UNIVERSITY DEPARTMENTS

ANNA UNIVERSITY : : CHENNAI 600 025

REGULATIONS – 2013

CURRICULUM I TO IV SEMESTERS (FULL TIME)

M.E. POWER ENGINEERING AND MANAGEMENT

SEMESTER I

SL. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1	PW8101	Climate Change and Energy Environment	3	0	0	3
2	PW8102	Computer Aided Power System Engineering	3	0	0	3
3	PW8103	Power Business Management	3	0	0	3
4	PW8104	Renewable Energy Technology	3	0	0	3
5	MA8156	Applied Mathematics for Electrical Engineers	3	1	0	4
6		Elective I	3	0	0	3
PRACTICAL						
7	PW8111	Power Engineering Laboratory	0	0	3	2
		TOTAL	**18**	**1**	**3**	**21**

SEMESTER II

SL. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1	PW8201	Distribution Systems Management and Automation	3	0	0	3
2	PW8202	Grid Integration of Renewable Energy Sources	3	0	0	3
3	PW8203	SCADA System and Applications Management	3	0	0	3
4	PS8255	Smart Grids	3	0	0	3
5		Elective II	3	0	0	3
6		Elective III	3	0	0	3
PRACTICAL						
7	PW8211	Energy Laboratory	0	0	3	2
		TOTAL	**18**	**0**	**3**	**20**

SEMESTER III

SL. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1		Elective IV	3	0	0	3
2		Elective V	3	0	0	3
3		Elective VI	3	0	0	3
PRACTICAL						
4	PW8311	Project Work Phase I	0	0	12	6
		TOTAL	**9**	**0**	**12**	**15**

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SEMESTER IV

SL. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
PRACTICAL						
1	PW8411	Project Work Phase II	0	0	24	12
		TOTAL	**0**	**0**	**24**	**12**

TOTAL NUMBER OF CREDITS = 68

ELECTIVES OF POWER ENGINEERING AND MANAGEMENT

SL. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1	PW8001	Electric Vehicles and Power Management	3	0	0	3
2	PW8002	Electricity Market Analysis	3	0	0	3
3	PW8003	Energy Economics, Financing, Regulation and Energy Modeling	3	0	0	3
4	PW8004	Energy Efficient Buildings	3	0	0	3
5	PW8005	Energy Systems Modeling and Analysis	3	0	0	3
6	PW8006	Governance and Management of Natural Resources	3	0	0	3
7	PW8007	Integrated Energy Systems	3	0	0	3
8	PW8008	Sustainable Energy Utilization	3	0	0	3
9	PW8009	Urban and Rural Energy Management	3	0	0	3
10	ET8072	MEMS Technology	3	0	0	3
11	PE8073	Power Quality	3	0	0	3
12	PE8152	Analysis of Electrical Machines	3	0	0	3
13	HV8073	Design of Substations	3	0	0	3
14	PS8072	Distributed Generation and Micro Grid	3	0	0	3
15	PS8073	Energy Management and Auditing	3	0	0	3
16	PS8075	Optimisation Techniques	3	0	0	3
17	PS8253	Flexible AC Transmission Systems	3	0	0	3
18	PS8077	Wind Energy Conversion System	3	0	0	3
19	PS8074	High Voltage Direct Current Transmission	3	0	0	3
20	PE8351	Power Electronics for Renewable Energy Systems	3	0	0	3
21	CO8002	Control of Electrical Drives	3	0	0	3

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PW8101 CLIMATE CHANGE AND ENERGY ENVIRONMENT L T P C
3 0 0 3

UNIT I CLIMATE CHANGE 9

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

UNIT II TECHNOLOGY AND POLICY OPTIONS FOR GHG EMISSION MITIGATION 9

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

UNIT III INTERNATIONAL CLIMATE CHANGE CONVENTIONS, PROTOCOLS AND PERSPECTIVES 9

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

UNIT IV ENVIRONMENTAL PROBLEMS RELATED TO ENERGY USE 9

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

UNIT V URBAN ENERGY USE AND THE ENVIRONMENT 9

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

TOTAL: 45 PERIODS

REFERENCES

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

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PW8102 COMPUTER AIDED POWER SYSTEM ENGINEERING

L	T	P	C
3	0	0	3

UNIT I MODELING OF POWER SYSTEM COMPONENTS 9

Basic Concepts, Single Phase, Three Phase Models, Matrix Representation of power system networks, Bus Admittance Matrix, Bus Impedance Matrix, Network Reduction Techniques

UNIT II POWER SYSTEM CONTIGENCY ANALYSIS 9

Basic Concepts, Contingency Analysis, Contingency Selection, Contingency analysis methods, Contingency ranking methods

UNIT III LOAD FLOW ANALYSIS 9

Concept of load flow, classification of buses, Formulation of Load Flow Problem, Gauss-Jacobi and Gauss Seidel MethodsNewton-Raphson Method, De-coupled, Fast De-coupled Methods, Distribution Load Flow Analysis, flow chart and compression of different methods

UNIT IV SHORT CIRCUIT ANALYSIS 9

System representation, Basic assumption in short circuit study, Effect of Short Circuits, Various Types of Faults, Symmetrical Components, Sequence Networks, Balance and Unbalanced Fault Analysis

UNIT V UNITCOMMITMENT AND ECONOMIC DISPATCH 9

Unit commitment (Spinning reserve, thermal unit constraints, hydro constraints, fuel constraints and other constraints), Priority lists methods, Solution techniques of Unit Commitment (Numerical problems only in priority-list method using full-load average production cost), Economic dispatch, cost of generation, Incremental cost curve, co-ordination equations with and without loss

