VELAMMAL

COLLEGE OF ENGINEERING & TECHNOLOGY, MADURAI – 625 009

(Autonomous)

(Accredited by NAAC with 'A' Grade and by NBA for 5 UG Programmes)

(Approved by AICTE and affiliated to Anna University, Chennai)

DEPARTMENT

OF

ELECTRICAL AND ELECTRONICS ENGINEERING

M.E. POWER SYSTEMS ENGINEERING (FULL TIME)

Curriculum and Syllabus I to IV Semesters

VELAMMAL COLLEGE OF ENGINEERING & TECHNOLOGY, MADURAI – 625 009
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DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

M.E. POWER SYSTEMS ENGINEERING (FULL TIME) Curriculum and Syllabus I to IV Semesters

SEMESTER I

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	MA5101	Applied Mathematics for Electrical Engineers	FC	4	4	0	0	4
2.	PS5101	Advanced Power System Analysis	PC	4	4	0	0	4
3.	PS5102	Analysis and Design of Power Converters	PC	3	3	0	0	3
4.	PS5103	Restructured Power System	PC	3	3	0	0	3
5.	PS5104	System Theory	PC	5	3	2	0	4
6.	PE51XX	Professional Elective I	PE	3	3	0	0	3
PRACTICALS								
7.	PS5105	Power System Simulation Laboratory	PC	4	0	0	4	2
			TOTAL	**26**	**20**	**2**	**4**	**23**

SEMESTER II

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	PS5201	Power System Dynamics	PC	3	3	0	0	3
2.	PS5202	HVDC and FACTS	PC	3	3	0	0	3
3.	PS5203	Advanced Power System Protection	PC	3	3	0	0	3
4.	PS5204	Smart Grid	PC	3	3	0	0	3
5.	PE52XX	Professional Elective II	PE	3	3	0	0	3
6.	PE52XX	Professional Elective III	PE	3	3	0	0	3

PRACTICALS								
7.	PS5205	Advanced Power System Simulation Laboratory	PC	4	0	0	4	2
8.	PS5206	Technical Seminar	EEC	2	0	0	2	1
			TOTAL	**24**	**18**	**0**	**6**	**21**

SEMESTER III

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	PE53XX	Professional Elective IV	PE	3	3	0	0	3
2.	PE53XX	Professional Elective V	PE	3	3	0	0	3
3.	PE53XX	Professional Elective VI	PE	3	3	0	0	3
PRACTICALS								
4.	PS5301	Project Work Phase I	EEC	12	0	0	12	6
			TOTAL	**21**	**9**	**0**	**12**	**15**

SEMESTER IV

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
PRACTICALS								
1.	PS5401	Project Work Phase II	EEC	24	0	0	24	12
			TOTAL	**24**	**0**	**0**	**24**	**12**

PROFESSIONAL ELECTIVES (PE)*

Semester I

Elective I

S.No	Course Code	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	PE5101	Analysis of Electrical Machines	PE	3	3	0	0	3
2.	PE5102	Soft Computing Techniques	PE	3	3	0	0	3
3.	PE5103	Industrial Power System Analysis and Design	PE	3	3	0	0	3

Semester II
Elective II and III

S.No	Course Code	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	PE5201	Energy Efficiency in Thermal Utilities	PE	3	3	0	0	3
2.	PE5202	Solar and Energy Storage Systems	PE	3	3	0	0	3
3.	PE5203	Micro Grid Operation And Control	PE	3	3	0	0	3
4.	PE5204	Advanced Digital Signal Processing	PE	3	3	0	0	3
5.	PE5205	Distributed Generation and Micro grid	PE	3	3	0	0	3
6.	PE5206	Energy Efficiency in Electrical Utilities	PE	3	3	0	0	3

Semester III
Elective IV, V and VI

S.No	Course Code	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	PE5301	Electrical Distribution System	PE	3	3	0	0	3
2.	PE5302	Energy Management and Auditing	PE	3	3	0	0	3
3.	PE5303	Wind Energy Conversion Systems	PE	3	3	0	0	3
4.	PE5304	Electric Vehicles and Power Management	PE	3	3	0	0	3
5.	PE5305	Waste to Energy	PE	3	3	0	0	3
6.	PE5306	Control System Design for Power Electronics	PE	3	3	0	0	3

7.	PE5307	Principles of Electric Power Transmission	PE	3	3	0	0	3
8.	PE5308	Machine Learning	PE	3	3	0	0	3
9.	PE5309	Design of Substations	PE	3	3	0	0	3

***Professional Electives are grouped according to elective number as was done previously.**

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

S.No	Course Code	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	PS5206	Technical Seminar	EEC	2	0	0	2	1
2.	PS5301	Project Work Phase I	EEC	12	0	0	12	6
3.	PS5401	Project Work Phase II	EEC	24	0	0	24	12

SEMESTER I

MA5101	APPLIED MATHEMATICS FOR ELECTRICAL ENGINEERS	L	T	P	C
		4	0	0	4

OBJECTIVES:

- Developing the basic mathematical skills of engineering students

UNIT I	MATRIX THEORY	12

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

UNIT II	CALCULUS OF VARIATIONS	12

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

UNIT III	ONE DIMENSIONAL RANDOM VARIABLES	12

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

UNIT IV	LINEAR PROGRAMMING	12

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

UNIT V	FOURIER SERIES	12

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

TOTAL: 60 PERIODS

OUTCOMES: At the end of the course, learners will be able to:

- Develop the ability to apply the concepts of matrix theory electrical engineering problems.
- Apply the basic concepts of one dimensional random variables and apply in electrical engineering problems
- Solve problems using Fourier transforms associated with engineering applications.
- Solve Linear programming problems
- Apply the basic concepts of fourier series

TEXT BOOKS :

1. Richard Bronson, " Matrix Operation ", Schaum's outline series, 2nd Edition, McGraw Hill, 2011.
2. Taha, H.A., " Operations Research, An introduction ", 9th Edition, Pearson education, New Delhi, 2016.

REFERENCES :

1. Andrews L.C. and Phillips R.L., " Mathematical Techniques for Engineers and Scientists ", Prentice Hall of India Pvt.Ltd., New Delhi, 2005.
2. O'Neil, P.V., " Advanced Engineering Mathematics ", Thomson Asia Pvt. Ltd., Singapore, 2003.
3. Johnson, R.A., Miller, I and Freund J., " Miller and Freund's Probability and Statistics for Engineers ", Pearson Education, Asia, 8th Edition, 2015.

4. Elsgolc, L. D. " Calculus of Variations ", Dover Publications, New York, 2007.

WEB RESOURCES

1. http:// nptel.ac.in
2. www. Hariganesh.com

PS5101	ADVANCED POWER SYSTEM ANALYSIS	L	T	P	C
		4	0	0	4

OBJECTIVES:

- To explain different techniques of dealing with sparse matrix for large scale power systems
- To illustrate different methods of power flow solutions.
- To interpret optimal power flow solutions in detail.
- To relate short circuit fault analysis of different type of faults.
- To summarize different numerical integration methods and factors influencing transient stability

UNIT I	SOLUTION TECHNIQUES	12

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	12

Power flow equation in real and polar forms; Review of Newton's method for solution; Adjustment of P-V buses; Power-Flow Studies in System Design and Operation; Review of Fast Decoupled Power Flow method; Sensitivity factors for P-V bus adjustment.

UNIT III	OPTIMAL POWER FLOW	12

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	12

Formation of bus impedance matrix with mutual coupling (single phase basis and three phase basis) - 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 – symmetrical and unsymmetrical faults.

UNIT V	TRANSIENT STABILITY ANALYSIS	12

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.

TOTAL: 60 PERIODS

OUTCOMES: At the end of the course, learners will be able to:

- Apply the concepts of sparse matrix for large scale power system analysis.

- Illustrate power system studies that needed for the transmission system planning.
- Solve for power optimal flow analysis in power systems
- Summarize the different types of faults in power systems and its solution techniques.
- Explain the transient Stability Analysis in power system

TEXT BOOKS:

1. A.J.Wood and B.F.Wollenberg, "Power Generation Operation and Control", John Wiley and Sons, 3rd edition, 2013.
2. P.Kundur, "Power System Stability and Control", McGraw Hill, 3rd edition, 2006.
3. John J Grianger& William D. Stevenson, "Power System Analysis", McGraw Hill, 2nd edition, 2017.
4. D P Kothari & I J Nagrath, "Power System Engineering", McGraw Hill, 3rd edition, 2019.

REFERENCES

1. M.A.Pai," Computer Techniques in Power System Analysis",Tata McGraw-Hill Publishing Company Limited, New Delhi, 2nd edition, 2006.
2. G W Stagg , A.H El. Abiad, "Computer Methods in Power System Analysis", McGraw Hill, 1st edition,1968.
3. AbhijitChakrabarti , SunitaHalder, "Power System Analysis:Operation and Control", Prentice Hall India, 3rd edition, 2017
4. HadiSaadat, "Power System Analysis", McGraw Hill, 3rd edition, 2006

WEB RESOURCES

1. https://nptel.ac.in/courses/108/107/108107127/
2. https://nptel.ac.in/courses/108/105/108105067/

PS5102	ANALYSIS AND DESIGN OF POWER CONVERTERS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To explain the operation and characteristics of controlled rectifiers.
- To apply switching techniques and basic topologies of DC-DC switching regulators.
- To outline the design of power converter components.
- To illustrate the depth knowledge about resonant converters.
- To summarize the concepts of AC-AC power converters and their applications.

UNIT I	SINGLE PHASE & THREE PHASE CONVERTERS	9

Principle of phase controlled converter operation – single-phase full converter and semi converter (RL,RLE load)- single phase dual converter – Three phase operation full converter and semi-converter (R,RL,RLE load) – reactive power – power factor improvement techniques –PWM rectifiers.

UNIT II	DC-DC CONVERTERS	9

Limitations of linear power supplies, switched mode power conversion, Non-isolated DC- DC converters: operation and analysis of Buck, Boost, Buck-Boost, Cuk& SEPIC – under continuous and discontinuous operation – Isolated converters: basic operation of Fly back, Forward and Push-pull topologies.

UNIT III	DESIGN OF POWER CONVERTER COMPONENTS	9

Introduction to magnetic materials- hard and soft magnetic materials –types of cores , copper windings – Design of transformer –Inductor design equations –Examples of inductor design for buck/fly back converter-selection of output filter capacitors – selection of ratings for devices – input filter design.

UNIT IV	RESONANT DC-DC CONVERTERS	9
Switching loss, hard switching, and basic principles of soft switching- classification of resonant converters- load resonant converters – series and parallel – resonant switch converters – operation and analysis of ZVS, ZCS converters comparison of ZCS/ZVS Introduction to ZVT/ZCT PWM converters.		
UNIT V	**AC-AC CONVERTERS**	**9**
Principle of on-off and phase angle control – single phase ac voltage controller – analysis with R & RL load – Three phase ac voltage controller – principle of operation of cyclo converter – single phase and three phase cyclo converters – Introduction to matrix converters.		
		TOTAL: 45 PERIODS

OUTCOMES: At the end of the course, learners will be able to:

- Illustrate the performance of semi and full converters for different load setup
- Explain the different configurations of DC – DC converters
- Apply various power converter components
- Outline Resonant DC-DC Converters
- Summarize the different types of AC – AC converters and its applications

TEXT BOOKS:

1. Ned Mohan,T.M Undeland and W.P Robbin, "Power Electronics: converters, Application and design" John Wiley and sons. Wiley India edition, 2006
2. Rashid M.H., "Power Electronics Circuits, Devices and Applications ", Prentice Hall India, Third Edition, New Delhi, 2004.
3. P.C. Sen, "Modern Power Electronics", Wheeler Publishing Co, First Edition, New Delhi, 1998.
4. P.S.Bimbra, "Power Electronics", Khanna Publishers, Eleventh Edition, 2003
5. Simon Ang, Alejandro Oliva, "Power-Switching Converters, Second Edition, CRC Press, Taylor & Francis Group, 2010

REFERENCES

1. V.Ramanarayanan, "Course material on Switched mode power conversion", 2007
2. Alex Van den Bossche and Vencislav Cekov Valchev, "Inductors and Transformers for Power Electronics", CRC Press, Taylor & Francis Group, 2005
3. W. G. Hurley and W. H.Wolfle, "Transformers and Inductors for Power Electronics Theory, Design and Applications", 2013 John Wiley & Sons Ltd.
4. Marian.K.Kazimierczuk and Dariusz Czarkowski, "Resonant Power Converters", John Wiley & Sons limited, 2011.

