	3	2	0	4
7.		Principles of Electric Power Transmission	PC	3	3	0	0	3
8.		Advanced High Voltage Laboratory	PC	4	0	0	4	2
9.		Design of High Voltage Switchgear	PC	3	3	0	0	3

PROFESSIONAL ELECTIVES (PE)

S.No	Course Code	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	CO7076	System Theory	PE	3	3	0	0	3
2.	CO7152	Soft Computing Techniques	PE	3	3	0	0	3
3.	PW7152	Renewable Energy Technology	PE	3	3	0	0	3
4.	PW7072	Electric Vehicles and Power Management	PE	3	3	0	0	3
5.	ET7152	Microcontroller Based System Design	PE	4	4	0	0	4
6.	PE7152	Analysis of Electrical Machines	PE	3	3	0	0	3
7.	PW7075	Sustainable Energy Utilization	PE	3	3	0	0	3
8.	PW7151	Distribution Systems Management and Automation	PE	3	3	0	0	3
9.	PW7071	Climate Change and Energy Environment	PE	3	3	0	0	3
10.	PW7074	Energy Economics, Financing, Regulation and Energy Modeling	PE	3	3	0	0	3
11.	HV7002	Pollution Performance of Power Apparatus and Systems	PE	3	3	0	0	3
12.	HV7073	Electromagnetic Interference and Compatibility	PE	3	3	0	0	3
13.	PE7073	Power Quality	PE	3	3	0	0	3
14.	PS7253	Flexible AC Transmission Systems	PE	3	3	0	0	3
15.	PS7254	Restructured Power System	PE	3	3	0	0	3
16.	PS7255	Smart Grids	PE	3	3	0	0	3
17.	PS7252	Analysis and Computation of Electromagnetic Transients in Power Systems	PE	3	3	0	0	3
18.	PW7073	Electricity Market Analysis	PE	3	3	0	0	3
19.	PW7251	SCADA System and Applications Management	PE	3	3	0	0	3
20.	PW7076	Urban and Rural Energy Management	PE	3	3	0	0	3
21.	HV7001	Nano Dielectrics	PE	3	3	0	0	3
22.	ET7074	MEMS Technology	PE	3	3	0	0	3
23.	HV7071	Applications of High Electric Fields	PE	3	3	0	0	3
24.	PE7072	Power Electronics for	PE	3	3	0	0	3

		Renewable Energy Systems						
25.	HV7072	Design of Substations	PE	3	3	0	0	3
26.	PS7071	Distributed Generation and Micro Grid	PE	3	3	0	0	3
27.	PE7351	Special Electrical Machines	PE	3	3	0	0	3
28.	PW7351	Energy Management and Auditing	PE	3	3	0	0	3
29.	PS7072	High Voltage Direct Current Transmission	PE	3	3	0	0	3
30.	PS7073	Optimisation Techniques	PE	3	3	0	0	3
31.	PS7074	Solar and Energy Storage System	PE	3	3	0	0	3
32.	PS7075	Wind Energy Conversion System	PE	3	3	0	0	3
33.	ET7072	Digital Image Processing	PE	3	3	0	0	3
34.	CO7071	Control of Electrical Drives	PE	3	3	0	0	3

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

S.No	Course Code	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.		Technical Seminar	EEC	2	0	0	2	1
2.		Project Work Phase I	EEC	12	0	0	12	6
3.		Project Work Phase II	EEC	24	0	0	24	12

MA7156 APPLIED MATHEMATICS FOR ELECTRICAL ENGINEERS LT P C
4 0 0 4

OBJECTIVES:

- To develop the ability to apply the concepts of Matrix theory and Linear programming in Electrical Engineering problems.
- To achieve an understanding of the basic concepts of one dimensional random variables and apply in electrical engineering problems.
- To familiarize the students in calculus of variations and solve problems using Fourier transforms associated with engineering applications..

UNIT I MATRIX THEORY 12

The Cholesky decomposition - Generalized Eigen vectors, Canonical basis - QR factorization - Least squares method - Singular value decomposition

UNIT II CALCULUS OF VARIATIONS 12

Concept of variation and its properties – Euler's equation – Functional dependant on first and higher order derivatives – Functionals dependant on functions of several independent variables – Variational problems with moving boundaries – problems with constraints - Direct methods: Ritz and Kantorovich methods

UNIT III ONE DIMENSIONAL RANDOM VARIABLES 12

Random variables - Probability function – moments – moment generating functions and their properties – Binomial, Poisson, Geometric, Uniform, Exponential, Gamma and Normal distributions – Function of a Random Variable

UNIT IV LINEAR PROGRAMMING 12

Formulation – Graphical solution – Simplex method – Two phase method - Transportation and Assignment Models

UNIT V FOURIER SERIES 12

Fourier Trigonometric series: Periodic function as power signals – Convergence of series – Even and odd function: cosine and sine series – Non-periodic function: Extension to other intervals - Power signals: Exponential Fourier series – Parseval's theorem and power spectrum – Eigen value problems and orthogonal functions – Regular Sturm-Liouville systems – Generalized Fourier series

TOTAL: 60 PERIODS

BOOKS FOR STUDY:

1. Richard Bronson, "Matrix Operation", Schaum's outline series, 2nd Edition, McGraw Hill, 2011.
2. Gupta, A.S., Calculus of Variations with Applications, Prentice Hall of India Pvt. Ltd., New Delhi, 1997.
3. Oliver C. Ibe, "Fundamentals of Applied Probability and Random Processes, Academic Press, (An imprint of Elsevier), 2010.

4. Taha, H.A., “Operations Research, An introduction”, 10th edition, Pearson education, New Delhi, 2010.
5. Andrews L.C. and Phillips R.L., Mathematical Techniques for Engineers and Scientists, Prentice Hall of India Pvt.Ltd., New Delhi, 2005.

REFERENCES

1. Elsgolts, L., Differential Equations and the Calculus of Variations, MIR Publishers, Moscow, 1973.
2. Grewal, B.S., Higher Engineering Mathematics, 42nd edition, Khanna Publishers, 2012.
3. O'Neil, P.V., Advanced Engineering Mathematics, Thomson Asia Pvt. Ltd., Singapore, 2003.
4. Johnson R. A. and Gupta C. B., “Miller & Freund’s Probability and Statistics for Engineers”, Pearson Education, Asia, 7th Edition, 2007.

HV7101 HIGH VOLTAGE GENERATION AND MEASURMENT L T P C

3 0 2 4

OBJECTIVE:

- To provide strong knowledge on different types electrical stresses on power system and equipment.
- To impart knowledge on generation of high AC, DC and impulse voltages and impulse currents.
- To generate and measure high voltages and high currents using the state of art techniques in the laboratory.

UNIT I GENERATION OF DIRECT VOLTAGES 9

Generation and transmission of electric energy, voltage stress, testing voltages, generation of direct voltages – AC to DC conversion – single phase rectifier circuits – cascade circuits – voltage multiplier circuits – Cockroft-Walton circuit – voltage regulation – ripple factor – Electrostatic generators.

UNIT II GENERATION OF ALTERNATING VOLTAGES 9

Testing transformer – single unit testing transformer, cascaded transformer – equivalent circuit of cascaded transformer – resonant circuits – resonant transformer – voltage regulation.

UNIT III GENERATION OF IMPULSE VOLTAGES 9

Impulse voltage generator circuit – Marx generator –analysis of various impulse voltage generator circuits – multistage impulse generator circuits – Switching impulse generator circuits – generation of non-standard impulse voltages and very fast transient voltage (VFTO)

UNIT IV MEASURMENT OF HIGH VOLTAGES 9

Measurement of high AC, DC Impulse voltages - Peak voltage measurements by sphere gaps – Electrostatic voltmeter – generating voltmeters and field sensors – Chubb-Fortescue

method – voltage dividers and impulse voltage measurements

UNIT V GENERATION AND MEASUREMENT OF IMPULSE CURRENTS 9

Generation of impulse currents, measurement of high DC, AC and impulse currents – shunts, measurement using magnetic potentiometers and magnetic coupling - Fast digital transient recorders for impulse measurements

L=45: P=30, Total = 75 PERIODS

PRACTICAL

1. Analysis and Design of high DC generators using circuit simulation package
2. Analysis and Design of high AC generators using circuit simulation package
3. Analysis and Design of high Impulse voltage generators using circuit simulation package
4. Generation and measurement of HVDC
5. Generation and measurement of HVAC
6. Generation and measurement of standard impulse voltages
7. Generation and measurement of non-standard impulse voltages

OUTCOME:

- Ability to design the suitable generating and measuring circuits.
- Acquire hands on experience in generating and measuring high voltages and currents necessary for testing of power equipment as per national and international standards.

REFERENCES

1. Kuffel, E., Zaengl, W.S. and Kuffel J., “High Voltage Engineering Fundamentals”, Elsvier India Pvt. Ltd, 2005
2. Dieter Kind, Kurt Feser, “High Voltage Test Techniques”, SBA Electrical Engineering Series, New Delhi, 1999.
3. Naidu M S and Kamaraju V, “High Voltage Engineering”, Tata McGraw-hill Publishing Company Ltd., New Delhi, 2004.
4. Gallagher, T.J., and Permain, A., “High Voltage Measurement, Testing and Design”, John Wiley Sons, New York, 1983.
5. R.Mazen Abdel-Salam, Hussein Anis, Ahdab El-Morshedy, Roshdy Radwan, “High Voltage Engineering Theory and Practice” Second Edition, Revised and Expanded, Marcel Dekker, Inc., New York, 2000.
6. N.H.Malik, A.A.Al_Arainy, M.I.Qureshi, “ Electrical Insulation in Power Systems”, marcel Dekker,Inc., New York 1988.
7. Adolf J. Schwab, “High Voltage Measurement Techniques”, M.I.T Press, 1972.

HV7102 INSULATION TECHNOLOGY L T P C

3 0 0 3

OBJECTIVES:

- To gain in-depth knowledge on characteristics and behavior of dielectrics under static and alternating fields.
- To study the breakdown mechanism of gaseous, liquid and solid dielectrics.
- To enable the students to become familiar with application of dielectric materials for power equipment.

UNIT I DIELECTRIC PROPERTIES OF INSULATORS IN STATIC FIELDS 9

Static dielectric constant – Polarization and dielectric constant – atomic interpretation of the dielectric constant of mono-atomic gases –dependence of permittivity on various factors– internal field in solids and liquids – static dielectric constant of solids – properties of ferroelectric materials – spontaneous polarization – Piezoelectricity.

UNIT II BEHAVIOR OF DIELECTRICS IN ALTERNATING FIELDS 9

Frequency dependence of the electronic polarizability – ionic polarization as a function of frequency – complex dielectric constant of non-dipolar solids – dipolar relaxation – dielectric losses.

UNIT III BREAKDOWN MECHANISMS IN GASEOUS DIELECTRICS 9

Behaviour of gaseous dielectrics in electric fields – gaseous discharges – different ionization processes – effect of electrodes on gaseous discharge – Townsend's theory, Streamer theory – electronegative gases, gaseous discharges in non-uniform fields - breakdown in vacuum insulation- alternate Green gases

UNIT IV BREAKDOWN MECHANISMS IN SOLID AND LIQUID DIELECTRICS 9

Solid Dielectrics-Intrinsic breakdown of solid dielectrics – electromechanical breakdown-Streamer breakdown, thermal breakdown - electrochemical breakdown – tracking and treeing – thermal and electrical ageing and partial discharges - classification of solid dielectrics, composite insulation. Liquids dielelctrics- conduction and breakdown in pure and commercial liquids, DGA -Cryogenic insulation.

UNIT V APPLICATION OF INSULATING MATERIALS 9

Application of insulating materials in transformers. rotating machines, circuit breakers, cables, power capacitors and bushings

TOTAL : 45 PERIODS

OUTCOME:

- Ability to understand the fundamental behavior of gaseous, liquid and solid dielectrics.
- Ability to select an appropriate dielectric material for various applications.

REFERENCES

1. Adrinaus, J.Dekker, "Electrical Engineering Materials", Prentice Hall of India Pvt. Ltd., New Delhi, 1979.
2. Dieter Kind and Hermann Karner, "High Voltage Insulation Technology", 1985. (Translated from German by Y. Narayana Rao, Friedr. Vieweg & Sohn, Braunschweig,).
3. Kuffel, E., Zaengl, W.S. and Kuffel J., "High Voltage Engineering Fundamentals", Elsvier India Pvt. Ltd, 2005
4. Alston, L.L, "High Voltage Technology", Oxford University Press, London, 1968 (B.S
5. Publications, First Indian Edition 2006)
6. M.S Naidu, V.Kamaraj, "High Voltage Engineering", Tata Mc Graw-Hill Publishing Company Ltd., New Delhi, 2004.
7. V.Y.Ushakov, "Insulation of High Voltage Equipment", Springer ISBN.3-540-20729-5, 2004.

HV7151 ELECTRICAL TRANSIENTS IN POWER SYSTEM **L T P C**

3 0 0 3

OBJECTIVE:

- To gain knowledge in the sources and effects of lightning, switching and temporary overvoltages.
- Ability to model and estimate the overvoltages in power system
- Ability to model and analyze power system and equipment for transient overvoltages using Electromagnetic Transient Program (EMTP).
- To coordinate the insulation of power system and protective devices.

UNIT I LIGHTNING OVERVOLTAGES 9

Mechanism and parameters of lightning flash, protective shadow, striking distance, electrogeometric model for lightning strike, Grounding for protection against lightning – Steadystate and dynamic tower-footing resistance, substation grounding Grid, Direct lightning strokes to overhead lines, without and with shield Wires

UNIT II SWITCHING AND TEMPORARY OVERVOLTAGES 9

Switching transients – concept – phenomenon – system performance under switching surges, Temporary overvoltages – load rejection – line faults – ferroresonance, VFTO

UNIT III TRAVELLING WAVES ON TRANSMISSION LINE 9

Circuits and distributed constants, wave equation, reflection and refraction – behaviour of travelling waves at the line terminations – Lattice Diagrams – attenuation and distortion – multiconductor system and multivelocity waves

UNIT IV COMPUTATION OF POWER SYSTEM TRANSIENTS 9

Digital computation of line parameters- Modal propagation in transmission lines- need for line parameter evaluation programs and salient features - effect of constructional features, line parameters for physical and equivalent phase conductors, elimination of ground wires, bundling of conductors, shunt capacitance matrix, Digital computation of transients- typical features and capabilities of electromagnetic transients programs (EMTP)- steady state and time step solution modules- basic solution methods- selected case studies.

UNIT V INSULATION CO-ORDINATION 9

Classification of overvoltages and insulations for insulation co-ordination – Characteristics of protective devices, applications, location of arresters – insulation co-ordination in AIS and GIS

TOTAL : 45 PERIODS

OUTCOME:

- Awareness towards the types and sources of overvoltages to design appropriate protection scheme.
- Enabling the students to design a reliable power system with appropriate insulation coordination.

REFERENCES

1. Pritindra Chowdhari, “Electromagnetic transients in Power System”, John Wiley and Sons Inc., Second Edition, 2009.
2. Allan Greenwood, “Electrical Transients in Power System”, Wiley & Sons Inc. New York, 2012.