TOTAL: 45 PERIODS

REFERENCES:

1. Hadi A. Sadat, .Power System Analysis., McGraw Hill Co. Ltd., India, 2000.
2. I.J. Nagarath, D.P. Kothari, Power System Engineering., Tata McGraw Hill Publishing Co. Ltd., New Delhi, 1994.
3. George L. Kusic, .Computer Aided Power System Analysis. Prentice Hall of India (P) Ltd., New Delhi, 1989.
4. A.J. Wood, B.F. Wollenberg, .Power Generation, Operation and Control., John Wiley & Sons, New York, 1984.
5. J. Arrilaga, C.P. Arnold, B.J. Harker, .Computer Modelling of Electric Power Systems. Wiley, New York, 1983.
6. A.K. Mahaianabis, D.P. Kothari, S.I. Ahson, .Computer Aided Power System Analysis & Control. Tata McGraw Hill, New Delhi, 1988.

PW8103 POWER BUSINESS MANGEMENT L T P C
3 0 0 3

UNIT I POWER MANAGEMENT IN INDIA 9

Growth of Power Industry in India, Organizational Structure of central and state companies and its major roles and regulations, Power scenario in India, Load management in power sector, Grid Management, Development of power projects in India vs. demand study, Management of Electricity Demand Scenario in state and overall India, Energy Management System, Energy conservation & Efficiency measures.

Case Study: Power demand study in state, Load management study in state

UNIT II ACT AND REGULATORY COMMISSIONS 9

Introduction to the Power Scenario, Overview of the Indian Electricity Act 1910, Electricity Supply Act1948, Electricity Regulatory Commissions Act 1998, Energy Conservation Act 2001, The Electricity Act 2003, State Electricity Regulatory commission(SERC),Central Electricity Regulatory commission (CERC), Tribunal, Electricity regulatory and Industry Structure in India

UNIT III TRANSMSISION AND DISTRIBUTION MANAGEMENT 9

General Concept of Power System, AC Transmission, FACTS, HVDC Transmission, Major Equipments & Accessories Power Transmission Network in the Indian Scenario,(Exchange of Energy between interconnected Systems), Electricity Grid Code, Distribution System, Commercial Operations of a Distribution Utility , Metering & Billing, Revenue Collection, Emerging Trends in Metering Technology, Available Transfer Capability losses and remedial measures.

UNIT IV TARIFF POLICY AND DETERMINATION OF TARIFF 9

Tariff policy, Tariff regulations, Tariff structure ,fixed tariff, availability based tariff, time of the day tariff, Multi Year Tariff, Assessment of tariff levels, Determination of tariff for Generation,taranismision and distribution levels, Comparison of year wise tariff/ state wise.

Case Study: Present tariff Scenario in tamilnadu and compare with other states.

UNIT V POWER PURCHASE MANAGEMENT 9

Scope of the power purchase management, Definition and interpretation of terms of a model power purchase agreement (PPA), Desirable Principles of power purchase agreements, Requirements of PPA, Risks and responsibilities in a power purchase agreement, Negotiating Power purchase agreements, PPA - Financial and legal issues, Drafting of a model PPA.

Case Study: Study and Analysis of a sample PPA between a Generation and Distribution Utility, Financial Statement Analysis of a State Power Sector Organization, Power Project Appraisal, Returns of a large Power Project etc.

TOTAL: 45 PERIODS

REFERENCES:

1. Turan Goneu, Electric Power Distribution System Engg , McGraw Hill company
2. Leon K. Kirchmayer, Economic Operation of Power Systems Publisher by Wiley Eastern Ltd.
3. Terms and Conditions of Tariff –CERC Regulations
4. Energy Pricing in India by Herry Sarkar and Gopal K. Kadekodi – Publisher - United

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National Development Program & Economic Commission for Asia & Pacific
5. Indian Electricity Act, 1910
6. Indian Electricity (Supply) Act, 1948
7. Electricity Act 2003
8. Central Regulatory Commission Act, 1998
9. Energy Conservation Act 2001
10. Governing Power by S.L . Rao, TERI Publication

PW8104 RENEWABLE ENERGY TECHNOLOGY **L T P C**
3 0 0 3

UNIT I INTRODUCTION **9**

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

UNIT II SOLAR ENERGY **9**

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

UNIT III WIND ENERGY **9**

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

UNIT IV BIO-ENERGY **9**

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

UNIT V OTHER TYPES OF ENERGY **9**

Energy conversion from Hydrogen and Fuel cells, Geo thermal energy Resources, types of wells, methods of harnessing the energy, potential in India. OTEC, Principles

utilization, setting of OTEC plants, thermodynamic cycles. Tidal and wave energy: Potential and conversion techniques, mini-hydel power plants and their economics.

TOTAL: 45 PERIODS

REFERENCES

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

MA8156 APPLIED MATHEMATICS FOR ELECTRICAL ENGINEERS L T P C
3 1 0 4

OBJECTIVES:

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

UNIT I MATRIX THEORY (9+3)

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

UNIT II CALCULUS OF VARIATIONS (9+3)

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

UNIT III ONE DIMENSIONAL RANDOM VARIABLES (9+3)

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 (9+3)

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

UNIT V FOURIER SERIES (9+3)

Fourier Trigonometric series: Periodic function as power signals – Convergence of series – Even and odd function: cosine and sine series – Non-periodic function:

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Extension to other intervals - Power signals: Exponential Fourier series – Parseval's theorem and power spectrum – Eigen value problems and orthogonal functions – Regular Sturm-Liouville systems – Generalized Fourier series.