WEB RESOURCES

1. http://kaliasgoldmedal.yolasite.com/apc.php
2. http://cktse.eie.polyu.edu.hk/MEAD-Tse-3.pdf
3. https://www.sciencedirect.com/topics/engineering/power-converter

PS5103	RESTRUCTURED POWER SYSTEM	L	T	P	C
		3	0	0	3

OBJECTIVES:

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

UNIT I	INTRODUCTION TO RESTRUCTURING OF POWER INDUSTRY	9

Introduction: Deregulation of power industry, Restructuring process, Issues involved in deregulation, Deregulation of various power systems – Fundamentals of Economics: Consumer behavior, Supplier behavior, Market equilibrium, Short and long run costs, Various costs of production – Market models: Market models based on Contractual arrangements, Comparison of various market models, Market architecture, Case study

UNIT II	TRANSMISSION CONGESTION MANAGEMENT	9

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

UNIT III	LOCATIONAL MARGINAL PRICES AND INANCIALTRANSMISSION RIGHTS	9

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

UNIT IV	ANCILLARY SERVICE MANAGEMENT AND PRICING OF TRANSMISSION NETWORK	9

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

UNIT V	REFORMS IN INDIAN POWER SECTOR	9

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

TOTAL: 45 PERIODS

OUTCOMES: At the end of the course, learners will be able to:

- Illustrate restructuring of power industry
- Explain basics of congestion management
- Interpret locational margin prices and financial transmission rights
- Infer the significance ancillary services and pricing of transmission network
- Outline the reforms in Indian power sector

TEXT BOOKS :

1. Mohammad Shahidehpour, MuwaffaqAlomoush, Marcel Dekker, "Restructured electrical power systems: operation, trading and volatility" Pub., 2001.
2. Kankar Bhattacharya, Jaap E. Daadler, Math H.J. Boolen, "Operation of restructured power systems", Kluwer Academic Pub., 2001.
3. Daniel Kirschen and GoranStrbac, 'Fundamentals of Power System economics', John Wiley & Sons Ltd, 2004.
4. Sally Hunt, 'Making competition work in electricity', John Wiley & Sons, Inc., 2002.
5. Loi Lei Lai , 'Power system restructuring and deregulation', John Wiley & Sons Ltd., 2001.

REFERENCES :

1. Steven Stoft, "Power system economics: designing markets for electricity", John Wiley & Sons2002.
2. LorrinPhilipson and H. Lee Willis, 'Understanding Electric Utilities and Deregulation', Marcel Dekker Inc, New York, CRC Press, 2002.
3. Marijallic by Francisco Galiana and Lestor Fink, 'Power System Restructuring Engineering & Economics' , Kulwer Academic Publisher, USA,1998.
4. Mohammad Shahidehpour, MuwaffaqAlomoush, Marcel Dekker, "Restructured electrical power systems: operation, trading and volatility" Pub., 2001.

WEB RESOURCES

1. https://nptel.ac.in/content/syllabus_pdf/108101005.pdf
2. https://www.academia.edu/33475490/LAI_Power_System_Restructuring_and_Deregulation.pdf

PS 5104	SYSTEM THEORY	L	T	P	C
		3	2	0	4

OBJECTIVES:

- To summarize the fundamentals of physical systems in terms of its linear and nonlinear models.
- To explain about systems representation in state variable form
- To infer the solution for linear and non-linear state equations
- To outline the properties of linear systems such as controllability and observability
- To illustrate the stability analysis of systems using Lyapunov's theory.

UNIT I	STATE VARIABLE REPRESENTATION	12

Introduction-Concept of State-State equations for Dynamic Systems -Time invariance and linearity- Non uniqueness of state model- Physical Systems and State Assignment – free and forced responses- State Diagrams.

UNIT II	SOLUTION OF STATE EQUATIONS	12
Existence and uniqueness of solutions to Continuous-time state equations - Solution of Nonlinear and Linear Time Varying State equations - State transition matrix and its properties – Evaluation of matrix exponential- System modes- Role of Eigen values and Eigen vectors.		
UNIT III	**STABILITY ANALYSIS OF LINEAR SYSTEMS**	**12**
Controllability and Observability definitions and Kalman rank conditions -Stabilizability and Detectability-Test for Continuous time Systems- Time varying and Time invariant case-Output Controllability-Reducibility- System Realizations.		
UNIT IV	**STATE FEEDBACK CONTROL AND STATE ESTIMATOR**	**12**
Introduction-Controllable and Observable Companion Forms-SISO and MIMO Systems- The Effect of State Feedback on Controllability and Observability-Pole Placement by State Feedback for both SISO and MIMO Systems-Full Order and Reduced Order Observers.		
UNIT V	**LYAPUNOV STABILTY ANALYSIS**	**12**
Introduction-Equilibrium Points- BIBO Stability-Stability of LTI Systems- Stability in the sense of Lyapunov - Equilibrium Stability of Nonlinear Continuous-Time Autonomous Systems-The Direct Method of Lyapunov and the Linear Continuous-Time Autonomous Systems-Finding Lyapunov Functions for Nonlinear Continuous-Time Autonomous Systems – Krasovskil's and Variable-Gradiant Method.		
		TOTAL: 60 PERIODS

OUTCOMES: At the end of the course, learners will be able to:

- Explain the time-invariant systems in state space form as well as analyze, whether the system is stabilizable, controllable, observable and detectable.
- Design state feedback controller and state observers
- Classify singular points and construct phase trajectory using delta and isocline methods.
- Apply the techniques such as describing function, Lyapunov Stability, Popov's Stability Criterion Circle Criterion and assess the stability of certain class of non-linear system.
- Describe non-linear behaviors such as Limit cycles, input multiplicity and output multiplicity, Bifurcation and Chaos.

TEXT BOOKS:

1. M. Gopal, "Modern Control System Theory", New Age International, 2005.
2. K. Ogatta, "Modern Control Engineering", PHI, 2002.

3. John S. Bay, "Fundamentals of Linear State Space Systems", McGraw-Hill, 1999.
4. D. Roy Choudhury, "Modern Control Systems", New Age International, 2005.

REFERENCES

1. John J. D'Azzo, C. H. Houpis and S. N. Sheldon, "Linear Control System Analysis and Design with MATLAB", Taylor Francis, 2003.
2. Z. Bubnicki, "Modern Control Theory", Springer, 2005.
3. C.T. Chen, "Linear Systems Theory and Design'' Oxford University Press, 3rd Edition, 1999.
4. M. Vidyasagar, "Nonlinear Systems Analysis', 2nd edition, Prentice Hall, Englewood Cliffs, New Jersey.

WEB RESOURCES

1. https://nptel.ac.in/courses/108106150/
2. https://nptel.ac.in/courses/110104074/

PS 5105	POWER SYSTEM SIMULATION LABORATORY	L	T	P	C
		0	0	4	2

OBJECTIVES:

- To examine various systems and different techniques used for system planning using Software packages
- To evaluate the dynamic analysis of power system

LIST OF EXPERIMENTS

1. Power flow analysis by Newton-Raphson method and Fast decoupled method
2. Transient stability analysis of single machine-infinite bus system using classical machine model
3. Contingency analysis: Generator shift factors and line outage distribution factors
4. Economic dispatch using lambda-iteration method
5. Unit commitment: Priority-list schemes and dynamic programming
6. State Estimation(DC)
7. Analysis of switching surge using EMTP: Energisation of a long distributed- parameter line
8. Analysis of switching surge using EMTP : Computation of transient recovery voltage
9. Simulation and Implementation of Voltage Source Inverter
10. DigitalOverCurrentRelaySettingandRelayCoordinationusingSuitablesoftware packages
11. Co-ordination of over-current and distance relays for radial line protection

TOTAL: 60 PERIODS

OUTCOMES: At the end of the course, learners will be able to:

- Analyze the power flow using Newton-Raphson method and Fast decoupled method.
- Build contingency analysis & economic dispatch.
- Solve for state estimation for error measurement
- Analyze various switching surges using EMTP

- Construct Digital Over Current Relay and Coordinate Relay.

LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS:

Sl. No.	Description of Equipment	Quantity Required
1.	Personal Computers (Intel Core i3, 250 GB, 1 GB RAM)	30
2.	Printer	1
3.	Server (Intel Core i3, 4 GB RAM) (High Speed Processor)	1
4.	Software: EMTP / ETAP / CYME / MiPOWER / Matlab/ any Power system simulation software	5 User Licenses
5.	Compilers: C / C++	30 users

SEMESTER II

PS5201	POWER SYSTEM DYNAMICS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To illustrate dynamic modeling of a synchronous machine
- To explain the modeling concepts of excitation system
- To classify transient, steady state and dynamic stability
- To analyze the stability for power system by numerical integration methods
- To infer the effects stability in single machine infinite bus system

UNIT I	MODELLING OF SYNCHRONOUS MACHINES	9

Simplest model of the synchronous machine – circuit equations – equation in physical quantities - Inductance of Synchronous Machine - Park's transformation - dq0 components – assumptions of balanced currents and voltages in the armature – phasor diagram – equivalent circuit – reactance – final machine dynamic equations – inclusion of damper winding.

UNIT II	MODELLING OF EXCITATION SYSTEMS	9

Excitation system requirements - elements of an excitation system – types of excitation system – dynamic performance measure – control and protective functions – modelling of excitation system.

UNIT III	POWER SYSTEM STABILITY	9

Power system stability considerations – definitions - classification of stability - rotor angle and voltage stability - stability of interconnected systems – bad effects of instability – Importance of stability to system operation and design

UNIT IV	TRANSIENT STABILITY	9

Inertia constant and equivalent inertia constant – power angle curve – swing equation – point by point solution- transient stability - swing equation - equal area criterion - solution of swing equation - Euler method - Runge-Kutte method - critical clearing time and angle.

UNIT V	SMALL SIGNAL STABILITY	9

State space representation - small signal stability of single machine infinite bus system (SMIB) – synchronous machine classical model representation - effect of field circuit dynamics- effect of excitation system – Power system stabilizer for small signal stability improvement.

	TOTAL: 45 PERIODS

OUTCOMES: At the end of the course, learners will be able to:

- Explain the dynamic modelling of synchronous machine
- Illustrate the modeling of excitation system for stability analysis
- Classify the power system stability with its effects on interconnected systems
- Analyze the stability for power system by point-by point method, Modified Euler's and Runke – Kutta method.
- Show the effects of small signal stability analysis in power system.

TEXT BOOKS:

1. P. W. Sauer and M. A. Pai, "Power System Dynamics and Stability", Stipes Publishing Co, 2007
2. P. Kundur, "Power System Stability and Control", McGraw-Hill, 1993.
3. P.M Anderson and A.A Fouad, "Power System Control and Stability", Iowa State University Press, Ames, Iowa, 1978
4. R.Ramunujam," Power System Dynamics Analysis and Simulation, PHI Learning Private Limited, New Delhi, 2009.

REFERENCES

1. E.W.Kimbark, Power System Stability Vol.1, John Wiley, 1995.
2. James A.Momoh, Mohamed. E. EI-Hawary. "Electric Systems, Dynamics and Stability with Artificial Intelligence applications", Marcel Dekker, USA First Edition, 2000.
3. Mircea Eremia and Mohammad Shahidehpour, "Handbook of Electrical Power System Dynamics: Modeling, Stability and Control", IEEE Press Series on Power Engineering, 2013.
4. L.P.Singh, Advanced Power system Analysis and Dynamics, New Age International Publishers, Sixth edition, 2012.

WEB RESOURCES

1. https://nptel.ac.in/courses/108102080/
2. https://home.iitk.ac.in/~saikatc/EE632_files/VS_SC.pdf
3. https://app.knovel.com/web/toc.v/cid:kpPSDSCE01/viewerType:toc/

PS5202	HVDC and FACTS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To explain the need for Flexible AC Transmission System(FACTS)controllers in power transmission.
- To illustrate the characteristics and applications of Static Var Compensator(SVC) & Static Compensator (STATCOM) in power transmission
- To summarize the applications of Thyristor Controlled Series Capacitor (TCSC) and Static Synchronous Series Compensator(SSSC)in power transmission
- To show the operational characteristics and control of HVDC link.
- To interpret power flow in AC/DC systems

UNIT I	INTRODUCTION TO POWER TRANSMISSION AND FACTS	9

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

UNIT II	SVC & STATCOM	9

Configuration of Static Var Compensator(SVC)- voltage regulation by SVC- Modelling of SVC for load flow analysis-Design of SVC to regulate the mid-point voltage of a SMIB system- Applications Static synchronous compensator (STATCOM) - Operation of STATCOM – Voltage regulation-Power flow control with STATCOM.