3. Klaus Ragaller, “Surges in High Voltage Networks”, Plenum Press, New York, 1980.
4. Rakosh Das Begamudre, “Extra High Voltage AC Transmission Engineering”, (Second edition) Newage International (P) Ltd., New Delhi, 2006.
5. Naidu M S and Kamaraju V, “High Voltage Engineering”, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2004.
6. IEEE Guide for safety in AC substation grounding IEEE Standard 80-2000.
7. Working Group 33/13-09 (1988), ‘Very fast transient phenomena associated with Gas Insulated System’, CIGRE, 33-13, pp. 1-20.
8. R. Ramanujam, “Computational Electromagnetic Transients: Modeling, Solution Methods and Simulation”, I.K. International Publishing House Pvt. Ltd, New Delhi - 110 016, 2014

HV7152 ELECTROMAGNETIC FIELD COMPUTATION AND MODELLING **L T P C**

3 2 0 4

OBJECTIVE:

- To refresh the fundamentals of Electromagnetic Field Theory.
- To provide foundation in formulation and computation of Electromagnetic Fields using analytical and numerical methods.
- To impart in-depth knowledge on Finite Element Method in solving Electromagnetic field problems.
- To provide knowledge in computer aided design of electrical equipment

UNIT I INTRODUCTION **9**

Review of basic field theory – Maxwell’s equations – Constitutive relationships and Continuity equations – Laplace, Poisson and Helmholtz equation – principle of energy conversion – force/torque calculation

UNIT II BASIC SOLUTION METHODS FOR FIELD EQUATIONS **9**

Limitations of the conventional design procedure, need for the field analysis based design, problem definition, boundary conditions, solution by analytical methods-direct integration method – variable separable method – method of images, solution by numerical methods-Finite Difference Method

UNIT III FORMULATION OF FINITE ELEMENT METHOD (FEM) **9**

Variational Formulation – Energy minimization – Discretisation – Shape functions –Stiffness matrix –1D and 2D planar and axial symmetry problems

UNIT IV COMPUTATION OF BASIC QUANTITIES USING FEM PACKAGES **9**

Basic quantities – Energy stored in Electric Field – Capacitance – Magnetic Field – Linked Flux – Inductance – Force – Torque – Skin effect – Resistance

UNIT V DESIGN APPLICATIONS **9**

Design of Insulators –Magnetic actuators – Transformers – Rotating machines.

L=45: T=30, TOTAL = 75 PERIODS

OUTCOME:

- Ability to formulate and compute Electromagnetic Fields from Maxwell's equations.
- Ability to design and analyze the performance of electrical apparatus using Finite Element Method.

REFERENCES

1. Matthew. N.O. Sadiku, "Elements of Electromagnetics", Fourth Edition, Oxford University Press, First Indian Edition 2007.
2. K.J.Binns, P.J.Lawrenson, C.W Trowbridge, "The analytical and numerical solution of Electric and magnetic fields", John Wiley & Sons, 1993.
3. Nicola Biyanchi , "Electrical Machine analysis using Finite Elements", Taylor and Francis Group, CRC Publishers, 2005.
4. Nathan Ida, Joao P.A.Bastos , "Electromagnetics and calculation of fields", SpringerVerlage, 1992.
5. S.J Salon, "Finite Element Analysis of Electrical Machines" Kluwer Academic Publishers, London, 1995, distributed by TBH Publishers & Distributors, Chennai, India.
6. Silvester and Ferrari, "Finite Elements for Electrical Engineers" Cambridge University press, 1983.

HV7201 HIGH VOLTAGE TESTING TECHNIQUES

L	T	P	C
3	0	0	3

OBJECTIVE:

To acquire knowledge,

- on the different types of testing and measurement techniques
- on pre-testing procedures by statistical evaluation methods
- on required tests and the procedures for various high voltage power apparatus as per Indian and international standards.

UNIT I INTRODUCTION 9

Objectives of high voltage testing, classification of testing methods- self restoration and non-self restoration systems-standards and specifications, measurement techniques ,Diagnostic testing – online measurement, standard test cells

UNIT II STATISTICAL EVALUTION OF MEASURED RESULTS 9

Determination of probability values, Distribution function of a measured quantity, confidence limits of the mean values of disruptive discharges - 'Up and Down' method for determining the 50% disruptive discharge voltage, multi stress ageing, life data analysis

UNIT III TESTING TECHNIQUES FOR ELECTRICAL EQUIPMENT 9

Testing of insulators, bushings, air break switches, isolators, circuit breakers, power transformers, voltage transformers, current transformers, surge diverters ,cable -testing methodology-recording of oscillograms - interpretation of test results

UNIT IV NON-DESTRUCTIVE INSULATION TEST TECHNIQUES 9

Dynamic properties of dielectrics-dielectric loss and capacitance measurement-partial discharge measurements-basic partial discharge (PD) circuit – PD currents- PD quantities - Digital PD instruments and measurements, acoustic emission technique and UHF Techniques for PD identification, Corona and RIV measurements on line hardware

UNIT V POLLUTION TESTS AND DESIGN OF HIGH VOLTAGE LAB 9

Artificial Pollution tests- salt-fog method, solid layer method, Dimensions of High voltage laboratory, equipment- fencing, earthing and shielding, circuits for high voltage experiments

L=45: TOTAL = 45 PERIODS

OUTCOME:

- Ability to select appropriate type of test for each high voltage power apparatus.
- Ability to conduct Dielectric tests as per standards.

REFERENCES

1. Dieter Kind, Kurt Feser, “High voltage test techniques”, SBA Electrical Engineering Series, New Delhi,1999.
2. Naidu M.S. and Kamaraju V., “High voltage Engineering”, Tata McGraw Hill Publishing Company Ltd., New Delhi, 2004.
3. Relevant test standards.
4. Kuffel, E., Zaengl, W.S. and Kuffel J., “High Voltage Engineering Fundamentals”, Elsvier India P Ltd, 2005
5. Gallagher, T.J., and Pearmain A., “High Voltage Measurements, Testing and Design”, John Willey & Sons, New York, 1983.
6. IS, IEC and IEEE standards for “Dielectric Testing of High Voltage Apparatus” W.Nelson, Applied Life Data Analysis, John Wiley and Sons, New York, 1982.
7. W.Kennedy, “Recommended Dielectric Tests and Test Procedures for Converter Transformer and Smoothing Reactors”, IEEE Transactions on Power Delivery, Vol.1, No.3, pp 161-166, 1986.
8. IEC – 60270, “HV Test technique – Partial Discharge Mechanism”, 3rd Edition December 2000.
9. M.D Judd, Liyang, Ian BB Hunter, “P.D Monitoring of Power Transformers using UHF Sensors” Vol.21, No.2, pp5-14, 2004.
10. M.D Judd, Liyang, Ian BB Hunter “P.D Monitoring of Power Transformers using UHF Sensors Part II, Vol.21, No.3, pp 5-13, 2004.

HV7202 INSULATION DESIGN OF HIGH VOLTAGE POWER APPARATUS

L T P C

3 2 0 4

OBJECTIVE:

- To provide fundamental knowledge about the role and schemes of insulation and stress control techniques in high voltage equipment.
- To acquire knowledge on design principles of Insulators, bushings and power transformers
  Instrument transformers, cable joints and surge arresters.

UNIT I INTRODUCTION 9

Basic arrangements of the insulation systems-factors affecting the performance of dielectric materials - Electric field distribution-utilization factor, field in homogeneous and multi-dielectric isotropic material

UNIT II INSULATORS AND BUSHINGS 9

Basic configurations, Classification based on insulating materials and application, design principles

UNIT III POWER TRANSFORMERS 9

Insulation schemes in transformer, design of transformer windings, surge phenomena in transformer windings-effect of series and shunt capacitance and stress control techniques

UNIT IV INSTRUMENT TRANSFORMERS AND CABLE JOINTS 9

Classification based on insulating materials and design of potential and current transformers, Types of cable joints and terminations-capacitive grading- non-linear resistive grading

UNIT V SURGE ARRESTER 9

Types of surge arresters - gapped and gapless - electrical characteristics – housing materials - pollution performance - modeling of arrestor

L = 45: T = 30, TOTAL = 75 PERIODS

OUTCOME:

- Ability to understand and analyze the factors influencing the performance of insulation of power equipment.
- Ability to design high voltage apparatus efficiently using suitable stress control techniques**.**

REFERENCES

1. Dieter Kind and Hermann Karner, “High Voltage insulation technology”, Translated from German by Y.Narayana Rao, Friedr. Vieweg & Sohn, Braunschweig, 1985.
2. Alston, L.L, “High Voltage Technology”, Oxford University Press, London 1968.
3. Kuffel, E., Zaengl, W.S. and Kuffel J., “High Voltage Engineering Fundamentals”, Elsvier India Pvt. Ltd, 2005.
4. Karsai, K.Kerenyi, D. and Kiss. L., “Large Power Transformers”, Elsevier, Armsterdam, 1987.
5. Feinberg, R., “Modern Power Transformer Practice”, The Macmillan Press Ltd., New York, 1979.
6. A.C.Franklin and J.S.C.Franklin, “The J & P Transformer Book”, Butterworth-Heinmann, New Delhi, 1995. Eleventh edition.
7. Minoo Mobedjina, Bengt Johnnerfelt, Lennart Stenstrom, “Design and testing of polymer – housed surge arrester”, GCC CIGRE 9th Symposium, 1998.
8. K.Steinfield, B.Krusha andW.Welsh, “Manufacturing and Application of Cage Design High Voltage Metaloxide Surge Arresters” XIII International Symposium on High Voltage Engineering, Netherland, 2003.
9. Dr.Ahmed Zahedi, “Effect of Day Band on Performance of UHV Surge Arrester and Leakage Current Monitoring using New Developed Model,” paper 7237, Proceedings of the 4th International Conference on Properties and Application of Dielectric Materials, 1994, Brishane Australia.

HV7251 PRINCIPLES OF ELECTRIC POWER TRANSMISSION **L T P C**

3 0 0 3

OBJECTIVE:

To impart knowledge on,

- types of power transmission and configurations
- various parameters and voltage gradients of transmission line conductors.
- the design requirements of EHV AC and DC lines.

UNIT I INTRODUCTION **9**

Standard transmission voltages-AC and DC – different line configurations– average values of line parameters – power handling capacity and line loss – costs of transmission lines and equipment – mechanical considerations in line performance

UNIT II CALCULATION OF LINE PARAMETERS **9**

Calculation of resistance, inductance and capacitance for multi-conductor lines – calculation of sequence inductances and capacitances – line parameters for different modes of propagation – effect of ground return

UNIT III VOLTAGE GRADIENTS OF CONDUCTORS **9**

Charge-potential relations for multi-conductor lines – surface voltage gradient on conductors – gradient factors and their use – distribution of voltage gradient on sub conductors of bundle - voltage gradients on conductors in the presence of ground wires on towers-I^2R loss and corona loss-RIV

UNIT IV ELECTROSTATIC FIELD AND DESIGN OF EHV LINES **9**

Effect of EHV line on heavy vehicles - calculation of electrostatic field of AC lines- effect of high field on humans, animals, and plants - measurement of electrostatic fields - electrostatic Induction in unenergised circuit of a D/C line - induced voltages in insulated ground wires - electromagnetic interference, Design of EHV lines

UNIT V HVDC LINES **9**

Introduction- Reliability and failure issues-Design-tower, ROW, clearances, insulators, electrical and mechanical protection-Maintenance-Control and protection-D.C Electric field and Magnetic field -Regulations and guide lines-under ground line design.

TOTAL : 45 PERIODS

OUTCOME:

- Ability to model the transmission lines and estimate the voltage gradients and losses
- Ability to design EHV AC and DC transmission lines

REFERENCES

1. Rakosh Das Begamudre, “Extra High Voltage AC Transmission Engineering”, Second Edition, New Age International Pvt. Ltd., 2006.
2. Pritindra Chowdhari, “Electromagnetic transients in Power System”, John Wiley and Sons Inc., 2009.
3. Power Engineer’s Handbook, Revised and Enlarged 6th Edition, TNEB Engineers’ Association, October 2002.
4. Sunil S.Rao, “EHV-AC, HVDC Transmission & Distribution Engineering”, Third Edition, Khanna Publishers, 2008
5. Gas Insulated Transmission Lines (GIL) - by Hermann Koch, Oct 2011, John Wiley & Sons.

6. William H. Bailey, Deborah E. Weil and James R. Stewart . “A Review on ,”HVDC Power Transmission Environmental Issues”, Oak Ridge National Laboratory.
7. J.C Molburg, J.A. Kavicky, and K.C. Picel ,”A report on The design, Construction and operation of Long-distance High-Voltage Electricity Transmission Technologies” , Argonne (National Laboratory)

HV7211 ADVANCED HIGH VOLTAGE LABORATORY **L T P C**

0 0 4 2

OBJECTIVE:

To acquire hands on experience

- on the AC and DC breakdown characterization of air, liquid and solid dielectric under uniform and non-uniform electric fields.
- on the characterization of insulating material under standard and non standard impulse voltages.
- to measure the partial discharges, harmonics and E/H fields

LIST OF EXPERIMENTS

1. Study on the AC and DC breakdown characteristics of air at different pressures
2. Study on the AC and Impulse voltage breakdown characteristics of Liquid Dielectrics
3. Study on the AC breakdown characteristics of Solid Dielectrics under Uniform and Non-Uniform fields
4. Measurement of Electric and Magnetic fields using field meters
5. Measurement of resonant frequencies and internal voltage distribution in transformer windings
6. Measurement of Partial Discharges
7. Measurement of Harmonics using energy analyzer
8. Capacitance and Tan delta measurements
9. Dielectric withstand tests on Insulator / Bushing
10. Dielectric withstand tests on Air Break Switch / Circuit Breaker
11. Dielectric withstand tests on Transformer

1. Impulse Generator- 19kJ, 1540kV
2. Cascaded transformer- 450kV
3. High Voltage DC/AC/Impulse Generator (2 stage)- 440kV
4. Digital storage Oscilloscope
5. Potential and current dividers
6. Capacitance and Tan δ test kit
7. Harmonic Analyzer
8. Impedance Analyzer
9. Sweep Frequency Response Analyzer
10. Partial Discharge Set up

P = 60 ,TOTAL = 60 PERIODS

OUTCOME:

- Ability to select the appropriate insulating materials using material characteristics.
- Ability to access the life of insulation under various operating conditions.

HV7301 DESIGN OF HIGH VOLTAGE SWITCHGEAR **L T P C**

3 0 0 3

OBJECTIVE:

To impart knowledge on,

- the clearances between contacts in different insulating media
- the arcing phenomenon in circuit breaker.
- the design techniques for different types of circuit breakers.

UNIT I INTRODUCTION 9

Insulation of switchgear - coordination between inner and external insulation, Insulation clearances in air, oil, SF6 and vacuum, bushing insulation, solid insulating materials – dielectric and mechanical strength consideration – Isolating, earthing and load switches.

UNIT II CIRCUIT INTERRUPTION 9

Switchgear terminology – Arc characteristics – direct and alternating current interruption – arc quenching phenomena – computer simulation of arc models – transient re-striking voltage – RRRV-recovery voltage-current chopping-capacitive current breaking-auto re-closing.

UNIT III DESIGN OF AIR CIRCUIT BREAKERS 9

General Layout – Electric Arc Behavior in a Longitudinal Flow of Compressed Air – Thermodynamic Clogging of the Blast Nozzle, Nozzle Section Vs Breaking Current Relation – Recovery of Dielectric Strength in Axial Blast Interrupters – Aiding Arc Extinction with Shunt Resistors and Capacitors – Gas Dynamics of Air Circuit Breakers – Analysis and Selection of Interrupting Chamber Parameters – Control System Components – Air Circuit Breaker Design – Case studies

UNIT IV DESIGN OF OIL CIRCUIT BREAKERS 9

Layout of Bulk and Low-Oil Breakers – Construction and Operation of Interrupters – ExtinctionChamber Pressure Analysis – Auto-Reclosing Duty and Frequent Make-Break Operations – Operating Mechanisms – Driving and Tripping Mechanisms – Trends in the Development of Oilless Circuit Breakers – Breaker Design – Case studies

UNIT V DESIGN OF SF_6 AND VACUUM CIRCUIT BREAKERS 9

Insulating and Interrupting Properties of SF6 –Analysis and Construction of SF6 Circuit Breakers – Vacuum circuit breakers: Status and trends in continuous current and interrupting ratings – Mechanical and thermal withstand capabilities– Construction and layout – Breaker design – Case studies.

TOTAL = 45 PERIODS

OUTCOME:

- Ability to analyze and model arc interruption in circuit breakers.
- Ability to design different circuit breakers effectively.

REFERENCES

1. Chunikhin, A. and Zhavoronkov, M., “High Voltage Switchgear Analysis and Design”, Mir Publishers, Moscow, 1989.
2. Kuffel, E., Zaengl, W.S. and Kuffel J., “High Voltage Engineering Fundamentals”, Elsvier India Pvt. Ltd, 2005
3. Flursscheim, C.H. (Editor), “Power Circuit Breaker-Theory and Design”, IEE Monograph Series 17, Peter Peregrinus Ltd., Southgate House, Stevenage, Herts, SC1 1HQ, England, 1977.