L:45 +T: 15 TOTAL: 60 PERIODS

BOOKS FOR STUDY:

1. Richard Bronson, "Matrix Operation", Schaum's outline series, 2nd Edition, McGraw Hill, 2011.
2. Gupta, A.S., Calculus of Variations with Applications, Prentice Hall of India Pvt. Ltd., New Delhi, 1997.
3. Oliver C. Ibe, "Fundamentals of Applied Probability and Random Processes, Academic Press, (An imprint of Elsevier), 2010.
4. Taha, H.A., "Operations Research, An introduction", 10th edition, Pearson education, New Delhi, 2010.
5. Andrews L.C. and Phillips R.L., Mathematical Techniques for Engineers and Scientists, Prentice Hall of India Pvt.Ltd., New Delhi, 2005.

REFERENCES:

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

PW8111	POWER ENGINEERING LABORATORY	L T P C 0 0 3 2

LIST OF EXPERIMENTS

1. Power flow analysis by Newton Raphson method
2. Power flow analysis by Fast decoupled method
3. Distribution Load Flow Analysis
4. ATC Calculation
5. Reconfiguration of Radial Distribution Networks
6. Contingency analysis: Generator shift factors and line outage distribution factors
7. Economic dispatch using lambda iteration method
8. Unit commitment: Priority - list schemes and dynamic programming
9. Study of Characteristics Solar Power Based Energy Source

10. Study of Characteristics Wind Power Based Energy Source
11. Study of Characteristics Fuel Cell Based Energy Source

TOTAL: 45 PERIODS

PW8201 DISTRIBUTION SYSTEMS MANAGEMENT AND AUTOMATION L T P C
3 0 0 3

UNIT I INTRODUCTION 9

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

UNIT II DISTRIBUTION SYSTEM PLANNING 9

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

UNIT III DISTRIBUTION SYSTEM DESIGN 9

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

UNIT IV POWER QUALITY AND DISTRIBUTION SYSTEM PERFORMANCE ANALYSIS 9

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

UNIT V DISTRIBUTION AUTOMATION 9

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

TOTAL: 45 PERIODS

REFERENCES:

1. James Northcote – Green, Robert Wilson, “Control and Automation of Electrical Power Distribution Systems”, CRC Press, New York, 2007.
2. Turan Gonen: .Electric Power Distribution System Engineering. McGraw Hill Company. 1986
3. M.V Deshpande: .Electrical Power System Design. Tata-McGraw Hill, 1966
4. IEEE Press: IEEE Recommended practice for Electric Power Distribution for Industrial Plants, published by IEEE, Inc., 1993

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5. Pansini, Electrical Distribution Engineering, The Fairmont Press, Inc., 2007
6. Pabla H S.: .Electrical Power Distribution Systems.. Tata McGraw Hill. 2004
7. IEEE Standerd 739. Recommended Practice for Energy Conservation and Cost Effective Planning in Industrial Facilities. 1984
8. G H Heydt .Electric Power Quality. McGram Hill, 2007
9. Wilson K. Kazibwe and Musoke H Semdaula .Electric Power Quality Control Techniques.. Van Nostarand Reinhold New York, 2006

PW8202 GRID INTEGRATION OF RENEWABLE ENERGY SOURCES **L T P C**
3 0 0 3

UNIT I INTRODUCTION **9**

Introduction to renewable energy grid integration, Concept of mini/micro grids and Smart grids.

UNIT II SYNCHRONOUS GENERATOR BASED SOURCES **9**

Review of synchronous generators, Permanent Magnet Synchronous Generator, Introduction to power system stability problems: rotor angle stability, voltage stability and voltage collapse, classification of stability. Modeling of synchronous machines: DG transformations, synchronous machine representation in stability studies.

UNIT III INDUCTION GENERATOR BASED SOURCES **9**

Introduction to induction machines: electrical characteristics, slip, speed-torque characteristics etc, Self excited induction generator, Constant speed Induction generators, Variable speed Induction generators, Doubly fed Induction generators.

UNIT IV CONVERTER BASED SOURCES **9**

Introduction to power electronic devices, AC/DC converters, PWM, THD, Permanent magnet synchronous generator, solar PV systems, fuel cell, aquaelectrolizer.

UNIT V GRID INTEGRATION **9**

Overview of grid integration, Different types of grid interfaces, Issues related to grid integration of small and large scale of synchronous generator based, induction generator based and converter based sources together, Network voltage management (discusses the issue of voltage levels), Power quality management (voltage dips, harmonics, flickers and reactive power control), Frequency management, Influence of WECS on system transient response. Interconnection standards and grid code requirements for integration.

