NATIONAL ENGINEERING COLLEGE

(An Autonomous Institution – Affiliated to Anna University Chennai)

K.R.NAGAR, KOVILPATTI – 628 503

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REGULATIONS - 2013

DEPARTMENT OF

ELECTRICAL AND ELECTRONICS ENGINEERING

CURRICULUM AND SYLLABI OF

M.E. – HIGH VOLTAGE ENGINEERING

REGULATIONS – 2013

CURRICULUM AND SYLLABI OF FULL TIME

M.E. HIGH VOLTAGE ENGINEERING

SEMESTER I

S. No.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1	HVC11	Applied Mathematics for Electrical Engineers (Common to HVE, C&I and EST)	3	1	0	4
2	HVC12	Dielectric and Insulation Engineering	3	0	0	3
3	HVC13	Generation and Measurement of High voltages	3	0	0	3
4	HVC14	Electrical Transients in Power System	3	0	0	3
5	HVC15	Electromagnetic Field Computation and Modeling	3	1	0	4
6	HVC16	High Voltage Switchgear	3	0	0	3
PRACTICAL						
7	HVC17	High Voltage Laboratory I	0	0	3	2
		Total	**18**	**2**	**3**	**22**

SEMESTER II

S. No.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1	HVC21	High Voltage Testing Technology	3	0	0	3
2	HVC22	EHVAC Transmission	3	0	0	3
3	HVC23	Insulation Design of High Voltage Power Apparatus	3	0	0	3
4		Elective – I	3	0	0	3
5		Elective – II	3	0	0	3
6		Elective – III	3	0	0	3
PRACTICAL						
7	HVC24	High Voltage Laboratory II	0	0	3	2
		Total	**18**	**0**	**3**	**20**

SEMESTER III

S.No	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1		Elective - IV	3	0	0	3
2		Elective - V	3	0	0	3
3		Elective - VI	3	0	0	3
PRACTICAL						
4	HVC31	Project Work (Phase – I)	0	0	12	6
		Total	**9**	**0**	**12**	**15**

SEMESTER IV

S. No	COURSE CODE	COURSE TITLE	L	T	P	C
PRACTICAL						
1	HVC41	Project Work (Phase – II)	0	0	24	12
		Total	**0**	**0**	**24**	**12**

II Semester (Elective I, II & III)

S. No.	COURSE CODE	COURSE TITLE	L	T	P	C
1	HVE2A	Electromagnetic Interference and Electromagnetic Compatibility (Common to HVE and C&I)	3	0	0	3
2	HVE2B	Soft Computing Techniques (Common to HVE and C&I)	3	0	0	3
3	HVE2C	System Theory (Common to C&I and HVE)	3	0	0	3
4	HVE2D	Analysis of Electrical Machines	3	0	0	3
5	HVE2E	Special Electrical Machines	3	0	0	3
6	HVE2F	Pulse Power Engineering	3	0	0	3
7	HVE2G	Wind Energy Conversion Systems	3	0	0	3
8	HVE2H	Power Electronics for Renewable Energy Systems	3	0	0	3
9	HVE2J	Flexible AC Transmission Systems	3	0	0	3
10	HVE2K	Advanced Electromagnetic Fields	3	0	0	3
11	HVE2L	Restructured Power Systems	3	0	0	3
12	HVE2M	Power System Planning and Reliability	3	0	0	3
13	HVE2N	Power System Analysis	3	0	0	3
14	HVE2P	Modern Rectifiers and resonant Converters	3	0	0	3
15	HVE2Q	Analysis of Power Converters	3	0	0	3
16	HVE2R	Power Electronics in Power Systems	3	0	0	3

III Semester (Elective IV, V & VI)

S. No	COURSE CODE	COURSE TITLE	L	T	P	C
1	HVE3A	Pollution Performance of Power Apparatus and Systems	3	0	0	3
2	HVE3B	Advanced Digital Signal Processing (Common to CS,CC,HVE and C&I)	3	0	0	3
3	HVE3C	Evolutionary Computing (Common to HVE,CSE,CS and CC)	3	0	0	3
4	HVE3D	Advanced Digital System Design (Common to C&I and HVE)	3	0	0	3
5	HVE3E	High Voltage Direct Current Transmission	3	0	0	3
6	HVE3F	Power Quality	3	0	0	3
7	HVE3G	Power System Operation and Control	3	0	0	3
8	HVE3H	Control of Electric Drives	3	0	0	3
9	HVE3J	Design of Embedded Systems	3	0	0	3
10	HVE3K	Applications of MEMS Technology	3	0	0	3
11	HVE3L	Microcontroller and DSP based System Design	3	0	0	3
12	HVE3M	Reactive Power Compensation and Management	3	0	0	3
13	HVE3N	Computer Aided Design of Power Electronics Circuits	3	0	0	3
14	HVE3P	Collision Phenomenon	3	0	0	3
15	HVE3Q	PC Based Instrumentation System Design (Common to C&I and HVE)	3	0	0	3
16	HVE3R	Condition Monitoring of High Voltage Power Apparatus	3	0	0	3
17	HVE3S	Advanced Topics in High Voltage Engineering	3	0	0	3

REGULATIONS – 2013

CURRICULUM AND SYLLABI OF PART TIME

M.E. HIGH VOLTAGE ENGINEERING

SEMESTER I

S. No	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1	HVC11	Applied Mathematics for Electrical Engineers (Common to HVE, C&I and EST)	3	1	0	4
2	HVC12	Dielectric and Insulation Engineering	3	0	0	3
3	HVC13	Generation and Measurement of High voltages	3	0	0	3
		TOTAL	**9**	**1**	**0**	**10**

SEMESTER II

S. No	COURSE CODE	COURSE TITLE	L	T	P	C
1	HVC21	High Voltage Testing Technology	3	0	0	3
2	HVC22	EHVAC Transmission	3	1	0	4
3	HVC23	Insulation Design of High Voltage Power Apparatus	3	0	0	3
		TOTAL	**9**	**1**	**0**	**10**

SEMESTER III

S. No	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1	HVC14	Electrical Transients in Power System	3	0	0	3
2	HVC15	Electromagnetic Field Computation and Modeling	3	0	0	3
3	HVC16	High Voltage Switchgear	3	0	0	3
PRACTICAL						
4	HVC17	High Voltage Laboratory I	0	0	3	2
		TOTAL	**9**	**0**	**3**	**11**

SEMESTER IV

S. No	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1		Elective – I	3	0	0	3
2		Elective – II	3	0	0	3
3		Elective – III	3	0	0	3
PRACTICAL						
4	HVC24	High Voltage Laboratory II	0	0	3	2
		TOTAL	**9**	**0**	**3**	**11**

IV Semester (Elective I, II & III)

S. No	COURSE CODE	COURSE TITLE	L	T	P	C
1	HVE2A	Electromagnetic Interference and Electromagnetic Compatibility (Common to HVE and C&I)	3	0	0	3
2	HVE2B	Soft Computing Techniques (Common to HVE and C&I)	3	0	0	3
3	HVE2C	System Theory (Common to C&I and HVE)	3	0	0	3
4	HVE2D	Analysis of Electrical Machines	3	0	0	3
5	HVE2E	Special Electrical Machines	3	0	0	3
6	HVE2F	Pulse Power Engineering	3	0	0	3
7	HVE2G	Wind Energy Conversion Systems	3	0	0	3
8	HVE2H	Power Electronics for Renewable Energy Systems	3	0	0	3
9	HVE2J	Flexible AC Transmission Systems	3	0	0	3
10	HVE2K	Advanced Electromagnetic Fields	3	0	0	3
11	HVE2L	Restructured Power Systems	3	0	0	3
12	HVE2M	Power System Planning and Reliability	3	0	0	3
13	HVE2N	Power System Analysis	3	0	0	3
14	HVE2P	Modern Rectifiers and resonant Converters	3	0	0	3
15	HVE2Q	Analysis of Power Converters	3	0	0	3
16	HVE2R	Power Electronics in Power Systems	3	0	0	3

SEMESTER V

S.No	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1		Elective - IV	3	0	0	3
2		Elective - V	3	0	0	3
3		Elective - VI	3	0	0	3
PRACTICAL						
4	HVC31	Project Work (Phase – I)	0	0	12	6
		Total	**9**	**0**	**12**	**15**

SEMESTER VI

S. No	COURSE CODE	COURSE TITLE	L	T	P	C
PRACTICAL						
1	HVC41	Project Work (Phase – II)	0	0	24	12
		Total	0	0	24	12

V SEMESTER (Elective IV, V & VI)

S. No	COURSE CODE	COURSE TITLE	L	T	P	C
1	HVE3A	Pollution Performance of Power Apparatus and Systems	3	0	0	3
2	HVE3B	Advanced Digital Signal Processing (Common to CS,CC,HVE and C&I)	3	0	0	3
3	HVE3C	Evolutionary Computing (Common to HVE,CSE,CS and CC)	3	0	0	3
4	HVE3D	Advanced Digital System Design (Common to C&I and HVE)	3	0	0	3
5	HVE3E	High Voltage Direct Current Transmission	3	0	0	3
6	HVE3F	Power Quality	3	0	0	3
7	HVE3G	Power System Operation and Control	3	0	0	3
8	HVE3H	Control of Electric Drives	3	0	0	3
9	HVE3J	Design of Embedded Systems	3	0	0	3
10	HVE3K	Applications of MEMS Technology	3	0	0	3
11	HVE3L	Microcontroller and DSP based System Design	3	0	0	3
12	HVE3M	Reactive Power Compensation and Management	3	0	0	3
13	HVE3N	Computer Aided Design of Power Electronics Circuits	3	0	0	3
14	HVE3P	Collision Phenomenon	3	0	0	3
15	HVE3Q	PC Based Instrumentation System Design (Common to C&I and HVE)	3	0	0	3
16	HVE3R	Condition Monitoring of High Voltage Power Apparatus	3	0	0	3
17	HVE3S	Advanced Topics in High Voltage Engineering	3	0	0	3

HVC11 APPLIED MATHEMATICS FOR ELECTRICAL ENGINEERS **L T P C**

(Common to HVE, C&I and EST) **3 1 0 4**

OBJECTIVES

- To learn the concepts of matrix theory
- To understand simplex method, two phase method and graphical solution in linear programming.
- To learn moment generating functions and one dimensional random variables.
- To understand queueing models and computation methods in engineering

UNIT I ADVANCED MATRIX THEORY **9**

Eigen values using QR transformations – Generalized eigen vectors – Canonical forms – Singular value decomposition and applications – Pseudo inverse – Least square approximations.

UNIT II LINEAR PROGRAMMING **9**

Formulation – Graphical Solution – Simplex Method – Two Phase Method – Transportation and Assignment Problems.

UNIT III ONE DIMENSIONAL RANDOM VARIABLES **9**

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 QUEUEING MODELS **9**

Poisson Process – Markovian queues – Single and Multi Server Models – Little's formula – Machine Interference Model – Steady State analysis – Self Service queue.

UNIT V COMPUTATIONAL METHODS IN ENGINEERING **9**

Boundary value problems for ODE – Finite difference methods – Numerical solution of PDE – Solution of Laplace and Poisson equations – Liebmann's iteration process – Solution of heat conduction equation by Schmidt explicit formula and Crank - Nicolson implicit scheme – Solution of wave equation.

L: 45 T: 15 TOTAL: 60 PERIODS

REFERENCE BOOKS:

1. Bronson,R., "Matrix Operation, Schaum's outline series", McGraw Hill, New York, 1989.
2. Taha, H. A., "Operations Research: An Introduction", 7th Edition, Pearson Education Edition, Asia, New Delhi, 2002.
3. R. E. Walpole, R. H. Myers, S. L. Myers, and K. Ye, "Probability and Statistics for Engineers & Scientists", 8th Edition, Asia, 2007.
4. Donald Gross and Carl M. Harris, "Fundamentals of Queueing theory", 2nd Edition, John Wiley and Sons, New York 1985.
5. Grewal, B.S., "Numerical methods in Engineering and Science", 7th Edition, Khanna Publishers, 2000.

HVC12 DIELECTRIC AND INSULATION ENGINEERING	L	T	P	C
	3	0	0	3

OBJECTIVES

- To study the general properties of insulating materials.
- To know the concept of various breakdown mechanism in gaseous dielectrics.
- To know the concept of various breakdown mechanism in solid dielectrics.
- To know the concept of various breakdown mechanism in liquid dielectrics.
- To understand the application of different insulating materials in electrical equipments.

UNIT I GENERAL PROPERTIES OF INSULATING MATERIALS 9

Requirements of insulating materials – electrical properties – molecular properties of dielectrics – dependence of permittivity on temperature, pressure, humidity and voltage - permittivity of mixtures, practical importance of permittivity – behavior of dielectric under alternating fields – complex dielectric constants – bipolar relaxation and dielectric loss - dielectric strength.

UNIT II 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 and their influence on gaseous discharge – Townsend's criterion for spark breakdown, gaseous discharges in non-uniform fields – breakdown in vacuum insulation.

UNIT III BREAKDOWN MECHANISMS IN SOLID DIELECTRICS 9

Intrinsic breakdown of solid dielectrics – electromechanical breakdown-Streamer breakdown, thermal breakdown and partial discharges in solid dielectrics - electrochemical breakdown – tracking and treeing – classification of solid dielectrics, composite insulation and its mechanism of failure.