4. Ananthakrishnan S and Guruprasad K.P., “Transient Recovery Voltage and Circuit Breakers”, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 1999.
5. Funio Nakanishi, “Switching Phenomena in High Voltage Circuit Breakers”, Marcel Dekker Inc., New York, 1991.

CO7076 SYSTEM THEORY LT P C
3 0 0 3

COURSE OBJECTIVES

- To educate on modeling and representing systems in state variable form.
- To educate on solving linear and non-linear state equations.
- To illustrate the role of controllability and observability.
- To educate on stability analysis of systems using Lyapunov’s theory.
- To educate on modal concepts and design of state and output feedback controllers and estimators.

UNIT I STATE VARIABLE REPRESENTATION 9

Introduction-Concept of State-State equation for Dynamic Systems -Time invariance and linearity-Non uniqueness of state model-State Diagrams - Physical System and State Assignment.

UNIT II SOLUTION OF STATE EQUATIONS 9

Existence and uniqueness of solutions to Continuous-time state equations-Solution of Nonlinear and Linear Time Varying State equations-Evaluation of matrix exponential-System modes- Role of Eigenvalues and Eigenvectors.

UNIT III CONTROLLABILITY AND OBSERVABILITY 9

Controllability and Observability-Stabilizability and Detectability-Test for Continuous time Systems-Time varying and Time invariant case-Output Controllability-Reducibility-System Realizations.

UNIT IV STABILTY 9

Introduction-Equilibrium Points-Stability in the sense of Lyapunov-BIBO Stability-Stability of LTI Systems-Equilibrium Stability of Nonlinear Continuous Time Autonomous Systems-The Direct Method of Lyapunov and the Linear Continuous-Time Autonomous Systems-Finding Lyapunov Functions for Nonlinear Continuous Time Autonomous Systems-Krasovskii and Variable-Gradiant Method.

UNIT V MODAL CONTROL 9

Introduction-Controllable and Observable Companion Forms-SISO and MIMO Systems The Effect of State Feedback on Controllability and Observability-Pole Placement by State Feedback for both SISO and MIMO Systems-Full Order and Reduced Order Observers.

TOTAL : 45 PERIODS

COURSE OUTCOME

- Acquire the concept of State-State equation for Dynamic Systems and understand the uniqueness of state model.
- Ability to differentiate the existence and uniqueness of Continuous time state equations.
- Ability to analyse the controllability and observability of a system.

- Acquire detail knowledge on stability analysis of Linear & Nonlinear Continuous Time Autonomous Systems.

REFERENCES:

1. M. Gopal, “Modern Control System Theory”, New Age International, 2005.
2. K. Ogatta, “Modern Control Engineering”, PHI, 2002.
3. John S. Bay, “Fundamentals of Linear State Space Systems”, McGraw-Hill, 1999.
4. D. Roy Choudhury, “Modern Control Systems”, New Age International, 2005.
5. John J. D’Azzo, C. H. Houpis and S. N. Sheldon, “Linear Control System Analysis and Design with MATLAB”, Taylor Francis, 2003.
6. Z. Bubnicki, ”Modern Control Theory”, Springer, 2005.

CO7152 SOFT COMPUTING TECHNIQUES LT P C

3 0 0 3

COURSE OBJECTIVES

- To review the fundamentals of ANN and fuzzy set theory.
- To make the students understand the use of ANN for modeling and control of non-linear system and to get familiarized with the ANN tool box.
- To impart knowledge of using Fuzzy logic for modeling and control of non-linear systems and get familiarized with the FLC tool box.
- To make the students to understand the use of optimization techniques.
- To familiarize the students on various hybrid control schemes, P.S.O and get familiarized with the ANFIS tool box.

UNIT I OVERVIEW OF ARTIFICIAL NEURAL NETWORK (ANN) & FUZZY LOGIC 9

Review of fundamentals - Biological neuron, Artificial neuron, Activation function, Single Layer Perceptron – Limitations – Multi Layer Perceptron – Back propagation algorithm (BPA); Fuzzy set theory – Fuzzy sets – Operation on Fuzzy sets - Scalar cardinality, fuzzy cardinality, union and intersection, complement (yager and sugeno), equilibrium points, aggregation, projection, composition, fuzzy relation – Fuzzy membership functions.

UNIT II NEURAL NETWORKS FOR MODELLING AND CONTROL 9

Generation of training data - optimal architecture – Model validation- Control of non linear system using ANN- Direct and Indirect neuro control schemes- Adaptive neuro controller – Case study - Familiarization of Neural Network Control Tool Box.

UNIT III FUZZY LOGIC FOR MODELLING AND CONTROL 9

Modeling of non linear systems using fuzzy models(Mamdani and Sugeno) –TSK model - Fuzzy Logic controller – Fuzzification – Knowledge base – Decision making logic – Defuzzification-Adaptive fuzzy systems- Case study - Familiarization of Fuzzy Logic Tool Box.

UNIT IV GENETIC ALGORITHM 9

Basic concept of Genetic algorithm and detail algorithmic steps, adjustment of free parameters. Solution of typical control problems using genetic algorithm. Concept on some other search techniques like Tabu search, Ant-colony search and Particle Swarm Optimization.

UNIT V HYBRID CONTROL SCHEMES 9

Fuzzification and rule base using ANN–Neuro fuzzy systems-ANFIS –Optimization of membership function and rule base using Genetic Algorithm and Particle Swarm Optimization - Case study– Familiarization of ANFIS Tool Box.

TOTAL : 45 PERIODS

COURSE OUTCOME

Students,

- Will be able to know the basic ANN architectures, algorithms and their limitations.
- Also will be able to know the different operations on the fuzzy sets.
- Will be capable of developing ANN based models and control schemes for non-linear system.
- Will get expertise in the use of different ANN structures and online training algorithm.
- Will be knowledgeable to use Fuzzy logic for modeling and control of non-linear systems.
- Will be competent to use hybrid control schemes and P.S.O.

REFERENCES

1. Laurene V.Fausett, "Fundamentals of Neural Networks, Architecture, Algorithms, and Applications", Pearson Education, 2008.
2. Timothy J.Ross, "Fuzzy Logic with Engineering Applications", Wiley, Third Edition, 2010.
3. David E.Goldberg, "Genetic Algorithms in Search, Optimization, and Machine Learning", Pearson Education, 2009.
4. W.T.Miller, R.S.Sutton and P.J.Webrose, "Neural Networks for Control", MIT Press, 1996.
5. George J.Klir and Bo Yuan, "Fuzzy Sets and Fuzzy Logic: Theory and Applications", Prentice Hall, First Edition, 1995.
6. N.P Padhy, S.P. Simon "Soft Computing With MATLAB Programming",OXFORD print February 2015.

PW7152 RENEWABLE ENERGY TECHNOLOGY L T PC

3 0 0 3

COURSE OBJECTIVE:

- To provide knowledge about various renewable energy technologies
- To provide knowledge about various possible hybrid energy systems
- To gain knowledge about application of various renewable energy technologies

UNIT I INTRODUCTION 9

Primary energy sources, renewable vs. non-renewable primary energy sources, renewable energy resources in India, Current usage of renewable energy sources in India, future potential of renewable energy in power production and development of renewable energy technologies.

UNIT II SOLAR ENERGY 9

Solar Radiation and its measurements, Solar Thermal Energy Conversion from Flat- Plate Solar Collectors, Concentrating Collectors and its Types, Efficiency and performance of collectors, Applications of Solar Thermal Energy use of low and medium, high temperature and recent advances in industry and buildings. Direct Solar Electricity Conversion from Photovoltaic, types of solar cells and its application of battery charger, domestic lighting, street lighting, and water pumping, power generation schemes. Recent Advances in PV Applications: Building Integrated PV, Grid Connected PV Systems, Hybrid Systems and Solar Cars, Solar Energy Storage system and their economic aspects.

UNIT III WIND ENERGY 9

Wind energy principles, wind site and its resource assessment, wind assessment, Factors influencing wind, wind turbine components, wind energy conversion systems(WECS), Classification of WECS devices, wind electric generating and control systems, characteristics and applications. Hybrid systems - safety and environmental aspects, economic aspects

UNIT IV BIO-ENERGY 9

Energy from biomass, Principle of biomass conversion technologies/process and their classification, Bio gas generation, types of biogas plants, selection of site for biogas plant, classification of biogas plants, Advantage and disadvantages of biogas generation, thermal gasification of biomass, biomass gasifies, Application of biomass and biogas plants and their economics.

UNIT V OTHER TYPES OF ENERGY 9

Energy conversion from Hydrogen and Fuel cells, Geo thermal energy Resources, types of wells, methods of harnessing the energy, potential in India. OTEC, Principles utilization, setting of OTEC plants, thermodynamic cycles. Tidal and wave energy: Potential and conversion techniques, mini-hydel power plants and their economics.

TOTAL: 45 PERIODS

OUTCOME:

- This subject gives a brief knowledge about the various renewable energy technologies and their applications.

REFERENCES:

1. Non-Conventional Energy Sources /G.D. Rai, Khanna Publishers
2. Renewable Energy Resources – Twidell & Wier, CRC Press(Taylor & Francis)
3. Renewable energy resources/ Tiwari and Ghosal/ Narosa.
4. Renewable Energy Technologies /Ramesh & Kumar /Narosa
5. Non-Conventional Energy Systems / K Mittal /Wheeler
6. Renewable energy sources and emerging technologies by D.P.Kothari, K.C.Singhal, P.H.I.

PW7072 ELECTRIC VEHICLES AND POWER MANAGEMENT L T P C

3 0 0 3

COUSE OBJECTIVE:

- To understand the concept of electrical vehicles and its operations
- To understand the need for energy storage in hybrid vehicles
- To provide knowledge about various possible energy storage technologies that can be used in electric vehicles

UNIT I ELECTRIC VEHICLES AND VEHICLE MECHANICS 9

Electric Vehicles (EV), Hybrid Electric Vehicles (HEV), Engine ratings, Comparisons of EV with internal combustion Engine vehicles, Fundamentals of vehicle mechanics

UNIT II ARCHITECTURE OF EV's AND POWER TRAIN COMPONENTS 9

Architecture of EV's and HEV's – Plug-n Hybrid Electric Vehicles (PHEV)- Power train components and sizing, Gears, Clutches, Transmission and Brakes

UNIT III CONTROL OF DC AND AC DRIVES 9

DC/DC chopper based four quadrant operations of DC drives – Inverter based V/f Operation (motoring and braking) of induction motor drive system – Induction motor and permanent motor based vector control operation – Switched reluctance motor (SRM) drives

UNIT IV BATTERY ENERGY STORAGE SYSTEM 9

Battery Basics, Different types, Battery Parameters, Battery modeling, Traction Batteries

UNIT V ALTERNATIVE ENERGY STORAGE SYSTEMS 9

Fuel cell – Characteristics- Types – hydrogen Storage Systems and Fuel cell EV – Ultra capacitors

TOTAL: 45 PERIODS

OUTCOME:

- This course equip the student to understand the operation of Electric vehicles and various energy storage technologies for electrical vehicles.

REFERENCES

1. Iqbal Hussain, CRC Press, Taylor & Francis Group, Second Edition (2011).
2. Ali Emadi, Mehrdad Ehsani, John M.Miller Vehicular Electric Power Systems, Special Indian Edition, Marcel dekker, Inc 2010

ET7152 MICROCONTROLLER BASED SYSTEM DESIGN L T P C

4 0 0 4

COURSE OBJECTIVES

- To introduce the fundamentals of microcontroller based system design.
- To teach I/O and RTOS role on microcontroller.
- To know Microcontroller based system design, applications.
- To teach I/O interface in system Design
- To involve Discussions/ Practice/Exercise onto revising & familiarizing the concepts acquired over the 5 Units of the subject for improved employability skills

UNIT I 8051 ARCHITECTURE 9

Architecture – memory organization – addressing modes – instruction set – Timers - Interrupts - I/O ports, Interfacing I/O Devices – Serial Communication.

UNIT II 8051 PROGRAMMING 12

Assembly language programming – Arithmetic Instructions – Logical Instructions –Single bit Instructions – Timer Counter Programming – Serial Communication Programming Interrupt Programming – RTOS for 8051 – RTOSLite – FullRTOS – Task creation and run – LCD digital clock/thermometer using FullRTOS

UNIT III PIC MICROCONTROLLER 12

Architecture – memory organization – addressing modes – instruction set – PIC progrmming in Assembly & C –I/O port, Data Conversion, RAM & ROM Allocation, Timer programming, practice in MP-LAB.

UNIT IV PERIPHERAL OF PIC MICROCONTROLLER 12

Timers – Interrupts, I/O ports- I2C bus-A/D converter-UART- CCP modules -ADC, DAC and Sensor Interfacing –Flash and EEPROM memories.

UNIT V SYSTEM DESIGN – CASE STUDY 15

Interfacing LCD Display – Keypad Interfacing - Generation of Gate signals for converters and Inverters - Motor Control – Controlling DC/ AC appliances – Measurement of frequency - Stand alone Data Acquisition System.

Note : Discussions/Practice on Workbench : 8051/PIC/ATMEL/other Microcontroller based Assembly/C language programming – Arithmetic Programming– Timer Counter Programming – Serial Communication- Programming Interrupt –use of RTOS basis in Task creation and run – Keil IDE Basics-LCD digital clock/thermometer- Motor Control

TOTAL : 60 PERIODS

COURSE OUTCOME:

- The learning process delivers insight into involving the capacities of a programmable microcontroller for system interface & automation of processes with improved design strategies.
- Improved Employability and entrepreneurship capacity due to knowledge up gradation on recent trends in embedded systems design.

REFERENCES:

1. Muhammad Ali Mazidi, Rolin D. Mckinlay, Danny Causey ' PIC Microcontroller and Embedded Systems using Assembly and C for PIC18', Pearson Education 2008
2. Rajkamal,"Microcontrollers Architecture, Programming,Interfacing,&System Design,Pearson, 2012
3. Myke Predko, "Programming and customizing the 8051 microcontroller", Tata Mc Graw Hill 2001.
4. Muhammad Ali Mazidi,Sarmad Naimi,Sepehr Naimi," The AVR Microcontroller and Embedded Systems' Using Assembly & C, Pearson Education,2014
5. Muhammad Ali Mazidi, Janice G. Mazidi and Rolin D. McKinlay, 'The 8051 Microcontroller and Embedded Systems' Prentice Hall, 2005.
6. John Iovine, 'PIC Microcontroller Project Book ', McGraw Hill 2000

PE7152 ANALYSIS OF ELECTRICAL MACHINES LT P C
3 0 0 3

OBJECTIVES:

- To provide knowledge about the fundamentals of magnetic circuits, energy, force and torque of multi-excited systems.
- To analyze the steady state and dynamic state operation of DC machine through mathematical modeling and simulation in digital computer.
- To provide the knowledge of theory of transformation of three phase variables to two phase variables.
- To analyze the steady state and dynamic state operation of three-phase induction

- machines using transformation theory based mathematical modeling and digital computer simulation.
- To analyze the steady state and dynamic state operation of three-phase synchronous machines using transformation theory based mathematical modeling and digital computer simulation.

UNITI PRINCIPLES OF ELECTROMAGNETIC ENERGY CONVERSION 9

Magnetic circuits, permanent magnet, stored magnetic energy, co-energy - force and torque in singly and doubly excited systems – machine windings and air gap mmf - winding inductances and voltage equations.

UNIT II DC MACHINES 9

Elementary DC machine and analysis of steady state operation - Voltage and torque equations – dynamic characteristics of permanent magnet and shunt d.c. motors – Time domain block diagrams - solution of dynamic characteristic by Laplace transformation – digital computer simulation of permanent magnet and shunt d.c. machines.

UNIT III REFERENCE FRAME THEORY 9

Historical background – phase transformation and commutator transformation – transformation of variables from stationary to arbitrary reference frame - variables observed from several frames of reference.

UNIT IV INDUCTION MACHINES 9

Three phase induction machine, equivalent circuit and analysis of steady state operation – free acceleration characteristics – voltage and torque equations in machine variables and arbitrary reference frame variables – analysis of dynamic performance for load torque variations – digital computer simulation.