TOTAL: 45 PERIODS

REFERENCES

1. Brendan Fox et. al.: Wind Power Integration connection and system operational aspects, IET Power and Energy Series 50 (2007).
2. Marco H. Balderas (ed.): Renewable Energy Grid Integration, (Nova Science Publishers, New York, 2009).
3. Nick Jenkin, Janaka Ekavayake: Wind Energy Generation Modeling and Control (Wiley and Sons).
4. AJ Wood and BF Wollenberg: Power Generation, Operation and Control (John Wiley

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& Sons, New York, 1996).
5. Analysis of demand response and wind integration in Germany's electricity market, M. Klobasa, IET Renew. Power Gener., Vol. 4, No.1, pp. 55–63 55, 2010.
6. Impact of wind power on the power system imbalances in Finland, A. Helander1, H. Holttinen, J. Paatero, IET Renew. Power Gener., Vol. 4, No. 1, pp. 75–84, 2010.
7. Comparative analyses of seven technologies to facilitate the integration of fluctuating renewable energy sources, B.V. Mathiesen H. Lund, IET Renew. Power Gener., Vol. 3, NO. 2, pp. 190–204, 2009.
8. Advanced grid requirements for the integration of wind farms into the Spanish transmission system, Morales1, X. Robe1, M. Sala, P. Prats, C. Aguerri, E. Torres, IET Renew. Power Gener., Vol. 2, No. 1, pp. 47–59, 2008.
9. Impact of widespread photovoltaic generation on distribution systems, M. Thomson and D.G. Infield, IET Renew. Power Gener, Vol. 1, No.1, pp. 33–40, and 2007.

PW8203 SCADA SYSTEM AND APPLICATIONS MANAGEMENT L T P C
3 0 0 3

UNIT I INTRODUCTION TO SCADA 9

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

UNIT II SCADA SYSTEM COMPONENTS 9

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

UNIT III SCADA COMMUNICATION 9

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

UNIT IV SCADA MONITORING AND CONTROL 9

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

UNIT V SCADA APPLICATIONS IN POWER SYSTEM 9

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

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

TOTAL: 45 PERIODS

REFERENCES:

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

PS8255 **SMART GRIDS** **L T P C**
3 0 0 3

COURSE OBJECTIVES

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

UNIT I INTRODUCTION TO SMART GRID **9**

Evolution of Electric Grid, Concept, Definitions and Need for Smart Grid, Smart grid drivers, functions, opportunities, challenges and benefits, Difference between conventional & Smart Grid, Concept of Resilient & Self Healing Grid, Present development & International policies in Smart Grid, Diverse perspectives from experts and global Smart Grid initiatives.

UNIT II SMART GRID TECHNOLOGIES **9**

Technology Drivers, Smart energy resources,Smart substations, Substation Automation, Feeder Automation ,Transmission systems: EMS, FACTS and HVDC, Wide area monitoring, Protection and control, Distribution systems: DMS, Volt/VAr control,Fault Detection, Isolation and service restoration, Outage management,High-Efficiency Distribution Transformers, Phase Shifting Transformers, Plug in Hybrid Electric Vehicles (PHEV).

UNIT III SMART METERS AND ADVANCED METERING INFRASTRUCTURE 9

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

UNIT IV POWER QUALITY MANAGEMENT IN SMART GRID 9

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

UNIT V HIGH PERFORMANCE COMPUTING FOR SMART GRID APPLICATIONS 9

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

TOTAL : 45 PERIODS

TEXT BOOKS *:*

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

REFERENCES*:*

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

PW8211 ENERGY LABORATORY L T P C
0 0 3 2

RENEWABLE ENERGY 18

1. Performance testing of Solar Water Collector
2. Characteristics of Solar photovoltaic devices
3. Testing of Gasifier
4. Testing of biogas plant
5. Properties of Fuels
6. Solar Radiation measurement

ENERGY CONSERVATION **18**

1. Boiler efficiency testing
2. Motor and Pump efficiency testing
3. Energy consumption measurement of lighting systems
4. VFD Drives
5. Heat Exchangers
6. Refrigeration and Air conditioning systems

ADVANCED ENERGY SYSTEMS **9**

1. Fuel Cell
2. Earth Energy
3. Thermal Storage Systems

EQUIPMENTS REQUIRED

1. Solar water heater – 100 LPD
2. SPV Educational Kit
3. 20 kW_e gasifier
4. Biogas plant (fixed dome or floating drum)
5. Bomb calorimeter
6. Junker's gas calorimeter
7. Hydrometer
8. Flash and fire point apparatus
9. Proximate analyser (Muffle furnace and micro weigh balance)
10. Solar Radiation Meters
11. Non-IBR boiler
12. 5 HP motor efficiency test rig
13. Pump efficiency test rig
14. VFD coupled to a varying load device
15. Heat Exchangers (plate, pipe-in-pipe, shell and tube)
16. Vapour Compression Refrigeration Test Rig
17. Fuel cell – Educational Kit
18. PCM based energy storage system

TOTAL: 45 PERIODS

PW8001 ELECTRIC VEHICLES AND POWER MANAGEMENT L T P C
3 0 0 3

UNIT I ELECTRIC VEHICLES AND VEHICLE MECHANICS 9

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

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

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

UNIT III CONTROL OF DC AND AC DRIVES 9

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

UNIT IV BATTERY ENERGY STORAGE SYSTEM 9

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

UNIT V ALTERNATIVE ENERGY STORAGE SYSTEMS 9

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

TOTAL: 45 PERIODS

REFERENCES

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

PW8002 ELECTRICITY MARKET ANALYSIS L T P C
3 0 0 3

UNIT I INTRODUCTION TO RESTRUCTURING AND MARKET MODELS 9

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

UNIT II DEMAND AND PRICE FORECASTING 9

Short Term Load Forecasting – Application of Load forecasting – Factors affecting load forecasting – Load forecasting categories - Electricity Price Forecasting –Electricity price basics – Electricity price volatility – Categorization of price forecasting – Factors considered in price Forecasting – Electricity Price simulation module- simulation example- Price forecasting module based on ANN- ANN factors in price forecasting – Performance Evaluation of price forecasting