UNIT III	TCSC and SSSC	9

Concepts of Controlled Series Compensation- Operation of Thyristor Controlled Series Capacitor (TCSC) - Analysis of TCS Coperation - Modelling of TCSC for load flow studies - Static synchronous seriescompensator(SSSC) - Operation of SSSC - Modelling of SSSC for power flow – operation of Unified Power Flow Controllers(UPFC).

UNIT IV	ANALYSIS OF HVDC LINK	9

Simplified analysis of six pulse Graetz bridge – Characteristics - Analysis of converter operations – Commutation overlap – Equivalence circuit of bipolar DC transmission link –Modes of operation – Mode ambiguity – Different firing angle controllers – Power flow control

UNIT V	POWER FLOW ANALYSIS IN AC/DC SYSTEMS	9

Per unit system for DC Quantities - Modelling of DC links - Solution of DC load flow - Solution

of AC-DC power flow – Unified and Sequential methods.

	TOTAL: 45 PERIODS

OUTCOMES: At the end of the course, learners will be able to:

- Outline the need for Flexible AC Transmission System(FACTS)controllers in power transmission
- Relate applications of Static VAR Compensator(SVC) &Static Compensator (STATCOM) in power transmission
- Show the applications of Thyristor Controlled Series Capacitor (TCSC) and Static Synchronous Series Compensator(SSSC) in power transmission
- Interpret the operational characteristics and control of HVDC link.
- Compare power flow in AC/DC systems

TEXT BOOKS:

1. K.R.Padiyar, "FACTS Controllers in Power Transmission and Distribution", New Age International Publishers, 2nd edition, Reprint 2016.
2. Mohan Mathur, R., Rajiv. K. Varma, "Thyristor – Based Facts Controllers for Electrical Transmission Systems", IEEE press and John Wiley & Sons, 1st edition, 2002
3. NarainG. Hingorani, "Understanding FACTS-Concepts and Technology of

REFERENCES :

1. K.R.Padiyar, "HVDC Power Transmission Systems", New Age International publishers,2nd

edition, 2016.

2.A.T.John,"Flexible A.C. Transmission Systems", Institution of Electrical and Electronic Engineers publishers,1st edition, 1999.

3.Xiao-Ping Zhang, "Flexible AC transmission systems, Modelling& Control", Springer Publications,2nd edition, 2012.

4. SumanBhowmick, "Flexible AC Transmission Systems (FACTS): Newton Power-Flow Modeling of Voltage-Sourced Converter-Based Controllers", CRC Press, 1st Edition, 2016.

WEB RESOURCES

1. https://nptel.ac.in/courses/108107114
2. https://nptel.ac.in/courses/108104013

PS5203	ADVANCED POWER SYSTEM PROTECTION	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To explain about the concept of overcurrent and earthfault protection
- To illustrate concepts of transformer protection
- To describe about the various schemes of Over current protection
- To analyze distance and carrier protection schemes
- To familiarize the concepts of Generator protection and Numerical protection

UNIT I	OVERCURRENT & EARTH FAULT PROTECTION	9

Zones of protection – Primary and Backup protection – operating principles and Relay Construction - Time – Current characteristics-Current setting – Time setting-Over current protective schemes –Concept of Coordination - Protection of parallel / ring feeders - Reverse power or directional relay –Polarisation Techniques – Cross Polarisation – Quadrature Connection -Earth fault and phase fault protection - Combined Earth fault and phase fault protection scheme - Phase fault protective - scheme directional earth fault relay - Static over current relays – Numerical over – current protection; numerical coordination example for a radial feeder

UNIT II	TRANSFORMER & BUSBAR PROTECTION	9

Types of transformers –Types of faults in transformers- Types of Differential Protection – High Impedance – External fault with one CT saturation – Actual behaviors of a protective CT – Circuit model of a saturated CT - Need for high impedance – Disadvantages - Percentage Differential Bias Characteristics – Vector group & its impact on differential protection - Inrush phenomenon – Zero Sequence filtering – High resistance Ground Faults in Transformers – Restricted Earth fault Protection - Inter-turn faults in transformers – Incipient faults in transformers - Phenomenon of overfluxing in transformers – Transformer protection application chart. Differential protection of busbars external and internal fault - Supervisory relay-protection of three – Phase busbars – Numerical examples on design of high impedance busbar differential scheme –Biased Differential characteristics – Comparison between Transformer differential & Busbar differential

UNIT III	DISTANCE AND CARRIER PROTECTION OF TRANSMISSION	9

Drawback of over – Current protection – Introduction to distance relay – Simple impedance relay – Reactance relay – mho relays. Comparison of distance relay – Distance protection of a three – Phase line-reasons for inaccuracy of distance relay reach - Three stepped distance protection -Trip contact configuration for the three - Stepped distance protection - Three-stepped protection of three-phase line against all ten shunt faults - Impedance seen from relay side - Three-stepped protection of double end fed lines-need for carrier – Aided protection – Various options for a carrier –Coupling and trapping the carrier into the desired line section - Unit type carrier aided directional comparison relaying – Carrier aided distance schemes for acceleration of zone II; numerical example for a typical distance protection scheme for a transmission line.

UNIT IV	GENERATOR PROTECTION	9

Electrical circuit of the generator –Various faults and abnormal operating conditions – Stator Winding Faults – Protection against Stator (earth) faults – third harmonic voltage protection – Rotor fault – Abnormal operating conditions - Protection against Rotor faults – Potentiometer Method – injection method – Pole slipping – Loss of excitation – Protection against Mechanical faults; Numerical examples for typical generator protection schemes

UNIT V	NUMERICALPROTECTION	9

Introduction–Block diagram of numerical relay - Sampling theorem- Correlation with a reference wave– Least error squared (LES) technique-Digital filtering-numerical over - Current protection– Numerical transformer differential protection-Numerical distance protection of transmission line

TOTAL: 45 PERIODS

OUTCOMES: At the end of the course, learners will be able to:

- Explain the knowledge on overcurrent and earth fault protection protection.
- Outline the various schemes available in Transformer protection
- Infer about distance and carrier protection in transmission lines.
- Summarize the concepts of Generator protection.
- Explain in detail about substation automation.

TEXT BOOKS:

1. Y.G. Paithankar and S.R Bhide, "Fundamentals of Power System Protection", Prentice-Hall of India, 2003
2. Badri Ram and D.N. Vishwakarma, "Power System Protection and Switchgear", Tata McGraw- Hill Publishing Company, 2002.
3. Sunil S.Rao, 'Switchgear and Protection', Khanna Publishers, New Delhi, 2008.
4. B.Rabindranath and N.Chander, 'Power System Protection and Switchgear', New Age International (P) Ltd., First Edition 2011.

REFERENCES :

1. T.S.M. Rao, "Digital Relay / Numerical relays", Tata McGraw Hill, New Delhi, 1989.
2. P.Kundur, "Power System Stability and Control", McGraw-Hill, 1993.
3. Ravindra P.Singh, 'Switchgear and Power System Protection', PHI Learning Private Ltd., NewDelhi, 2009.
4. Rohit Metha and VK Metha," Principles of Power Systems" S. Chand Publishers, 2005

WEB RESOURCES

1. www.iisc.ac.in
2. www.npti.gov.in › advance-power-system-protection
3. www. new.siemens.com/pss-cape

PS5204	SMART GRID	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To infer the need of smart grid technologies
- To explain the integration of distributed generation and control elements of smart grid.
- To classify the various communication and sensor networks used for smart grid system monitoring.
- To interpret the pricing and energy scheduling for effective demand side management.

UNIT I INTRODUCTION TO SMART GRID **9**

Evolution of Electric Grid, Difference between conventional & Smart Grid, National and International Initiatives in Smart Grid, Basis for Smart Grid, Computational Intelligence, Power System Enhancement, Communication and Standards, Environment and Economics,

Shareholders Roles and Function, Smart grid Architecture.

UNIT II DISTRIBUTED GENERATION 9

Distributed generation resources, Advantages and disadvantages of DG, Distributed Generation Utilization Barriers, Distributed Generation integration to power grid Smart Grid components control elements, Smart Grid Technologies

UNIT III SENSOR FOR SMART GRID TECHNOLOGIES 9

Sensors for Smart Grid, Monitoring and Measurement Technologies, PMU, Smart meters, Smart Appliances, Multi Agent Systems (MAS) Technology, Micro grid and Smart grid comparison, Wide Area Measurement, smart grid system monitoring, Phasor estimation, Dynamic Phasor estimation.

UNIT IV COMMUNICATION INFRASTRUCTURE IN SMART GRID 9

Power Line Communications, Two-way Digital Communications Paradigm, Network Architectures, IP-based Systems, Advanced Metering Infrastructure, Fiber Optical Networks, Wide Area Network WAN based on Fiber Optical Networks, IP based Real Time data Transmission, Substation communication network, Bluetooth, Zig-Bee, GPS, Geographic Information System (GIS), Broadband over Power line(BPL).

UNIT V DEMAND SIDE MANAGEMENT OF SMART GRID 9

Demand side management, Demand response analysis of Smart Grid, Pricing and Energy Consumption Scheduling, Controllable Load Models, Dynamics and Challenges, Electric Vehicles and Vehicle-to-Grid Systems, Demand Side Ancillary Services Energy Management, Practical study of Smart Grid.

TOTAL: 45 PERIODS

OUTCOMES: At the end of the course, learners will be able to:

- Outline the concepts and need for Smart Grid
- Summarize the integration of distributed generation to power grid.
- Interpret the role of sensor in smart grid technologies
- Classify the various communication system used in smart grid.
- Explain the demand side response analysis and various demand side ancillary services of smart gird.

TEXT BOOKS:

1. Stuart Borlase "Smart Grid :Infrastructure, Technology and Solutions", CRC Press 2012.
2. Janaka Ekanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama, "Smart Grid: Technology and Applications", Wiley 2012.
3. Husheng Li, "Communications for Control in Cyber Physical Systems -Theory, Design and Applications in Smart Grids", Morgan Kaufmann,1st edition, 2016.
4. David Bakken, "Smart Grids: Clouds, Communications, Open Source, and Automation", CRC Press,2014.

REFERENCES

1. Keyhani, Ali, "Design of smart power grid renewable energy systems", Wiley,2011.
2. Sawan Sen, Samarjit Sengupta, Abhijit Chakrabarti, "Electricity Pricing: Regulated, Deregulated and Smart Grid Systems", CRC Press,2014.
3. Hongjian Sun and Nikos Hatziargyriou, "Smarter Energy. From Smart Metering to the Smart Grid", The Institution of Engineering and Technology,2016.
4. Qing Chang Zhong, Tomas Hornik, "Control of Power Inverters in Renewable Energy

and Smart Grid Integration", Wiley-IEEE Press,2013.

WEB RESOURCES

1. https://www.coursera.org/lecture/electric-utilities/5-2-smart-grid-YUPgW
2. https://nptel.ac.in/courses/108/107/108107113
3. https://nptel.ac.in/courses/106/105/106105166/

PS5205	ADVANCED POWER SYSTEM SIMULATION LABORATORY	L	T	P	C
		0	0	4	2

OBJECTIVES:

- To analyze load flow studies and fault analysis of two bus system with STATCOM
- To analyze small-signal stability analysis of Single machine and Multi machine configuration
- To analyze the effect of FACTS controllers by performing steady state analysis and also to have hands on experience on different wind energy conversion technologies

LIST OF EXPERIMENTS

1. Small-signal stability analysis of single machine-infinite bus system using classical machine model
2. Small-signal stability analysis of multi-machine configuration with classical machine model
3. Induction motor starting analysis
4. Load flow analysis of two-bus system with STATCOM
5. Transient analysis of two-bus system with STATCOM
6. Available Transfer Capability calculation using an existing load flow program
7. Study of variable speed wind energy conversion system- DFIG
8. Study of variable speed wind energy conversion system- PMSG
9. Computation of harmonic indices generated by a rectifier feeding a R-Load
10. Design of active filter for mitigating harmonics

TOTAL: 60 PERIODS

OUTCOMES: At the end of the course, learners will be able to:

- Analyze on various power system dynamic studies for single machine configuration using own program and validation of results using software packages.
- Design steady state and transient analysis of two bus with STATCOM
- Solve for ATC calculation using load flow program
- Outline variable speed wind energy conversion system using DFIG and PMSG
- Design of active filter for mitigating harmonics

LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS:

Sl. No.	Description of Equipment	Quantity Required
1.	Personal Computers (Intel Core i3, 250 GB, 1 GB RAM)	30
2.	Laser Printer	1
3.	Dot matrix Printer	1
4.	Server (Intel Core i3, 4 GB RAM) (High Speed Processor)	1
5.	Software: EMTP / ETAP / CYME / Mi-POWER / any Power system simulation software	5 User Licenses
6.	Compilers: C / C++ / Matlab	30 users

Semester III

PS5206	TECHNICAL SEMINAR	L	T	P	C
		0	0	2	1

OBJECTIVES:

- To encourage the students to study advanced engineering developments.
- To prepare and present technical reports.
- To motivate the students to use various teaching aids such as overhead projectors, power point presentation and demonstrative models

METHOD OF EVALUATION:

During the seminar session, each student is expected to prepare and present a topic on engineering/ technology, for duration of about 8 to 10 minutes. In a session of three periods per week, 15 students are expected to present the seminar. Each student is expected to present atleast twice during the semester and the student is evaluated based on that. At the end of the semester, he / she can submit a report on his / her topic of seminar and marks are given based on the report. A faculty guide is to be allotted and he / she will guide and monitor the progress of the student and maintain attendance also. Evaluation is 100% internal.