UNIT V SYNCHRONOUS MACHINES 9

Three phase synchronous machine and analysis of steady state operation - voltage and torque equations in machine variables and rotor reference frame variables (Park's equations) – analysis of dynamic performance for load torque variations – digital computer simulation.

TOTAL : 45 PERIODS

OUTCOMES:

- Ability to acquire and apply knowledge of mathematics and converter/machine dynamics in Electrical engineering.
- Ability to model and analyze power electronic systems and equipment using computational software.
- Ability to formulate, design, simulate power supplies for generic load and for machine loads.
- Ability to optimally design magnetics required in power supplies and drive systems.

TEXT BOOKS

1. Paul C.Krause, Oleg Wasyzczuk, Scott S, Sudhoff, "Analysis of Electric Machinery and Drive Systems", John Wiley, Second Edition, 2010.

REFERENCES

1. P S Bimbhra, "Generalized Theory of Electrical Machines", Khanna Publishers, 2008.
2. A.E, Fitzgerald, Charles Kingsley, Jr, and Stephan D, Umanx, " Electric Machinery", Tata McGraw Hill, 5th Edition, 1992.

PW7075 SUSTAINABLE ENERGY UTILZATION L T P C

3 0 0 3

COURSE OBJECTIVE:

- To understand the need of energy in building
- To study the heat flow calculations in building
- To understand the passive cooling/heating concept
- To provide knowledge about energy efficient building and electric energy conservation in buildings

UNIT I HEAT FLOW CALCULATION IN BUILDING 9

Unsteady heat flows through walls, roof, windows etc. Direct heat gains through windows. Convective gains/losses, air exchange rates. Gains from people, appliances etc. Air conditioning load calculations

UNIT II NEED OF ENERGY IN BUILDINGS 9

Role of building design and building services to evaluate the energy performance in buildings. Study of Climate and its influence in building design for energy requirement - Environmental science of buildings - Study of Thermal environment and visual environment - Heat gain and heal loss phenomenon of buildings - Role of building enclosures, openings and materials in thermal environment -Energy efficient light design of buildings - Design for visual environment. Energy rating of buildings - Description of different components of HVAC Passive and low energy concepts and applications.

UNIT III PASSIVE COOLING / HEATING CONCEPTS 9

Building form and orientation, internal and external shading devices, ventilation, passive concepts for composite climates, evaporative and nocturnal cooling, earth–air tunnel, sky-therm system, and solar chimney-based hybrid system. Introduction and use of different building simulation software such as TRNSYS, ECOTECT etc.- Case studies of non-air conditioned buildings- Case studies of air conditioned buildings

UNIT IV ENERGY EFFICIENT BUILDINGS 9

Introduction - Definition and concepts, Energy and Water as a resource,- Criticality of resources and needs of modern living - Envelop heat loss and heat gain and its evaluation, Thermal Comport improvement methods, Optimum performance, other building comports, IAQ requirements.

UNIT V ELECTRICAL ENERGY CONVERSION 9

Opportunities and Techniques for energy conservation in Buildings - Adoption to sustainable resources, process and Technologies. Green Buildings, Intelligent Buildings, Rating of Buildings, Efficient Use of Buildings, Solar Passive Architecture, Eco-housing concepts and National and International norms.

TOTAL : 45 PERIODS

OUTCOMES:

- This course equips students to know about need of energy in building and various conservation techniques to use energy in sustainable manner.

REFERENCES

1. Koenigsberger, et.al Manual of Tropical housing and Building Longman Group Ltd London (now published by Orient Longman Ltd, Madras, India),1974
2. Oliver and Daniel, D Chiras Natural Resource Conservation Management for a sustainable future, Prentice Hall International Ltd, London, 1992
3. USAID International resource book, Energy Conservation Building design Tip Sheet - Building Lighting Design,
4. MS Sodha, NK Bansal, PK Bansal, A Kumar and MAS Malik, Solar Passive Building, Science and Design, Pergamon Press, 1986
5. JR Williams, Passive Solar Heating, Ann Arbar Science, 1983

6. RWJones, JD Balcomb, CE Kosiewiez, GS Lazarus, RD McFarland and WOWray, Passive Solar Design Handbook, Vol 3, Report of US Department of Energy (DOE/CS-0127/3), 1982
7. J Krieder and A Rabi, Heating and Cooling of Buildings: Design for Efficiency, McGraw-Hill, 1994
8. RD Brown, TJ Gillespie, Microclimatic Landscape Design, John Wiley and Sons, New York, 1990
9. TA Markus, EN Morris, Building, Climate and Energy, Spottwoode Ballantype Ltd, London, 1980

PW7151 DISTRIBUTION SYSTEMS MANAGEMENT AND AUTOMATION L T P C

3 0 0 3

COURSE OBJECTIVE:

- To provide knowledge about management of distribution system and distribution automation
- To gain knowledge about planning and designing of distribution system
- To analyze power quality in distribution system

UNIT I INTRODUCTION 9

Overview of the distribution system, Importance of Distribution Systems, the Differences of Power Supply between Urban and Rural Area, Distribution system Consumer Classification

UNIT II DISTRIBUTION SYSTEM PLANNING 9

Factors effecting planning, present techniques, planning models(Short term planning, long term planning and dynamic planning), planning in the future, future nature of distribution planning, Role of computer in Distribution planning. Load forecast, Load characteristics and Load models.

UNIT III DISTRIBUTION SYSTEM DESIGN 9

Types of sub- transmission, Distribution substation, bus schemes, substation location, rating of substation, calculation of voltage drops with primary feeders and secondary feeders, uniformly distributed load and Non uniformly distributed load.

UNIT IV POWER QUALITY AND DISTRIBUTION SYSTEM PERFORMANCE ANALYSIS 9

Power quality problems in distribution systems, Power quality study as per IEEE and IEC standards, Distribution Feeder Analysis – the ladder Iterative technique, Power loss calculations and control measures. Distribution system voltage regulation: voltage control, Application of capacitors in Distribution system. Case study on TNEB distribution system

UNIT V DISTRIBUTION AUTOMATION 9

Definitions, Distribution automation planning, communication, Wireless and wired Communications- DA Communication Protocols, Architectures and user interface, sensors, Supervisory Control and Data Acquisition Systems (SCADA), Case Studies

TOTAL : 45 PERIODS

OUTCOMES:

- This course will equip students to have basic knowledge in distribution system management and automation and will enhance their capability of planning and designing of distribution system.

REFERENCES:

1. James Northcote – Green, Robert Wilson, "Control and Automation of Electrical Power Distribution Systems", CRC Press, New York, 2007.
2. Turan Gonen: .Electric Power Distribution System Engineering. McGraw Hill Company. 1986
3. M.V Deshpande: .Electrical Power System Design. Tata-McGraw Hill, 1966
4. IEEE Press: IEEE Recommended practice for Electric Power Distribution for Industrial Plants, published by IEEE, Inc., 1993
5. Pansini, Electrical Distribution Engineering, The Fairmont Press, Inc., 2007
6. Pabla H S.: .Electrical Power Distribution Systems.. Tata McGraw Hill. 2004
7. IEEE Standerd 739. Recommended Practice for Energy Conservation and Cost Effective Planning in Industrial Facilities. 1984
8. G H Heydt .Electric Power Quality. McGram Hill, 2007 Wilson K. Kazibwe and Musoke H Semdaula .Electric Power Quality Control Techniques.. Van Nostarand Reinhold New York, 2006

PW7071 CLIMATE CHANGE AND ENERGY ENVIRONMENT L T P C
3 0 0 3

COURSE OBJECTIVE:

- To provide knowledge about climate change and its environmental impact
- To provide knowledge about technology and policy options for GHG emission
- To provide knowledge about international climate change conventions, protocols and perspectives

UNIT I CLIMATE CHANGE 9

Energy use and Global Warming, Climate Change Concerns, Climate Change in India, the Greenhouse Effect, Earth's Radiation balance, Greenhouse Gases (GHG) types and Sources, Climate Change Impacts

UNIT II TECHNOLOGY AND POLICY OPTIONS FOR GHG EMISSION MITIGATION 9

Renewable Energy, Energy Efficient Technologies by Sector and End-Use, Cleaner Production, Barriers to GHG Mitigation Technologies, Carbon tax and Tradable Emission Permits, Other Policy Options

UNIT III INTERNATIONAL CLIMATE CHANGE CONVENTIONS, PROTOCOLS AND PERSPECTIVES 9

Climate Change in India and mitigation measures on Indian perspectives, United Nations Framework Convention on Climate Change (UNFCCC), Clean Development Mechanism (CDM) as per the Kyoto Protocol and Flexible Mechanisms, comparison on India vs developed countries perspectives on GHG mitigations

UNIT IV ENVIRONMENTAL PROBLEMS RELATED TO ENERGY USE 9

Energy use and its air pollution, acid rain, Technological and policy options for control of SO2 and NOx emissions, the problem of Atmospheric Brown Cloud (ABC) and possible mitigation options

UNIT V URBAN ENERGY USE AND THE ENVIRONMENT 9

Efficient/cleaner transport options of electric vehicles and their effects on energy use, environment and GHG emissions, other options to improve energy use and environment in urban areas.

TOTAL: 45 PERIODS

OUTCOME:

- This course provides brief knowledge about climate change and its environmental impact and provides knowledge about technologies and policy options to overcome the impact of climate change.

REFERENCES

1. R. T. Watson, M. C. Zinyowera, and R. H. Moss (eds.): Technologies, Policies, and Measures for Mitigating Climate Change, IPCC Technical Paper No. 1, Intergovernmental Panel on Climate Change, 1996.
2. L. D. D. Harvey: Climate and Global Environmental Change, Prentice Hall, 2000.
3. W. D. Nordhaus: Managing the Global Commons: The Economics of Climate Change, The MIT Press, Cambridge, USA, 1994.
4. C.S.Pearson: Economics and the Global Environment, Cambridge University Press, Cambridge, UK, 2000.
5. W.R. Cline: The Economics of Global Warming, Institute for International Economics, Washington, D.C., 1992.
6. United Nations Framework Convention on Climate Change (UNFCCC), Kyoto Protocol to the United Nations Framework Convention on Climate Change, 1998.
7. Intergovernmental Panel on Climate Change (IPCC), Special Report on Emission Scenarios, Cambridge University Press, Cambridge, 2000.
8. M. Grubb, C. Vrolijk and D. Brack: The Kyoto Protocol, Earthscan, London, 1999
9. UNEP and C4, The Asian Brown Cloud: Climate and Other Environmental Impacts, UNEP, Nairobi, 2002

PW7074 ENERGY ECONOMICS, FINANCING, REGULATION AND ENERGY MODELING **L T P C 3 0 0 3**

COURSE OBJECTIVE:

To provide knowledge about importance of energy economics

- To give an overview about the energy policies, energy planning and policy making in india
- To model and analyze the energy demand

UNIT I INTRODUCTION **9**

Law of demand, Elasticity of demand, Theory of firm: Production function, output maximization, cost minimization and profit maximization principles. Theory of market, National income and other macroeconomic parameters; Integrated framework for energy pricing, basic pricing principles, short run versus long run marginal cost pricing, peak load and seasonal pricing. Energy Prices and Markets, Pricing of Exhaustible Resources, Economic regulation of energy markets.

UNIT II BASIC CONCEPTS OF ENERGY ECONOMICS **9**

Calculation of unit cost of power generation from different sources with examples Ground rules for investment in Energy sector, Payback period, NPV, IRR and Benefit-cost analysis with

example Investment in Energy Resources: Economics of discount rate, concept of net present value, incremental costs and benefits, cash flow analysis, private and social costs Discussion on investing in energy projects, financial and economic analysis of energy technologies, short run and long run implications of conventional energy systems,

UNIT III SOCIO-ECONOMIC EVALUATION OF ENERGY CONSERVATION PROGRAMMES 9

Net Social Benefit incorporating- Free riding concept and Rebound affects Energy-GDP elasticity,

UNIT IV OVERVIEW OF ENERGY POLICIES, ENERGY PLANNING AND POLICY MAKING IN INDIA 9

National energy policy in the last plan periods, Energy use and Energy supply, Overview of renewable energy policy and the Five Year Plan programmes, Basic concept of Input-Output analysis, Concept of energy multiplier and implication of energy multiplier for analysis of regional and national energy policy Organizational structure, key developments and changes in India's energy policies and planning in the context of energy efficiency and environmental concerns, regulatory frameworks and reforms across various energy sectors, success stories, failures and lessons learnt.

UNIT V MODELS AND ANALYSIS OF ENERGY DEMAND 9

Analysis of Environmental Pollution through decomposition of different sectors using I-O model, Interdependence of energy, economy and environment, Modeling concepts and application of SIMA model and I-O model for energy policy analysis, Simulation and forecasting of future energy demand consistent with macroeconomic parameters in India. Basic concept of Econometrics (OLS) and statistical analysis (Multiple Regression), Econometrics techniques used for energy analysis and forecasting with case studies from India Economy-Energy-Environment Modeling Quantitative modeling frameworks, review of various energy sector models, concepts in modeling energy resources, technological developments; Energy modeling in the context of climate change

TOTAL: 45 PERIODS

OUTCOME:

- This course gives an overview about the energy economics, energy planning, energy policies and energy demand.

REFERENCES

1. EA Diulio, Macroeconomic Theory, Schaum's Outline Series, 2nd Ed, McGraw-Hill Publishing Company (1990)
2. R Loulou, P R Shukla and A Kanudia, Energy and Environment Policies for a sustainable Future, Allied Publishers Ltd, New Delhi, 1997
3. J Parikh, Energy Models for 2000 and Beyond, Tata McGraw-Hill Publishing Company Ltd, New Delhi,1997
4. "Energy," Science, Vol. 285, No. 5427 (30 July 1999), pp. 677-711.
5. Adelman, M.A. (2002): "World Oil Production and Prices 1947-2000," The Quarterly Review of Economics and Finance, 42: 169-191.
6. Barretto, L., A. Makihira and K. Riahi (2003): "The hydrogen economy in the 21st century: a sustainable development scenario," International Journal of Hydrogen Energy, 28: 267-284.
7. Ben Esty and Michael Kane. 2001. "Calpine Corp: The Evolution from Project to Corporate Finance," Harvard Business School Case: 201098.
8. Bentley, R.W. (2002): "Global oil & gas depletion: an overview," Energy Policy, 30: 189-205
9. Bohi, D. P. (1981): Analyzing Demand Behavior: A Study of Energy Elasticities, Johns Hopkins University Press.

HV7002 POLLUTION PERFORMANCE OF POWER APPARATUS AND SYSTEMS **L T P C**
3 0 0 3

OBJECTIVE:

To provide in-depth knowledge on

- the mechanism and effect of pollution
- types and procedure of pollution testing
- the pollution performance of insulators, surge diverters and indoor equipment.

UNIT I INTRODUCTION 9

Fundamental process of pollution flashover – development and effect of contamination layer – creepage distance – pollution conductivity – mechanism of pollution flashover – analytical determination of flashover voltage.

UNIT II POLLUTION TESTING 9

Artificial pollution testing – salt-fog method – solid layer method – monitoring of parameters – measurement of layer conductivity – field testing methods.

UNIT III POLLUTION PERFORMANCE OF INSULATORS 9

Ceramic and non-ceramic insulators – design of shed profiles – rib factor effect in AC and DC insulators – modeling.

UNIT IV POLLUTION PERFORMANCE OF SURGE DIVERTERS 9

External insulation – effect of pollution on the protective characteristics of gap and gapless arresters – modeling of surge diverters under polluted conditions.

UNIT V POLLUTION PERFORMANCE OF INDOOR EQUIPMENT 9

Condensation and contamination of indoor switch gear – performance of organic insulator under polluted conditions – accelerated testing techniques.

TOTAL : 45 PERIODS

OUTCOME:

- Awareness towards different types of pollution tests.
- The students are expected to design HV equipment for substations and transmission lines at different polluted regions.