Price volatility – Price spike analysis – Probability distribution of Electricity price-Applications of price forecasting – Application of price forecast to make generation schedule – Application of probability Distribution of price to asset valuation and risk analysis – application of probability distribution to options valuation – Application of conditional probability distribution of price on Load to forward price forecasting

UNIT III PRICE BASED UNIT COMMITMENT 9

Introduction – PBUC formulation – System constraints- Unit constraints – PBUC solution – solution without emission or fuel constraints- solution with emission and fuel constraints – discussion and solution methodology – Energy purchase – Derivation of steps for updating multipliers – Optimality condition – Additional features of PBUC – Different prices among buses – Variable fuel price as a function of fuel consumption – Application of Lagrangian augmentation –Bidding strategy based on PBUC

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

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

UNIT IV TRANSMISSION CONGESTION MANAGEMENT AND PRICING 9

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

transmission dispatch – Calculation of transmission usage and congestion charges and FTR credits

TOTAL: 45 PERIODS

REFERENCES

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

PW8003 ENERGY ECONOMICS, FINANCING, REGULATION AND ENERGY MODELING **L T P C 3 0 0 3**

UNIT I INTRODUCTION **9**

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

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

Calculation of unit cost of power generation from different sources with examples Ground rules for investment in Energy sector, Payback period, NPV, IRR and Benefit-cost analysis with example Investment in Energy Resources: Economics of discount rate, concept of net present value, incremental costs and benefits, cash flow analysis, private and social costs Discussion on investing in energy projects, financial and economic analysis of energy technologies, short run and long run implications of conventional energy systems,

UNIT III SOCIO-ECONOMIC EVALUATION OF ENERGY CONSERVATION PROGRAMMES **9**

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

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

National energy policy in the last plan periods, Energy use and Energy supply, Overview of renewable energy policy and the Five Year Plan programmes, Basic concept of Input-Output analysis, Concept of energy multiplier and implication of energy multiplier for analysis of regional and national energy policy

Organizational structure, key developments and changes in India's energy policies and planning in the context of energy efficiency and environmental concerns, regulatory

frameworks and reforms across various energy sectors, success stories, failures and lessons learnt.

UNIT V MODELS AND ANALYSIS OF ENERGY DEMAND 9

Analysis of Environmental Pollution through decomposition of different sectors using I-O model, Interdependence of energy, economy and environment, Modeling concepts and application of SIMA model and I-O model for energy policy analysis, Simulation and forecasting of future energy demand consistent with macroeconomic parameters in India. Basic concept of Econometrics (OLS) and statistical analysis (Multiple Regression), Econometrics techniques used for energy analysis and forecasting with case studies from India

Economy-Energy-Environment Modeling Quantitative modeling frameworks, review of various energy sector models, concepts in modeling energy resources, technological developments; Energy modeling in the context of climate change

TOTAL: 45 PERIODS

REFERENCES

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

PW8004 ENERGY EFFICIENT BUILDINGS L T P C
3 0 0 3

UNIT I CLIMATE AND SHELTER 9

Historic buildings – Modern architecture – Examples from different climate zones – Thermal comfort – Solar geometry and shading – Heating and cooling loads – Energy estimates and site planning – Integrative Modeling methods and building simulation.

UNIT II PRINCIPLES OF ENERGY CONSCIOUS BUILDING DESIGN 9

Energy conservation in buildings – Day lighting – Water heating and photovoltaic systems – Advances in thermal insulation – Heat gain/loss through building components – Solar architecture.

UNIT III PASSIVE SOLAR HEATING 9

Direct gain – thermal storage wall – Sunspace – Convective air loop – Passive cooling – Ventilation - Radiation – Evaporation and Dehumidification – Mass effect – Design guidelines.

UNIT IV ENERGY CONSERVATION IN BUILDING 9

Air conditioning – HVAC equipments – Computer packages for thermal design of buildings and performance prediction – Monitoring and instrumentation of passive buildings – Control systems for energy efficient buildings – Illustrative passive buildings – Integration of emerging technologies –Intelligent building design principles.

UNIT V EFFICIENT TECHNOLOGIES IN ELECTRICAL SYSTEMS 9

Maximum demand controllers, automatic power factor controllers, energy efficient motors, and soft starters

TOTAL: 45 PERIODS

REFERENCES

1. J. A. Clarke, Energy Simulation in Building Design (2e) Butterworth 2001.
2. J. K. Nayak and J. A. Prajapati Hadbook on Energy Consious Buildings, Solar Energy control MNES,2006.
3. Energy conservation Building Codes 2006; Bereau of Energy Efficiency.
4. J. R. Williams, Passive Solar Heating, Ann Arbar Science, 1983.
5. R. W. Jones, J. D. Balcomb, C. E. Kosiewiez, G. S. Lazarus, R. D. McFarland and W. O. Wray,Passive Solar Design Handbook, Vol. 3, Report of U. S. Department of Energy (DOE/CS-0127/3),1982.
6. M. S. Sodha, N. K,. Bansal, P. K. Bansal, A. Kumar and M. A. S. Malik. Solar Passive Building,Science and Design, Pergamon Press, 1986.
7. J. L. Threlkeld, Thermal Environmental Engineering, Prentice Hall, 1970.