UNIT IV BREAKDOWN MECHANISMS IN LIQUID DIELECTRICS 9

Liquids as insulators - conduction and breakdown in pure and commercial liquids - Cryogenic insulation.

UNIT V APPLICATION OF INSULATING MATERIALS 9

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

L =45 Total = 45 Periods

REFERENCE BOOKS:

1. Adrinaus, Dekker J., "Electrical Engineering Materials", Prentice Hall of India Pvt. Ltd., New Delhi, 1979.
2. Alston L.L, "High Voltage Technology", Oxford University Press, London, 1968 (B.S Publications, First Indian Edition 2006).
3. Kuffel E., Zaengl W.S. and Kuffel J., "High Voltage Engineering Fundamentals", Elsevier India Pvt. Ltd, 2005.
4. Dieter Kind and Hermann Karner, "High Voltage Insulation Technology", (Translated from German by Narayana Rao Y., Friedr. Vieweg & Sohn, Braunschweig), 1985.
5. Naidu M.S. and Kamaraju V., "High Voltage Engineering", Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2009.
6. Ushakov V.Y., "Insulation of High Voltage Equipment", Springer, ISBN.3-540-20729-5, 2004.

HVC13 GENERATION AND MEASUREMENT OF HIGH VOLTAGES

L	T	P	C
3	0	0	3

OBJECTIVES

- To understand the various types of high voltages in power system and protection methods.
- To study the various methods for generation of AC, DC and impulse voltage.
- To learn the various measurement techniques of AC, DC and impulse voltage.
- To know the various methods for generation and measurement of impulse currents.

UNIT I GENERATION OF DIRECT VOLTAGES 9

Generation and transmission of electric energy – voltage stress – testing voltages - AC to DC conversion – single phase rectifier circuits – cascaded circuits – voltage multiplier circuits – Cockroft-Walton circuits – voltage regulation – ripple factor – Design of HVDC generator – Vande-Graff generator.

UNIT II GENERATION OF ALTERNATING VOLTAGES 9

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

UNIT III GENERATION OF IMPULSE VOLTAGES 9

Marx generator – Impulse voltage generator circuit – analysis of various impulse voltage generator circuits – multistage impulse generator circuits – Switching impulse generator circuits – impulse current generator circuits – generation of non-standard impulse voltages and nanosecond pulses.

UNIT IV MEASURMENT OF HIGH VOLTAGES 9

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 impulse currents – Resistive shunts, Hall Generators and Faraday generators and their applications – measurement using magnetic coupling - Fast digital transient recorders for impulse measurements.

L =45 Total = 45 Periods

REFERENCE BOOKS:

1. Kuffel E., Zaengl W. S. and Kuffel J., "High Voltage Engineering Fundamentals", Elsevier India Pvt. Ltd, 2005.
2. Dieter Kind, Kurt Feser, "High Voltage Test Techniques", SBA Electrical Engineering Series, New Delhi, 2001.
3. Naidu M.S. and Kamaraju V., "High Voltage Engineering", Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2009.
4. Gallagher T.J., and Permain A., "High Voltage Measurement, Testing and Design", John Wiley Sons, New York, 1983.
5. Mazen Abdel Salam R., Hussein Anis, Ahdab El-Morshedy, Roshdy Radwan, "High Voltage Engineering Theory and Practice" Marcel Dekker, Inc., New York, Second Edition (Revised and Expanded), 2000.
6. Malik N.H., Al-Arainy A.A, Qureshi M.I., "Electrical Insulation in Power Systems", Marcel Dekker, Inc., New York 1997.
7. Adolf J. Schwab, "High Voltage Measurement Techniques", M.I.T Press, ANSI, IEEE STD, Sixth Edition, 1978.

HVC14 ELECTRICAL TRANSIENTS IN POWER SYSTEM

L	T	P	C
3	0	0	3

OBJECTIVES

- To understand the concept of travelling waves on transmission line.
- To solve transient problems in power networks and components.
- To learn the basic concepts of lightning and switching and temporary over voltages.
- To understand the behavior of electrical equipments under transient conditions.
- To learn how to design the insulation coordination of different types of sub stations.

UNIT I TRAVELLING WAVES ON TRANSMISSION LINE 9

Lumped and Distributed Parameters – Wave Equation – Reflection - Refraction - Behaviour of Travelling waves at the line terminations – Lattice Diagrams – Attenuation and Distortion – Multi conductor system and Velocity wave.

UNIT II COMPUTATION OF POWER SYSTEM TRANSIENTS 9

Principle of digital computation – Matrix method of solution - Modal analysis - Z transforms - Computation using EMTP, MNA Program– Simulation of switches and non-linear elements.

UNIT III LIGHTNING, SWITCHING AND TEMPORARY OVERVOLTAGES 9

Lightning: Physical phenomena of lightning – Interaction between lightning and power system – Factors contributing to line design – Switching: Short line or kilometric fault – Energizing transients - closing and re-closing of lines - line dropping, load rejection – Voltage induced by fault – Very Fast Transient Overvoltage (VFTO).

UNIT IV BEHAVIOUR OF WINDING UNDER TRANSIENT CONDITION 9

Initial and Final voltage distribution - Winding oscillation - traveling wave solution -Behaviour of the transformer core under surge condition – Rotating machine – Surge in generator and motor.

UNIT V INSULATION CO-ORDINATION 9

Principle of insulation co-ordination in Air Insulated Substation (AIS) and Gas Insulated Substation (GIS) - insulation level - statistical approach - co-ordination between insulation and protection level – overvoltage protective devices – lightning arresters - substation earthing.

L =45 Total = 45 Periods

REFERENCE BOOKS:

1. Pritindra Chowdhari, "Electromagnetic transients in Power System", John Wiley and Sons Inc., 1996.
2. Allan Greenwood, "Electrical Transients in Power System", Wiley & Sons Inc. New York, 1991.
3. Klaus Ragaller, "Surges in High Voltage Networks", Plenum Press, New York, 1980.
4. Rakosh Das Begamudre, "Extra High Voltage AC Transmission Engineering", New Age International (P) Ltd., New Delhi, Second Edition, 2011.
5. Naidu M.S and Kamaraju V., "High Voltage Engineering", Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2009.
6. IEEE Guide for safety in AC substation grounding IEEE Standard 80-2000.
7. Working Group 33/13-09, "Very fast transient phenomena associated with Gas Insulated System", CIGRE, 33-13, pp. 1-20, 1988.

HVC15	ELECTROMAGNETIC FIELD COMPUTATION AND MODELING	L	T	P	C
		3	1	0	4

OBJECTIVES

- To learn the basic concepts in electric and magnetic fields.
- To learn how to find the solutions of electro static boundary value problems.
- To find the field computations of basic configurations.
- To put into practice the FE method to analyze and design electrical machines and apparatus.

UNIT I INTRODUCTION 12

Review of basic field theory – electric and magnetic fields – Maxwell's equations –Laplace, Poisson and Helmoltz equations – principle of energy conversion – force/torque calculation – Electro thermal formulation**.**

UNIT II SOLUTION OF FIELD EQUATIONS I 12

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

UNIT III SOLUTION OF FIELD EQUATIONS II 12

Finite element method (FEM) – Differential/ integral functions – Variational method –Energy minimization – Discretisation – Shape functions –Stiffness matrix –1D and 2D planar and axial symmetry problem.

UNIT IV FIELD COMPUTATION FOR BASIC CONFIGURATIONS 12

Computation of electric and magnetic field intensities– Capacitance and Inductance –Force, Torque, Energy for basic configurations.

UNIT V DESIGN APPLICATIONS 12

Insulators- Bushings – Cylindrical magnetic actuators – Transformers – Rotating machines.

L =45 T = 15 Total = 60 Periods

REFERENCE BOOKS:

1. Binns K.J., Lawrenson P.J. and Trowbridge C.W, "The analytical and numerical solution of Electric and magnetic fields", John Wiley & Sons, 1993.
2. Nathan Ida and Joao Bastos P.A., "Electromagnetics and calculation of fields", Springer-Verlage, Second Edition, 2002.
3. Nicola Biyanchi, "Electrical Machine analysis using Finite Elements", Taylor and Francis Group, CRC Publishers, 2005.
4. Salon S.J., "Finite Element Analysis of Electrical Machines." Kluwer Academic Publishers, London, 1995(distributed by TBH Publishers & Distributors, Chennai, India).
5. User manuals of MAGNET, MAXWELL & ANSYS software.
6. Silvester and Ferrari, "Finite Elements for Electrical Engineers" Cambridge University press, Third Edition, 1996.
7. Marcel Dector "Finite Element Analysis of Electrical Machines." Tata McGraw-Hill Edition 2003.
8. William Hayt, "Engineering Electromagnetics" Tata McGraw-Hill Edition 2012.
9. Mathew Sadiku,"Elements of Electromagnetics", Oxford University Press, Ninth Edition, 2007.
10. Bhag Singh Guru, Hüseyin R. Hızıroğlu, "Electromagnetic Field Theory Fundamentals", Cambridge University Press, 2004.

HVC16 HIGH VOLTAGE SWITCHGEAR

L	T	P	C
3	0	0	3

OBJECTIVES

- To discuss the causes of abnormal operating conditions (faults, lightning and switching surges) of the apparatus and system.
- To understand the characteristics and functions of relays and protection schemes.
- To understand the problems associated with circuit interruption by a circuit breaker.
- To study about the testing and types of circuit breakers.

UNIT I INTRODUCTION 9

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

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 reclosing.

UNIT III SHORT CIRCUIT CALCULATIONS AND RATING OF CIRCUIT BREAKERS 9

Types of faults in power systems-short circuit current and short circuit MVA calculations for different types of faults-rating of circuit breakers – symmetrical and asymmetrical ratings.

UNIT IV TYPES OF CIRCUIT BREAKERS 9

Classification of circuit breakers-design, construction and operating principles of bulk oil, minimum oil, air blast, SF6 and vacuum circuit breakers – Comparison of different types of circuit breakers.

UNIT V TESTING OF CIRCUIT BREAKERS 9

Type tests and routine tests – short circuit testing - synthetic testing of circuit breakers - recent advancements in high voltage circuit breakers.

L =45 Total = 45 Periods

REFERENCE BOOKS:

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", Elsevier 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, 1982.
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.

HVC17 HIGH VOLTAGE LABORATORY I

L	T	P	C
0	0	3	2

1. Basics of Dielectrics Laboratory
2. Measurement of dielectric strength of liquid dielectric (Transformer Oil)
3. Measurement of Loss angle and resistivity of liquid dielectric (Transformer Oil)
4. Measurement of Flash point & Fire point of liquid dielectrics
5. Measurement of Viscosity of liquid dielectrics
6. Measurement of pH
7. Measurement of Conductivity of samples
8. FEM Simulation of different electrode configurations
9. FEM Simulation of single and composite dielectrics field distribution
10. Simulation of Lightning and Switching Impulse voltage generator
11. Simulation of RL,RC and RLC-DC transient circuit
12. Analyzing Field distribution of dielectric in Rogowski Profile, 11 kV disc insulator and coaxial cable

Total = 45 Periods

HVC21 HIGH VOLTAGE TESTING TECHNOLOGY

L	T	P	C
3	0	0	3

OBJECTIVES

- To brief concept about the various classification of testing methods, measurement techniques and standards.
- To learn statistical evaluation of distribution function, confidence limits and up and down method.
- To study the testing techniques of various types of electrical equipments.
- To study the partial discharge measurements, corona and RIV measurements.
  To know pollution tests and design of high voltage lab.

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.

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 - PD equivalent model – PD quantities - Digital PD instruments and measurements - acoustic emission technique and UHF Techniques for PD identification - Corona and RIV measurements.

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

REFERENCE BOOKS:

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, 2009.
3. Kuffel E., Zaengl W.S. and Kuffel J., "High Voltage Engineering Fundamentals", Elsevier India P Ltd, 2005.
4. Gallagher T.J. and Pearmain A., "High Voltage Measurements, Testing and Design", John Willey & Sons, New York, 1983.
5. IS, IEC and IEEE standards for Dielectric Testing of High Voltage Apparatus.
6. Nelson W., "Applied Life Data Analysis", John Wiley and Sons, New York, 1982.
7. Kennedy W., "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. Judd M.D., Liyang and Ian BB Hunter, "P.D Monitoring of Power Transformers using UHF Sensors" Vol.21, No.2, pp. 5-14, 2004.

HVC22 EHVAC TRANSMISSION

L	T	P	C
3	0	0	3

OBJECTIVES

- To study the role of EHV AC Transmission and Mechanical considerations in line parameters.
- To know the calculation methods of the line parameters for multiconductor lines.
- To learn surface voltage gradient and distribution of voltage gradient for multiconductor lines.
- To study the concepts of generation of audible noise and corona pulse, limitation of radio interference.
- To understand the effect of electrostatic field on humans and vehicles and calculation of electrostatic field of AC lines and unenergised circuit of D/C line.

UNIT I INTRODUCTION 9

EHVAC Transmission - line trends and preliminary aspects - standard transmission voltages – power handling capacities and line losses – mechanical aspects.

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 – resistance and inductance of ground return - numerical example involving a typical 400/220kV line using line constant program.

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.

UNIT IV CORONA EFFECTS 9

Power losses and audible losses: I^2R loss and corona loss - audible noise generation and characteristics - limits for audible noise - Day-Night equivalent noise level- radio interference - corona pulse generation and properties - limits for radio interference fields.