REFERENCES

1. Kind and Karner, “High Voltage Insulation”, Translated from German by Y.Narayana Rao, Frider. Vieweg, & Sohn, Braunschweig, Weishaden, 1985.
2. Kuffel, E., Zaengl, W.S. and Kuffel J., “High Voltage Engineering Fundamentals”, Elsvier India Pvt. Ltd, 2005.
3. Klaus Ragaller, “Surges in High Voltage Networks”, Plenum Press, New York, 1980.
4. Looms, J.S.T., “Insulators for High Voltages”, Peter Peregrinus Ltd., London, 1988.
5. Dieter Kind and Kurt Feser, “High Voltage Test Techniques”, Second Edition, SBA Electrical Engineering Series, New Delhi, 1999.
6. Ravi S. Gorur, “Outdoor Insulators”, Inc. Phoenix, Arizona 85044, USA, 1999

HV7073 ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY **L T P C 3 0 0 3**

OBJECTIVE:

- To provide fundamental knowledge on electromagnetic interference and electromagnetic compatibility.
- To study the important techniques to control EMI and EMC.
- To expose the knowledge on testing techniques as per Indian and international standards in EMI measurement.

UNIT I INTRODUCTION 9

Definitions of EMI/EMC -Sources of EMI- Intersystems and Intrasystem- Conducted and radiated interference- Characteristics - Designing for electromagnetic compatibility (EMC)- EMC regulation- typical noise path- EMI predictions and modeling, Cross talk - Methods of eliminating interferences.

UNIT II GROUNDING AND CABLING 9

Cabling- types of cables, mechanism of EMI emission / coupling in cables –capacitive couplinginductive coupling- shielding to prevent magnetic radiation- shield transfer impedance, Grounding – safety grounds – signal grounds- single point and multipoint ground systemshybrid grounds- functional ground layout –grounding of cable shields- -guard shields- isolation, neutralizing transformers, shield grounding at high frequencies, digital grounding- Earth measurement Methods

UNIT III BALANCING, FILTERING AND SHIELDING 9

Power supply decoupling- decoupling filters-amplifier filtering –high frequency filtering- EMI filters characteristics of LPF, HPF, BPF, BEF and power line filter design -Choice of capacitors, inductors, transformers and resistors, EMC design components -shielding – near and far fieldsshielding effectiveness- absorption and reflection loss- magnetic materials as a shield, shield discontinuities, slots and holes, seams and joints, conductive gaskets-windows and coatings - grounding of shields

UNIT IV EMI IN ELEMENTS AND CIRCUITS 9

Electromagnetic emissions, noise from relays and switches, non-linearities in circuits, passive inter modulation, transients in power supply lines, EMI from power electronic equipment, EMI as combination of radiation and conduction

UNIT V ELECTROSTATIC DISCHARGE, STANDARDS AND TESTING TECHNIQUES 9

Static Generation- human body model- static discharges- ESD versus EMC, ESD protection in equipments- standards – FCC requirements – EMI measurements – Open area test site measurements and precautions- Radiated and conducted interference measurements, Control requirements and testing methods

TOTAL : 45 PERIODS

OUTCOME:

- Awareness towards the EMI/EMC in elements and circuits.
- Ability to design and analyze the filtering circuits for the reduction of EMI
- To design and implement the test setup

REFERENCES

1. V.P. Kodali, “Engineering Electromagnetic Compatibility”, S. Chand, 1996.
2. Henry W.Ott, “ Noise reduction techniques in electronic systems”, John Wiley & Sons, 1989.
3. Bernhard Keiser, “Principles of Electro-magnetic Compatibility”, Artech House, Inc. (685 canton street, Norwood, MA 020062 USA) 1987.
4. Bridges, J.E Milleta J. and Ricketts.L.W., “EMP Radiation and Protective techniques”, John Wiley and sons, USA 1976.
5. William Duff G., & Donald White R. J, “Series on Electromagnetic Interference and Compatibility”, Vol.
6. Weston David A., “Electromagnetic Compatibility, Principles and Applications”, 1991.

PE7073 POWER QUALITY LT P C
3 0 0 3

OBJECTIVES :

- To understand the various power quality issues.
- To understand the concept of power and power factor in single phase and three phase systems supplying non linear loads
- To understand the conventional compensation techniques used for power factor correction and load voltage regulation.
- To understand the active compensation techniques used for power factor correction.
- To understand the active compensation techniques used for load voltage regulation.

UNIT I INTRODUCTION 9

Introduction – Characterisation of Electric Power Quality: Transients, short duration and long duration voltage variations, Voltage imbalance, waveform distortion, Voltage fluctuations, Power frequency variation, Power acceptability curves – power quality problems: poor load power factor, Non linear and unbalanced loads, DC offset in loads, Notching in load voltage,
Disturbance in supply voltage – Power quality standards.

UNIT II ANALYSIS OF SINGLE PHASE AND THREE PHASE SYSTEM 9

Single phase linear and non linear loads – single phase sinusoidal, non sinusoidal source – supplying linear and nonlinear load – three phase Balance system – three phase unbalanced system – three phase unbalanced and distorted source supplying non linear loads – concept of pf – three phase three wire – three phase four wire system.

UNIT III CONVENTIONAL LOAD COMPENSATION METHODS 9

Principle of load compensation and voltage regulation – classical load balancing problem : open loop balancing – closed loop balancing, current balancing – harmonic reduction and voltage sag reduction – analysis of unbalance – instantaneous of real and reactive powers – Extraction of fundamental sequence component from measured.

UNIT IV LOAD COMPENSATION USING DSTATCOM 9

Compensating single – phase loads – Ideal three phase shunt compensator structure – generating reference currents using instantaneous PQ theory – Instantaneous symmetrical components theory – Generating reference currents when the source is unbalanced – Realization and control of STATCOM – DSTATCOM in Voltage control mode

UNIT V SERIES COMPENSATION OF POWER DISTRIBUTION SYSTEM 9

Rectifier supported DVR – Dc Capacitor supported DVR – DVR Structure – voltage Restoration – Series Active Filter – Unified power quality conditioner.

TOTAL : 45 PERIODS

OUTCOME:

- Ability to formulate, design, simulate power supplies for generic load and for machine loads.
- Ability to conduct harmonic analysis and load tests on power supplies and drive systems.
- Ability to understand and design load compensation methods useful for mitigating power quality problems.

TEXT BOOKS

1. ArindamGhosh “Power Quality Enhancement Using Custom Power Devices”, Kluwer Academic Publishers, 2002
2. G.T.Heydt, “Electric Power Quality”, Stars in a Circle Publications, 1994(2nd edition)
3. Power Quality - R.C. Duggan
4. Power system harmonics –A.J. Arrillga
5. Power Electronic Converter Harmonics –Derek A. Paice

PS7253 FLEXIBLE AC TRANSMISSION SYSTEMS L T P C

3 0 0 3

COURSE OBJECTIVES

- To emphasis the need for FACTS controllers.
- To learn the characteristics, applications and modelling of series and shunt FACTS controllers.
- To analyze the interaction of different FACTS controller and perform control coordination

UNIT I INTRODUCTION 9

Review of basics of power transmission networks-control of power flow in AC transmission line- Analysis of uncompensated AC Transmission line- Passive reactive power compensation: Effect of series and shunt compensation at the mid-point of the line on power transfer- Need for FACTS controllers- types of FACTS controllers.

UNIT II STATIC VAR COMPENSATOR (SVC) 9

Configuration of SVC- voltage regulation by SVC- Modelling of SVC for load flow analysis- Modelling of SVC for stability studies-Design of SVC to regulate the mid-point voltage of a SMIB system- Applications: transient stability enhancement and power oscillation damping of SMIB system with SVC connected at the mid-point of the line.

UNIT III THYRISTOR AND GTO THYRISTOR CONTROLLED SERIES CAPACITORS (TCSC and GCSC) 9

Concepts of Controlled Series Compensation – Operation of TCSC and GCSC- Analysis of TCSC-GCSC – Modelling of TCSC and GCSC for load flow studies- modelling TCSC and GCSC for stability studied- Applications of TCSC and GCSC

UNIT IV VOLTAGE SOURCE CONVERTER BASED FACTS CONTROLLERS 9

Static synchronous compensator(STATCOM)- Static synchronous series compensator(SSSC)- Operation of STATCOM and SSSC-Power flow control with STATCOM and SSSC- Modelling of STATCOM and SSSC for power flow and transient stability studies –operation of Unified and Interline power flow controllers(UPFC and IPFC)- Modelling of UPFC and IPFC for load flow and transient stability studies- Applications.

UNIT V CONTROLLERS AND THEIR COORDINATION 9

FACTS Controller interactions – SVC–SVC interaction - co-ordination of multiple controllers using linear control techniques – Quantitative treatment of control coordination.

TOTAL : 45 PERIODS

OUTCOMES

- Learners will be able to refresh on basics of power transmission networks and need for FACTS controllers
- Learners will be able to explain about static var compensator in detail
- Learners will attain knowledge about Controlled Series Compensation
- Learners will understand the significance about different voltage source converter based facts controllers
- Learners will be able to analyze on FACTS controller interaction and control coordination

TEXT BOOKS

1. Mohan Mathur, R., Rajiv. K. Varma, "Thyristor – Based Facts Controllers for Electrical Transmission Systems", IEEE press and John Wiley & Sons, Inc.
2. K.R.Padiyar," FACTS Controllers in Power Transmission and Distribution", New Age International(P) Ltd., Publishers, New Delhi, Reprint 2008,

REFERENCES:

1. A.T.John, "Flexible AC Transmission System", Institution of Electrical and Electronic Engineers (IEEE), 1999.
2. Narain G.Hingorani, Laszio. Gyugyl, "Understanding FACTS Concepts and Technology of Flexible AC Transmission System", Standard Publishers, Delhi 2001.
3. V.K.Sood, "HVDC and FACTS controllers- Applications of Static Converters in Power System", 2004, Kluwer Academic Publishers.

PS7254 RESTRUCTURED POWER SYSTEM L T P C
3 0 0 3

COURSE OBJECTIVES

- To introduce the restructuring of power industry and market models.
- To impart knowledge on fundamental concepts of congestion management.
- To analyze the concepts of locational marginal pricing and financial transmission rights.
- To Illustrate about various power sectors in India

UNIT I INTRODUCTION TO RESTRUCTURING OF POWER INDUSTRY 9

Introduction: Deregulation of power industry, Restructuring process, Issues involved in deregulation, Deregulation of various power systems – Fundamentals of Economics: Consumer behavior, Supplier behavior, Market equilibrium, Short and long run costs, Various

costs of production – Market models: Market models based on Contractual arrangements, Comparison of various market models, Electricity vis – a – vis other commodities, Market architecture, Case study.

UNIT II TRANSMISSION CONGESTION MANAGEMENT 9

Introduction: Definition of Congestion, reasons for transfer capability limitation, Importance of congestion management, Features of congestion management – Classification of congestion management methods – Calculation of ATC - Non – market methods – Market methods – Nodal pricing – Inter zonal and Intra zonal congestion management – Price area congestion management – Capacity alleviation method.

UNIT III LOCATIONAL MARGINAL PRICES AND FINANCIAL TRANSMISSION RIGHTS 9

Mathematical preliminaries: - Locational marginal pricing– Lossless DCOPF model for LMP calculation – Loss compensated DCOPF model for LMP calculation – ACOPF model for LMP calculation – Financial Transmission rights – Risk hedging functionality - Simultaneous feasibility test and revenue adequency – FTR issuance process: FTR auction, FTR allocation – Treatment of revenue shortfall – Secondary trading of FTRs – Flow gate rights – FTR and market power - FTR and merchant transmission investment.

UNIT IV ANCILLARY SERVICE MANAGEMENT AND PRICING OF TRANSMISSION NETWORK 9

Introduction of ancillary services – Types of Ancillary services – Classification of Ancillary services – Load generation balancing related services – Voltage control and reactive power support devices – Black start capability service - How to obtain ancillary service –Co-optimization of energy and reserve services - International comparison Transmission pricing – Principles – Classification – Rolled in transmission pricing methods – Marginal transmission pricing paradigm – Composite pricing paradigm – Merits and demerits of different paradigm.

UNIT V REFORMS IN INDIAN POWER SECTOR 9

Introduction – Framework of Indian power sector – Reform initiatives - Availability based tariff – Electricity act 2003 – Open access issues – Power exchange – Reforms in the near future

TOTAL: 45 PERIODS

OUTCOMES

- Learners will have knowledge on restructuring of power industry
- Learners will understand basics of congestion management
- Learners will attain knowledge about locational margin prices and financial transmission rights
- Learners will understand the significance ancillary services and pricing of transmission network
- Learners will have knowledge on the various power sectors in India

TEXT BOOKS

1. Mohammad Shahidehpour, Muwaffaq Alomoush, Marcel Dekker, "Restructured electrical power systems: operation, trading and volatility" Pub., 2001

2. Kankar Bhattacharya, Jaap E. Daadler, Math H.J. Boolen," Operation of restructured power systems", Kluwer Academic Pub., 2001.

REFERENCES

1. Sally Hunt," Making competition work in electricity", , John Willey and Sons Inc. 2002
2. Steven Stoft," Power system economics: designing markets for electricity", John Wiley & Sons, 2002.

PS7255 **SMART GRIDS** **L T P C**
3 0 0 3

COURSE OBJECTIVES

- To Study about Smart Grid technologies, different smart meters and advanced metering infrastructure.
- To familiarize the power quality management issues in Smart Grid.
- To familiarize the high performance computing for Smart Grid applications

UNIT I INTRODUCTION TO SMART GRID 9

Evolution of Electric Grid, Concept, Definitions and Need for Smart Grid, Smart grid drivers, functions, opportunities, challenges and benefits, Difference between conventional & Smart Grid, National and International Initiatives in Smart Grid.

UNIT II SMART GRID TECHNOLOGIES (Transmission) 9

Technology Drivers, Smart energy resources, Smart substations, Substation Automation, Feeder Automation ,Transmission systems: EMS, FACTS and HVDC, Wide area monitoring, Protection and control

UNIT III SMART GRID TECHNOLOGIES (Distribution) 9

DMS, Volt/VAr control,Fault Detection, Isolation and service restoration, Outage management, High-Efficiency Distribution Transformers, Phase Shifting Transformers, Plug in Hybrid Electric Vehicles (PHEV).

UNIT IV SMART METERS AND ADVANCED METERING INFRASTRUCTURE 9

Introduction to Smart Meters, Advanced Metering infrastructure (AMI) drivers and benefits, AMI protocols, standards and initiatives, AMI needs in the smart grid, Phasor Measurement Unit(PMU), Intelligent Electronic Devices(IED) & their application for monitoring & protection.

UNIT V HIGH PERFORMANCE COMPUTING FOR SMART GRID APPLICATIONS 9

Local Area Network (LAN), House Area Network (HAN), Wide Area Network (WAN), Broadband over Power line (BPL), IP based Protocols, Basics of Web Service and CLOUD Computing to make Smart Grids smarter, Cyber Security for Smart Grid.

TOTAL : 45 PERIODS

OUTCOMES

- Students will develop more understanding on the concepts of Smart Grid and its present developments.
- Students will study about different Smart Grid technologies.
- Students will acquire knowledge about different smart meters and advanced metering infrastructure.
- Students will have knowledge on power quality management in Smart Grids
- Students will develop more understanding on LAN, WAN and Cloud Computing for Smart Grid applications.

TEXT BOOKS

1. Stuart Borlase “Smart Grid :Infrastructure, Technology and Solutions”,CRC Press 2012.
2. Janaka Ekanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama, “Smart Grid: Technology and Applications”, Wiley.

REFERENCES*:*

1. Vehbi C. Güngör*,* DilanSahin, TaskinKocak, Salih Ergüt, Concettina Buccella*,* Carlo Cecati*,* and Gerhard P. Hancke*,* Smart Grid Technologies: Communication Technologies and Standards IEEE Transactions On Industrial Informatics, Vol. 7, No. 4, November 2011.
2. Xi Fang, Satyajayant Misra, Guoliang Xue, and Dejun Yang "Smart Grid – The New and Improved Power Grid: A Survey" , IEEE Transaction on Smart Grids,

PS7252	ANALYSIS AND COMPUTATION OF ELECTROMAGNETIC TRANSIENTS IN POWER SYSTEMS	L T P C 3 0 0 3

COURSE OBJECTIVE

- To impart knowledge on the travelling wave phenomena
- To impart knowledge on the modeling of overhead lines, underground cables, transformers.
- To analyze about power system transients.