PW8005 ENERGY SYSTEMS MODELING AND ANALYSIS

L	T	P	C
3	0	0	3

AIM:

To provide a comprehensive and rigorous introduction to energy system design and optimization from a contemporary perspective.

OBJECTIVES:

- To learn to apply mass and energy balances for the systems enable to perform enthalpy
- Learn to calculate to size performance and cost of energy equipments turns modeling and simulation techniques.
- Learn to optimize the energy system for its maximum or minimum performance output.

UNIT I INTRODUCTION **9**

Primary energy analysis - dead states and energy components - energy balance for closed and control volume systems - applications of energy analysis for selected energy system design - modeling overview - levels and steps in model development - examples of models – curve fitting and regression analysis.

UNIT II MODELLING AND SYSTEMS SIMULATION **9**

Modeling of energy systems – heat exchanger - solar collectors – distillation -rectification turbo machinery components - refrigeration systems - information flow diagram - solution of set of non- linear algebraic equations - successive substitution - Newton Raphson method- examples of energy systems simulation**.**

UNIT III OPTIMISATION TECHNIQUES **9**

Objectives - constraints, problem formulation - unconstrained problems - necessary and sufficiency conditions.Constrained optimization - lagrange multipliers, constrained variations, Linear Programming - Simplex tableau, pivoting, sensitivity analysis.

UNIT IV ENERGY- ECONOMY MODELS **9**

Multiplier Analysis - Energy and Environmental Input / Output Analysis - Energy Aggregation –Econometric Energy Demand Modeling - Overview of Econometric Methods - Dynamic programming - Search Techniques - Univariate / Multivariate.

UNIT V APPLICATIONS AND CASE STUDIES **9**

Case studies of optimization in Energy systems problems- Dealing with uncertainty-probabilistic techniques – Trade-offs between capital and energy using Pinch analysis.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Stoecker, W.F., Design of Thermal Systems, McGraw Hill, 1989.
2. Bejan, A, Tsatsaronis, G and Moran, M., Thermal Design and Optimization, John Wiley & Sons 1996.

REFERENCES:

1. Rao, S.S., Engineering Optimization - Theory and Applications, Wiley Eastern, 2000.

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Anna University, Chennai-600 025.

2. Meier, P., Energy Systems Analysis for Developing Countries, Springer Verlag, 1984.
3. Beveridge and Schechter, Optimization Theory and Practice, McGraw Hill, 1970.
4. Jaluria, S., Design and Optimization of Thermal Systems, McGrawHill, 1997.

PW8006 GOVERNANCE AND MANAGEMENT OF NATURAL RESOURCES

L	T	P	C
3	0	0	3

UNIT I INTRODUCTION **9**

Legal and political environments in resource management - Global and local governance, challenges of good governance - Ostrom design principles and basic frameworks - organizational structure and stakeholders in NRM and livelihood - Natural Resource Governance in rapidly changing world

UNIT II INTERNATIONAL AND NATIONAL EFFORTS **9**

CITES and other international treaties and conventions, roles of international organizations and NGOS with special reference to UN and specialized agencies, institutional regulatory bodies and authorities: direct intervention by the state, green business and green ethics, stakeholder analysis, understanding and managing governance issue - governance tactics and tools - CSR (Corporate Social Responsibility) as a tool for sustainable NRM based business - Case studies about corporate social responsibility - Corporate social responsibility (CSR), NRM based CSR action - E-governance, Climate change and corporate responses

UNIT III IMPORTANCE OF THE ENVIRONMENT AND NATURAL RESOURCES **9**

A brief account of natural resources and their utilization and conservation in India - Sustaining the Environment -Resource Conservation -Population Demands. International and National Policy instruments - Principles of integrated Natural Resource Management.

UNIT IV ENERGY RESOURCES **9**

Renewable and Non renewable sources of energy and their management- Fossil fuel management - coal, oil and petroleum, oil shale, natural gas. Wind Energy- prospects and limitations. Solar energy – applications for rural and urban energy subsidy. Wave, Tidal, Geothermal energy - –biodiesel production and its importance Bio-energy – wood, fuels from crops-Ethanol-Production.

UNIT V ECONOMICS OF NATURAL RESOURCES **9**

Systems approach in natural capital management - Fundamentals of renewable and non-renewable resource economics. Valuation of natural resources - Environmental accounting, Ecological footprints, Bioprospecting for genetic resources - Principles of

handling risk, uncertainty, and sensitivity. Decision making under uncertainty and option value. Understanding the Stakeholders approach- Subsistence groups- Governments- Academic institutions- Conflicts and competing uses

TOTAL: 45 PERIODS

REFERENCES

1. Natural Resource Management: Need for 21st Century/Sunit Gupta and Mukta Gupta. 1998, Community-Based Natural Resource Management: Issues and Cases from South Asia by Ajit Menon, Praveen Singh, Esha Shah, Sharachchandra Lélé, Suhas Paranjape and K.J.Joy, SAGE, 2007
2. Natural Resources Management Practices: A Primer. by Peter F. F Folliott, Luis A. Bojorquez- Topia, Mariano Hernandez-Narvaez, 2001, Iowa State University Press Remote Sensing And Gis For Natural Resource Management, Bir Abhimanyu Kumar, Academic Excellence Publishers, 2007.
3. Bhattacharya P., Kandya A.K. and Krishna Kumar 2008. Joint Forest management in india, aavishkar publisher, jaipur.
4. Daily, Gretchen, editor, et al. 1997. Nature's services: societal dependence on natural ecosystems. Island press.
5. Kareiva, peter, et al. 2011. Natural capital: theory and practice of mapping ecosystemservices. Oxford.
6. Kareiva, peter, and Michelle marview. 2010. Conservation science: balancing the needs of people and nature. roberts and company
7. Knight, Richard l., editor, et al. 1995. A new century for natural resources management. Island press.
8. Heal, Geoffrey. 2000. Nature and the marketplace: capturing the value of ecosystem services. Island press.