UNIT V ELECTROSTATIC FIELD 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 un-energized circuit of a D/C line - induced voltages in insulated ground wires - electromagnetic interference.

L =45 Total = 45 Periods

REFERENCE BOOKS:

1. Rakosh Das Begamudre, "Extra High Voltage AC Transmission Engineering", New Age International Pvt. Ltd., Second Edition, 2011.
2. Power Engineer's Handbook, TNEB Engineers' Association, Revised and Enlarged Sixth Edition, October 2002.
3. Microtran Power System Analysis Corporation, Microtran Reference Manual, Vancouver Canada. (Website: www.microtran.com).

HVC23	**INSULATION DESIGN OF HIGH VOLTAGE POWER APPARATUS**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

OBJECTIVES

- To study the arrangements of the insulation systems and electric field distribution in homogeneous and multi dielectric isotropic material.
- To study the design principles and classifications insulators, capacitors and bushings.
- To learn insulation schemes and design of transformer.
- To study the design of instrumental transformers and cables joints.
- To know the characteristics and types of 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 DESIGN OF INSULATORS, BUSHINGS AND CAPACITORS **9**

Basic configurations - Classification based on insulating materials and application - design principles.

UNIT III INSULATION DESIGN OF 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 DESIGN OF 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 - insulation co-ordination.

L =45 Total = 45 Periods

REFERENCE BOOKS:

1. Dieter Kind and Hermann Karner, "High Voltage Insulation Technology", translated from German by Y.Narayana Rao, Friedr. Vieweg & Sohn, Braunschweig, 1985.
2. Kuffel E., Zaengl W.S. and Kuffel J., "High Voltage Engineering Fundamentals", Elsevier India Pvt. Ltd, 2005
3. Alston L.L., "High Voltage Technology", Oxford University Press, London 2006.
4. Karsai K., Kerenyi D. and Kiss L., "Large Power Transformers", Elsevier, Armsterdam, 1987.
5. Feinberg R., "Modern Power Transformer Practice", Macmillan Press Ltd., New York, 1979.
6. Franklin A.C. and Franklin J.S.C., "The J & P Transformer Book", Butterworth- Heinmann, New Delhi, Eleventh Edition, 1995.
7. Minoo Mobedjina, Bengt Johnnerfelt, Lennart Stenstrom, "Design and testing of polymer – housed surge arrester", GCC CIGRE 9th Symposium, 1998.
8. Steinfield K., Krusha B. and Welsh W., "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, Brishane Australia, 1994.

HVC24 HIGH VOLTAGE LABORATORY II

L	T	P	C
0	0	3	2

1. Basics of High Voltage lab
2. Measurement of dielectric strength of solid dielectric (Rubber gloves)
3. Measurement of capacitance and tan delta using high voltage Schering Bridge
4. Generation and measurement of AC, DC and Impulse voltage
5. Breakdown measurement of gaseous dielectric under AC Voltage
6. Breakdown measurement of gaseous dielectric under DC Voltage
7. Measurement of Partial discharge in dielectric using Partial Discharge Meter
8. Measurement of total harmonics distortion (THD) using harmonic analyzer
9. Earth resistance measurement
10. Power frequency test on Insulators
11. Power frequency test on Cables
12. Lightning Impulse voltage test on 11kV Pin type insulator
13. Lightning Impulse voltage test on 11kV Disc type insulator

Total = 45 Periods

		L	T	P	C
HVE2A	**ELECTROMAGNETIC INTERFERENCE AND ELECTROMAGNETIC COMPATIBILITY**	**3**	**0**	**0**	**3**
	(Common to HVE and C&I)				

OBJECTIVES

- To study characteristics and design of electromagnetic compatibility and methods of eliminating interferences.
- To learn coupling, grounding and guard shields.
- To know filtering, shielding and methods of coating.
- To study digital logic noise and digital circuit ground noise**.**
- To learn electrostatic discharge, standards and laboratory techniques.

UNIT I INTRODUCTION 9

Sources of EMI - Conducted and radiated interference - Characteristics - Designing for electromagnetic compatibility (EMC) - EMC regulation - typical noise path - use of network theory - methods of eliminating interferences.

UNIT II METHOD OF GROUNDING 9

Cabling – capacitive coupling - inductive coupling - shielding to prevent magnetic radiation - shield transfer impedance - Grounding – safety grounds – signal grounds - single point and multipoint ground systems- hybrid grounds - functional ground layout – grounding of cable shields- ground loops - guard shields.

UNIT III BALANCING, FILTERING AND SHIELDING 9

Power supply decoupling - decoupling filters - amplifier filtering – high frequency filtering shielding – near and far fields - shielding effectiveness - absorption and reflection loss - Shielding with magnetic material - conductive gaskets - windows and coatings - grounding of shields.

UNIT IV DIGITAL CIRCUIT NOISE AND LAYOUT 9

Frequency versus time domain - analog versus digital circuits - digital logic noise- internal noise sources - digital circuit ground noise – power distribution - noise voltage objectives measuring noise voltages - unused inputs - logic families.

UNIT V ELECTROSTATIC DISCHARGE, STANDARDS AND LABORATORY TECHNIQUES 9

Static Generation - human body model - static discharges -ED protection in equipment design - ESD versus EMC - Industrial and Government standards – FCC requirements – CISPR recommendations - Laboratory techniques - Measurement methods for field strength - EMI.

L =45 Total = 45 Periods

REFERENCE BOOKS:

1. Henry W. Ott, “Noise reduction techniques in electronic systems”, John Wiley &Sons, 2011.
2. Bernhard Keiser, “Principles of Electro-magnetic Compatibility”, Artech House, Inc. (685 canton street, Norwood, MA 020062 USA) 1987.
3. Bridges J.E., Milleta J. and Ricketts L.W., “EMP Radiation and Protective techniques”, John Wiley and sons, USA 1976.
4. IEEE National Symposium on “Electromagnetic Compatibility”, IEEE, 445, Hoes Lane, Piscataway, NJ 08854. USA.

HVE2B SOFT COMPUTING TECHNIQUES (Common to HVE and C&I)

	L	T	P	C
	3	0	0	3

OBJECTIVES

- To understand the fundamental concept of intelligent control.
- To study about the applications of ANN, various transformations and its controllers.
- To aware about the fuzzy logic system and to design a various control schemes for non-linear systems.
- To understand the basic concepts of genetic algorithms.
- To study about the applications of GA, ANN and Fuzzy logic system.

UNIT I INTRODUCTION 9

Approaches to intelligent control - Architecture for intelligent control - Symbolic reasoning system-rule-based systems - AI approach - Knowledge representation - Expert systems.

UNIT II ARTIFICIAL NEURAL NETWORKS 9

Concept of Artificial Neural Networks and its basic mathematical model, McCulloch-Pitts neuron model - simple perceptron - Adaline and Madaline - Feed-forward Multilayer Perceptron. Learning and Training the neural network - Data Processing: Scaling, Fourier transformation, principal-component analysis and wavelet transformations - Hopfield network, Self-organizing network and Recurrent network - Neural Network based controller.

UNIT III FUZZY LOGIC SYSTEM 9

Introduction to crisp sets and fuzzy sets - basic fuzzy set operation and approximate reasoning - Introduction to fuzzy logic modeling and control - Fuzzification, inferencing and defuzzification - Fuzzy knowledge and rule bases. Fuzzy modeling and control schemes for nonlinear systems - Self-organizing fuzzy logic control - Fuzzy logic control for nonlinear time-delay system.

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 and ant-colony search techniques for solving optimization problems.

UNIT V APPLICATIONS 9

GA application to power system optimization problem - Case studies: Identification and control of linear and nonlinear dynamic systems using Matlab - Neural Network toolbox - Stability analysis of Neural-Network interconnection systems - Implementation of fuzzy logic controller using Matlab fuzzy-logic toolbox - Stability analysis of fuzzy control systems.

L =45 Total = 45 Periods

REFERENCE BOOKS:

1. Jacek M Zurada, "Introduction to Artificial Neural Systems", Jaico Publishing House, 1999.
2. Kosko.B, "Neural Networks and Fuzzy Systems", Prentice-Hall of India Pvt Ltd., 1994.
3. Klir G.J. and Folger T.A., "Fuzzy sets, Uncertainty and Information", Prentice-Hall of India Pvt. Ltd., 1993.
4. Zimmerman H.J., "Fuzzy set theory-and its Applications"-Kluwer Academic Publishers, 1994.
5. Driankov and Hellendroon, "Introduction to Fuzzy Control", Narosa Publishers, 2001.

HVE2C	SYSTEM THEORY (Common to C&I and HVE)	L	T	P	C
		3	0	0	3

OBJECTIVES

The student can able

- To design a state space model for a system
- To determine the controllability, observability, and stability of state variable systems.
- To use state variable feedback to place systems poles.
- To design state variable observers and controllers.

UNIT I MODERN CONTROL THEORY **9**

Limitations of conventional control theory - Concepts of state, State variables and state model – state model for linear time invariant systems: State space representation using physical-Phase and canonical variables.

UNIT II SYSTEM RESPONSE **9**

Transfer function from state model - Transfer matrix - Decomposition of transfer functions Direct, cascade and parallel decomposition techniques - Solution of state equation - State transition matrix computation.

UNIT III SYSTEM MODELS **9**

Characteristic equation - Eigen values and Eigen vectors - Invariance of Eigen values - Diagonalization - Jordan Canonical form - Concepts of controllability and observability - Kalman's and Gilbert's tests - Controllable and observable phase variable forms - Effect of pole-zero cancellation on controllability and observability.

UNIT IV MODEL CONTROL **9**

Introduction – Stability improvement by State Feedback – Necessary and sufficient conditions for Arbitary Pole Placement - Pole Placement by State Feedback - Full-Order Observers - Reduced-Order Observers - Deadbeat Control by State Feedback - Deadbeat Observers.

UNIT V LIAPUNOV STABILITY **9**

Liapunov stability analysis - Stability in the sense of Liapunov - Definiteness of Scalar Functions – Quadratic forms - Second method of Liapunov - Liapunov stability analysis of linear time invariant systems.

L =45 Total = 45 Periods

REFERENCE BOOKS:

1. Katsuhiko Ogata, "Modern Control Engineering", 3rd Edition, Prentice Hall of India Private Ltd., New Delhi, 2002.
2. Nagrath I J and Gopal M, "Control Systems Engineering", New Age International Publisher, New Delhi, 2006.
3. Nise S Norman, "Control Systems Engineering", 3rd Edition, John Wiley & Sons, Inc, Delhi, 2000.
4. Benjamin C Kuo, "Automatic Control Systems", John Wiley & Sons, Inc., Delhi, 2002.

HVE2D ANALYSIS OF ELECTRICAL MACHINES

L	T	P	C
3	0	0	3

OBJECTIVES

- To study the conversion characteristic of Electro Magnetic Energy conversion with the help of single and doubly excited system.
- To study the fundamentals of reference frame and its transformation.
- To evaluate the steady state and dynamic characteristic of DC machines.
- To analyze the steady state and dynamic characteristic of Induction Machines using reference frame variables.
- To study the steady state analysis, dynamic characteristic with computer simulation.

UNIT I PRINCIPLES OF ELECTROMAGNETIC ENERGY CONVERSION 9

General expression of stored magnetic energy - co-energy and force/ torque – example using single and doubly excited system – Calculation of air gap mmf and per phase machine inductance using physical machine data.

UNIT II REFERENCE FRAME THEORY 9

Static and rotating reference frames – transformation of variables – reference frames– transformation between reference frames – transformation of a balanced set – balanced steady state phasor and voltage equations – variables observed from several frames of reference.

UNIT III DC MACHINES 9

Voltage and toque equations – dynamic characteristics of permanent magnet and shunt DC motors – state equations - solution of dynamic characteristic by Laplace transformation.

UNIT IV INDUCTION MACHINES 9

Voltage and toque equations – transformation for rotor circuits – voltage and torque equations in reference frame variables – analysis of steady state operation – free acceleration characteristics – dynamic performance for load and torque variations – dynamic performance for three phase fault – computer simulation in arbitrary reference frame.

UNIT V SYNCHRONOUS MACHINES 9

Voltage and Torque Equation – voltage Equation in arbitrary reference frame and rotor reference frame – Park equations - rotor angle and angle between rotor – steady state analysis – dynamic performances for torque variations- dynamic performance for three phase fault – transient stability limit – critical clearing time – computer simulation.

L =45 Total = 45 Periods

REFERENCE BOOKS:

1. Paul C. Krause, OlegWasyzczuk, Scott S., and Sudhoff, "Analysis of Electric Machinery and Drive Systems", IEEE Press, Second Edition, 2002.
2. Krishnan R., "Electric Motor Drives, Modeling, Analysis and Control", Prentice Hall of India, 2002.
3. Samuel Seely, " Electromechanical Energy Conversion", Tata McGraw-Hill Publishing Company, 1962.
4. Fitzgerald A.E., Charles Kingsley, Jr, and Stephan D. Umanx, "Electric Machinery", Tata McGraw-Hill, Fifth Edition, 1992.