UNIT I REVIEW OF TRAVELLING WAVE PHENOMENA 9

Lumped and Distributed Parameters – Wave Equation – Reflection, Refraction, Behaviour of Travelling waves at the line terminations – Lattice Diagrams – Attenuation and Distortion-switching overvoltage: Short line or kilometric fault, energizing transients - closing and re-closing of lines, methods of control; temporary over voltages: line dropping, load rejection; voltage induced by fault; very fast transient overvoltage (VFTO).

UNIT II PARAMETERS AND MODELLING OF OVERHEAD LINES 9

Review of line parameters for simple configurations: series resistance, inductance and shunt capacitance; bundle conductors : equivalent GMR and equivalent radius; modal propagation in transmission lines: modes on multi-phase transposed transmission lines, α-β-0 transformation and symmetrical components transformation, modal impedances; analysis of modes on un-transposed lines; effect of ground return and skin effect; transposition schemes; introduction to frequency-dependent line modelling.

UNIT III PARAMETERS AND MODELLING OF UNDERGROUND CABLES 9

Distinguishing features of underground cables: technical features, electrical parameters, overhead lines versus underground cables; cable types; series impedance and shunt admittance of single-core self-contained cables, impedance and admittance matrices for three phase system formed by three single-core self-contained cables; approximate formulas for cable parameters

UNIT IV PARAMETERS AND MODELLING OF TRANSFORMERS 9

Transformer modelling guidelines for transient phenomena – Generalization of [R]-[ωL] model single phase N-coil transformer-Generalization of $[R]-[\omega L]^{-1}$ model single phase N-coil transformer- Inverse Inductance Matrix representation of three-phase N-coil transformers- inclusion of exciting current-modelling of autotransformers.

UNIT V COMPUTATION OF POWER SYSTEM TRANSIENTS 9

Digital computation of line parameters: why line parameter evaluation programs? salient features of a typical line parameter evaluation program; constructional features of that affect transmission line parameters; line parameters for physical and equivalent phase conductors elimination of ground wires bundling of conductors; principle of digital computation of transients: features and capabilities of electromagnetic transients program; steady state and time step solution modules: basic solution methods; case studies on simulation of various types of transients

TOTAL : 45 PERIODS

OUTCOMES

- Learners will be able to model over head lines, cables and transformers.

- Learners will be able to analyze power system transients.

TEXT BOOKS

1. Allan Greenwood, "*Electrical Transients in Power System*", Wiley & Sons Inc. New York, 1991.
2. R. Ramanujam, Computational Electromagnetic Transients: Modelling, Solution Methods and Simulation, I.K. International Publishing House Pvt. Ltd, New Delhi -110 016, ISBN 978-93-82332-74-9, 2014; email: info@ikinternational.com

REFERENCES

1. Rakosh Das Begamudre, "*Extra High Voltage AC Transmission Engineering*", (Second edition) Newage International (P) Ltd., New Delhi, 1990.
2. Naidu M S and Kamaraju V, "*High Voltage Engineering*", Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2004.

PW7073 ELECTRICITY MARKET ANALYSIS L T P C

3 0 0 3

COURSE OBJECTIVE:

- To provide brief introduction on restructuring of power system and various market models
- To provide knowledge about demand and price forecasting and price based unit commitment
- To provide knowledge about transmission congestion management and pricing
- To provide knowledge about electricity trading, generator asset valuation and risk management

UNIT I INTROUCTION OF RESTRUCTURING AND MARKET MODELS 9

Restructuring of Utilities- Different Models: PoolCo Model, Bilateral Contracts Model, Hybrid Model - Independent System Operator (ISO)- The Role of ISO - Power Exchange(PX): Market Clearing Price(MCP) - Market operations: Day-ahead and Hour-Ahead Markets, Elastic and Inelastic Markets– Block forwards Market - Market Structure – Power Market Types: Energy, Ancillary services and Transmission markets - Market Power - Stranded costs – Key components in power market operation

UNIT II DEMAND AND PRICE FORECASTING 9

Short Term Load Forecasting – Application of Load forecasting – Factors affecting load forecasting – Load forecasting categories - Electricity Price Forecasting –Electricity price basics – Electricity price volatility – Categorization of price forecasting – Factors considered in price Forecasting – Electricity Price simulation module- simulation example- Price forecasting module based on ANN-ANN factors in price forecasting – Performance Evaluation of price forecasting Price volatility – Price spike analysis – Probability distribution of Electricity price-Applications of price forecasting – Application of price forecast to make generation schedule – Application of probability Distribution of price to asset valuation and risk analysis – application of probability distribution to options valuation – Application of conditional probability distribution of price on Load to forward price forecasting

UNIT III PRICE BASED UNIT COMMITMENT 9

Introduction – PBUC formulation – System constraints- Unit constraints – PBUC solution – solution without emission or fuel constraints- solution with emission and fuel constraints – discussion and solution methodology – Energy purchase – Derivation of steps for updating multipliers – Optimality condition – Additional features of PBUC – Different prices among buses –

Variable fuel price as a function of fuel consumption – Application of Lagrangian augmentation – Bidding strategy based on PBUC

UNIT IV ELECTRICITY TRADING ,GENERATION ASSET VALUATION, RISK ANALYSIS -RISK MANAGEMENT 9

Introduction – Essence of Electric Energy trading – Framework: Qualifying factors – Derivative instruments of energy trading –Application of derivatives in energy trading – Portfolio management – Energy trading Hubs-Brokers in Electricity trading – Market Risk – Hedge – Sources of Electricity market risk –Counter party risk –Risk valuation in electricity trading -- Generation Assert valuation – Asset valuation – Value at Risk(VaR)-Application of VaR to Asset valuation – VaR for Generation asset valuation- Generation capacity valuation

UNIT IV TRANSMISSION CONGESTION MANAGEMENT AND PRICING 9

Introduction – Transmission cost allocation methods – Postage stamp rate method – contract path method – MW-Mile method – Unused transmission capacity method – MVA – Mile method – Counter Flow method – Distribution factor method – AC power flow method – Tracing methods-Comparison of cost allocation methods – Examples for transmission cost allocation methods – Locational Marginal Pricing (LMP) – Firm Transmission Rights(FTR) – Congestion Management – FTR Auction - Zonal congestion management – A comprehensive transmission pricing scheme – outline – prioritization of transmission dispatch – Calculation of transmission usage and congestion charges and FTR credits

TOTAL : 45 PERIODS

OUTCOMES :

- This subject gives an insight on the various electricity market models and provide knowledge about restructuring of power system.

REFERENCES:

1. Mohammad Shahidehpour, Muwaffaq Almoush - Restructured Electrical Power Systems – Operation, Trading and Volatility – Marcel Dekker, Inc, NewYork
2. Mohammad Shahidehpour, Hatim Yamn, Zuyi LI – Market Operations in Electric Power Systems – Forecasting, Scheduling and Risk management – John Wiley & Sons, Inc, Publication

PW7251 SCADA SYSTEM AND APPLICATIONS MANAGEMENT LT P C

3 0 0 3

COURSE OBJECTIVE:

- To understand about the SCADA system components and SCADA communication protocols
- To provide knowledge about SCADA applicatios in power system

UNIT I INTRODUCTION TO SCADA 9

Evolution of SCADA, SCADA definitions, SCADA Functional requirements and Components, SCADA Hierarchical concept, SCADA architecture, General features, SCADA Applications, Benefits

UNIT II SCADA SYSTEM COMPONENTS 9

Remote Terminal Unit (RTU), Interface units, Human- Machine Interface Units (HMI), Display Monitors/Data Logger Systems, Intelligent Electronic Devices (IED), Communication Network, SCADA Server, SCADA Control systems and Control panels

UNIT III SCADA COMMUNICATION 9

SCADA Communication requirements, Communication protocols: Past, Present and Future, Structure of a SCADA Communications Protocol, Comparison of various communication protocols, IEC61850 based communication architecture, Communication media like Fiber optic, PLCC etc. Interface provisions and communication extensions, synchronization with NCC, DCC.

UNIT IV SCADA MONITORING AND CONTROL 9

Online monitoring the event and alarm system, trends and reports, Blocking list, Event disturbance recording. Control function: Station control, bay control, breaker control and disconnector control.

UNIT V SCADA APPLICATIONS IN POWER SYSTEM 9

Applications in Generation, Transmission and Distribution sector, Substation SCADA system Functional description, System specification, System selection such as Substation configuration, IEC61850 ring configuration, SAS cubicle concepts, gateway interoperability list, signal naming concept. System Installation, Testing and Commissioning.

CASE STUDIES:

SCADA Design for 66/11KV and 132/66/11KV or 132/66 KV any utility Substation and IEC 61850 based SCADA Implementation issues in utility Substations,

TOTAL: 45 PERIODS

OUTCOME:

- This course gives knowledge about various system components and communication protocols of SCADA system and its applications.

REFERENCES:

1. Stuart A. Boyer: SCADA-Supervisory Control and Data Acquisition, Instrument Society of America Publications,USA,2004
2. Gordon Clarke, Deon Reynders: Practical Modern SCADA Protocols: DNP3, 60870.5 and Related Systems, Newnes Publications, Oxford, UK,2004
3. William T. Shaw, Cybersecurity for SCADA systems, PennWell Books, 2006
4. David Bailey, Edwin Wright, Practical SCADA for industry, Newnes, 2003
5. Michael Wiebe, A guide to utility automation: AMR, SCADA, and IT systems for electric Power, PennWell 1999
6. Dieter K. Hammer, Lonnie R. Welch, Dieter K. Hammer, “Engineering of Distributed Control Systems”, Nova Science Publishers, USA, 1st Edition, 2001

PW7076 URBAN AND RURAL ENERGY MANAGEMENT L T P C

3 0 0 3

COURSE OBJECTIVE:

- To give introduction about indian energy scenario
- To provide knowledge about urban and rural environment and its energy demand
- To understand the concept of green building and electric vehicle charging station

UNIT I INDIAN ENERGY SCENARIO 9

Commercial and non-commercial forms of energy, energy consumption pattern and Its variation as a function of time, energy resources available in India, urban and rural energy consumption, nuclear energy - promise and future, energy as a factor limiting growth, need for use of new and renewable energy sources.

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UNIT II URBAN ENVIRONMENT AND GREEN BUILDINGS 9

Patterns of fuel consumption: agricultural, domestic, industrial and community needs, Projection of energy demands, Optimization of use of various energy sources, Substitution of conventional energy sources by alternative sources and more efficient modern technologies Utility of Solar energy in buildings concepts of Solar Passive Cooling and Heating of Buildings Low Energy Cooling. Case studies of Solar Passive Cooled and Heated Buildings

UNIT III URBAN ELECTRIC VEHICLE CHARGING STATIONS 9

Electric vehicle charging stations- Integration of PHEV into Energy Networks – Impact on Distribution Systems – DC Fast Charging – Co-ordinated charging- V2G technology

UNIT IV THE RURAL ENERGY SITUATION 9

effects of Bio fuel use in rural India. Pollution and Health Ecological damage, Energy efficiency, the transition to modern energy, Rural Electrification policy.

UNIT V OPTION FOR RURAL ELECTRIFICATION 9

Cost Effectiveness and choice of options, Costs of Grid Supplies, Reducing initial investment costs by using appropriate design standards, Micro-grids supplied by diesel generators, Electricity Supplies from Renewable Energy Sources.

TOTAL : 45 PERIODS

OUTCOMES:

- Students will get idea about utilization of energy in rural and urban areas.

REFERENCES

1. Tools & methods for Integrated Resource Planning - Joel N.Swisher, Gilberto de Martino Jannzzi Robert Y. Red Linger,Publisher UNEP Collaborating Centre on Energy & Environment, RISO National Laboratory, Denmark, Nov. - 1997
2. Integrated Resource Planning & Demand Side Management through Regulation – 2002 sponsored by US AID. Integrated Energy Policy of India - 2006

HV7001 NANO DIELECTRICS L T P C
3 0 0 3

OBJECTIVE:

- To enable the students to become familiar with different types and properties of nano materials.
- To expose the knowledge on synthesization of nano materials.
- To impart knowledge on characterization methods of nano composites and nano polymers.

UNIT I INTRODUCTION TO NANO MATERIALS 9

Introduction to nanomaterials- Definition of nanocomposite, nanofillers, classification of nanofillers, carbon and noncarbon based nanofillers - Properties of nanomaterials- role of size in nanomaterials, nanoparticles, semiconducting nanoparticles, nanowires, nanoclusters, quantum wells, conductivity and enhanced catalytic activity in the macroscopic state

UNIT II PROPERTIES OF NANOMATERIALS 9

Nanocomposites and Properties- Metal-Metal nanocomposites, Polymer-Metal nanocomposites, Ceramic nanocomposites: Dielectric and CMR based nanocomposites. Mechanical Properties, Modulus and the Load-Carrying Capability of Nanofillers, Failure Stress and Strain Toughness, Glass Transition and Relaxation Behavior, Abrasion and Wear Resistance, Permeability, Dimensional Stability Contents, Thermal Stability and Flammability, Electrical and Optical Properties, Resistivity, Permittivity and Breakdown Strength, Refractive Index.

UNIT III SYNTHESIZATION AND CHARACTERIZATION METHODS 9

Synthesis of Nanomaterials by Physical Methods -Inert gas condensation, Arc discharge, Ball Milling, Molecular beam epitaxy-Chemical vapour deposition method and Electro deposition.

Chemical methods for Synthesis of Nanomaterials: Chemical precipitation and co-precipitation, Sol-gel synthesis, Microwave heating synthesis, Sonochemical synthesis; Electrochemical synthesis; Photochemical synthesis.

Introduction to microscopy- Scanning Electron Microscopy, Transmission Electron Microscopy, Optical Absorption and Emission Spectroscopy, Thermogravimetric Analysis, Differential Scanning Calorimetry

UNIT IV NANOCOMPOSITE 9

Direct Mixing, Solution Mixing ,Preparation and characterization of inorganic nanofillersproperties ,synthesis, characterization and applications of SiO_2, TiO_2, ZrO_2, Al_2O_3 and CNTcomposite

UNIT V NANOPOLYMERS 9

Polymerization, Particle Processing Ceramic/Polymer Composites, Preparation and characterization of Copolymer based nanocomposites- Barrier properties of polymer nanocomposites- Permeation and diffusion models - Thermo Electric Materials – Applications.

TOTAL : 45 PERIODS

OUTCOME:

- Awareness towards the nano materials, properties, synthesization methods and measurement techniques.

- Ability to synthesize new nano materials.
- Ability to design and fabricate the electrical insulations with nano dielectric materials.

REFERENCES

1. Handbook of Nanofabrication. Edited by Gary Wiederrcht. Elsevier, 2010.
2. Nanocomposite Science and Technology: by P.M. Ajayan, L.S. Schadler, P.V.Braun, 2003 WILEY-VCH Verlag GmbH Co. KGaA, Weinheim.
3. Nanoporous materials: Advance techniques for characterization, Modeling and Processing Edited by Nick Kanello Poulos. CRC press, 2011.
4. Inorganic Nanoparticles: Synthesis, Application and Perspectives. Edited by Claudia Altavilla and Enrico Ciliberto. CRC Press, 2011.
5. Polymer nanocomposites: by Yiu-Wing Mai and Zhong-Zhen Yu, First published 2006, Woodhead Publishing Limited and CRC Press LLC, USA.
6. CRC Handbook of Thermoelectrics, Ed. CR Rowe.

ET7074 MEMS TECHNOLOGY L T P C
3 0 0 3

Course objectives

- To teach the students properties of materials ,microstructure and fabrication methods.
- To teach the design and modeling of Electrostatic sensors and actuators.
- To teach the characterizing thermal sensors and actuators through design and modeling
- To teach the fundamentals of piezoelectric sensors and actuators through exposure to different MEMS and NEMS devices
- To involve Discussions/ Practice/Exercise onto revising & familiarizing the concepts acquired over the 5 Units of the subject for improved employability skills

UNIT I MICRO-FABRICATION, MATERIALS AND ELECTRO-MECHANICAL CONEPTS 9

Overview of micro fabrication – Silicon and other material based fabrication processes – Concepts: Conductivity of semiconductors-Crystal planes and orientation-stress and strain-flexural beam bending analysis-torsional deflections-Intrinsic stress- resonant frequency and quality factor.