TOTAL: 30 PERIODS

OUTCOMES: At the end of the course, learners will be able to:

- Develop presentation and technical skill.
- Make use of the skills for placement activities.

PS5301	PROJECT WORK PHASE I	L	T	P	C
		0	0	12	6

OBJECTIVES:

1. To develop the ability to solve a specific problem right from its identification and literature review till the successful solution of the same.
2. To design the project reports and to test the ability in reviews and viva voce examination.

METHOD OF EVALUATION:

Student should work on a topic approved by the Head of the Department under the guidance of a faculty member and prepares a comprehensive project report after completing the work to the satisfaction of the supervisor. The progress of the project is evaluated based on a minimum of three reviews. The review committee may be constituted by the Head of the Department. A project report is required at the end of the semester. The project work is evaluated based on oral presentation and the project report jointly by external and internal examiners constituted by the Head of the Department.

TOTAL: 300 PERIODS

OUTCOMES: At the end of the course, learners will be able to:

On Completion of the project work, student will be in a position to solve any challenging practical problems and find solution by formulating proper methodology.

SEMESTER IV

PS5401	PROJECT WORK PHASE II	L	T	P	C
		0	0	24	12

OBJECTIVES:

1. To develop the ability to solve a specific problem right from its identification and literature review till the successful solution of the same.
2. To improve the students skill in preparing project reports and to face reviews and viva voce examination.

METHOD OF EVALUATION:

Student should work on a topic approved by the Head of the Department under the guidance of a faculty member and prepares a comprehensive project report after completing the work to the satisfaction of the supervisor. The progress of the project is evaluated based on a minimum of three reviews. The review committee may be constituted by the Head of the Department. A project report is required at the end of the semester. The project work is evaluated based on oral presentation and the project report jointly by external and internal examiners constituted by the Head of the Department.

TOTAL: 600 PERIODS

OUTCOMES:

On Completion of the project work, student will be in a position to solve any challenging practical problems and find solution by formulating proper methodology.

PROFESSIONAL ELECTIVES (PE)

Semester I

Elective I

PE5101	ANALYSIS OF ELECTRICAL MACHINES	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To explain the fundamentals of magnetic circuits, energy, force and torque of multi-excited systems
- To analyze the steady state and dynamic state operation of DC machine through mathematical modeling and simulation in digital computer
- To outline the knowledge of theory of transformation of three phase variables to two phase variables
- To relate the steady state and dynamic state operation of three-phase induction machines and synchronous machines using transformation theory based mathematical modeling and digital computer simulation

UNIT I	PRINCIPLES OF ELECTROMAGNETIC ENERGY CONVERSION	9

Magnetic circuits, Permanent magnet, Stored magnetic energy, Co-energy - Force and Torque in singly and doubly excited systems – Machine windings and Air-gap mmf - Winding inductances and Voltage equations.

UNIT II	DC MACHINES	9

Elementary DC machine and Analysis of steady state operation - Voltage and Torque equations - Dynamic characteristics of permanent magnet and shunt D.C. motors – Time domain block diagrams - Solution of dynamic characteristic by Laplace transformation – Digital computer simulation of permanent magnet and shunt D.C machines.

UNIT III	REFERENCE FRAME THEORY	9

Historical background – Phase transformation and Commutator transformation – Transformation of variables from stationary to arbitrary reference frame - Variables observed from several frames of reference.

UNIT IV	INDUCTION MACHINES	9

Three phase induction machine, Equivalent circuit and Analysis of steady state operation – Free acceleration characteristics – Voltage and Torque equations in machine variables and arbitrary reference frame variables – Analysis of dynamic performance for load torque variations – Digital computer simulation.

UNIT V	SYNCHRONOUS MACHINES	9

Three phase synchronous machine and Analysis of steady state operation - Voltage and Torque equations in machine variables and rotor reference frame variables (Park's equations) – Analysis of dynamic performance for load torque variations – Generalized theory of rotating electrical machine and Krons primitive machine.

TOTAL: 45 PERIODS

OUTCOMES: At the end of the course, learners will be able to:

- Illustrate the various electrical parameters in mathematical form.
- Outline the concepts of DC machines
- Explain the different types of reference frame theories and transformation relationships.
- Relate the equivalent circuit parameters and modeling of induction machine
- Analyze the different parameters of synchronous machines

TEXT BOOKS :

1. R. Krishnan, "Electric Motor Drives - Modeling, Analysis& control", Pearson Publications, First Edition, 2002.
2. P.C.Krause, Oleg Wasynczuk, Scott D.Sudhoff, "Analysis of Electrical Machinery and Drive systems", IEEE Press, John Wiley, Second Edition,2010.
3. Paul Krause "Reference Frame Theory, IEEE Press, John Wiley, Second,2021
4. Braham Ferreira" The principles of contemporary power electronics and electromechanic power conversion", IEEE Press, John Wiley,2014

REFERENCES

1. P S Bimbhra, "Generalized Theory of Electrical Machines", Khanna Publishers,2008.
2. A.E, Fitzgerald, Charles Kingsley, Jr, and Stephan D, Umanx, " Electric Machinery", Tata McGraw Hill, Fifth edition,1992.
3. U. A. Bakshi "Transformers & Induction Machines" Technical Publications2013
4. Lipo " Analysis of Synchronous Machines "Taylor & Francis 2012

WEB RESOURCES

1. https://ieeexplore.ieee.org/book/6712180
2. https://nptel.ac.in/courses/108106023/
3. https://www.researchgate.net/publication/321408514_A_review_of_electrical_machine_design_processes_from_the_standpoint_of_software_selection
4. http://www.ijsce.org/wp-content/uploads/papers/v4i6/F2495014615.pdf

PE 5102	SOFTCOMPUTING TECHNIQUES	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To summarize the functions of feed forward and feedback neural networks.
- To explain the concept of fuzziness involved in various systems. ·
- To infer the idea about genetic algorithm
- To outline Fuzzy Logic Control and Neural Network toolbox

UNIT I	INTRODUCTION AND ARTIFICIAL NEURAL NETWORKS	12

Introduction to intelligent systems - Soft computing techniques - Conventional Computing versus Swarm Computing – Classification of meta-heuristic techniques – Properties of Swarm intelligent Systems - Application domain – Discrete and continuous problems - Single objective and multi-objective problems – Neuron – Nerve structure and synapse - Artificial Neuron and its model – activation functions – Neural network architecture – single layer and multilayer feed forward networks - Mc Culloch Pitts neuron model - perceptron model - Adaline and Madaline – multi layer perception model – back propagation learning methods – effect of learning rule coefficient – back propagation algorithm – factors affecting back propagation training - applications.

UNIT II	ARTIFICIAL NEURAL NETWORKS AND ASSOCIATIVE MEMORY	9

Counter propagation network – architecture – functioning & characteristics of counter Propagation network - Hopfield/ Recurrent network configuration – stability constraints associative memory and characteristics – limitations and applications – Hopfield v/s Boltzman machine – Adaptive Resonance Theory – Architecture – classifications – Implementation and training - Associative Memory.

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**
Evolutionary programs – Genetic algorithms, genetic programming and evolutionary programming – Genetic Algorithm versus Conventional Optimization Techniques – Genetic representations and selection mechanisms; Genetic operators – different types of crossover and mutation operators – Optimization problems using GA – discrete and continuous - Single objective and multi-objective problems - Procedures in evolutionary programming.		
UNIT V	**HYBRID CONTROL SCHEMES**	**6**
Fuzzification and rule base using ANN – Neuro fuzzy systems – ANFIS – Fuzzy Neuron – Optimization of membership function and rule base using Genetic Algorithm – Introduction to Support Vector Machine – Evolutionary Programming – Particle Swarm Optimization (PSO) - Case study – Familiarization of NN,FLC and ANFIS Tool Box.		
		TOTAL: 45 PERIODS

OUTCOMES:

At the end of the course, learners will be able to:

- Explain the basic ANN architectures, algorithms and their limitations.
- Summarize the different operations on the fuzzy sets.
- Explain ANN based models and Fuzzy Logic control schemes for non-linear system.
- Show the use of different ANN structures and online training algorithm.
- Interpret hybrid control schemes and PSO and support vector regressive.

TEXT BOKS:

1. Laurene V. Fausett, "Fundamentals of Neural Networks: Architectures, Algorithms And Applications", Pearson Education. 1st Edition, 1993.
2. Timothy J. Ross, "Fuzzy Logic with Engineering Applications" Wiley India, 2008.
3. Zimmermann H.J. "Fuzzy set theory and its Applications" Springer ,Edition, 2011.
4. David E. Goldberg, "Genetic Algorithms in Search, Optimization, and Machine Learning", Pearson Education,2009.

REFERENCES

1. W.T.Miller, R.S.Sutton and P.J.Webrose,"Neural Networks for Control" MIT Press", 1996.
2. Ethem Alpaydin, "Introduction to Machine Learning (Adaptive Computation and Machine Learning Series)", MIT Press,2004.
3. Corinna Cortes and V. Vapnik, " Support –Vector Networks, Machine Learning "1995.
4. Jyh-Shing Roger Jang, Chuen-Tsai Sun, Eiji Mizutani, ―Neuro-Fuzzy and Soft Computing Prentice-Hall of India, 1st Edition, 2002.

WEB RESOURCES:

1. https://link.springer.com › journal/soft computing
2. https://en.wikipedia.org › wiki › Soft_computing
3. https://www.sciencedirect.com › science › article › pii

PE5103	INDUSTRIAL POWER SYSTEM ANALYSIS AND DESIGN	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To explain the industrial motor starting methods
- To illustrate the power factor correction methods in industrial motors.
- To infer the harmonic elimination techniques in power system
- To summarize the flickers and its effects in industrial loads.
- To demonstrate the effects of switching surges

UNIT I	MOTOR STARTING STUDIES	9

Introduction - evaluation criteria - starting methods - system data - voltage drop calculations - calculation of acceleration time - motor starting with limited capacity generators – computer aided analysis.

UNIT II	POWER FACTOR CORRECTION	9

Introduction - system description and modeling - acceptance criteria - frequency scan analysis - voltage magnification analysis - sustained over voltages - switching surge analysis - back-to-back switching.

UNIT III	HARMONIC ANALYSIS	9

Harmonic sources - system response to harmonics - system model for computer - aided analysis - acceptance criteria - harmonic filters - harmonic evaluation - case study.

UNIT IV	FLICKER ANALYSIS	9

Sources of flicker - flicker analysis – flicker criteria - data for flicker analysis - case study - arc furnace load - minimizing the flicker effects.

UNIT V	SWITCHING SURGES	9

Modeling of system – effects of switching surges – capabilities - voltage acceptance criteria - insulation coordination - case study - methods of minimizing switching surges.

TOTAL: 45 PERIODS

OUTCOMES: At the end of the course, learners will be able to:

- Explain various industrial motor starting methods
- Summarize different power factor correction methods
- Illustrate about computer-aided harmonic analysis to design filters.
- Outline the various methods flicker analysis
- Summarize various switching surges minimizing techniques

TEXT BOOKS :

1. Ramasamy Natarajan, “Computer-Aided Power System Analysis”, Marcel Dekker Inc., 2002.
2. Roger.C.Dugan, Mark.F.Mc.Granagham,Surya Santoso, H.Wayne Beaty,“Electrical Power Systems Quality”, McGraw Hill,2003.
3. J. Arrillaga, N.R. Watson, S. Chen, “Power System Quality Assessment”, Wiley, New York, 2000.
4. Andrew R. Hileman, “Insulation Coordination for Power Systems” CRC Press - Technology & Engineering,1999.