HVE2E SPECIAL ELECTRICAL MACHINES

L	T	P	C
3	0	0	3

OBJECTIVES

- To study the construction, operation and the drive systems for stepper motor.
- To study the construction, operation and controller for Switched Reluctance Motor.
- To illustrate the constructional based types, operation and characteristics of Synchronous Reluctance motor.
- To study the principle operation and control techniques & its characteristics of PMSM.
- To study the construction, drives and controller of Permanent Magnet BLDC motor.

UNIT I STEPPING MOTOR 9

Constructional features – Principle of operation – Modes of excitation – Torque production in variable reluctance stepping motor - Dynamic characteristics – Drive systems and circuit for open loop control – Closed loop control of stepping motor.

UNIT II SWITCHED RELUCTANCE MOTORS 9

Constructional features – principle of operation – Torque equation – Power controllers – Characteristics and control - microprocessor based controller.

UNIT III SYNCHRONOUS RELUCTANCE MOTORS 9

Constructional features: axial and radial air gap Motors – Operating principle –Reluctance torque – phasor diagram - motor characteristics.

UNIT IV PERMANENT MAGNET SYNCHRONOUS MOTROS 9

Principle of operation – EMF –Power input and torque expressions –Phasor diagram –Power controllers - Speed-torque characteristics-Self control –Vector control – Current control schemes.

UNIT V PERMANENT MAGNET BRUSHLESS DC MOTORS 9

Commutation in DC motors, Difference between mechanical and electronic commutators - Hall sensors, Optical sensors - Multiphase Brushless motor –Square wave permanent magnet brushless motor drives –Torque and emf equation- Speed-torque characteristics - Controllers –Microprocessors based controller.

L =45 Total = 45 Periods

REFERENCE BOOKS:

1. Miller T.J.E., "Brushless permanent magnet and reluctance motor drives", Clarendon Press, Oxford, 1989.
2. Kenjo T., "Stepping motors and their microprocessor control", Clarendon Press, Oxford 1989.
3. Krishnan R., "Switched Reluctance Motors Drives: Modeling, Simulation, Analysis Design and Applications", CRC Press, New York, 2010.

HVE2F PULSE POWER ENGINEERING

L	T	P	C
3	0	0	3

OBJECTIVES

- To study the static and dynamic breakdown strength of dielectric materials.
- To learn energy storage in Marx generators and pulse discharge capacitors.
- To know the types and operation of various switches.
- To learn production of pulses with lossless transmission line.
- To study pulse transmission and transformation.

UNIT I STATIC AND DYNAMIC BREAKDOWN STRENGTH OF DIELECTRIC MATERIALS **9**

Introduction – Gases - static breakdown - pulsed breakdown - spark formation - liquids-basic electrical process - steamer breakdown-practical considerations-solids-General observations-charge transport, injection and Breakdown-statistical Interpretation of breakdown Strength Measurements.

UNIT II ENERGY STORAGE **9**

Pulse Discharge Capacitors-Marx Generators-Classical Marx generators-LC Marx Generator-Basic Pulsed-Power Energy Transfer Stage-inductive energy storage-power and voltage multiplication-rotors and homopolar Generators.

UNIT III SWITCHES **9**

Closing switches-gas switches-semi conductor closing switches-magnetic switches-summary-opening switches-fuses-mechanical interrupters-superconducting opening switches-plasma opening switches-plasma flow switches-semiconductor opening switches.

UNIT IV PULSE FORMING NETWORKS **9**

Transmission lines-terminations and junctions-transmission lines with losses-the finite transmission line as a circuit element-production of pulses with lossless transmission lines-RLC networks

UNIT V PULSE TRANSMISSION AND TRANSFORMATION **9**

Self magnetic insulation in vacuum lines-vacuum break down in metallic surfaces-qualitative description of self magnetic insulation-quantitative description of self magnetic insulation-pulse Transformers-High Voltage Power supplies-Capacitor-Charging Techniques-Cascade Circuits-Transformation Lines.

L =45 Total = 45 Periods

REFERENCE BOOKS:

1. Hansjoachim Bluhm, "Pulsed Power Systems: Principles and Applications", Springer; 2006.
2. Pai S.T., "Introduction to High Power Pulse Technology (Advanced Series in Electrical and Computer Engineering)", Wspc Publisher, 1995.
3. Paul W. Smith, "Transient Electronics: Pulsed Circuit Technology", Wspc, Wiley; First Edition 2002.

HVE2G WIND ENERGY CONVERSION SYSTEMS

L	T	P	C
3	0	0	3

OBJECTIVES

- To study about the fundamentals of wind energy conversion systems.
- To illustrate the wind turbine concept with its design considerations.
- To develop the model of fixed speed system for WECS.
- To study about the variable speed system and the various generator used in WECS.
- To study the Grid connected WECS and its controller.

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 modeling - Variable speed variable frequency schemes.

UNIT V GRID CONNECTED SYSTEMS 9

Stand alone and Grid Connected WECS system-Grid connection Issues-Machine side & Grid side controllers-WECS in various countries.

L =45 Total = 45 Periods

REFERENCE BOOKS:

1. Freris L.L., "Wind Energy conversion Systems", Prentice Hall, 1990.
2. Ion Boldea, "Variable speed generators", Taylor & Francis group, 2006.
3. Golding E.W., "The generation of Electricity by wind power", Redwood burn Ltd.,Trowbridge, 1976.
4. Heir S.,"Grid Integration of WECS", Wiley 1998.
5. Rai G.D., "Non-conventional Sources of Energy", Khanna publishers, Fourth Edition, 2009.

HVE2H	POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS	L	T	P	C
		3	0	0	3

OBJECTIVES

- To aware about the various renewable energy resources.
- To study the fundamental of reference frame and operation of various generator used for renewable energy system.
- To study about the variety of converters used in solar and wind energy generation system.
- To study in detail about the solar and wind power system.
- To develop the hybrid power system.

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: Solar, Wind, Ocean, Biomass, Fuel cell, Hydrogen energy systems and hybrid renewable energy systems.

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 -Principle of operation: 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**

Stand alone 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-PV Maximum Power Point Tracking (MPPT).

L =45 Total = 45 Periods

REFERENCE BOOKS:

1. Rashid M.H., "Power Electronics Hand book", Academic press, 2011.
2. Rai G.D, "Non-conventional energy sources", Khanna publishes, 2009.
3. Rai G.D," Solar energy utilization", Khanna publishes, 1993.
4. Gray L. Johnson, "Wind energy system", prentice hall linc, 1995.
5. Khan B.H., "Non-conventional Energy sources", Tata McGraw-Hill Publishing Company, New Delhi, 2006.

HVE2J FLEXIBLE AC TRANSMISSION SYSTEMS

L	T	P	C
3	0	0	3

OBJECTIVES:

- To know the importance of compensation in transmission lines and the concepts of FACTS devices.
- To know the design, modeling and applications of SVC.
- To learn the operation, modes, modeling and applications of TCSC.
- To study the principle, characteristics, modeling and applications of STATCOM and SSSC.
- To learn about the importance in coordination of FACTS controllers.

UNIT I INTRODUCTION 9

Reactive power control in electrical power transmission lines –Uncompensated transmission line - series compensation – Basic concepts of Static Var Compensator (SVC) – Thyristor Controlled Series capacitor (TCSC) – Unified power flow controller (UPFC).

UNIT II STATIC VAR COMPENSATOR (SVC) AND APPLICATIONS 9

Voltage control by SVC – Advantages of slope in dynamic characteristics – Influence of SVC on system voltage – Design of SVC voltage regulator –Modeling of SVC for power flow and transient stability – Applications: Enhancement of transient stability –Steady state power transfer – Enhancement of power system damping – Prevention of voltage instability.

UNIT III THYRISTOR CONTROLLED SERIES CAPACITOR AND APPLICATIONS 9

Operation of the Thyristor Controlled Series Capacitor (TCSC) – Different modes of operation – Modeling of TCSC – Variable reactance model – Modeling for Power Flow and stability studies - Applications: Improvement of the system stability limit – Enhancement of system damping - SSR Mitigation.

UNIT IV VOLTAGE SOURCE CONVERTER BASED FACTS CONTROLLERS 9

Static Synchronous Compensator (STATCOM) – Principle of operation – V-I Characteristics - Applications: Steady state power transfer-Enhancement of transient stability - Prevention of voltage instability - SSSC-operation of SSSC and the control of power flow –Modeling of SSSC in load flow and transient stability studies - Applications: SSR Mitigation-UPFC and IPFC.

UNIT V CO-ORDINATION OF FACTS CONTROLLERS 9

Controller interactions – SVC – SVC interaction – Coordination of multiple controllers using linear control techniques – Control coordination using genetic algorithms.

L =45 Total = 45 Periods

REFERENCE BOOKS:

1. Mohan Mathur R. and Rajiv K. Varma, "Thyristor – Based Facts Controllers for Electrical Transmission Systems", IEEE press and John Wiley & Sons, Inc, 2002.
2. Narain G. Hingorani, "Understanding FACTS -Concepts and Technology of Flexible AC Transmission Systems", Standard Publishers Distributors, Delhi.
3. Padiyar K.R.," FACTS Controllers in Power Transmission and Distribution", New Age International (P) Limited, Publishers, New Delhi, 2008.
4. John A.T., "Flexible A.C. Transmission Systems", Institution of Electrical and Electronic Engineers (IEEE), 1999.
5. Sood V.K., "HVDC and FACTS controllers – Applications of Static Converters in Power System", Kluwer Academic Publishers, April 2004.

HVE2K ADVANCED ELECTROMAGNETIC FIELDS

L	T	P	C
3	0	0	3

OBJECTIVES

- To learn the basic concepts in electrostatics.
- To study the concepts of electric fields and space charge free fields.
- To study the different techniques for analyzing the electric fields.
- To know the concept of analyzing the electric fields with combination of different computation techniques.
- To study the electric filed behavior in conductors and dielectrics.

UNIT I ELECTROSTATICS 9

Electrostatic Fields – Coulomb's Law – Electric Field Intensity (EFI) – EFI due to a line and a surface charge – Work done in moving a point charge in an electrostatic field – Electric Potential – Properties of potential function – Potential gradient – Gauss's law – Application of Gauss's Law – Maxwell's first law – Laplace's and Poisson's equations – Solution of Laplace's equation in one variable.

UNIT II ELECTRIC FIELDS-1 9

Introduction - Analytical calculation of space-charge-free fields - simple geometries - transmission conductors to ground - fields in multi dielectric media - experimental analogs for space charge free fields - electrolytic tank - semi conducting paper analog – resistive mesh analog.

UNIT III ELECTRIC FIELDS-2 9

Numerical computation of space charge free fields - successive imaging technique - the dipole method - charge-simulation technique - finite-difference technique - combined charge-simulation and finite difference technique - finite element technique - combined charge simulation and finite-element technique - boundary-element method – integral equations technique – monte carlo technique.

UNIT IV ELECTRIC FIELDS-3 9

Analytical calculations of fields with space charges - numerical computation of fields with space charges finite element technique - finite element technique combined with the method of characteristics - charge-simulation technique combined with the method of residues - electric stress control and optimization.

UNIT V CONDUCTORS & DIELECTRICS 9

Behavior of conductors in an electric field – conductors and insulators – electric field inside a dielectric material – polarization – dielectric – conductor and dielectric – dielectric boundary conditions – energy stored and energy density in a static electric field – current density – conduction and convection current densities – ohm's law in point form – equation of continuity.

L =45 Total = 45 Periods

REFERENCE BOOKS:

1. William H. Hayt and John. A. Buck, "Engineering Electromagnetics", Tata McGraw-Hill Companies, Seventh Edition, 2012.
2. Kraus J. D., "Electromagnetics", McGraw-Hill Inc., Fourth Edition, 1999.
3. Gangadhar, "Field Theory", Khanna Publishers, 2002.
4. Sadiku, "Elements of Electromagnetic field theory", Oxford Publication, 2010.
5. Paul C.R. and Nasar S.A., "Introduction to E-Magnetics", Tata McGraw-Hill Publications, 2005.

HVE2L RESTRUCTURED POWER SYSTEMS

L	T	P	C
3	0	0	3

OBJECTIVES

- To study the operators involved in Restructured market and methods used for pricing and congestion process.
- To know the functions and operations of U.S. Re-structured markets.
- To study the structure and functions of OASIS and ATC calculation.
- To know the importance, factors and derivative instruments of electric energy trading.
- To understand the factors and challenges of eclectic price volatility and forecasting methods.

UNIT I OVERVIEW OF KEY ISSUES IN ELECTRIC UTILITIES RESTRUCTURING 9

Restructuring Models: Pool Co 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 - Market Power - Stranded costs - Transmission Pricing: Contract Path Method, The MW-Mile Method - Congestion Pricing: Congestion Pricing Methods, Transmission Rights - Management of Inter-Zonal/Intra Zonal Congestion: Solution procedure, Formulation of Inter-Zonal Congestion Sub problem, Formulation of Intra-Zonal Congestion Sub problem.

UNIT II ELECTRIC UTILITY MARKETS IN THE UNITED STATES 9

California Markets: ISO, Generation, Power Exchange, Scheduling Coordinator, UDCs, Retailers and Customers, Day-Ahead and Hour-Ahead Markets, Block forwards Market, Transmission Congestion Contracts(TCCs) - New York Market: Market operations - PJM interconnection – ERCOT ISO - New England ISO - Midwest ISO: MISO's Functions, Transmission Management, Transmission System Security, Congestion Management, Ancillary Services Coordination, Maintenance Schedule Coordination - Summary of functions of U.S. ISOs.