PW8007 INTEGRATED ENERGY SYSTEMS LT P C
3 0 0 3

UNIT I ENERGY CONSUMPTION PATTERN 9

Projection of energy demands – Possible substitution of conventional sources –Modern technological options – Introduction to hybrid and integrated energy systems – Total energy concept and waste heat utilization.

UNIT II MODELING OF INTEGRATED ENERGY SYSTEMS 9

Load matching and scheduling – Various possibilities to build hybrid systems – Problems associated with integrated energy systems – Performance analysis.

UNIT III OPTIMAL DESIGN OF HYBRID ENERGY SYSTEMS 9

Special optimization techniques applicable – Energy economics and cost optimization of integrated energy systems – Sample problems and case studies.

UNIT IV INTEGRATION OF VARIOUS POWER GENERATION SYSTEMS 9

Feasibility studies – Site selection – Related social, economic and technical problems – Special role of wind and biogas systems – Future prospects and case studies.

UNIT V SYSTEM ASPECTS OF INTEGRATION 9

Voltage effects, thermal effects, fault level. Islanding - Stand Alone Systems: Network voltage and system efficiency, Energy storage methods, Lead-Acid Batteries, Battery charger, case studies of stand alone system.- Hybrid Energy Systems and its economic evaluation - Mathematical modeling of Integrated Energy Systems - Technological aspects of power electronic systems connection to the grid

TOTAL: 45 PERIODS

REFERENCES

1. P. R. Shukla, T. K. Moulik, S. Modak and P. Deo; Strategic Management of Energy Conservation,Oxford & IBM Publishing Co., 1993.
2. W. R. Murthy and G. McKay; Energy Management, Butherworth Heinemann, 2001.
3. S. S. Rao; Textbook on Engineering Optimization – Theory and Practice, 3rd Edition, J. Wiley, 1996.
4. R. D. Begamudre: Energy Conversion Systems, New Age Int. Pub., 2000.
5. D. Merick and R. Marshall; Energy, Present and Future Options, Vol. I & Vol. II, J. Wiley, 1981.

PW8008 SUSTAINABLE ENERGY UTILZATION L T P C
3 0 0 3

UNIT I HEAT FLOW CALCULATIONS IN BUILDINGS 9

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

UNIT II NEED OF ENERGY IN BUILDINGS 9

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

UNIT III PASSIVE COOLING / HEATING CONCEPTS 9

Building form and orientation, internal and external shading devices, ventilation, passive concepts for composite climates, evaporative and nocturnal cooling, earth–air tunnel, sky-therm system, and solar chimney-based hybrid system.

Introduction and use of different building simulation software such as TRNSYS, ECOTECT etc.- Case studies of non-air conditioned buildings- Case studies of air conditioned buildings

UNIT IV ENERGY EFFICIENT BUILDINGS 9

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

UNIT V ELECTRICAL ENERY CONVERSION 9

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

TOTAL: 45 PERIODS

REFERENCES

1. Koenigsberger, et.al Manual of Tropical housing and Building Longman Group Ltd London (now published by Orient Longman Ltd, Madras, India),1974
2. Oliver and Daniel, D Chiras Natural Resource Conservation Management for a sustainable future, Prentice Hall International Ltd, London, 1992
3. USAID International resource book, Energy Conservation Building design Tip Sheet - Building Lighting Design,
4. MS Sodha, NK Bansal, PK Bansal, A Kumar and MAS Malik, Solar Passive Building, Science and Design, Pergamon Press, 1986
5. JR Williams, Passive Solar Heating, Ann Arbar Science, 1983
6. RWJones, JD Balcomb, CE Kosiewiez, GS Lazarus, RD McFarland and WOWray, Passive Solar Design Handbook, Vol 3, Report of US Department of Energy (DOE/CS-0127/3), 1982
7. J Krieder and A Rabi, Heating and Cooling of Buildings: Design for Efficiency, McGraw-Hill, 1994
8. RD Brown, TJ Gillespie, Microclimatic Landscape Design, John Wiley and Sons, New York, 1990
9. TA Markus, EN Morris, Building, Climate and Energy, Spottwoode Ballantype Ltd, London, 1980

PW8009 URBAN AND RURAL ENERGY MANAGEMENT L T P C
3 0 0 3

UNIT I INDIAN ENERGY SCENE 9

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

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UNIT II URBAN ENVIRONMENT AND GREEN BUILDINGS 9

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

UNIT III URBAN ELECTRIC VEHICLE CHARGING STATIONS 9

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

UNIT IV THE RURAL ENERGY SITUATION 9

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

UNIT V OPTION FOR RURAL ELECTRIFICATION 9

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

TOTAL: 45 PERIODS

REFERENCES

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

ET8072 **MEMS TECHNOLOGY** **L T P C**
3 0 0 3

Pre-requisites: Basic Instrumentation ,Material Science,Programming

COURSE OBJECTIVES

- To teach the students properties of materials ,microstructure and fabrication methods.
- To teach the design and modeling of Electrostatic sensors and actuators.
- To teach the characterizing thermal sensors and actuators through design and modeling
- To teach the fundamentals of piezoelectric sensors and actuators
- To give exposure to different MEMS and NEMS devices.