REFERENCES :

1. J. C. Das, “Power System Analysis - Short-Circuit Load Flow and Harmonics”, Marcel Dekker, Inc. New York, 2002
2. Shoaib Khan , “Industrial power systems” , CRC Press, Taylor & Francis , 2007
3. N H Malik, “Electrical Insulation in Power Systems” , Taylor and Francis, 2017
4. P.S.R. Murty, “Electrical Power Systems”1st Edition, 2017.

WEB RESOURCES:

1. http://www.icsenggroup.com/motor-starting-studies.shtml
2. https://www.academia.edu/2539492/Power_factor_improvement_using_active_power_factor_correction_methods
3. https://www.academia.edu/10604638/Harmonic_Analysis_of_Power_Converters_and_Its_Mitigation_by_Using_Passive_Filters
4. https://www.enernex.com/blog/electric-power-systems-flicker-analysis

Semester II

Elective II and III

PE5201	ENERGY EFFICIENCY IN THERMAL UTILITIES	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To infer basic Knowledge in thermal utilities
- To explain the concepts behind energy efficiency in thermal utilities
- To summarize various energy saving opportunities in thermal utilities

UNIT I	FUELS AND COMBUSTION	9

Introduction to fuels, properties of fuel oil, coal and gas, storage, handling and preparation of fuels, principles of combustion, combustion of oil, coal and gas. Agro-residue/biomass handling, preparation and combustion.

UNIT II	BOILERS	9

Types, combustion in boilers, performances evaluation, analysis of losses, feed water treatment, blow down, energy conservation opportunities. Boiler efficiency calculation, evaporation ratio and efficiency for coal, oil and gas. Soot blowing and soot deposit reduction, reasons for boiler tube failures, start up, shut down and preservation, Thermic fluid heaters, super critical boilers.

UNIT III	STEAM SYSTEM	9

Properties of steam, assessment of steam distribution losses, steam leakages, steam trapping, condensate and flash steam recovery system, identifying opportunities for energy savings. Steam utilization, Performance assessment, installation, thermo-compressor, steam pipe insulation, condensate pumping, steam dryers

UNIT IV	FURNACES , INSULATION AND REFRACTORIES	9

Classification, general fuel economy measures in furnaces, excess air, heat distribution, temperature control, draft control, waste heat recovery. Forging furnace heat balance, Cupola, non ferrous melting, Induction furnace, performance evaluation of a furnace, hot air generators- Insulation and Refractories : Insulation-types and application, economic thickness of insulation, heat savings and application criteria, Refractory-types, selection and application of refractories, heat loss. Cold insulation.

UNIT V	COGENERATION & HEAT EXCHANGERS	9

Cogeneration : Definition, need, application, advantages, classification, saving potentials. heat balance, steam turbine efficiency, tri-generation, micro turbine. Heat Exchangers : Types, networking, pinch analysis, multiple effect evaporators, condensers, distillation column, etc

TOTAL: 45 PERIODS

OUTCOMES: At the end of the course, learners will be able to:

- Illustrate the concept of fuels and combustion system
- Explain the role of boilers, steam , Furnaces , Insulation and Refractories to improve the efficiency
- Summarize the impact of co-generation system to improve the efficiency
- Outline the role of heat exchangers to improve the efficiency
- Summarize various energy saving opportunities to improve the overall efficiency for thermal utilities.

TEXT BOOKS :

1. Energy Efficiency in Thermal Utilities Guide book for National Certification Examination for Energy Manager and Auditors, Bureau of Energy Efficiency, Fourth Edition, 2015.

2. Rajiv Shankar, "Energy Auditing in Electrical Utilities" , MV Learning, 1st Edition, 2015

3. Scott Dunning and Larry S. Katz, Energy Calculations and Problem Solving Sourcebook: A Practical Guide for the Certified Energy Manager Exam, River Publishers , 1st Edition, 2017

4. D. Paul Mehta and Albert Thumann, "Handbook of Energy Engineering" ,Rivers Publishers, 7th Edition, 2013

REFERENCES :

1. David Thorpe, "Energy Management in Industry- The Earthscan Expert Guide", Routledge Publishers, 1st Edition, 2014.

2. Sonal Desai, Handbook of Energy Audit, Kindle Edition, Tata McGraw Hill Publishers 2017.

3 . Dr. Subhash Gadhave Anup Goel Siddu S. Laxmikant D. Jathar, Energy Audit &Management, Technical Publishers , 2019

4. Y P Abb, Handbook on Energy Audit and Environment Management , The Energy Resources Institute, Kindle Edition.

WEB RESOURCES

1. www.aipnpc.org
2. www.em-ea.org

PE5202	SOLAR AND ENERGY STORAGE SYSTEMS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To explain solar modules and PV system design and their applications.
- To summarize the concept of grid connected PV systems
- To classify different energy storage systems.

UNIT I	INTRODUCTION	9

Characteristics of sunlight – Sun and its radiation –Apparent motion of the sun –solar energy and photo voltaic - semiconductors and P-N junctions –behavior of solar cells – cell properties – PV cell interconnection.

UNIT II	STAND ALONE PV SYSTEM	9

Modules –storage systems–- power conditioning and regulation-Diodes, regulators and inverters -MPPT- protection– standalone PV systems design–PV design approach -sizing

UNIT III	GRID CONNECTED PV SYSTEMS	9

Systems in buildings– Module mounting approaches – Utility applications for photo voltaics –design issues for central power stations–safety–Economic aspect– Efficiency and performance - International PV programs

UNIT IV	ENERGY STORAGE SYSTEMS	9

Impact of intermittent generation–Battery energy storage– Batteries – Types and applications – solar thermal energy storage– pumped hydro electric energy storage.

UNIT V	APPLICATIONS	9

Pumping–battery chargers–solar car–direct-drive applications–Space– Telecommunications- Marine navigational aids- Electric fences -Photovoltaic powered transport- Photovoltaic for developing countries

TOTAL: 45 PERIODS

OUTCOMES: At the end of the course, learners will be able to:

- Explain the characteristics of solar energy storage systems
- Outline the concept of standalone PV system
- Summarize the issues in grid connected PV systems
- Infer the modeling of different energy storage systems and their performances
- Illustrate different applications of solar energy

TEXT BOOKS :

1. Solanki C.S., "Solar Photo voltaics: Fundamentals, Technologies And Applications", PHI LearningPvt.Ltd.,2015.
2. Stuart R.Wenham, Martin A.Green, Muriel E.Wattand Richard Corkish, "Applied Photovoltaics",2007,Earthscan, UK.
3. Hee-Je Kim ,'Solar Power and Energy Storage Systems', Kindle Ediion, Taylor and Francis, 2019
4. Ameta S C, Solar Energy Conversion And Storage Photochemical Modes, Taylor and Francis,2015

REFERENCES

1. Eduardo Lorenzo G. Araujo, "Solar electricity engineering of photovoltaic systems", Progensa, 1994.
2. Frank S. Barnes & Jonah G.Levine, "Large Energy storage Systems Handbook", CRC Press, 2011.
3. McNeils, Frenkel, Desai, "Solar & Wind Energy Technologies", Wiley Eastern, 1990 S.P.Sukhatme , "Solar Energy", Tata McGraw Hill,1987.
4. Antonio D Lopez , Solar Energy Batteries & Energy Storage Assessments of Federal Initiatives, Nova Science 2013

WEB RESOURCES

1. https://www.energy.gov/eere/solar/solar-integration-solar-energy-and-storage-basics

2. https://www.sciencedirect.com/book/9780124095403/solar-energy-storage

PS5203	MICRO GRID OPERATION AND CONTROL	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To explain the concept of micro sources and storage.
- To interpret the concept of AC micro grid and its controllers.
- To summarize the role of DC micro grid and its controllers.
- To illustrate the concept of hybrid micro grid and its controllers.
- To outline the various protection systems in micro grid

UNIT I	MICRO SOURCES AND STORAGE	9

Microgrid Structure and Operating Modes – Solar PV – Wind Energy – Fuel Cell –Battery – Super capacitor- Biomass –mini hydel power

UNIT II	AC MICROGRID	9

Hierarchical Control: Primary, Secondary and Tertiary Control– Primary Control: Droop Control, Virtual Synchronous Generator Control for VSC – Secondary Control – Simulation Studies

UNIT III	DC MICROGRID	9

Hierarchical Control: Primary, Secondary and Tertiary Control – Primary Control: Droop Control, Virtual Inertia Control – Secondary Control: Centralized and Decentralized Control – Simulation Studies

UNIT IV	HYBRID MICROGRID	9

Hybrid AC/DC Microgrid Structure: AC Coupled, DC Coupled, AC-DC Coupled –Control Strategies: different modes of operation, during transition – Simulation Studies

UNIT V	MICROGRID PROTECTION	9

Protection: Effect on Relay Protection of distribution network, Differential Relay Protection, Directional Impedance Relay Protection– Islanding: Active and Passive Techniques– Earthing: Requirements, Earthing mode of DG in TN/TT Earthing System, Earthing mode of DG in IT

TOTAL: 45 PERIODS

OUTCOMES: At the end of the course, learners will be able to:

- Analyze micro-sources and storage systems.
- Explain the configurations and control aspects of AC microgrid.
- Summarize the configurations and control aspects of DC microgrid.
- Illustrate about configurations and control aspects of Hybrid microgrid.

- Outline the protection aspects of microgrid.

TEXT BOOKS :

1. H. Bevrani, Bruno Francois and ToshifumiIse, 'Microgrid Dynamics and Control', Wiley, 2017.

2. Li Fusheng, Li Ruisheng and Zhou Fengquan, 'Microgrid Technology and Engineering Application', Elsevier, 2016.

3. M.S. Mahmoud, 'Microgrid - Advanced Control Methods and Renewable Energy System Integration', Elsevier, 2017.

4. FarzamNejabatkhah and Yun Wei Li, 'Overview of Power Management Strategies of Hybrid

REFERENCES :

1. C. Sharmeela (Editor), P. Sivaraman (Editor), P. Sanjeevikumar (Editor), Jens Bo Holm-Nielsen (Editor), 'Microgrid Technologies' , Wiley ,April 2021.
2. Microgrid: Operation, Control, Monitoring and Protection: 625 (Lecture Notes in Electrical Engineering) , Springer ,January 2020.
3. Hassan Farhangi; Geza Joos, 'Microgrid Planning and Design: A Concise Guide' , Wiley-IEEE Press, 2019.
4. AC/DC Microgrid', IEEE Transactions on Power Electronics, 2014.

WEB RESOURCES

1. https://www.wiley.com / Micro grid Technology.
2. https://microgridtechsol.com/

PE 5204	ADVANCED DIGITAL SIGNAL PROCESSING	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To summarize the fundamentals of digital signal processing in time-frequency domain & its application
- To compare Architectures & features of Programmable digital signal processors & develop logical functions of digital signal processors.
- To illustrate about the application development with commercial family of digital signal processors.

UNIT I	FUNDAMENTALS OF DSP	9

Frequency interpretation, sampling theorem, aliasing, discrete-time systems, constant- coefficient difference equation. Digital filters: FIR filter design – rectangular, Hamming, Hanning windowing technique. IIR filter design – Butterworth filter, bilinear transformation method, frequency transformation. Fundamentals of multirate processing – decimation and interpolation.