UNIT III OASIS: OPEN ACCESS SAME TIME INFORMATION SYSTEM 9

FERC order 889 - Structure of OASIS: Functionality and Architecture of OASIS - Implementation of OASIS Phases: Phase 1, Phase 1-A, Phase 2 - Posting of information: Types of information available on OASIS, Information requirement of OASIS, Users of OASIS - Transfer Capability on OASIS: Definitions, Transfer Capability Issues, ATC Calculation, TTC Calculation, TRM Calculation, CBM Calculation - Transmission Services - Methodologies to Calculate ATC - Experiences with OASIS in some Restructuring Models: PJM OASIS, ERCOT OASIS.

UNIT IV ELECTRIC ENERGY TRADING 9

Essence of Electric Energy Trading - Energy Trading Framework: The Qualifying factors - Derivative Instruments of Energy Trading: Forward Contracts, Futures Contracts, Options, Swaps, Applications of Derivatives in Electric Energy Trading – Port Folio Management: Effect of Positions on Risk Management - Energy Trading Hubs - Brokers in Electricity Trading - Green Power Trading.

UNIT V ELECTRICITY PRICING - VOLATILITY, RISK AND FORECASTING 9

Electricity Price Volatility: Factors in Volatility, Measuring Volatility - Electricity Price Indexes: Case Study for Volatility of Prices in California, Basis Risk - Challenges to Electricity Pricing: Pricing Models, Reliable Forward Curves - Construction of Forward Price Curves: Time frame for Price Curves, Types of Forward Price Curves – Short-term Price Forecasting: Factors Impacting Electricity Price, Forecasting Methods, Analyzing Forecasting Errors, Practical Data Study.

L =45 Total = 45 Periods

REFERENCE BOOKS:

1. Jain M.K. and Rao N.D., G.J.Berg, "Improved Area Interchange Control Method for use with any Numerical Technique", I.E.E.E. P.E.S Winter Power Meeting 1974.
2. Britton J.P., "Improved Area Interchange Control for Newton's method Load Flows", Paper 69 TP 124-PWR presented at IEEE Winter Power Meeting, NewYork, Jan 26-31, 1969.
3. Tinney W.F. and Meyer W.S., "Solution of Large Sparse System by Ordered Triangular Factorization" IEEE Trans. on Automatic Control, Vol: AC-18, pp: 333-346, Aug 1973.
4. Zollenkopf K., "Bi-Factorization: Basic Computational Algorithm and Programming Techniques; pp: 75-96, 1970.
5. Book on "Large Sparse Set of Linear Systems" Editor: Rerd J.K., Academic Press, 1971.

HVE2M POWER SYSTEM PLANNING AND RELIABILITY

L	T	P	C
3	0	0	3

OBJECTIVES

- To study the objectives and importance of load forecasting and the methods involved in it.
- To determine LOLP and reliability of ISO.
- To learn contingency analysis and load flow reliability analysis.
- To learn the concept, procedure and problems faced in Expansion planning.
- To understand the planning, protection and coordination of protective devices in distribution systems.

UNIT I LOAD FORECASTING 9

Objectives of forecasting - Load growth patterns and their importance in planning - Load forecasting based on discounted multiple regression technique-Weather sensitive load forecasting - Determination of annual forecasting-Use of AI in load forecasting.

UNIT II GENERATION SYSTEM RELIABILITY ANALYSIS 9

Probabilistic generation and load models- Determination of LOLP and expected value of demand not served –Determination of reliability of ISO and interconnected generation systems.

UNIT III TRANSMISSION SYSTEM RELIABILITY ANALYSIS 9

Deterministic contingency analysis-probabilistic load flow-Fuzzy load flow probabilistic transmission system reliability analysis-Determination of reliability indices like LOLP and expected value of demand not served.

UNIT IV EXPANSION PLANNING 9

Basic concepts on expansion planning-procedure followed for integrate transmission system planning, current practice in India-Capacitor placer problem in transmission system and radial distributions system.

UNIT V DISTRIBUTION SYSTEM PLANNING OVERVIEW 9

Introduction - sub transmission lines and distribution substations-Design of primary and secondary systems-distribution system protection and coordination of protective devices.

L =45 Total = 45 Periods

REFERENCE BOOKS:

1. Sullivan R.L., “Power System Planning”, Tata McGraw-Hill, US, 1977.
2. Roy Billinton and Allan Ronald, “Power System Reliability”, Gordon and Breach, Science Publishers, 1970.
3. Proceeding of work shop on energy systems planning & manufacturing CI.
4. Turan Gonen, “Electric power distribution system engineering”, Tata McGraw-Hill, 1986.

HVE2N POWER SYSTEM ANALYSIS

L	T	P	C
3	0	0	3

OBJECTIVES

- To learn the various solution techniques for large scale power systems.
- To study the various load flow analysis techniques and assessment of ATC.
- To facilitate the importance of optimal power flow and methods involved in calculating OPF.
- To know the fault analysis calculation using bus impedance matrix.
- To learn the numerical integration methods and factors influencing numerical and transient stability.

UNIT I SOLUTION TECHNIQUE 9

Sparse Matrix techniques for large scale power systems: Optimal ordering schemes for preserving sparsity - Flexible packed storage scheme for storing matrix as compact arrays – Factorization by Bifactorization and Gauss elimination methods - Repeat solution using Left and Right factors and L and U matrices.

UNIT II POWER FLOW ANALYSIS 9

Power flow equation in real and polar forms - Review of Newton’s method for solution - Adjustment of P-V buses - Review of Fast Decoupled Power Flow method - Sensitivity factors for P-V bus adjustment - Net Interchange power control in Multi-area power flow analysis: ATC, Assessment of Available Transfer Capability (ATC) using Repeated Power Flow method - Continuation Power Flow method.

UNIT III OPTIMAL POWER FLOW 9

Problem statement - Solution of Optimal Power Flow (OPF) – The gradient method, Newton’s method, Linear Sensitivity Analysis - LP methods – With real power variables only – LP method with AC power flow variables and detailed cost functions - Security constrained Optimal Power Flow - Interior point algorithm - Bus Incremental costs.

UNIT IV SHORT CIRCUIT ANALYSIS 9

Fault calculations using sequence networks for different types of faults - Bus impedance matrix (ZBUS) construction using Building Algorithm for lines with mutual coupling - Simple numerical problems - Computer method for fault analysis using ZBUS and sequence components - Derivation of equations for bus voltages - fault current and line currents - both in sequence and phase domain using Thevenin’s equivalent and ZBUS matrix for different faults.

UNIT V TRANSIENT STABILITY ANALYSIS 9

Introduction, Numerical Integration Methods: Euler and Fourth Order Runge-Kutta methods - Algorithm for simulation of SMIB and multi-machine system with classical synchronous machine model - Factors influencing transient stability - Numerical stability and implicit Integration methods.

L =45 Total = 45 Periods

REFERENCE BOOKS:

1. Stagg G.W. and El-Abiad A.H., “Computer Methods in Power System Analysis”, Tata McGraw-Hill, 1968.
2. Kundur P., “Power System Stability and Control”, Tata McGraw-Hill, 1994.
3. Wood A.J. and Wollenberg B.F., “Power Generation Operation and Control”, John Wiley and sons, New York, 1996.
4. Tinney W.F. and Meyer W.S., “Solution of Large Sparse System by Ordered Triangular Factorization” IEEE Trans. on Automatic Control, Vol.18, pp. 333-346, Aug 1973.
5. Zollenkopf K., “Bi-Factorization: Basic Computational Algorithm and Programming Techniques” pp. 75-96.
6. Book on “Large Sparse Set of Linear Systems” Editor: J.K.Rerd,Academic Press, 1971.

HVE2P MODERN RECTIFIERS AND RESONANT CONVERTERS

L	T	P	C
3	0	0	3

OBJECTIVES

- To study about the causes for arising the harmonics and basic filter techniques.
- To study about the pulse width modulated rectifier and its control techniques.
- To study and analyze the performance of resonant converter of its various types.
- To develop the state space model and dynamic analysis of switching converter.
- To design the various control scheme for resonant converter**.**

UNIT I POWER SYSTEM HARMONICS & LINE COMMUTATED RECTIFIERS 9

Average power-RMS value of waveform-Power factor-AC line current harmonic standards IEC-1000 – IEEE-519 - The Single phase full wave rectifier – Continuous Conduction Mode-Discontinuous Conduction Mode-Behavior - Minimizing THD - Three phase rectifiers- Continuous Conduction Mode-Discontinuous Conduction Mode-Harmonic trap filters.

UNIT II PULSE WIDTH MODULATED RECTIFIERS 9

Properties of Ideal rectifiers-Realization of non ideal rectifier-Control of current waveform-Average current control-Current programmed Control- Hysteresis control- Nonlinear carrier control-Single phase converter system incorporating ideal rectifiers- Modeling losses and efficiency in CCM high quality rectifiers-Boost rectifier Example - expression for controller duty cycle-expression for DC load current-solution for converter Efficiency.

UNIT III RESONANT CONVERTERS 9

Review on Parallel and Series Resonant Switches-Soft Switching- Zero Current Switching - Zero Voltage Switching -Classification of Quasi resonant switches-Zero Current Switching of Quasi Resonant Buck converter, Zero Current Switching of Quasi Resonant Boost converter, Zero Voltage Switching of Quasi Resonant Buck converter, Zero Voltage Switching of Quasi Resonant Boost converter: Steady State analysis.

UNIT IV DYNAMIC ANLYSIS OF SWITCHING CONVERTERS 9

Review of linear system analysis-State Space Averaging-Basic State Space Average Model-State Space Averaged model for an ideal Buck Converter, ideal Boost Converter, ideal Buck Boost Converter, ideal Cuk Converter.

UNIT V CONTROL OF RESONANT CONVERTERS 9

Pulse Width Modulation-Voltage Mode PWM Scheme-Current Mode PWM Scheme- Design of Controllers: PI Controller, Variable Structure Controller, Optimal Controller for the source current shaping of PWM rectifiers.

L =45 Total = 45 Periods

REFERENCE BOOKS:

1. Robert W. Erickson and Dragon Maksimovic, "Fundamentals of Power Electronics", Second Edition, Springer science and Business media, 2001.
2. William Shepherd and Li zhang, "Power Converters Circuits", Marceld Ekkerin,C, 2005.
3. Simon Ang and Alejandro Oliva, "Power Switching Converters", Taylor & Francis Group, 2010.

HVE2Q ANALYSIS OF POWER CONVERTERS

L	T	P	C
3	0	0	3

OBJECTIVES

- To study the types and its principle operation of single phase AC-DC converter.
- To study the various three phase AC-DC converter and its operation.
- To study about the types of DC-DC converter and fundamentals of Resonant converter
- To study about the various inverter and its analysis with different loads.
- To study about the voltage controller, cycloconverter and matrix converter.

UNIT I SINGLE PHASE AC-DC CONVERTERS **9**

Uncontrolled, half controlled and fully controlled with RL, RLE loads and freewheeling diode - continuous and discontinuous modes of operation – inverter operation –Dual converter – Sequence control of converters – Performance parameters: harmonics, ripple, distortion, power factor – effect of source impedance and overlap.

UNIT II THREE PHASE AC-DC CONVERTERS **9**

Uncontrolled, half controlled and fully controlled with RL, RLE loads and freewheeling diodes – Inverter operation and its limit – Dual converter – Performance parameter effect of source impedance and overlap.

UNIT III DC – DC CONVERTERS **9**

Principles of step-down and step-up converters – Analysis of buck, boost, buck-boost and Cuk converters – Time ratio and current limit control – Full bridge converter – Resonant and Quasi-resonant converters.

UNIT IV DC – AC CONVERTERS **9**

Voltage source inverters - Principle of operation of half and full bridge inverters – 180 degree and 120 degree conduction mode inverters – Voltage control of three phase inverters using various PWM techniques – Harmonics and various harmonic elimination techniques – Analysis with RL, RLE loads – Multi level inverters.

UNIT V AC – AC CONVERTERS **9**

Principle of operation of AC Voltage Controllers, Cycloconverters – Analysis with RL, RLE loads – Introduction to Matrix converters.

L =45 Total = 45 Periods

REFERENCE BOOKS:

1. Ned Mohan, Undeland and Robbin, “Power Electronics: Converters, Application and Design”, A John Wiley and Sons Inc., Newyork, 2012.
2. Rashid M.H., “Power Electronics Circuits, Devices and Applications”, Prentice Hall of India, New Delhi, 2011.
3. Sen P.C, ”Modern Power Electronics”, Wheeler publishing Co, New Delhi, First Edition, 2005.
4. Bimbhra P.S., “Power Electronics”, Eleventh Edition, Khanna Publishers, 2003.
5. Bin Wu, “High Power Converters and AC Drives”, IEEE Press, A John Wiley and Sons Inc., 2006.

HVE2R POWER ELECTRONICS IN POWER SYSTEMS

L	T	P	C
3	0	0	3

OBJECTIVES

- To study about the fundamental concept of power electronic devices.
- To study about the single phase and three phase power converter and its operation.
- To study about the single phase and three phase inverter with its control strategies.
- To illustrate the reactive power compensation and the FACTS devices.
- To aware about the power quality and various power quality problems.