UNIT II ELECTROSTATIC SENSORS AND ACTUATION 9

Principle, material, design and fabrication of parallel plate capacitors as electrostatic sensors and actuators-Applications

UNIT III THERMAL SENSING AND ACTUATION 9

Principle, material, design and fabrication of thermal couples, thermal bimorph sensors, thermal resistor sensors-Applications.

UNIT IV PIEZOELECTRIC SENSING AND ACTUATION 9

Piezoelectric effect-cantilever piezo electric actuator model-properties of piezoelectric materials-Applications.

UNIT V CASE STUDIES **9**

Piezoresistive sensors, Magnetic actuation, Micro fluidics applications, Medical applications, Optical MEMS.-NEMS Devices

Note :Discussions/Exercise/Practice on Workbench : on the basics /device model design aspects of thermal/peizo/resistive sensors etc.

TOTAL : 45 PERIODS

COURSE OUTCOME:

- The learning process delivers insight onto design of micro sensors, embedded sensors & actuators in power aware systems like grid
- Improved Employability and entrepreneurship capacity due to knowledge up gradation on recent trends in embedded systems design.

REFERENCES

1. Chang Liu, “Foundations of MEMS”, Pearson International Edition, 2006.
2. Marc Madou , “Fundamentals of microfabrication”,CRC Press, 1997.
3. Boston , “Micromachined Transducers Sourcebook”,WCB McGraw Hill, 1998.
4. M.H.Bao “Micromechanical transducers :Pressure sensors, accelerometers and gyroscopes”, Elsevier, Newyork, 2000.

HV7071 APPLICATIONS OF HIGH ELECTRIC FIELDS **L T P C**
3 0 0 3

OBJECTIVE:

To impart knowledge on,

- different HV applications in industry and food preservation
- different HV applications in cancer treatments and microbial inactivation
- the awareness on hazards and safety issues.

UNIT I APPLICATION IN INDUSTRY **9**

Introduction – electrostatic applications- electrostatic precipitation, separation , painting / coating, spraying ,imaging ,printing ,Transport of materials – Sandpaper Manufacture – Smoke particle detector – Electrostatic spinning ,pumping , propulsion – Ozone generation – Biomedical applications.

UNIT II APPLICATION IN MICROBIAL INACTIVATION **9**

Introduction-definitions, descriptions and applications-mechanisms of microbial in-activationselectrical breakdown-electroporation-inactivation models -Critical factors-analysis of process, product and microbial factors-pulse generators and treatment chamber design-Research needs

UNIT III APPLICATION IN FOOD PRESERVATION **9**

Processing of juices, milk, egg, meat and fish products- Processing of water and waste – Industrial feasibility, cost and efficiency analysis

UNIT IV APPLICATION IN CANCER TREATMENT 9

Different types of cancer – Different types of treatments, anti-cancer drugs – Electrochemotherapy – Electric fields in cancer tissues – Modeling, analysis of cancer tissues

UNIT V SAFETY AND ELECTROSTATIC HAZARDS 9

Introduction – Nature of static electricity – Triboelectric series – Basic laws of Electrostatic electricity– materials and static electricity – Electrostatic discharges (ESD) – Static electricity problems – Hazards of Electrostatic electricity in industry – Hazards from electrical equipment and installations – Static eliminators and charge neutralizers – Lightning protection- safety measures and standards

TOTAL : 45 PERIODS

OUTCOME:

- To prepare the students in application of high electric fields in industries, food preservation, and cancer treatment.
- To provide an opportunity to students to work in multidisciplinary projects.

REFERENCES

1. N.H.Malik, A.A.Ai-Arainy, M.I.Qureshi, “Electrical Insulation in power systems”, Marcel Dekker, inc., 1998.
2. Mazen Abdel-Salam, Hussien Anis, Ahdab El-Morshedy, “High Voltage Engineering”, Second Edition, Theory and Practice, Marcel Dekker, Inc. 2000,
3. John D.Kraus, Daniel A.Fleisch, “Electromagnetics with Applications” McGraw Hill International Editions, 1992.
4. Shoait Khan, “ Industrial Power System”, CRC Press, Taylor & Francis group, 2008.
5. G.V. Barbosa – Canovas, “Pulsed electric fields in food processing:Fundamental aspects and applications” CRC Publisher Edition March 1 2001.
6. H L M Lelieveld and Notermans.S,et.al., “Food preservation by pulsed electric fields: From research to application”, Woodhead Publishing Ltd. October 2007.
7. Indian Electricity Rules; IS-5216; Electrical Safety Handbook by John Cadick

PE7072 POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS LT P C
3 0 0 3

OBJECTIVES :

- To Provide knowledge about the stand alone and grid connected renewable energy systems.
- To equip with required skills to derive the criteria for the design of power converters for renewable energy applications.
- To analyse and comprehend the various operating modes of wind electrical generators and solar energy systems.
- To design different power converters namely AC to DC, DC to DC and AC to AC converters for renewable energy systems.
- To develop maximum power point tracking algorithms.

UNIT I INTRODUCTION 9

Environmental aspects of electric energy conversion: impacts of renewable energy generation on environment (cost-GHG Emission) - Qualitative study of different renewable energy resources ocean, Biomass, Hydrogen energy systems : operating principles and characteristics of: Solar PV, Fuel cells, wind electrical systems-control strategy, operating area.

UNIT II ELECTRICAL MACHINES FOR RENEWABLE ENERGY CONVERSION 9

Review of reference theory fundamentals-principle of operation and analysis: IG, PMSG, SCIG and DFIG.

UNIT III POWER CONVERTERS 9

Solar: Block diagram of solar photo voltaic system : line commutated converters(inversion mode) - Boost and buck-boost converters- selection Of inverter, battery sizing, array sizing.
Wind: three phase AC voltage controllers- AC-DC-AC converters: uncontrolled rectifiers, PWM Inverters, Grid Interactive Inverters-matrix converters.

UNIT IV ANALYSIS OF WIND AND PV SYSTEMS 9

Standalone operation of fixed and variable speed wind energy conversion systems and solar system-Grid connection Issues -Grid integrated PMSG and SCIG Based WECS-Grid Integrated solar system

UNIT V HYBRID RENEWABLE ENERGY SYSTEMS 9

Need for Hybrid Systems- Range and type of Hybrid systems- Case studies of Wind-PVMaximum Power Point Tracking (MPPT).

TOTAL : 45 PERIODS

OUTCOME:

- Ability to design grid connected/standalone renewable energy system employing embedded energy storage and MPPT strategy.

TEXT BOOK

1. S.N.Bhadra, D. Kastha, & S. Banerjee “Wind Electricaal Systems”, Oxford University Press, 2009

REFERENCES:

1. Rashid .M. H “power electronics Hand book”, Academic press, 2001.
2. Rai. G.D, “Non conventional energy sources”, Khanna publishes, 1993.
3. Rai. G.D,” Solar energy utilization”, Khanna publishes, 1993.
4. Gray, L. Johnson, “Wind energy system”, prentice hall linc, 1995.
5. Non-conventional Energy sources B.H.Khan Tata McGraw-hill Publishing Company, New Delhi.

HV7072 DESIGN OF SUBSTATIONS L T P C
3 0 0 3

OBJECTIVE:

- To provide in-depth knowledge on design criteria of Air Insulated Substation (AIS) and Gas Insulated Substation (GIS).
- To study the substation insulation co-ordination and protection scheme.
- To study the source and effect of fast transients in AIS and GIS.

UNIT I INTRODUCTION TO AIS AND GIS 9

Introduction – characteristics – comparison of Air Insulated Substation (AIS) and Gas Insulated Substation (GIS) – main features of substations, Environmental considerations, Planning and installation- GIB / GIL

UNIT II MAJOR EQUIPMENT AND LAYOUT OF AIS AND GIS 9

Major equipment – design features – equipment specification, types of electrical stresses, mechanical aspects of substation design- substation switching schemes- single feeder circuits; single or main bus and sectionalized single bus- double main bus-main and transfer bus- main, reserve and transfer bus- breaker-and-a- half scheme-ring bus

UNIT III INSULATION COORDINATION OF AIS AND GIS 9

Introduction – stress at the equipment – insulation strength and its selection – standard BILs – Application of simplified method – Comparison with IEEE and IEC guides.

UNIT IV GROUNDING AND SHIELDING 9

Definitions – soil resistivity measurement – ground fault currents – ground conductor – design of substation grounding system – shielding of substations – Shielding by wires and masts.

UNIT V FAST TRANSIENTS PHENOMENON IN AIS AND GIS 9

Introduction – Disconnector switching in relation to very fast transients – origin of VFTO – propagation and mechanism of VFTO – VFTO characteristics – Effects of VFTO.

TOTAL : 45 PERIODS

OUTCOME:

- Awareness towards substation equipment and their arrangements.
- Ability to design the substation for present requirement with proper insulation coordination and protection against fast transients.

REFERENCES

1. Andrew R. Hileman, “Insulation coordination for power systems”, Taylor and Francis, 1999.
2. M.S. Naidu, “Gas Insulation Substations”, I.K. International Publishing House Private Limited, 2008.
3. Klaus Ragallar, “Surges in high voltage networks” Plenum Press,New York, 1980.
4. “Power Engineer’s handbook”, TNEB Association.
5. Pritindra Chowdhuri, “Electromagnetic transients in power systems”, PHI Learning Private Limited, New Delhi, Second edition, 2004.
6. “Design guide for rural substation”, United States Department of Agriculture, RUS Bulletin, 1724E-300, June 2001.
7. AIEE Committee Report, “Substation One-line Diagrams,” AIEE Trans. on Power Apparatus and Systems, August 1953
8. Hermann Koch , “Gas Insulated Substations”, Wiley-IEEE Press,2014

PS7071 DISTRIBUTED GENERATION AND MICRO GRID L T P C
3 0 0 3

OBJECTIVES

- To illustrate the concept of distributed generation
- To analyze the impact of grid integration.
- To study concept of Microgrid and its configuration

UNIT I INTRODUCTION 9

Conventional power generation: advantages and disadvantages, Energy crises, Non conventional energy (NCE) resources: review of Solar PV, Wind Energy systems, Fuel Cells, micro-turbines, biomass, and tidal sources.

UNIT II DISTRIBUTED GENERATIONS (DG) 9

Concept of distributed generations, topologies, selection of sources, regulatory standards/ framework, Standards for interconnecting Distributed resources to electric power systems: IEEE 1547. DG installation classes, security issues in DG implementations. Energy storage elements: Batteries, ultra-capacitors, flywheels. Captive power plants

UNIT III IMPACT OF GRID INTEGRATION 9

Requirements for grid interconnection, limits on operational parameters,: voltage, frequency, THD, response to grid abnormal operating conditions, islanding issues. Impact of grid integration with NCE sources on existing power system: reliability, stability and power quality issues.

UNIT IV BASICS OF A MICROGRID 9

Concept and definition of microgrid, microgrid drivers and benefits, review of sources of microgrids, typical structure and configuration of a microgrid, AC and DC microgrids, Power Electronics interfaces in DC and AC microgrids,

UNIT V CONTROL AND OPERATION OF MICROGRID 9

Modes of operation and control of microgrid: grid connected and islanded mode, Active and reactive power control, protection issues, anti-islanding schemes: passive, active and communication based techniques, microgrid communication infrastructure, Power quality issues in microgrids, regulatory standards, Microgrid economics, Introduction to smart microgrids.

TOTAL : 45 PERIODS

OUTCOMES

- Students will attain knowledge on the various schemes of conventional and non-conventional power generation.
- Students will have knowledge on the topologies and energy sources of distributed generation.
- Students will learn about the requirements for grid interconnection and its impact with NCE sources
- Students will understand the fundamental concept of Microgrid.

REFERENCES

1. “Voltage Source Converters in Power Systems: modelling, Control and Applications”, Amirnaser Yezdani, and Reza Iravani, IEEE John Wiley Publications.
2. “Power Switching Converters: Medium and High Power”, DorinNeacsu, CRC Press, Taylor & Francis, 2006.
3. “Solar Photo Voltaics”, Chetan Singh Solanki, PHI learning Pvt. Ltd., New Delhi,2009
4. “Wind Energy Explained, theory design and applications,” J.F. Manwell, J.G. McGowan Wiley publication
5. “Biomass Regenerable Energy”, D. D. Hall and R. P. Grover, John Wiley, New York, 1987.
6. “Renewable Energy Resources” John Twidell and Tony Weir, Tyalor and Francis Publications, Second edition.

PE7351 SPECIAL ELECTRICAL MACHINES L T P C
3 0 0 3

OBJECTIVES

- To review the fundamental concepts of permanent magnets and the operation of permanent magnet brushless DC motors.
- To introduce the concepts of permanent magnet brushless synchronous motors and synchronous reluctance motors.
- To develop the control methods and operating principles of switched reluctance motors.
- To introduce the concepts of stepper motors and its applications.
- To understand the basic concepts of other special machines.

UNIT I PERMANENT MAGNET BRUSHLESS DC MOTORS 9

Fundamentals of Permanent Magnets- Types- Principle of operation- Magnetic circuit analysis- EMF and Torque equations- Characteristics and control

UNIT II PERMANENT MAGNET SYNCHRONOUS MOTORS 9

Principle of operation – EMF and Torque equations - Phasor diagram - Power controllers – Torque speed characteristics – Digital controllers – Constructional features, operating principle and characteristics of synchronous reluctance motor.

UNIT III SWITCHED RELUCTANCE MOTORS 9

Constructional features –Principle of operation- Torque prediction–Characteristics Power controllers – Control of SRM drive- Sensorless operation of SRM – Applications.

UNIT IV STEPPER MOTORS 9

Constructional features –Principle of operation –Types – Torque predictions – Linear and Non-linear analysis – Characteristics – Drive circuits – Closed loop control –Applications.

UNIT V OTHER SPECIAL MACHINES 9

Principle of operation and characteristics of Hysteresis motor – AC series motors – Linear motor – Applications.

TOTAL: 45 PERIODS

OUTCOME:

- Ability to model and analyze power electronic systems and equipment using computational software.
- Ability to optimally design magnetics required in special machines based drive systems using FEM based software tools.
- Ability to design and conduct experiments towards research.

TEXT BOOKS:

1. T.J.E. Miller, ‘Brushless magnet and Reluctance motor drives’, Claredon press, London, 1989.
2. R.Krishnan, ‘ Switched Reluctance motor drives’ , CRC press, 2001.
3. T.Kenjo, ‘ Stepping motors and their microprocessor controls’, Oxford University press, New Delhi, 2000.

REFERENCES:

1. T.Kenjo and S.Nagamori, ‘Permanent magnet and Brushless DC motors’, Clarendon ‘ press, London, 1988.
2. R.Krishnan, ‘ Electric motor drives’ , Prentice hall of India,2002.
3. D.P.Kothari and I.J.Nagrath, ‘ Electric machines’, Tata McGraw hill publishing company, New Delhi, Third Edition, 2004.
4. Irving L.Kosow, “Electric Machinery and Transformers” Pearson Education, Second Edition, 2007.

PW7351 ENERGY MANAGEMENT AND AUDITING L T P C
3 0 0 3

COURSE OBJECTIVES

- To study the concepts behind economic analysis and Load management.
- To emphasize the energy management on various electrical equipments and metering.
- To illustrate the concept of lighting systems and cogeneration.

UNIT I INTRODUCTION 9

Need for energy management - energy basics- designing and starting an energy management program – energy accounting -energy monitoring, targeting and reporting- energy audit process.

UNIT II ENERGY COST AND LOAD MANAGEMENT 9

Important concepts in an economic analysis - Economic models-Time value of money-Utility rate structures- cost of electricity-Loss evaluation Load management: Demand control techniques-Utility monitoring and control system- HVAC and energy management-Economic justification

UNIT III ENERGY MANAGEMENT FOR MOTORS, SYSTEMS, AND ELECTRICAL EQUIPMENT 9

Systems and equipment- Electric motors-Transformers and reactors-Capacitors and synchronous machines

UNIT IV METERING FOR ENERGY MANAGEMENT 9

Relationships between parameters-Units of measure-Typical cost factors- Utility meters - Timing of meter disc for kilowatt measurement - Demand meters - Paralleling of current transformers - Instrument transformer burdens-Multitasking solid-state meters - Metering location vs. requirements- Metering techniques and practical examples

UNIT V LIGHTING SYSTEMS & COGENERATION 9

Concept of lighting systems - The task and the working space -Light sources - Ballasts - Luminaries - Lighting controls-Optimizing lighting energy - Power factor and effect of harmonics on power quality - Cost analysis techniques-Lighting and energy standards Cogeneration: Forms of cogeneration - feasibility of cogeneration- Electrical interconnection.