UNIT II	TRANSFORMS AND PROPERTIES	9
Discrete Fourier transform (DFT): - properties, Fast Fourier transform (FFT), DIT-FFT, and DIF-FFT. Wavelet transforms: Introduction, wavelet coefficients – Ortho normal wavelets and their relationship to filter banks, multi-resolution analysis, and Haar and Daubechies wavelet.		
UNIT III	**ADAPTIVE FILTERS**	**9**
Wiener filters – an introduction. Adaptive filters: Fundamentals of adaptive filters, FIR adaptive filter – steepest descent algorithm, LMS algorithm, NLMS, applications – channel equalization. Adaptive recursive filters – exponentially weighted RLS algorithm.		
UNIT IV	**ARCHITECTURE OF COMMERCIAL DIGITAL SIGNAL PROCESSORS**	**9**
Introduction to commercial digital signal processors, Categorization of DSP processor – Fixed point and floating point, Architecture and instruction set of the TI TMS 320 C54xx and TMS 320 C6xxx DSP processors, On-chip and On-board peripherals – memory (Cache, Flash, SDRAM), codec, Multichannel Buffered I/O Serial Ports (McBSPs), interrupts, direct memory access (DMA), timers and general purpose I/Os.		
UNIT V	**INTERFACING I/O PERIPHERALS FOR DSP BASED APPLICATIONS**	**9**
Introduction, External Bus Interfacing Signals, Memory Interface, I/O Interface, Programmed I/O, Interrupts, Design of Filter, FFT Algorithm, ,Application for Serial Interfacing, DSP based Power Meter, Position control , CODEC Interface .		
		TOTAL: 45 PERIODS

OUTCOMES: At the end of the course, learners will be able to:

- Solve various types of practical problems in Digital Signal Processing.
- Illustrate the concept of DFTs and FFTs for digital filters.
- Explain the different types of adaptive filters
- Summarize the conceptual aspects of Signal processing Transforms.
- Compare the commercial available DS Processors for interfacing.

TEXT BOOKS :

1. John. G. Proakis, Dimitris G. Manolakis, “Digital signal processing”, Pearson Edu, 2002
2. Sen M.Kuo,Woon-Seng S.Gan, “Digital Signal Processors- Pearson Edu, 2012
3. Ifeachor E. C., Jervis B. W ,”Digital Signal Processing: A practical approach, Pearson Education, PHI/ 2002

4. Shaila D. Apte, " Digital Signal Processing", Second Edition, Wiley, 2016.

5. Robert J.Schilling,Sandra L.Harris, "Introduction To Digital Signal Processing with Matlab", Cengage,2014.

REFERENCES :

1. Steven A. Tretter, "Communication System Design Using DSP Algorithms with Laboratory Experiments for the TMS320C6713™ DSK", Springer, 2008.
2. Rulph Chassaing and Donald Reay, "Digital Signal Processing and Applications with the
3. TMS320C6713 and TMS320C6416 DSK", John Wiley & Sons, Inc., Hoboken, New Jersey, 2008.
4. K.P. Soman and K.L. Ramchandran, Insight into WAVELETS from theory to practice, Eastern Economy Edition, 2008
5. B Venkataramani and M Bhaskar "Digital Signal Processors", TMH, 2nd, 2010
6. Vinay K.Ingle,John G.Proakis,"DSP-A Matlab Based Approach",Cengage Learning,2010
7. Taan S.Elali,"Discrete Systems and Digital Signal Processing with Matlab",CRC Press2009.
8. Monson H. Hayes, "Statistical Digital signal processing and modelling", John Wiley & Sons, 2008.
9. Avatar Sing, S. Srinivasan, "Digital Signal Processing- Implementation using DSP
10. Microprocessors with Examples from TMS320C54xx", Thomson India,2004.

WEB RESOURCES

1. https://nptel.ac.in/courses/117102060/
2. https://nptel.ac.in/courses/108105055/

PE5205	DISTRIBUTED GENERATION AND MICROGRID	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To explain the concept of distributed generation
- To outline the knowledge in impact of grid integration.
- To summarize the concept of Microgrid and its configuration
- To Relate the various control operations of micro grid

UNIT I	INTRODUCTION	9

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

UNIT II	DISTRIBUTED GENERATIONS (DG)	9

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

flywheels. Captive power plants.		
UNIT III	**IMPACT OF GRID INTEGRATION**	**9**
Requirements for grid interconnection, limits on operational parameters: voltage, frequency, THD, response to grid abnormal operating conditions, islanding issues. Impact of grid integration with NCE sources on existing power system: reliability, stability and power qualityissues.		
UNIT IV	**BASICS OF MICROGRID**	**9**
Concept and definition of microgrid, microgrid drivers and benefits, review of sources of microgrids, typical structure and configuration of a microgrid, AC and DC microgrids, Power Electronics interfaces in DC and AC microgrids.		
UNIT V	**CONTROL AND OPERATION OF MICROGRID**	**9**
Modes of operation and control of microgrid: grid connected and islanded mode, Active and reactive power control, protection issues, anti-islanding schemes: passive, active and communication based techniques, microgrid communication infrastructure, Power quality issues in microgrids, regulatory standards, Microgrid economics, Introduction to smart microgrids.		
		TOTAL: 45 PERIODS

OUTCOMES: At the end of the course, learners will be able to:

- Summarize the various schemes of conventional and Non-conventional power generation.
- Explain different topologies and energy sources of distributed generation.
- Illustrate the requirements for grid interconnection and its impact with NCE sources
- Outline the basic operation of Microgrid.
- Relate the various control operations of micro grid

TEXT BOKS:

1. Math H. J. Bollen, FainanHussain," Integration of distributed generation power system" Wiley IEEE press, 2011.
2. Qing - Chang Zhong, Tomas Hornlk, " Control of Power Inverters in Renewable Energy and Smart Grid Integration" Wiley IEEE press, 2012.

3.D. Hall and R. P. Grover, "Biomass Regenerable Energy", John Wiley, New York,1987.

4.John Twidell and Tony Weir, "Renewable Energy Resources" Taylor and Francis Publications, Second edition 2006

REFERENCES

1. Amirnaser Yezdani, and Reza Iravani, "Voltage Source Converters in Power Systems: Modeling, Control and Applications", IEEE John Wiley Publications, 2010.
2. Dorin Neacsu, "Power Switching Converters: Medium and High Power", CRC Press, Taylor & Francis, 2006
3. Chetan Singh Solanki, "Solar Photo Voltaics, Fundamentals, Technologies and Applications", PHI learning Pvt. Ltd., New Delhi,2009.
4. J.F. Manwell, J.G. McGowan "Wind Energy Explained, Theory design and applications", Wiley publication 2010.

WEB RESOURCES

1. https://digital-library.theiet.org/content/books/10.1049/pbrn006e_ch1
2. https://www.researchgate.net/publication/245289734_Microgrids_And_Distributed_Generation

PE5206	ENERGY EFFICIENCY IN ELECTRICAL UTILITIES	L	T	P	C

		3	**0**	**0**	**3**

PREREQUITIES COURSES :

- Electrical Machines
- Power Plant Engineering
- Energy management and auditing
- Energy efficiency in electrical and thermal utilities

OBJECTIVES:

- To infer the basic knowledge on electrical utilities
- To explain the concepts behind energy efficiency in electrical utilities
- To summarize various energy saving opportunities in electrical utilities

UNIT I	**ELECTRICAL SYSTEM**	**9**

Electricity billing, electrical load management and maximum demand control, power factor improvement and its benefit, Electric motors: Types, losses in induction motors, motor efficiency, factors affecting motor performance, rewinding and motor replacement issues Compressed Air System: Types of air compressors, compressor efficiency, efficient compressor operation, Compressed air system components, capacity assessment, leakage test

UNIT II	**HVAC AND REFRIGERATION SYSTEM**	**9**

Vapour compression refrigeration cycle, refrigerants, coefficient of performance- Vapour absorption refrigeration system: Working principle, types and comparison with vapour compression system- Fans and blowers: Types, performance evaluation, efficient system operation, Pumps and Pumping System: Types, performance evaluation, efficient system operation.

UNIT III	**LIGHTING SYSTEM**	**9**

Light source, choice of lighting, luminance requirements, and energy conservation avenues. Diesel Generating system: Factors affecting selection, energy performance assessment of diesel conservation avenues.

UNIT IV	**DIESEL / NATURAL GAS POWER GENERATING SYSTEMS**	**9**

Diesel / Natural gas Power Generating systems: Factors affecting selection, energy performance assessment of diesel conservation avenues, Waste heat recovery.

UNIT V	**ENERGY CONSERVATION IN BUILDINGS AND ENERGY CONSERVATION BUILDING CODES (ECBC)**	**9**

Introduction about Energy Conservation Building Codes (ECBC), building envelope, insulation, lighting, Heating, ventilation, air conditioning (HVAC), fenestrations, water pumping, inverter and energy storage/captive generation, elevators and escalators, star labeling for existing buildings, Energy Service Companies based case studies.

TOTAL: 45 PERIODS

OUTCOMES: At the end of the course, learners will be able to:

- Explain the performance of electrical utilities like electric motors and compressed air systems
- Illustrate the role of HVAC and Refrigeration System, Lighting system to improve the efficiency in electrical utilities
- Explain the performance of Diesel / Natural gas Power Generating systems
- Outline the concept of Energy conservation in Buildings and Energy Conservation Building Codes (ECBC)
- Summarize various energy saving opportunities to improve the overall efficiency for electrical utilities.

TEXT BOOKS :

1. Energy Efficiency in Electrical Utilities , Guide book for National Certification Examination for Energy Manager and Auditors, Bureau of Energy Efficiency , 4th Edition, 2015.
2. Rajiv Shankar, "Energy Auditing in Electrical Utilities" , MV Learning, 1st Edition, 2015
3. Scott Dunning and Larry S. Katz, Energy Calculations and Problem Solving Sourcebook: A Practical Guide for the Certified Energy Manager Exam, River Publishers , 1st Edition, 2017
4. D. Paul Mehta and Albert Thumann, "Handbook of Energy Engineering" ,Rivers Publishers, 7th Edition, 2013

REFERENCES :

1. Sonal Desai,Hand book of Energy Audit, Kindle Edition, Tata McGraw Hill Publishers 2017.
2. Dr. Subhas Gadhave Anup Goel Siddu S. Laxmi kant D. Jathar, Energy Audit & Management, Technical Publishers , 2019
3. Y P Abb, Handbook on Energy Audit and Environment Management , The Energy Resources Institute, Kindle Edition
4. David Thorpe, "Energy Management in Industry- The Earthscan Expert Guide", Routledge Publishers, 1st Edition, 2014.

WEB RESOURCES

1. www.aipnpc.org
2. www.em-ea.org

Semester III

Elective IV, V and VI

PE 5301	ELECTRICAL DISTRIBUTION SYSTEM	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To explain the electrical characteristics of distribution system
- To relate the knowledge about planning and designing of distribution system
- To summarize the basic concept of power quality in distribution system
- To analyze the concept of power flow analysis in distribution feeder systems

UNIT I	INTRODUCTION	9

Distribution System-Distribution Feeder Electrical Characteristics-Nature of Loads: Individual Customer Load, Distribution Transformer Loading and Feeder Load-Approximate Method of Analysis: Voltage Drop, Line Impedance, "K" Factors, and Lumping Loads in Geometric Configurations.

UNIT II	DISTRIBUTION SYSTEM PLANNING	9

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

UNIT III	DISTRIBUTION SYSTEM LINE MODEL	9
Exact Line Segment Model-Modified Line Model-Approximate Line Segment Model-Modified "Ladder" Iterative Technique-General Matrices for Parallel Lines.		
UNIT IV	**VOLTAGE REGULATION**	**9**
Standard Voltage Ratings-Two-Winding Transformer Theory-Two-Winding Autotransformer-Step-Voltage Regulators: Single-Phase Step-Voltage Regulators-Three-Phase Step-Voltage Regulators- Application of capacitors in Distribution system.		
UNIT V	**DISTRIBUTION FEEDER ANALYSIS**	**9**
Power-Flow Analysis- Ladder Iterative Technique -Unbalanced Three-Phase Distribution Feeder- Modified Ladder Iterative Technique- Load Allocation- Short-Circuit Studies.		
		TOTAL: 45 PERIODS

OUTCOMES: At the end of the course, learners will be able to:

- Explain the knowledge about distribution system.
- Apply the concepts of planning and design of distribution system for utility systems
- Summarize the various concepts of distribution system line model
- Make use of voltage control concept in distribution system.
- Develop the power flow analysis in balanced and unbalanced systems

TEXT BOKS:

1. William H. Kersting," Distribution System Modeling and Analysis " CRC press 3rd edition,2012.
2. TuranGonen, "Electric Power Distribution System Engineering", McGraw Hill Company. 1986.
3. Math H. J. Bollen, FainanHussain," Integration of distributed generation power system" Wiley IEEE press, 2011.
4. William H. Kersting," Distribution System Modeling and Analysis " CRC press 2nd edition,2006

REFERENCES

1. James Northcote – Green, Robert Wilson, "Control and Automation of Electrical Power Distribution Systems", CRC Press, New York, 2007.

2. Pabla H S, "Electrical Power Distribution Systems", Tata McGraw Hill. 2004.

3.kamaraju V, "Electrical Power Distribution Systems", Tata McGraw Hill. 2004.