UNIT I INTRODUCTION 9

Basic Concept of Power Electronics - Different types of Power Electronic Devices – Diodes, Transistors and SCR, MOSFET, IGBT and GTO's.

UNIT II AC TO DC CONVERTERS 9

Single Phase and three phase bridge rectifiers - Half Controlled and Fully Controlled Converters with R, RL and RLE loads - Free Wheeling Diodes - Dual Converter - Sequence Control of Converters – inverter operation - Input Harmonics and Output Ripple - Smoothing Inductance – Power Factor Improvement effect of source impedance - Overlap, Inverter limit.

UNIT III DC TO AC CONVERTERS 9

General Topology of single Phase and three phase voltage source and current source inverters- Need for feedback diodes in anti parallel with switches – Multi Quadrant Chopper viewed as a single phase inverter- Configuration of Single phase voltage source inverter: Half and Full bridge, Selection of Switching Frequency and Switching Device - Voltage Control and PWM strategies.

UNIT IV STATIC REACTIVE POWER COMPENSATION 9

Shunt Reactive Power Compensation – Fixed Capacitor Banks, Switched Capacitors, Static Reactor Compensator, Thyristor Controlled Shunt Reactors (TCR) – Thyristor Controlled Transformer - FACTS Technology-Applications of static thyristor controlled shunt compensators for load compensation - Static VAR Systems for Voltage Control - Power Factor Control and Harmonic Control of Converter fed Systems.

UNIT V POWER QUALITY 9

Power Quality – Terms and Definitions – Transients – Impulsive and Oscillatory Transients – Harmonic Distortion – Harmonic Indices – Total Harmonic Distortion – Total Demand Distortion-Locating Harmonic Sources - Harmonics from commercial and industrial Loads –Devices for Controlling Harmonics - Passive and Active Filters - Harmonic Filter Design.

L =45 Total = 45 Periods

REFERENCE BOOKS:

1. Ned Mohan, Undeland and Robbin, "Power Electronics: Converters, Application and Design", A John Wiley and Sons Inc., Newyork, 2012.
2. Rashid M.H., "Power Electronics Circuits, Devices and Applications", Prentice Hall of India, 2011.
3. Bose B.K., "Power Electronics and A.C. Drives", Prentice Hall, 2010.
4. Roger C Dugan, Mark F Mc Granaghan, Surya Santaso and Wayne Beaty H., "Electrical Power Systems Quality", Second Edition, Tata McGraw-Hill, 2003.
5. Miller T.J.E., "Static Reactive Power Compensation", John Wiley and Sons, Newyork, 1982.
6. Mohan Mathur R., Rajiv K Varma, "Thyristor Based FACTS controllers for Electrical Transmission Systems", IEEE press 2002.

HVE3A	POLLUTION PERFORMANCE OF POWER APPARATUS AND SYSTEMS	L	T	P	C
		3	0	0	3

OBJECTIVES

- To study the mechanism of pollution flashover, Analytical determination.
- To study the artificial pollution testing methods.
- To study the pollution performance of insulators.
- To study the pollution performance of surge diverters.

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.

L =45 Total = 45 Periods

REFERENCE BOOKS:

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", ElseHvier India Pvt. Ltd, 2005.
3. Klaus Ragaller, "Surges in High Voltage Networks", Plenum Press, New York, 1980.
4. Loom. J.S.T., "Insulators for High Voltages", Peter Peregrinus Ltd., London, 1988.
5. Dieter Kind and Kurt Feser, "High Voltage Test Techniques",SBA Electrical Engineering Series, New Delhi, Second Edition,1999.
6. Ravi S Gorur "Outdoor Insulators", Inc. Phoenix, Arizona 85044, USA, 1999.

HVE3B ADVANCED DIGITAL SIGNAL PROCESSING **L T P C**

(Common to M.E CS, M.E CC, M.E HVE and M.E C&I) **3 0 0 3**

OBJECTIVES

- Estimate the spectrum using parametric methods and non parametric methods.
- Estimation and prediction using wiener FIR & IIR filters
- Study adaptive filtering techniques using LMS algorithm and to study the applications of adaptive filtering.
- Apply multirate signal processing fundamentals.

UNIT I DISCRETE RANDOM SIGNAL PROCESSING **9**

Discrete Random Processes - Ensemble Averages, Stationary processes, Bias and Estimation, Auto covariance, Autocorrelation, Parseval's theorem, Wiener-Khintchine relation, White noise, Power Spectral Density, Spectral factorization, Filtering Random Processes, Special types of Random Processes, ARMA, AR, MA.

UNIT II SPECTRAL ESTIMATION **9**

Estimation of spectra from finite duration signals, Nonparametric methods, Periodogram, Modified periodogram, Bartlett, Welch and Blackman-Tukey methods, Parametric methods, ARMA, AR and MA model based spectral estimation, Yule-Walker equations, Solution using Levinson-Durbin algorithm.

UNIT III LINEAR ESTIMATION AND PREDICTION **9**

Linear prediction, Forward and Backward prediction, Signal modeling, Solution of Prony's normal equations, Least mean-squared error criterion, Wiener filter for filtering and prediction, FIR and IIR Wiener filters, Discrete Kalman filter.

UNIT IV ADAPTIVE FILTERS **9**

FIR adaptive filters, adaptive filter based on steepest descent method- Widrow-Hoff LMS algorithm, Normalized LMS algorithm, Adaptive channel equalization, Adaptive echo cancellation, Adaptive noise cancellation, RLS adaptive algorithm.

UNIT V MULTIRATE DIGITAL SIGNAL PROCESSING **9**

Upsampling and down sampling, Interpolation and Decimation, Sampling rate conversion by a rational factor, Polyphase filter structures, Multistage implementation of multirate system, Application to subband coding.

TOTAL: 45 PERIODS

REFERENCES:

1. Monson H. Hayes, "Statistical Digital Signal Processing and Modeling", John Wiley and Sons, Inc, Singapore, 1st Edition, 2008.
2. John G. Proakis and Dimitris K Manolakis, "Digital Signal Processing", Pearson Education, 4th Edition, 2009.
3. Alan V. Oppenheim and Ronald W. Schafer, "Discrete-Time Signal Processing" 3rd Edition, Prentice Hall, 2009.
4. Emmanuel C. Ifeachor and Barrie W. Jervis, "Digital signal processing: A practical approach" 2nd Edition, Prentice Hall, 2002.

HVE3C	**EVOLUTIONARY COMPUTING**	**L**	**T**	**P**	**C**
	(Common to HVE, CSE, CS and CC)	**3**	**0**	**0**	**3**

OBJECTIVES

- To brief the basic concepts of evolutionary computation
- To give idea about various representation, selection and search operations
- To discuss the basic of fitness evaluation and constraint handling mechanism
- To outline the concepts of hybrid systems
- To understand the effect of parameter setting and applications

UNIT I INTRODUCTION TO EVOLUTIONARY COMPUTATION 9

Introduction – Possible applications of evolutionary computations – History of evolutionary computation – Genetic algorithms – Evolution strategic – Evolutionary programming – Derivative methods – Stochastic processes – Modes of stochastic convergence – Schema processing – Transform methods – Fitness landscape – Probably Approximately Correct (PAC) learning analysis – Limitation of evolutionary computation methods – Local performance measures.

UNIT II REPRESENTATION, SELECTION AND SEARCH OPERATORS 9

Representation – Binary strings – Real-valued vectors – Permutations – finite-state representation – Parse trees – Guidelines for a suitable encoding – Other representations Selection – Proportional selection and sampling algorithms – Tournament selection – Rank based selection – Boltzmann selection – Other selection methods – Hybrids Generation gap methods –A comparison of selection mechanisms – Interactive evolution – Search Operators – Mutation – recombination – Other operators.

UNIT III FITNESS EVALUATION AND CONSTRAINT HANDLING 9

Fitness Evaluation – Encoding and decoding functions – Competitive fitness evaluation – Complexity based fitness evaluation – Multi objective optimization – Constraint handling techniques – Penalty functions – Decoders – Repair algorithms – Constraint preserving operators – Other constraint handling methods – Constraint satisfaction problems – Population structures – Niching Methods – Specification methods – Island(migration)models.

UNIT IV HYBRID SYSTEM 9

Self-adaptation – Meta evolutionary approaches – Neural – Evolutionary systems – New areas for evolutionary computation research in evolutionary systems – Fuzzy-Evolutionary Systems – Combination with Other Optimization Methods – Combination with local search – Combination with dynamic programming – Simulated annealing and tabu search – Comparison with existing optimization.

UNIT V PARAMETER SETTING AND APPLICATIONS 9

Heuristics for Parameter setting Issues – Population size – Mutation parameters – Recombination parameters – Implementation of Evolutionary Algorithms – Efficient implementation of algorithms – Computation time of evolutionary operators – Applications – Classical optimization problems – Control Identification – Scheduling – Pattern recognition – Simulation models

L =45 Total = 45 Periods

REFERENCE BOOKS:

1. Thomas Back et al, "Handbook on evolutionary computation", Institute of Physics, Publishing, 2000.
2. Xin Yao, "Evolutionary Computations: Theory and Applications", World Scientific 39 Publishing, 1999.
3. Goldberg, "Genetic algorithm in search, optimization and machine learning", Addison Wesley, 1998.
4. Davis, "Hand book on Genetic Algorithms", NewYork, 1991.
5. Kenneth A De Jong, "Evolutionary Computation: A Unified Approach", MIT Press, 2006.

HVE3D	ADVANCED DIGITAL SYSTEM DESIGN	L	T	P	C
	(Common to C&I, HVE)	3	0	0	3

OBJECTIVES

- Able to design a small digital system to the specified functionality
- Able to have good understanding and experience of modern techniques in combinational and sequential circuit design with VHDL
- Able to be aware of modern technology in implementation of digital designs
- Ability to know the structure of field programmable logic circuits FPGAs

UNIT I SEQUENTIAL CIRCUIT DESIGN 9

Analysis of Clocked Synchronous Sequential Networks (CSSN) Modelling of CSSN –State Stable Assignment and Reduction – Design of CSSN – Design of Iterative Circuits – ASM Chart – ASM Realization, Design of Arithmetic circuits for Fast adder- Array Multiplier.

UNIT II ASYNCHRONOUS SEQUENTIAL CIRCUIT DESIGN 9

Analysis of Asynchronous Sequential Circuit (ASC) – Flow Table Reduction – Races in ASC – State Assignment Problem and the Transition Table – Design of ASC – Static and Dynamic Hazards – Essential Hazards – Data Synchronizers – Designing Vending Machine Controller – Mixed Operating Mode Asynchronous Circuits.

UNIT III FAULT DIAGNOSIS AND TESTABILITY ALGORITHMS 9

Fault Table Method – Path Sensitization Method – Boolean Difference Method – Kohavi Algorithm – Tolerance Techniques – The Compact Algorithm – Practical PLA's – Fault in PLA – Test Generation – Masking Cycle – DFT Schemes – Built-in Self Test.

UNIT IV SYSTEM DESIGN USING VHDL 9

VHDL operators – Arrays – concurrent and sequential statements – packages- Data flow – Behavioral – structural modeling – compilation and simulation of VHDL code –Test bench **-** Realization of combinational and sequential circuits using HDL – Registers – counters – sequential machine – serial adder – Multiplier- Divider – Design of simple microprocessor.

UNIT V NEW GENERATION PROGRAMMABLE LOGIC DEVICES 9

Foldback Architecture with GAL,PEEL, PML; PROM – Realization State machine using PLD – FPGA – Xilinx FPGA – Xilinx 2000 **-** Xilinx 3000.

L =45 Total = 45 Periods

TEXT BOOKS:

1. Donald G. Givone, "Digital principles and Design", Tata McGraw Hill 2001.
2. Stephen Brown and Zvonk Vranesic, "Fundamentals of Digital Logic with VHDL Design", Tata McGraw Hill –Higher Education, 2009.

REFERENCE BOOKS:

1. Mark Zwolinski, "Digital System Design with VHDL", Pearson Education, 2001.V
2. Parag K Lala, "Digital System design using PLD", BS Publications, 2001.II
3. John M Yarbrough, "Digital Logic applications and Design", Thomson Learning, 2001.
4. Nripendra N Biswas, "Logic Design Theory", Prentice Hall of India, 2001.
5. Charles H. Roth Jr., "Fundamentals of Logic design", Thomson Learning, 6^{th} Edition 2010.
6. Charles H Roth Jr."Digital System Design using VHDL" Thomson learning, 2004.
7. Douglas L.Perry "VHDL programming by Example" Tata McGraw.Hill – 2006.

HVE3E HIGH VOLTAGE DIRECT CURRENT TRANSMISSION

L	T	P	C
3	0	0	3

OBJECTIVES

- To understand the concept, planning of DC power transmission and comparison with AC power transmission.
- To analyze HVDC converters.
- To study about compounding and regulation.
- To analyze harmonics and design of filters.
- To learn about HVDC cables and simulation tools.

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 – Detailed analysis of converters - General principles of DC link control – Converter control – System control hierarchy - Firing angle control – Current and extinction angle control – Generation of harmonics and filtering.

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 – Modeling of DC links – Solution of DC load flow – Solution of AC-DC power flow – Case studies.

UNIT V SIMULATION OF HVDC SYSTEMS 9

Introduction – System simulation: Philosophy and tools – HVDC system simulation –Modeling of HVDC systems for digital dynamic simulation – Dynamic interaction between DC and AC systems.