TOTAL : 45 PERIODS

OUTCOME

- Students will develop the ability to learn about the need for energy management and auditing process
- Learners will learn about basic concepts of economic analysis and load management.
- Students will understand the energy management on various electrical equipments.
- Students will have knowledge on the concepts of metering and factors influencing cost function
- Students will be able to learn about the concept of lighting systems, light sources and various forms of cogeneration

TEXT BOOKS

1. Barney L. Capehart, Wayne C. Turner, and William J. Kennedy, Guide to Energy Management, Fifth Edition, The Fairmont Press, Inc., 2006

2. Eastop T.D & Croft D.R, Energy Efficiency for Engineers and Technologists,. Logman Scientific & Technical, ISBN-0-582-03184, 1990.

REFERENCES

1. Reay D.A, Industrial Energy Conservation, 1st edition, Pergamon Press, 1977.
2. IEEE Recommended Practice for Energy Management in Industrial and Commercial Facilities, IEEE, 196.
3. Amit K. Tyagi, Handbook on Energy Audits and Management, TERI, 2003.

PS7072 HIGH VOLTAGE DIRECT CURRENT TRANSMISSION L T P C
3 0 0 3

COURSE OBJECTIVES

- To impart knowledge on operation, modelling and control of HVDC link.
- To perform steady state analysis of AC/DC system.
- To expose various HVDC simulators.

UNIT I DC POWER TRANSMISSION TECHNOLOGY 6

Introduction - Comparison of AC and DC transmission **–** Application of DC transmission – Description of DC transmission system - Planning for HVDC transmission **–** Modern trends in DC transmission – DC breakers – Cables, VSC based HVDC.

UNIT II ANALYSIS OF HVDC CONVERTERS AND HVDC SYSTEM CONTROL 12

Pulse number, choice of converter configuration **–** Simplified analysis of Graetz circuit - Converter bridge characteristics – characteristics of a twelve pulse converter- detailed analysis of converters.General principles of DC link control **–** Converter control characteristics **–** System control hierarchy - Firing angle control **–** Current and extinction angle control **–** Generation of harmonics and filtering - power control **–** Higher level controllers.

UNIT III MULTITERMINAL DC SYSTEMS 9

Introduction **–** Potential applications of MTDC systems - Types of MTDC systems - Control and protection of MTDC systems - Study of MTDC systems.

UNIT IV POWER FLOW ANALYSIS IN AC/DC SYSTEMS 9

Per unit system for DC Quantities - Modelling of DC links - Solution of DC load flow - Solution of AC-DC power flow – Unified, Sequential and Substitution of power injection method.

UNIT V SIMULATION OF HVDC SYSTEMS 9

Introduction – DC LINK Modelling , Converter modelling and State Space Analysis , Philosophy and tools **–** HVDC system simulation, Online and Offline simulators – Dynamic interactions between DC and AC systems.

TOTAL : 45 PERIODS

OUTCOMES:

- Students will develop understanding on DC power transmission technologies,
- Students will study about HVDC converters and HVDC system control,
- Students will develop understanding on multi-terminal DC system,
- Students will attain knowledge on AC/DC power flow analysis,
- Students will study about modeling of HVDC systems and HVDC system simulation techniques.

TEXT BOOKS

1. P. Kundur, “Power System Stability and Control”, McGraw-Hill, 1993
2. K.R.Padiyar, , “HVDC Power Transmission Systems”, New Age International (P) Ltd., New Delhi, 2002.

REFERENCES

1. J.Arrillaga, , “High Voltage Direct Current Transmission”, Peter Pregrinus, London, 1983.
2. Erich Uhlmann, “ Power Transmission by Direct Current”, BS Publications, 2004.
3. V.K.Sood,HVDC and FACTS controllers – Applications of Static Converters in Power System, APRIL 2004 , Kluwer Academic Publishers.

PS7073 OPTIMISATION TECHNIQUES L T P C
3 0 0 3

COURSE OBJECTIVES

- To introduce the different optimization problems and techniques
- To study the fundamentals of the linear and non-linear programming problem.
- To understand the concept of dynamic programming and genetic algorithm technique

UNIT I INTRODUCTION 9

Definition, Classification of optimization problems, Classical Optimization Techniques, Single and Multiple Optimization with and without inequality constraints.

UNIT II LINEAR PROGRAMMING (LP) 9

Simplex method of solving LPP, revised simplex method, duality, Constrained optimization, Theorems and procedure, Linear programming, mathematical model, solution technique, duality.

UNIT III NON LINEAR PROGRAMMING 9

Steepest descent method, conjugates gradient method, Newton’s Method, Sequential quadratic programming, Penalty function method, augmented Lagrange multiplier method.,

UNIT IV DYNAMIC PROGRAMMING (DP) 9

Multistage decision processes, concept of sub-optimization and principle of optimality, Recursive relations, Integer Linear programming, Branch and bound algorithm

UNIT V GENETIC ALGORITHM 9

Introduction to genetic Algorithm, working principle, coding of variables, fitness function, GA operators; Similarities and differences between Gas and traditional methods; Unconstrained and constrained optimization using genetic Algorithm, real coded gas, Advanced Gas, global optimization using GA, Applications to power system.

TOTAL : 45 PERIODS

OUTCOMES

- Students will learn about different classifications of optimization problems and techniques.
- Students will attain knowledge on linear programming concepts

- Students will understand the application of non- linear programming in optimization techniques
- Students will understand the fundamental concepts of dynamic programming
- Students will have knowledge about Genetic algorithm and its application to optimization in power system.

TEXT BOOKS

1. S.S. Rao ,"Optimization – Theory and Applications", Wiley-Eastern Limited, 1984.
2. G.Luenberger," Introduction of Linear and Non-Linear Programming" , Wesley Publishing Company, 2011.

REFERENCE BOOKS:

1. Computational methods in Optimization, Polak , Academic Press,1971.
2. Optimization Theory with applications, Pierre D.A., Wiley Publications,1969.
3. Taha, H. A., Operations Research: An Introduction, Seventh Edition, Pearson Education Edition, Asia, New Delhi ,2002.

PS7074 SOLAR AND ENERGY STORAGE SYSTEM L T P C
3 0 0 3

COURSE OBJECTIVES

- To Study about solar modules and PV system design and their applications
- To Deal with grid connected PV systems
- To Discuss about different energy storage systems

UNIT I INTRODUCTION 9

Characteristics of sunlight – semiconductors and P-N junctions –behavior of solar cells – cell properties – PV cell interconnection

UNIT II STAND ALONE PV SYSTEM 9

Solar modules – storage systems – power conditioning and regulation - protection – stand alone PV systems design – sizing

UNIT III GRID CONNECTED PV SYSTEMS 9

PV systems in buildings – design issues for central power stations – safety – Economic aspect – Efficiency and performance - International PV programs

UNIT IV ENERGY STORAGE SYSTEMS 9

Impact of intermittent generation – Battery energy storage – solar thermal energy storage – pumped hydroelectric energy storage

UNIT V APPLICATIONS 9

Water pumping – battery chargers – solar car – direct-drive applications –Space – Telecommunications.

TOTAL : 45 PERIODS

OUTCOME

- Students will develop more understanding on solar energy storage systems
- Students will develop basic knowledge on standalone PV system
- Students will understand the issues in grid connected PV systems

- Students will study about the modelling of different energy storage systems and their performances
- Students will attain more on different applications of solar energy

TEXT BOOKS

1. Eduardo Lorenzo G. Araujo, Solar electricity engineering of photovoltaic systems, Progensa,1994.
2. Stuart R.Wenham, Martin A.Green, Muriel E. Watt and Richard Corkish, Applied Photovoltaics, 2007,Earthscan, UK.

REFERENCES:

1. Frank S. Barnes & Jonah G. Levine, Large Energy storage Systems Handbook , CRC Press, 2011.
2. Solar & Wind energy Technologies – McNeils, Frenkel, Desai, Wiley Eastern, 1990
3. Solar Energy – S.P. Sukhatme, Tata McGraw Hill,1987.

PS7075 WIND ENERGY CONVERSION SYSTEM L T P C
3 0 0 3

COURSE OBJECTIVES

- To learn the design and control principles of Wind turbine.
- To understand the concepts of fixed speed and variable speed, wind energy conversion systems.
- To analyze the grid integration issues.

UNIT I INTRODUCTION 9

Components of WECS-WECS schemes-Power obtained from wind-simple momentum theory-Power coefficient-Sabinin's theory-Aerodynamics of Wind turbine

UNIT II WIND TURBINES 9

HAWT-VAWT-Power developed-Thrust-Efficiency-Rotor selection-Rotor design considerations-Tip speed ratio-No. of Blades-Blade profile-Power Regulation-yaw control-Pitch angle control-stall control-Schemes for maximum power extraction.

UNIT III FIXED SPEED SYSTEMS 9

Generating Systems- Constant speed constant frequency systems -Choice of Generators-Deciding factors-Synchronous Generator-Squirrel Cage Induction Generator- Model of Wind Speed- Model wind turbine rotor - Drive Train model-Generator model for Steady state and Transient stability analysis.

UNIT IV VARIABLE SPEED SYSTEMS 9

Need of variable speed systems-Power-wind speed characteristics-Variable speed constant frequency systems synchronous generator- DFIG- PMSG -Variable speed generators modelling - Variable speed variable frequency schemes.

UNIT V GRID CONNECTED SYSTEMS 9

Wind interconnection requirements, low-voltage ride through (LVRT), ramp rate limitations, and supply of ancillary services for frequency and voltage control, current practices and industry trends wind interconnection impact on steady-state and dynamic performance of the power system including modelling issue.

TOTAL: 45 PERIODS

OUTCOMES

- Students will attain knowledge on the basic concepts of Wind energy conversion system.
- Students will have the knowledge of the mathematical modelling and control of the Wind turbine
- Students will develop more understanding on the design of Fixed speed system
- Students will study about the need of Variable speed system and its modelling.
- Students will learn about Grid integration issues and current practices of wind interconnections with power system.

TEXT BOOKS

1. L.L.Freris "Wind Energy conversion Systems", Prentice Hall, 1990
2. S.N.Bhadra, D.Kastha,S.Banerjee,"Wind Electrical Sytems",Oxford University Press,2010.

REFERENCES

2. Ion Boldea, "Variable speed generators", Taylor & Francis group, 2006.
3. E.W.Golding "The generation of Electricity by wind power", Redwood burn Ltd., Trowbridge,1976.
4. N. Jenkins," Wind Energy Technology" John Wiley & Sons,1997
5. S.Heir "Grid Integration of WECS", Wiley 1998.

ET7072 DIGITAL IMAGE PROCESSING L T P C
3 0 0 3

OBJECTIVES

To understand the techniques for image enhancement.; image segmentation;the echniques for compression etc for Grey scale & Color Images

UNIT I IMAGE REPRESENTATION 9

Image representation-Image Basis Functions- Two dimensional DFT- Discrete Cosine TransformWalsh- Hadamard transform-Wavelet transform- Principal component analysis.

UNIT II IMAGE ENHANCEMENT AND RESTORATION 9

Gray level transformation techniques- Spatial domain techniques - Half toning, Median filtering, contrast stretching, Histogram Equalization- Frequency domain techniques - einer filteringHomomorphic filtering- PSFs for different forms of blur - noise models- color image processing.

UNIT III IMAGE SEGMENTATION 9

Segmentation - Similarity and dissimilarity methods- Thresholding - Edge based and Region based methods- Hough transform- Morphological operations - Clustering methods.

UNIT IV IMAGE COMPRESSION 9

Source coding techniques - Run length coding - Shannon- Fano coding- Huffman coding- Arithmetic coding- LZW coding - Transform and Predictive compression methods - Vector quantization- case studies - JPEG-MPEG.

UNIT V COLOR IMAGE PROCESSING 9

Percception of color,color model,chromaticity diagram,color image -quantization, filtering,gamma correction,pseudo color ,segmentation.

TOTAL: 45 PERIODS

OUTCOMES:

To be able to design and implement image enhancement schemes; compression schemes.; restoration schemes; segmentation schemes

REFERENCES:

1. Gonzalez R. C. and Woods R.E., "Digital Image Processing", 3rd Edition, Prentice-Hall, 2008.
2. Jayaraman,Esakirajan,Veerakumar,"Digital Image Processing";McGrawHill,2013
   William K. Pratt, "Digital Image Processing", John Wiley, 4th Edition, 2007.
4. Sonka M, "Image Processing, Analysis and Machine Vision", Vikas Publishing Home (Thomson) 2001.
5. Schalkoff R.J., "Digital Image Processing & Computer Vision", John Wiley & Sons, 1992.
6. Richard O. Duda, Peter E. Hart and David G. Stork., "Pattern Classification", Wiley, 2001.
7. J.W. Woods, "Multidimensional Signal, Image, Video Processing and Coding", 2nd Edition,Academic Press, 2012.
8. Jain A.K., "Fundamentals of Digital Image Processing", PHI Learning Private Ltd., 1989.

CO7071 CONTROL OF ELECTRICAL DRIVES L T P C

3 0 0 3

COURSE OBJECTIVES

- To introduce the PWM converters and their analysis.
- To educate on modeling of dc motor, drives and control techniques To educate on dynamic modeling of Induction motor drive.
- To educate on the V/f and vector control of Induction motor.
- To educate on generation of firing pulses and control algorithms in embedded platforms.

UNIT I POWER ELECTRONIC CONVERTERS FOR DRIVES 9

Power electronic switches-state space representation of switching converters-Fixed frequency PWM-variable frequency PWM- space vector PWM- Hysteresis current control-dynamic analysis of switching converters-PWM modulator model.

UNIT II CONTROL OF DC DRIVES 9

Modelling of DC machines-block diagram/transfer function-phase control-1phase/3phase converter fed DC drives- Chopper fed DC drives-four quadrant chopper circuit-closed loop control-speed control-current control-cascade control –constant torque/power operation-comparison of chopper/converter fed drives- techniques-merits/demits.

UNIT III ANALYSIS AND MODELLING OF INDUCTION MOTOR DRIVE 9

Basics of induction motor drive-classification – equivalent circuit- torque Vs slip

characteristics-steady state performance- Dynamic modeling of induction motor, Three phase to two phase transformation-stator, rotor, synchronously rotating reference frame model.

UNIT IV CONTROL OF INDUCTION MOTOR DRIVE 9

VSI fed induction motor drives- waveforms for 1-phase, 3-phase Non-PWM and PWM VSI fed induction motor drives -principles of V/F control- principle of vector control-direct vector control- space vector modulation- indirect vector control .

UNIT V EMBEDDED CONTROL OF DRIVES 9

Generation of firing pulses- generation of PWM pulses using embedded processors-IC control of DC drives- fixed frequency/variable frequency/current control- V/F control using PIC microcontroller- vector control using embedded processors.

TOTAL : 45 PERIODS

COURSE OUTCOME

- Will get a thorough knowledge on Power Electronic Converter Switches and different PWM approach.
- Confidently design and analyze both converter and chopper driven dc drives.
- Will have a thorough understanding of conventional control techniques of Induction motor drive.
- Get a detailed knowledge on V/f Control using PIC MicroController and Vector control usings Embedded processor.

REFERENCES

1. R.Krishnan, “Electric Motor Drives, Modeling, Analysis and Control” Prentice Hall of India, 2002.
2. Thyristor control of Electric drives, Vedam Subrahmanyam, Tata McGraw Hill, 1988
3. Ion Boldea & S.A.Nasar “ELECTRIC DRIVES”, CRC Press, 2006
4. Simon Ang, Alejandro Oliva “POWER SWITCHING CONVERTERS”, CRC Press, 2005
5. Buxbaum, A. Schierau, and K.Staughen, “A design of control systems for DC Drives”, Springer- Verlag, Berlin,1990.