4.Dale R,patrick, "Electrical Power Distribution Systems", S.Chand (G/L) & Company Ltd. 2009.

WEB RESOURCES

1. www.nptel.ac.in/ distribution system
2. www.classcentral.com

PE5302	ENERGY MANAGEMENT AND AUDITING	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To explain the various step involved in an energy auditing process.
- To interpret the concepts behind electricity billing and load management.
- To infer the energy management on various electrical equipment and metering system.
- To illustrate the concept of lighting systems.
- To summarize the performance assessment made on various utilities and its need.

UNIT I	INTRODUCTION	9

Definition, Energy audit- Need for energy management - energy basics- energy accounting - energy monitoring, targeting and reporting- energy audit process- Types of energy audit, matching energy use to requirement, Maximizing system efficiencies, Optimizing the input energy requirements, Fuel and energy substitution, Energy audit instruments

UNIT II	ECONOMIC ANALYSIS AND LOAD MANAGEMENT	9

Definition of load management- Demand control techniques- Utility monitoring and control system -HVAC and energy management- Economic justification for load management systems - Economic analysis - Economic models- models- applications and limitations-Time value of money-Utility rate structures- Calculating the cost of electricity-Loss evaluation.

UNIT III	ENERGY MANAGEMENT FOR ELECTRICAL EQUIPMENTS AND METERING SYSTEM	9

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

UNIT IV	ENERGY MANAGEMENT FOR LIGHTING SYSTEMS	9

Concept of lighting systems - Task and working space -Light sources - Ballasts - Luminaries - Lighting controls-Optimizing lighting energy - Power factor and effect of harmonics on power quality - Cost analysis techniques-Lighting and energy standards.

UNIT V	ENERGY PERFORMANCE ASSESSMENT FOR UTILITY SYSTEMS	9

Performance terms- definition- Purpose of performance test- Performance on Thermal power station- Steel industry- Cement industry- Paper and pulp industry- Textile industry- Fertilizer industry-Building & commercial establishments

TOTAL: 45 PERIODS

OUTCOMES: At the end of the course, learners will be able to:

- Develop the ability to learn about the need for energy management and auditing process
- Infer the load management and economic analysis performed in a system.
- Outline the energy management concepts for electrical equipments and metering system.
- Explain the concept of lighting systems and energy standards.
- Interpret the performance assessment made on various utility systems.

TEXT BOOKS:

1. Barney L. Capehart, Wayne C. Turner, and William J. Kennedy, "Guide to Energy

Management", 7th edition, The Fairmont Press, Inc., 2011.
2. Amit K. Tyagi, "Handbook on Energy Audits and Management", TERI, 2003.
3. Ian M . Shapiro , "Energy audits and improvements for commercial buildings : a guide for energy managers and energy auditors", 1st edition, John Wiley & Sons, 2016.
4. Anil Kumar , Om Prakash , **Prashant Singh Chauhan** , Samsher Gautam, "Energy Management-Conservation and Audits",1st edition, CRC Press, 2020.

REFERENCES

1. Frank Kreith, D. Yogi Goswami, " Energy management and conservation handbook", 1st edition, CRC Press, 2008.
2. Patrik Thollander, Jenny Palm ,"Improving Energy Efficiency in Industrial Energy Systems: An Interdisciplinary Perspective on Barriers, Energy Audits, Energy Management, Policies, and Programs", 1st edition , Springer-Verlag London, 2013.
3. General Aspects of Energy Management and Energy Audit, 4th edition, Bureau of Energy Efficiency India, 2015.
4. Moncef Krarti, " Energy Audit of Building Systems: An Engineering Approach", 2nd edition,CRC Press, 2010.

WEB RESOURCES

1. https://www.emanz.org.nz/energy-management-audits/what-energy-audit
2. https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-20956.pdf
3. https://beeindia.gov.in/sites/default/files/1Ch3.pdf

PE5303	WIND ENERGY CONVERSION SYSTEMS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To explain the design and control principles of Wind turbine.
- To summarize the concepts of fixed speed and variable speed wind energy conversion systems.
- To illustrate the grid integration issues with wing energy conversion systems.

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 (Horizontal and Vertical Axis Wind Turbine) -Power developed-Thrust-Efficiency-Rotor selection-Rotor design considerations- Tip speed ratio-No. of Blades-Blade profile-Power Regulation-yaw control-Pitch angle control and 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 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 (doubly-fed induction generator) - PMSG (Permanent Magnet synchronous Generator) -Variable speed generators modeling - Variable speed variable frequency schemes.		
UNIT V	**GRID CONNECTED SYSTEMS**	**9**
Wind interconnection requirements, low-voltage ride through (LVRT), ramp rate limitations, and supply of ancillary services for frequency and voltage control, current practices and industry trends wind interconnection impact on steady-state and dynamic performance of the power system including modeling issue.		
		TOTAL: 45 PERIODS

OUTCOMES: At the end of the course, learners will be able to:

- Explain the basic concepts of Wind energy conversion system.
- Illustrate the mathematical modeling and control of the Wind turbine
- Construct the different types of Fixed speed system
- Identify the characteristics of variable speed systems.
- Interpret the issues of Grid connected wind energy conversion system

TEXT BOOKS:

5. L.L.Freris "Wind Energy conversion Systems", Prentice Hall, 1990
6. S.N.Bhadra, D.Kastha, S.Banerjee,"Wind Electrical Sytems",Oxford University Press,2010.
7. Ion Boldea, "Variable speed generators", Taylor & Francis group, 2006.
8. S.M.Muyeen, "Wind Energy conversion Systems Technology and Trends" Springer, 2012.

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1. E.W.Golding "The generation of Electricity by wind power", Redwood burn Ltd.,Trowbridge,1976.
2. N. Jenkins," Wind Energy Technology" John Wiley & Sons,1997
3. S.Heir "Grid Integration of WECS", Wiley 1998.
4. N. Jenkins," Wind Energy Technology" John Wiley & Sons,1997
5. IulianMunteanu, AntonetaIulianaBratcu, Nicolaos-Antonio Cutululis " Optimal Control of Wind Energy Systems: Towards a Global" , Springer, 2008.

WEB RESOURCES

1. https://nptel.ac.in/content/storage2/courses/108108078/pdf/chap6/teach_slides06.pdf
2. https://nptel.ac.in/courses/108105058/

PE5304	**ELECTRIC VEHICLES AND POWER MANAGEMENT**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

OBJECTIVES:

- To summarize the concept of electrical vehicles and its operations
- To infer the need for energy storage in hybrid vehicles
- To explain the various energy storage technologies in electric vehicles

UNIT I	**ELECTRIC VEHICLES AND VEHICLE MECHANICS**	**9**

Electric Vehicles (EV), Hybrid Electric Vehicles (HEV), Engine ratings, Comparison of EV with internal combustion Engine vehicles, Fundamentals of vehicle mechanics.		
UNIT II	**ARCHITECTURE OF EV's AND POWER TRAIN COMPONENTS**	**9**
Architecture of EV's and HEV's – Plug-in Hybrid Electric Vehicles (PHEV)- Power train components and sizing, Gears, Clutches, Transmission and Brakes		
UNIT III	**CONTROL OF DC AND AC DRIVES**	**9**
DC/DC chopper based four quadrant operations of DC drives – Inverter based V/f Operation (motoring and braking) of induction motor drive system – Induction motor and permanent motor based vector control operation – Switched reluctance motor (SRM) drives.		
UNIT IV	**BATTERY ENERGY STORAGE SYSTEM**	**9**
Battery Basics, Different types, Battery Parameters, Battery modeling, Traction Batteries		
UNIT V	**ALTERNATIVE ENERGY STORAGE SYSTEMS**	**9**
Fuel cell – Characteristics- Types – hydrogen Storage Systems and Fuel cell EV – UltraCapacitors		
	TOTAL: 45 PERIODS	

OUTCOMES: At the end of the course, learners will be able to:

- Explain the fundamental operation of Electric vehicles
- Illustrate the architecture and components of Electric vehicles and Plug-in Hybrid Electric Vehicles
- Compare the operation of inverter based operation of induction motor and Switched reluctance motor drive system
- Summarize various types of batteries and their operation
- Interpret the characteristics of hydrogen storage systems Fuel cell EV systems with Ultra capacitor

TEXT BOOKS:

1. Tom Denton, 'Electric and Hybrid Vehicle' ,Newyork,NY,Routledge,Taylor& Francis Group, 2016.
2. Ali Emadi, MehrdadEhsani, John M.Miller, "Vehicular Electric Power Systems", Special Indian Edition, Marcel dekker, Inc 2010.
3. Iqbal Hussein, 'Electric and Hybrid Vehicles: Design Fundamentals', Second Edition" CRC Press, Taylor & Francis Group, Second Edition (2011).
4. Amir Khajepour, M. Saber Fallah, AvestaGoodarzi, 'Electric and Hybrid Vehicles: Technologies, Modeling and Control - A Mechatronic Approach' ,Wiley, 2014.

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1. MehrdadEhsani, YimiGao, Sebastian E. Gay, Ali Emadi, Modern Electric, HybridElectric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press,Tird Edition, 2018.
2. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.
3. A.K.Babu, ' Electric& Hybrid Vehicles' , Khanna Publishing, 2019.
4. Ronald K. Jurgen**,**'Electric and Hybrid-Electric Vehicles: Batteries', SAE International ,2011.

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1. http://nptel.ac.in/courses/108103009/
2. https://www.sciencedirect.com/topics/engineering/hybrid-electric-vehicle
3. https://afdc.energy.gov/vehicles/how-do-hybrid-electric-cars-work

PE5305	WASTE TO ENERGY	L	T	P	C
		3	0	0	3

OBJECTIVES:

- Interpret the various types of wastes from which energy can be generated
- Develop knowledge on biomass pyrolysis process and its applications
- Outline various types of biomass gasifiers and their operations
- Explain the biomass combustors and its applications on generating energy
- Summarize the principles of bio-energy systems and their features

UNIT I	INTRODUCTION TO EXTRACTION OF ENERGY FROM WASTE	9

Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors

UNIT II	BIOMASS PYROLYSIS	9

Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application –

Manufacture of pyrolytic oils and gases, yields and applications.

UNIT III	BIOMASS GASIFICATION	9

Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

UNIT IV	BIOMASS COMBUSTION	9

Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types,

inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

UNIT V	BIO ENERGY	9

Properties of biogas (Calorific value and composition), Biogas plant technology and status – Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion – biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production –Urban waste to energy conversion - Biomass energy programme in India.

TOTAL: 45 PERIODS

OUTCOMES: At the end of the course, learners will be able to:

- Summarize the various types of wastes from which energy can be generated

- Explain about biomass pyrolysis process and its applications
- List the various types of biomass gasifiers and their operations
- Outline biomass combustors and its applications on generating energy
- Illustrate the principles of bio-energy systems and their features

TEXT BOOKS :

1. Khandelwal, K. C. and Mahdi, S. S., 'Biogas Technology - A Practical Hand Book' , Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.

2. C. Y. WereKo-Brobby and E. B. Hagan, John , 'Biomass Conversion and Technology', Wiley & Sons, 1996.

3. D.S. Challal, 'Food, Feed and Fuel from Biomass' , IBH Publishing Co. Pvt. Ltd., 1991.

4. Desai and Ashok V, 'Non Conventional Energy', Wiley Eastern Ltd., 1990.

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1. Marc Rogoff, Francois Screve, 'Waste-to-Energy Technologies and Project Implementation' Elsevier, 3rd Edition - March 9, 2019
2. Naomi B. Klinghoffer and Marco J. Castaldi, 'Waste to Energy Conversion Technology', Science Direct, 2013.
3. Paul Breeze, 'Energy from Waste', Elsevier, 1st Edition - October 20, 2017
4. Rajeev Pratap Singh, Vishal Prasad and Barkha Vaish, 'Advances in Waste-to-Energy Technologies', CRC Press, December 2, 2019

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1. https://mnre.gov.in/waste-to-energy/current-status
2. https://www.worldenergy.org/assets/images/imported/2013/10/WER_2013_7b_Waste_to_Energy.pdf

PE 5306	CONTROL SYSTEM DESIGN FOR POWER ELECTRONICS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To explain the various types of power converters
- To interpret Sliding Mode Controller Design and types of converters
- To classify Linear and Nonlinear Controller Design for converters
- To relate System Faults and Diagnosis in Power Converters.