L =45 Total = 45 Periods

REFERENCE BOOKS:

1. Padiyar K.R., "HVDC Power Transmission Systems", New Age International (P)Ltd., New Delhi, 2002.
2. Arrillaga J., "High Voltage Direct Current Transmission", Peter Pregrinus, London, 2007.
3. Kundur P., "Power System Stability and Control", Tata McGraw-Hill, 1993.
4. Erich Uhlmann, "Power Transmission by Direct Current", BS Publications, 2004.
5. Sood V.K., "HVDC and FACTS controllers – Applications of Static Converters in Power System", Kluwer Academic Publishers, April 2004.

HVE3F POWER QUALITY

L	T	P	C
3	0	0	3

OBJECTIVES

- To study the production of voltages sags, over voltages and harmonics and methods of control.
- To study various methods of power quality monitoring.
- To discuss the various types of measurements and analysis methods.
- To outline the concepts of Mitigation methods.
- To study the overview of power quality improvement.

UNIT I INTRODUCTION **9**

Introduction – Characterization 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 NON-LINEAR LOADS **9**

Single phase static and rotating AC/DC converters – Three phase static AC/DC converters – Battery chargers – Arc furnaces – Fluorescent lighting – Pulse modulated devices – Adjustable speed drives.

UNIT III MEASUREMENT AND ANALYSIS METHODS **9**

Voltage, Current, Power and Energy measurements – Power factor measurements and definitions – Event recorders – Measurement Error – Analysis: Analysis in the periodic steady state – Time domain methods – Frequency domain methods: Laplace's, Fourier and Hartley transform – The Walsh Transform – Wavelet Transform.

UNIT IV ANALYSIS AND CONVENTIONAL MITIGATION METHODS **9**

Analysis of power outages – Analysis of unbalance – Symmetrical components of phasor quantities – Instantaneous symmetrical components – Instantaneous real and reactive powers – Analysis of distortion – On-line extraction of fundamental sequence components from measured samples – Harmonic indices – Analysis of voltage sag – Detroit Edison sag score – Voltage sag energy – Voltage Sag Lost Energy Index (VSLEI) – Analysis of voltage flicker – Reduced duration and customer impact of outages – Classical load balancing problem – Open loop balancing – Closed loop balancing – Current balancing – Harmonic reduction – Voltage sag reduction.

UNIT V POWER QUALITY IMPROVEMENT **9**

Utility – Customer interface – Harmonic filters: passive, Active and hybrid filters – Custom power devices – Network reconfiguring Devices – Load compensation using DSTATCOM – Voltage regulation using DSTATCOM – Protecting sensitive loads using DVR, UPQC – control strategies – P-Q theory – Synchronous detection method – Custom power park – Status of application of custom power devices.

L =45 Total = 45 Periods

REFERENCE BOOKS:

1. Arindam Ghosh, "Power Quality Enhancement Using Custom Power Devices", Kluwer Academic Publishers, 2002.
2. Heydt G.T., "Electric Power Quality", Stars in a Circle Publications, 2nd Edition, 1994.
3. Duggan R.C., "Electrical Power Systems Quality", McGraw-Hill, 2012.
4. Arrillga A.J., "Power system harmonics", John Wiley & Sons Ltd., 2nd Edition, 2003.
   Derek A Paice, "Power electronic converter harmonics", IEEE Press, 1996.

HVE3G POWER SYSTEM OPERATION AND CONTROL

L	T	P	C
3	0	0	3

OBJECTIVES

- To understand the basic concept of load prediction and various approaches.
- To develop the various method to get the solution for constraints.
- To study about the generation scheduling and the economic dispatch.
- To develop t the various control strategies of power systems.
- To design the state estimation using different algorithms.

UNIT I LOAD FORECASTING 9

Introduction – Estimation of Average and trend terms – Estimation of periodic components – Estimation of Stochastic components – Time series approach – Auto-Regressive Model – Auto-Regressive Moving – Average Models – Kalman Filtering Approach – On-line techniques for non stationary load prediction.

UNIT II UNIT COMMITMENT 9

Constraints in unit commitment – Spinning reserve – Thermal unit constraints – Other constraints – Solution using Priority List method - Dynamic programming method – Forward DP approach – Lagrangian relaxation method – adjusting λ.

UNIT III GENERATION SCHEDULING 9

The Economic dispatch problem – Thermal system dispatching with network losses considered – The Lambda-iteration method – Gradient method of economic dispatch – Economic dispatch with Piecewise Linear cost functions – Transmission system effects – A two generator system – coordination equations – Incremental losses and penalty factors – Hydro Thermal Scheduling using DP.

UNIT IV CONTROL OF POWER SYSTEMS 9

Review of AGC and reactive power control – System operating states by security control functions – Monitoring, evaluation of system state by contingency analysis – Corrective controls (Preventive, emergency and restorative) – Energy control center – SCADA system – Functions – Monitoring – Data acquisition and controls – EMS system.

UNIT V STATE ESTIMATION 9

Maximum likelihood Weighted Least Squares Estimation – Concepts – Matrix formulation – Example for Weighted Least Squares state estimation – State estimation of an AC network – development of method – Typical results of state estimation on an AC network – State Estimation by Orthogonal Decomposition algorithm – Introduction to Advanced topics –Detection and Identification of Bad Measurements – Estimation of Quantities Not Being Measured – Network observability and Pseudo measurements – Application of Power Systems State Estimation .

L =45 Total = 45 Periods

REFERENCE BOOKS:

1. Elgerd O.I., "Electric Energy System Theory - an Introduction", Tata McGraw-Hill, New Delhi, 2002.
2. Kundur P., "Power System Stability and Control", EPRI Publications, California, 1994.
3. Allen J Wood and Bruce F Wollenberg, "Power Generation Operation and Control', John Wiley & Sons, New York, 1996.
4. Mahalanabis A.K., Kothari D.P. and Ahson S.I., "Computer Aided Power System Analysis and Control", Tata McGraw-Hill, 1984.

HVE3H CONTROL OF ELECTRIC DRIVES

L	T	P	C
3	0	0	3

OBJECTIVES

- To understand the concept of converter fed DC drives.
- To study the various modes of operation of chopper fed DC drives.
- To analyze the various inverters fed DC drives and its sampling techniques.
- To develop the mathematical model of the frequency controlled drive also to study the steady state and dynamic behavior.
- To study the various measurement and control techniques**.**

UNIT I CONVERTER FED DC DRIVES 9

Microcontroller hardware circuit – flow charts waveforms – Performance characteristics of dc drives fed through single phase converters – 3-phase converters – dual converters – 1-phase fully controlled converter and 3-phase fully controlled converter fed dc drive.

UNIT II CHOPPER FED DC DRIVES 9

Microcontroller hardware circuits and waveforms of various modes of operation of chopper fed DC drives.

UNIT III INVERTER FED INDUCTION MOTOR DRIVE 9

Microcomputer controlled VSI fed induction motor drive – Detailed power circuit – generation of firing pulses and firing circuit – flow charts and waveforms for 1-phase, 3-phase Non-PWM and 3-phase PWM VSI fed induction motor drives – Sampling techniques for PWM inverter.

UNIT IV MATHEMATICAL MODELING OF FREQUENCY CONTROLLED DRIVE 9

Development of mathematical model for various components of frequency controlled induction drive – mathematical model of the system for steady state and dynamic behavior – Study of stability based on the dynamic model of the system.

UNIT V CLOSED LOOP CONTROL OF MICROCOMPUTER BASED DRIVES 9

Voltage, Current, Torque and Speed measurements using digital measurement techniques – Types of controllers – position and velocity measurement algorithm – closed loop control of microcomputer based drives.

L =45 Total = 45 Periods

REFERENCE BOOKS:

1. Bose B.K., “Power Electronics and Motor Drives - Advances and Trends”, IEEE Press, 2006.
2. Buxbaum, Schierau A., and Staughen K., “A design of control systems for DC drives”, Springer- Verlag, Berlin, 1990.
3. Vedam Subrahmanyam, “Thyristor control of Electric drives”, Tata McGraw-Hill, 1988.
4. Krishnan R., “Electric Motor Drives, Modeling, Analysis and Control”, Prentice Hall of India, 2002.
5. Bin Wu, “High Power Converters and AC Drives”, IEEE Press, A John Wiley and Sons, Inc., 2006.
6. Dubey G.K., “Power semiconductor controlled drives”, Prentice-HALL,1989.
7. Leonard W., “Control of Electric Drives”, Springer Verlag, NY, 1985.
8. Bose B.K., “Microcomputer control of power electronics and drives”, IEEE Press, 1987.
9. Bose B.K., “Adjustable Speed A.C. drives”, IEEE Press, 1993.

HVE3J DESIGN OF EMBEDDED SYSTEMS

L	T	P	C
3	0	0	3

OBJECTIVES

- To learn about embedded design life cycle, product testing and performance tools.
- To study partition decision in embedded systems and hardware manipulation.
- To study the interrupt service routines, debugging and computer optimization.
- To learn about the circuit emulators.
- To learn the concept of testing and analyze the performance and maintenance

UNIT I EMBEDDED DESIGN LIFE CYCLE **9**

Product specification – Hardware / Software partitioning – Detailed hardware and software design – Integration – Product testing – Selection Processes – Microprocessor Vs. Microcontroller – Performance tools – Bench marking – RTOS Microcontroller – Performance tools – Bench marking – RTOS availability – Tool chain availability – Other issues in selection processes.

UNIT II PARTITIONING DECISION **9**

Hardware / Software duality – coding Hardware – ASIC revolution – Managing the Risk – Co-verification – Execution environment – Memory organization – System startup – Hardware manipulation – Memory mapped access – Speed and code density.

UNIT III INTERRUPT SERVICE ROUTINES **9**

Watch dog timers – Flash Memory basic toolset – Host based debugging – Remote debugging – ROM emulators – Logic analyzer – Caches – Computer optimization – Statistical profiling.

UNIT IV IN CIRCUIT EMULATORS **9**

Buller proof run control – Real time trace – Hardware break points – Overlay memory – Timing constraints – Usage issues – Triggers.

UNIT V TESTING **9**

Bug tracking – Reduction of risks & costs – Performance – Unit testing – Regression testing – Choosing test cases – Functional tests – Coverage tests – Testing embedded software – Performance testing – Maintenance.

L =45 Total = 45 Periods

REFERENCE BOOKS:

1. Arnold S Berger, "Embedded System Design", CMP books, USA 2002.
2. Sriram Iyer, "Embedded Real time System Programming" Tata McGraw-Hill Publishing Company Ltd., 2004.
3. Arkin R.C., "Behaviour-based Robotics", The MIT Press, 1998.

HVE3K APPLICATIONS OF MEMS TECHNOLOGY

L	T	P	C
3	0	0	3

OBJECTIVES

- To learn the basic of fabrication processes and electro mechanical concepts.
- To give idea about electrostatic sensors, actuators and its applications.
- To outline the concepts of thermal sensing and actuation techniques.
- To discuss the concepts of piezoelectric sensing and actuation techniques.
- To discuss the various case studies in MEMS technology.

UNIT I MICRO-FABRICATION, MATERIALS AND ELECTRO-MECHANICAL CONCEPTS **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 piezoelectric actuator model – Properties of piezoelectric materials – Applications.

UNIT V CASE STUDIES **9**

Piezo resistive sensors - Magnetic actuation - Micro fluidics applications - Medical applications - Optical MEMS.

L =45 Total = 45 Periods

REFERENCE BOOKS:

1. Chang Liu, "Foundations of MEMS", Pearson International Edition, 2006.
2. Marc Madou, "Fundamentals of Microfabrication", CRC Press, 2009.
3. Boston, "Micromachined Transducers Sourcebook", WCB Tata McGraw-Hill, 1998.
4. Bao M.H., "Micromechanical transducers: Pressure sensors, accelerometers and gyroscopes", Elsevier, Newyork, 2000.

HVE3L MICROCONTROLLER AND DSP BASED SYSTEM DESIGN

L	T	P	C
3	0	0	3

OBJECTIVES

- To study the architecture, addressing modes and programming techniques of PIC 16C7X microcontroller.
- To study the various peripherals of 16C7X microcontroller.
- To study the architecture, addressing modes and programming techniques of digital signal processors (TMS320LF2407).
- To study the various peripherals of digital signal processors.
- To outline the applications of 16C7X microcontroller and TMS320LF2407 signal processors.

UNIT I PIC 16C7X MICROCONTROLLER 9

Architecture memory organization – Addressing modes – Instruction set – Programming techniques – Simple programs.

UNIT II PERIPHERALS OF PIC 16C7X 9

Timers – Interrupts – I/O ports – I2C bus for peripheral chip access – A/D converter –UART.

UNIT III DIGITAL SIGNAL PROCESSORS (TMS320LF2407) 9

Introduction – System configuration registers – Memory Addressing modes – Instruction set – Programming techniques – Simple programs.

UNIT IV PERIPHERALS OF SIGNAL PROCESSORS 9

General Purpose Input/Output (GPIO) Functionality – Interrupts – A/D converter – Event Managers (EVA, EVB) – PWM signal generation.

UNIT V APPLICATIONS OF PIC AND SIGNAL PROCESSORS 9

Voltage regulation of DC-DC converters – Stepper motor and DC motor control – Clarke's and parks transformation – Space vector PWM – Control of Induction Motors and PMSM.

L =45 Total = 45 Periods

REFERENCE BOOKS:

1. John B Peatman, "Design with PIC Microcontrollers", Pearson Education, Asia, 2004.
2. Hamid A Toliyat, Steven Campbell, "DSP based Electromechanical Motion Control", CRC Press, 2004.

HVE3M REACTIVE POWER COMPENSATION AND MANAGEMENT

L	T	P	C
3	0	0	3

OBJECTIVES

- To understand the basic concepts of load compensation.
- To develop the reactive power compensation in transmission line and its characteristics.
- To study about the basic concepts of power quality and its issues.
- To understand the concepts of load shaping and tariffs.
- To study about the reactive power management and its consideration.

UNIT I LOAD COMPENSATION 9

Objectives and specifications – Reactive power characteristics – Inductive and capacitive approximate biasing – Load compensator as a voltage regulator – Phase balancing and power factor correction of unsymmetrical loads – Examples.

UNIT II REACTIVE POWER COMPENSATION IN TRANSMISSION SYSTEM 9

Steady state reactive power compensation in transmission system: Uncompensated line – Types of compensation – Passive shunt and series and dynamic shunt compensation – Examples.
Transient state reactive power compensation in transmission systems: Characteristic time periods – Passive shunt compensation – Static compensations – Series capacitor compensation –Compensation using synchronous condensers – Examples.

UNIT III REACTIVE POWER COORDINATION 9

Objective – Mathematical modeling – Operation planning – Transmission benefits – Basic concepts of quality of power supply – Disturbances – Steady-state variations – Effects of under voltages – Frequency – Harmonics, radio frequency and electromagnetic interferences.

UNIT IV DEMAND SIDE MANAGEMENT 9

Load patterns – Basic methods of load shaping – Power tariffs – KVAR based tariffs – Penalties for voltage flickers and Harmonic voltage levels.

UNIT V REACTIVE POWER MANAGEMENT 9

Distribution side Reactive power Management: System losses – Loss reduction methods – Examples – Reactive power planning – Objectives – Economics Planning - capacitor placement – Retrofitting of capacitor banks.
User side reactive power management: KVAR requirements for domestic appliances – Purpose of using capacitors – Selection of capacitors – Deciding factors – Types of available capacitor, characteristics and Limitations.

L =45 Total = 45 Periods

REFERENCE BOOKS:

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

HVE3N	COMPUTER AIDED DESIGN OF POWER ELECTRONICS CIRCUITS	L	T	P	C
		3	0	0	3

OBJECTIVES

- To aware about the fundamentals of simulation and analysis of basic power electronic devices.
- To develop the advanced algorithms in computer simulation.
- To develop the model of power electronic devices in simulation.
- To study the various analysis in simulation circuits.
- To study the various case studies about the simulation of different power electronic devices.

UNIT I INTRODUCTION **9**

Importance of simulation – General purpose circuit analysis – Methods of analysis of power electronic systems – Review of power electronic devices and circuits.

UNIT II ADVANCED TECHNIQUES IN SIMULATION **9**

Analysis of power electronic systems in a sequential manner – Coupled and decoupled systems – Various algorithms for computing steady state solution in power electronic systems – Future trends in computer simulation.

UNIT III MODELING OF POWER ELCTRONIC DEVICES **9**

Introduction – AC sweep and DC sweep analysis – Transients and the time domain analysis – Fourier series and harmonic components – BJT, FET, MOSFET and its model- Amplifiers and Oscillator – Non-linear devices.

UNIT IV SIMULATION OF CIRCUITS **9**

Introduction – Schematic capture and libraries – Time domain analysis – System level integration and analysis – Monte Carlo analysis – Sensitivity/stress analysis – Fourier analysis.

UNIT V CASE STUDIES **9**

Simulation of Converters, Choppers, Inverters, AC voltage controllers, and Cycloconverters feeding R, R-L, and R-L-E loads – Computation of performance parameters: harmonics, power factor, angle of overlap.

L =45 Total = 45 Periods

REFERENCE BOOKS:

1. Rashid M., "Simulation of Power Electronic Circuits using PSPICE", PHI, 2006.
2. Rajagopalan V., "Computer Aided Analysis of Power Electronic systems" Marcell –Dekker Inc., 1987.
3. John Keown, "Microsim, Pspice and Circuit Analysis"- Prentice Hall Inc., 1998.

HVE3P COLLISION PHENOMENON

	L	T	P	C
	3	0	0	3

OBJECTIVES

- To brief the concepts of collision phenomenon.
- To know the behavior of charged particles in gaseous medium under different electric fields conditions.
- To study the concept of self sustaining discharge breakdown mechanisms.
- To study the concepts of partial discharge and breakdown mechanism under alternating fields.
- To study the concepts of breakdown, glow and plasma.

UNIT I INTRODUCTION 9

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

UNIT II BEHAVIOUR OF CHARGED PARTICLES IN A GAS IN ELECTRIC FIELDS OF LOW E/p AND HIGH E/p 9

Definition and significance of mobility – Forces between ions and molecules – Diffusion under low fields – Electron drift velocity – High E/p – Coefficient of ionization by electron collision – Evaluation of $\propto$ – Electron avalanche – Effect of the cathode – Ionization coefficient in alternating fields.

UNIT III SELF-SUSTAINING DISCHARGE BREAKDOWN MECHANISMS 9

Ionization by positive-ion collision – Cathode processes – Space-charge field of an avalanche – Critical avalanche size – Townsend mechanism and its limitations – Streamer formation – The transition between the breakdown mechanisms – The effect of electron attachment.

UNIT IV PARTIAL BREAKDOWN AND BREAKDOWN UNDER ALTERNATING FIELDS 9

Electron current – positive ion current – Total current – Characteristic time – Effect of space charge – Anode coronas – Cathode coronas.

UNIT V BREAKDOWN GLOW AND PLASMA 9

Breakdown: Mobility controlled breakdown, Microwave of diffusion controlled breakdown, Non-uniform alternating field breakdown – Laser breakdown.
Glow and Plasma: General description – The cathode zone – Negative glow and Faraday dark space – Positive column – Anode region – Other effects – Definition of plasma – Debye length – Scope of known plasmas – Plasma oscillations – High-temperature plasmas – Plasma diagnostics.

L =45 Total = 45 Periods

REFERENCE BOOKS:

1. Essam Nasser, "Fundamentals of Gaseous Ionization and Plasma Electronics", John Willey & Sons, 1971.
2. Alexander Fridman and Lawrence A Kennedy, "Plasma Physics and Engineering", Taylor & Francis, 2004.
3. Kwan Chi Kao, "Dielectric Phenomena in Solids [Electronic Resource]", Academic Press 2004.

HVE3Q PC BASED INSTRUMENTATION SYSTEM DESIGN	**L**	**T**	**P**	**C**
(Common to C&I and HVE)	**3**	**0**	**0**	**3**

COURSE OBJECTIVES:

i. To make the students to gain a clear knowledge of basics of digital instruments and measurements techniques.
ii. To have an adequate knowledge in various display and recording devices.
iii. To have a study of virtual instrumentation and its applications.

UNIT I DATA ACQUISITION AND INSTRUMENT INTERFACE 9

Programming and simulation of Building block of instrument Automation system – Signal analysis – I/O port configuration with instrument bus protocols – ADC, DAC, DIO, counters & timers, PC hardware structure, timing, interrupts, DMA, software and hardware installation, current loop.

UNIT II VIRTUAL INSTRUMENTATION PROGRAMMING TECHNIQUES 9

Block diagram and architecture of a virtual instrument, Graphical programming in data flow, comparison with conventional programming, VI's and sub-VI's, loops and charts, arrays, clusters and graphs, case and sequence structures, formula nodes, local and global variables, string and file I/O.

UNIT III DESIGN TEST AND ANALYSIS 9

Spectral estimation using Fourier Transform, power spectrum, correlation methods, Stability analysis, Fault analysis – Sampling, Data Parity and error coding checks, Synchronization testing – Watch dog timer, DMA method – Real time Clocking, Noise- Gaussian, White analysis.

UNIT IV PC BASED INSTRUMENTATION 9

Introduction – Evolution of signal standard – HART Communication protocol communication modes – HART networks – control system interface – HART commands – HART field controller implementation – HART and the OSI model

UNIT V SIMULATION OF PHYSICAL SYSTEMS 9

Simulation of linear & Nonlinear models of systems, Hardware in loop simulation of physical systems using special softwares.

L =45 Total = 45 Periods

TEXT BOOKS

1. N. Mathivanan, "PC- Based Instrumentation: Concepts and Practice", PHI Learning Pvt. Ltd., 2007.
2. K. Ogatta, "Modern control engineering", 5th Edition, Pearson Education, 2010.
3. Jovitha Jerome, "Virtual Instrumentation using Labview", PHI Learning Pvt. Ltd., 2010.

REFERENCES

1. Dorf and Bishop, "Modern Control Systems", Prentice Hall, 2008.
2. Patrick H Garrett," High performance Instrumentation and Automation", CRC Press, Taylor & Francis Group, 2005.
3. MAPLE V programming guide.
4. MATLAB/SIMULINK user manual.
5. MATHCAD/VIS SIM user manual.
6. LABVIEW simulation user manual.

HVE3R	**CONDITION MONITORING OF HIGH VOLTAGE POWER APPARATUS**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

OBJECTIVES

- To brief the general concept of condition monitoring of high voltage power apparatus.
- To study the condition monitoring in power transformer.
- To study the power generation condition monitoring.
- To give the idea of various diagnostic techniques and condition monitoring.
- To study the insulation materials in application area and various testing techniques.

UNIT I INTRODUCTION 9

General concept of condition monitoring – General issues of condition monitoring – Main Components in a condition monitoring system – Condition monitoring techniques.

UNIT II POWER TRANSFORMER CONDITION MONITORING 9

Transformer faults and monitoring techniques – Monitoring for on-load tap changer – Insulation monitoring – Sweep frequency response test for condition monitoring – Recent trend/research on Power transformer condition monitoring.

UNIT III POWER GENERATION CONDITION MONITORING 9

Power generation faults and monitoring methods – Stator winding faults – Rotor body faults – rotor winding faults – Stator-core faults – Condition monitoring for generator stator windings.

UNIT IV DIAGNOSTICS AND CONDITION MONITORING 9

Need for diagnostics and condition monitoring – On-line/on-site testing – Diagnostic tests – transformer impulse test – Digital techniques – Data acquisition principles and problems – winding structure – Natural frequencies – PD measurement – Background, analysis, calibration – digital PD measurement – PD as a diagnostic tool – PD signal – Noise reduction methods – PD pattern – Fault discrimination – Insulation degradation.

UNIT V INSULATION MATERIALS AND SYSTEMS 9

Outdoor insulation: Materials, ageing, diagnostic, polymeric materials, semi-conducting, Ceramic glazes – AC and impulse voltage flashover studies on a string of insulators – RIV and Corona Studies on insulator strings – High voltage testing – Dry, wet and pollution testing.

L =45 Total = 45 Periods

REFERENCE BOOKS:

1. Naidu M. S. and Kamaraju V., "High Voltage Engineering", Tata McGraw-Hill, 1995.
2. Kulkarni S.V. and Khaparde S.A., "Transformer Engineering", Marcel and Dekker Inc., 2004.
3. Tavner P. J. and Penman J., "Condition Monitroing of Electrical Machine", Letchworth, England,Research Studies Press, Ltd., 1987.
4. Kuffel E., Zaengl W.S. and Kuffel L., "High Voltage Engineering Fundamentals," Butterworth Heimann, 2nd Edition, 2000.
5. Rao B. K. N., "Handbook of Condition Monitoring", Elsevier Science Publisher, 1st Edition, 1996.
6. Han Y. and Song Y. H., "Condition Monitoring Techniques for Electrical Equipment – A Literature Survey." IEEE Trans. on Power Delivery, Vol. 18, No. 1, January 2003.
7. Wadhwa C. L., "High Voltage Engineering", Wiley Eastern Limited, New Delhi, 1994.

HVE3S ADVANCED TOPICS IN HIGH VOLTAGE ENGINEERING

L	T	P	C
3	0	0	3

OBJECTIVES

- To study the measurement and diagnostic technologies
- To know the various application of high voltage engineering in industry.
- To get knowledge about the safety and electrostatic hazards, Lightning protection.
- To study the electrical breakdown, pulse generators and treatment chamber design.

UNIT I MEASUREMENT AND DIAGNOSTIC TECHNOLOGIES 9

Introduction – Digital Impulse Recorders – Digital Techniques in HV tests – Testing automation – Electric field measurement – Electro-optic Sensors- Magneto-optic Sensors – Measurement of very fast transients in GIS – Space charge measurement techniques – Electro-optical imaging techniques.

UNIT II APPLICATION OF HIGH VOLTAGE ENGINEERING IN INDUSTRY 9

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

UNIT III 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.

UNIT IV PULSED ELECTRIC FIELDS 9

Introduction – Definitions, descriptions and applications – Mechanisms of microbial inactivation's – Electrical breakdown – Electroporation – Inactivation models – Critical factors analysis of process, product and microbial factors – Pulse generators and treatment chamber design – Research needs.

UNIT V APPLICATION OF PEF TECHNOLOGY IN FOOD PRESERVATION 9

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

L =45 Total = 45 Periods

REFERENCE BOOKS:

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