UNIT I	MODELLING OF DC-TO-DC POWER CONVERTERS	9

Modeling of Buck Converter , Boost Converter ,Buck-Boost Converter, Cuk Converter ,Sepic Converter,

Zeta Converter, Quadratic Buck Converter ,Double Buck-Boost Converter, Boost- Boost Converter Forward converter , Fly back Converter and Push –Pull Converter- General Mathematical Model for Power Electronics Devices

UNIT II	SLIDING MODE CONTROLLER DESIGN	9

Variable Structure Systems. Single Switch Regulated Systems Sliding Surfaces, Accessibility of the Sliding Surface Sliding Mode Control-Implementation of Boost Converter ,Buck-Boost Converter, Cuk Converter ,Sepic Converter, Zeta Converter, Quadratic Buck Converter ,Double Buck-Boost Converter, Boost-Boost Converter - Forward converter , Fly back Converter and Push –Pull Converter

UNIT III	APPROXIMATE LINEARIZATION CONTROLLER DESIGN	9

Linear Feedback Control, Pole Placement by Full State Feedback , Pole Placement Based on Observer Design ,Reduced Order Observers , Generalized Proportional Integral Controllers, Passivity Based Control , Sliding Mode Control Implementation of Buck Converter , Boost Converter ,Buck-Boost Converter – Performance indices design examples.

UNIT IV	NONLINEAR CONTROLLER DESIGN	9

Feedback Linearization Isidori's Canonical Form , Input-Output Feedback Linearization ,State Feedback Linearization, Passivity Based Control , Full Order Observers , Reduced Order Observers-Design on Closed loop control performance of converter.

UNIT V	PREDICTIVE CONTROL OF POWER CONVERTERS	9

Basic Concepts, Theory, and Methods, Application of Predictive Control in Power Electronics, AC-DC-AC Converter System, AC-DC converter system-Resonant converter-Faults and Diagnosis Systems in Power Converters.

TOTAL: 45 PERIODS

OUTCOMES: At the end of the course, learners will be able to:

- Classify the various dc-dc power converters
- Illustrate sliding mode controller technique in power converters
- Explain the different linear controller techniques for power converters
- Identify the various non-linear controller techniques for power converters
- Utilize the predictive controllers for fault diagnosis in power converters

TEXT BOOKS:

1. Hebertt Sira-Ramírez PhD, Ramón Silva-Ortigoza, "Control Design Techniques in Power Electronics Devices", Springer 2012.

2. Mahesh Patil, Pankaj Rodey, "Control Systems for Power Electronics: A Practical Guide", Springer India, 2015.
3. M.H.Rashid, _Power Electronics: Circuits, Devices and Applications', Pearson Education, PHI Third Edition, New Delhi, 2004.
4. P.S.Bimbra ―Power Electronica‖ Khanna Publishers, third Edition, 2003.
5. Ashfaq Ahmed 'Power Electronics for Technology', Pearson Education, Indian reprint, 2003.

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1. Blaabjerg José Rodríguez, "Advanced and Intelligent Control in Power Electronics and Drives", Springer, 2014.
2. Enrique Acha, Vassilios Agelidis, Olimpo Anaya, TJE Miller, "Power Electronic Control in Electrical Systems", Newnes, 2002.
3. Marija D. Aranya Chakrabortty, Marija , "Control and Optimization Methods for Electric Smart Grids", Springer, 2012.
4. Joseph Vithayathil,' Power Electronics, Principles and Applications', McGraw Hill Series, 6th Reprint, 2013.
5. Philip T. Krein, "Elements of Power Electronics" Oxford University Press, 2004 Edition.

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2. https://nptel.ac.in/content/storage2/nptel_data3/html/mhrd/ict/text/108107128/lec37.pdf
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PE 5307	PRINCIPLES OF ELECTRIC POWER TRANSMISSION	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To summarize the types of power transmission and configurations.
- To illustrate various parameters and voltage gradients of transmission line conductors.
- To interpret voltage gradients on various conductor systems.
- To explain electro static field developed on Extra High Voltage (EHV) lines
- To outline the design requirements of High Voltage Direct Current (HVDC) lines.

UNIT I	INTRODUCTION	9

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

UNIT II	CALCULATION OF LINE PARAMETERS	9

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

UNIT III	VOLTAGE GRADIENTS OF CONDUCTORS	9

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

UNIT IV	ELECTROSTATIC FIELD AND DESIGN OF EHV LINES	9

Effect of Extra High Voltage(EHV) lines on heavy vehicles - calculation of electrostatic field of Alternating Current (AC) lines- effect ofhigh field on humans, animals, and plants - measurement of electrostatic fields –electrostatic Induction in unenergised circuit of a Direct Current (DC) line - induced voltages in insulatedground wires - electromagnetic interference, Design of EHV lines.

UNIT V	HVDC LINES	9

Introduction- Reliability and failure issues-Design-tower, Right of Way (ROW), clearances,

insulators,electrical and mechanical protection-Maintenance-Control and protection-DC Electric field and Magnetic field -Regulations and guide lines-underground line design

	TOTAL: 45 PERIODS

OUTCOMES: At the end of the course, learners will be able to:

- Outline the various configurations of power transmission
- Illustrate the significance of line parameters and effect of ground return path based FACTS controllers
- Explain the importance of voltage gradient developed on conductors
- Interpret the effect of electrostatic field on AC & DC lines
- Demonstrate the design of HVDC lines.

TEXT BOOKS:

1. Rakosh Das Begamudre, "Extra High Voltage AC Transmission Engineering", Second Edition, New Age International publishers.4th edition, 2011.
2. Pritindra Chowdhuri, "Electromagnetic transients in power systems", PHI Learning Private Limited, New Delhi, 2nd edition, 2009
3. Sunil S.Rao, "EHVAC, HVDC Transmission & Distribution Engineering", 3rd edition, Khanna Publishers, 2008.
4. Waddicor, Harold,"The Principles of Electric Power Transmission", Springer science publishers,5th edition, 1994

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1. Rama Subbanna, "Electric Power Transmission and Distribution", Notion publications, 3rd edition, 2019
2. Luces M. Faulkenberry, "Electrical Power Distribution and Transmission",Pearson Education, 1st edition, 2019
3. Lionel Ratnakar,"Electrical Power Transmission And Distribution", New Age International Publishers,1st edition, 2016
4. "Power Engineer's Handbook", Revised and Enlarged 6th Edition, TNEB Engineers' Association, October 2011.

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PE5308	MACHINE LEARNING	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To infer the concepts of Machine Learning.
- To outline supervised learning and their applications.
- To relate the concepts and algorithms of unsupervised learning.
- To summarize the theoretical and practical aspects of Probabilistic Graphical Models.
- To illustrate the concepts and algorithms of advanced learning.

UNIT I INTRODUCTION 9

Machine Learning– Machine Learning process- Preliminaries for Machine Learning algorithms Turning data into Probabilities and Statistics for Machine Learning- Probability theory – Probability Distributions – Decision Theory.

UNIT II SUPERVISEDLEARNING 9

Linear Models for Regression – Linear Models for Classification- Discriminant Functions, Probabilistic Generative Models, Probabilistic Discriminative Models – Decision Tree Learning – Bayesian Learning, Naïve Bayes – Ensemble Methods, Bagging, Boosting, Neural Networks , Multi- layer Perceptron – Deriving Back Propagation - Support Vector Machines.

UNIT III UNSUPERVISED LEARNING 9

Clustering- K-means – EM Algorithm- Mixtures of Gaussians – Dimensionality Reduction – Linear Discriminant Analysis - Principal Components Analysis – Locally Linear Embedding – Isomap

UNIT IV PROBABILISTIC GRAPHICAL MODELS 9

Graphical Models – Undirected Graphical Models – Markov Random Fields – Directed Graphical Models –Bayesian Networks – Conditional Independence properties – Markov Random Fields- Hidden Markov Models – Conditional Random Fields(CRFs).

UNIT V ADVANCED LEARNING 9

Sampling-Basic Sampling methods, Monte Carlo, Gibbs Sampling – Computational Learning Theory-Mistake Bound Analysis – Reinforcement learning – Markov Decision processes, Deterministic and Non-deterministic Rewards and Actions, Temporal Difference Learning Exploration.

TOTAL: 45PERIODS

OUTCOMES: At the end of the course, learners will be able to:

- Apply a learning model appropriate to the application.
- Construct a Neural Network for an application of your choice.
- Identify Probabilistic Discriminative and Generative algorithms for an application of your choice and analyze the results.
- Develop an HMM for a Sequence Model type of application.
- Choose applications suitable for different types of Machine Learning with suitable justification.

TEXT BOOKS:

5. Christopher Bishop, "Pattern Recognition and Machine Learning" Springer, 2007.

6. Stephen Marsland, “Machine Learning – An Algorithmic Perspective”, Chapman and Hall, CRC Press, Second Edition, 2014.
7. Kevin P. Murphy, “Machine Learning: A Probabilistic Perspective”, MIT Press, 2012.
8. EthemAlpaydin, “Introduction to Machine Learning”, MIT Press, Third Edition, 2014.

REFERENCES

1. Tom Mitchell, “Machine Learning”, McGraw-Hill, 1997.
2. EthemAlpaydin, (2004) “Introduction to Machine Learning (Adaptive Computation and Machine Learning)”, The MIT Press
3. T. astie, R. Tibshirani, J. H. Friedman, “The Elements of Statistical Learning”, Springer(2nd ed.), 2009
4. David E. Goldberg - Genetic Algorithm in Search, Optimization and Machine Learning, PearsonEducation, 1999.

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1. https://www.techtarget.com/searchenterpriseai/definition/machine-learning-ML
2. https://www.ibm.com/in-en/cloud/learn/machine-learning
3. https://www.geeksforgeeks.org/machine-learning

PE5309	DESIGN OF SUBSTATIONS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To illustrate the layout of Air Insulated Substation (AIS) and Gas Insulated Substation (GIS).
- To explain the operation of Air Insulated Substation (AIS) and Gas Insulated Substation (GIS).
- To summarize various substations insulation co-ordination of AIS and GIS
- To outline various grounding and protection schemes.
- To interpret the effects of transients on substations.

UNIT I	INTRODUCTION TO AIS AND GIS	9

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

UNIT II	MAJOR EQUIPMENT AND LAYOUT OF AIS AND GIS	9

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

UNIT III	INSULATION COORDINATION OF AIS AND GIS	9

Introduction – stress at the equipment – insulation strength and its selection – standard Basic insulation level (BIL) –Application of simplified method – Comparison with Institute of Electrical and Electronics Engineers (IEEE) and International Electrotechnical Commission (IEC) guides.

UNIT IV	GROUNDING AND SHIELDING	9

Definitions – soil resistivity measurement – ground fault currents – ground conductor – design

of substation grounding system – shielding of substations – Shielding by wires and masts

UNIT V	FAST TRANSIENTS PHENOMENON IN AIS AND GIS	9

Introduction – Disconnector switching in relation to very fast transients – origin of Very Fast Transient Overvoltages(VFTO) –propagation and mechanism of VFTO – VFTO characteristics – Effects of VFTO.

	TOTAL: 45 PERIODS

OUTCOMES: At the end of the course, learners will be able to:

- Explain the basic layout of AIS and GIS

- Illustrate the electrical and mechanical aspects of AIS and GIS
- Outline the need for insulation co-ordination and protection schemes for substations
- Illustrate the grounding and shielding schemes in substations
- Show the effects of very fast transient over voltages on substations.

TEXT BOOKS:

1. Andrew R. Hileman, "Insulation coordination for power systems", Taylor and Francis, 1st edition,1999.
2. M.S. Naidu, "Gas Insulation Substations", I.K. International Publishing House Private Limited, 2nd edition,2008.
3. Klaus Ragallar, "Surges in high voltage networks" Plenum Press,New York, 1stedition,1980.
4. Hermann Koch , "Gas Insulated Substations", Wiley-IEEE Press,3rd edition, 2014

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1. John Finn, Terry Krieg,"Substations", CIGRE green books, Springer Reference series,2019
2. "Design guide for rural substation", United States Department of Agriculture, RUS Bulletin, 1724E-300, June 2001.
3. PritindraChowdhuri, "Electromagnetic transients in power systems", PHI Learning Private Limited, New Delhi, 2ndedition, 2009
4. "Power Engineer's Handbook", Revised and Enlarged 6th Edition, TNEB Engineers' Association, October 2011.

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2. https://nptel.ac.in/courses/108108099/
3. https://www.digimat.in/nptel/courses/video/108108099/L23.html