UNIT I MEMS:MICRO-FABRICATION, MATERIALS AND ELECTRO-MECHANICAL CONCEPTS **9**

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

UNIT II ELECTROSTATIC SENSORS AND ACTUATION **9**

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

UNIT III THERMAL SENSING AND ACTUATION **9**

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

UNIT IV PIEZOELECTRIC SENSING AND ACTUATION **9**

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

UNIT V CASE STUDIES **9**

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

TOTAL : 45 PERIODS

REFERENCES

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

PE8073 POWER QUALITY LT P C
3 0 0 3

OBJECTIVES :

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

UNIT I INTRODUCTION 9

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

UNIT II ANALYSIS OF SINGLE PHASE AND THREE PHASE SYSTEM 9

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

UNIT III CONVENTIONAL LOAD COMPENSATION METHODS 9

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

UNIT IV LOAD COMPENSATION USING DSTATCOM 9

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

UNIT V SERIES COMPENSATION OF POWER DISTRIBUTION SYSTEM 9

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

TOTAL : 45 PERIODS

TEXT BOOKS

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

PE8152 ANALYSIS OF ELECTRICAL MACHINES LT P C
3 0 0 3

OBJECTIVES:

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

UNITI PRINCIPLES OF ELECTROMAGNETIC ENERGY CONVERSION 9

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

UNIT II DC MACHINES 9

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

UNIT III REFERENCE FRAME THEORY 9

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

UNIT IV INDUCTION MACHINES 9

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

UNIT V SYNCHRONOUS MACHINES 9

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

TOTAL : 45 PERIODS

TEXT BOOKS

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

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

HV8073 DESIGN OF SUBSTATIONS L T P C
3 0 0 3

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

UNIT I INTRODUCTION TO AIS AND GIS 9
Introduction – characteristics – comparison of Air Insulated Substation (AIS) and Gas Insulated Substation (GIS) – main features of substations, Environmental considerations, Planning and installation.

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.

UNIT III INSULATION COORDINATION OF AIS AND GIS 9
Introduction – stress at the equipment – insulation strength and its selection – standard BILs – Application of simplified method – Comparison with IEEE and IEC guides.

UNIT IV GROUNDING AND SHIELDING 9
Definitions – soil resistivity measurement – ground fault currents – ground conductor – design of substation grounding system – shielding of substations – Shielding by wires and masts.

UNIT V FAST TRANSIENTS PHENOMENON IN AIS AND GIS 9
Introduction – Disconnector switching in relation to very fast transients – origin of VFTO – propagation and mechanism of VFTO – VFTO characteristics – Effects of VFTO.

TOTAL : 45 PERIODS

REFERENCES
1. Andrew R. Hileman, "Insulation coordination for power systems", Taylor and Francis, 1999.
2. M.S. Naidu, "Gas Insulation Substations", I.K. International Publishing House Private Limited, 2008.
3. Klaus Ragallar, "Surges in high voltage networks" Plenum Press,New York, 1980. "Power Engineer's handbook", TNEB Association.

4. Pritindra Chowdhuri, “Electromagnetic transients in power systems”, PHI Learning Private Limited, New Delhi, Second edition, 2004.
5. “Design guide for rural substation”, United States Department of Agriculture, RUS Bulletin, 1724E-300, June 2001.

PS8072 DISTRIBUTED GENERATION AND MICRO GRID L T P C
3 0 0 3

OBJECTIVES

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

UNIT I INTRODUCTION 9

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

UNIT II DISTRIBUTED GENERATIONS (DG) 9

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

UNIT III IMPACT OF GRID INTEGRATION 9

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

UNIT IV BASICS OF A MICROGRID 9

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

UNIT V CONTROL AND OPERATION OF MICROGRID 9

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

TOTAL : 45 PERIODS

REFERENCES

1. “Voltage Source Converters in Power Systems: Modeling, Control and Applications”, Amirnaser Yezdani, and Reza Iravani, IEEE John Wiley Publications.

Attested

DIRECTOR
Centre For Academic Courses
Anna University, Chennai-600 025.

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

PS8073 ENERGY MANAGEMENT AND AUDITING L T P C
3 0 0 3

COURSE OBJECTIVES

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

UNIT I INTRODUCTION 9

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

UNIT II ENERGY COST AND LOAD MANAGEMENT 9

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

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

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

UNIT IV METERING FOR ENERGY MANAGEMENT 9

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

UNIT V LIGHTING SYSTEMS & COGENERATION 9

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

Attested

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Anna University, Chennai-600 025.

Cogeneration: Forms of cogeneration - feasibility of cogeneration- Electrical interconnection.

TEXT BOOKS

1. Barney L. Capehart, Wayne C. Turner, and William J. Kennedy, Guide to Energy Management, Fifth Edition, The Fairmont Press, Inc., 2006
2. Eastop T.D & Croft D.R, Energy Efficiency for Engineers and Technologists,. Logman Scientific & Technical, ISBN-0-582-03184, 1990.

REFERENCES

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

PS8075 OPTIMISATION TECHNIQUES L T P C
3 0 0 3

COURSE OBJECTIVES

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

UNIT I INTRODUCTION 9

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

UNIT II LINEAR PROGRAMMING (LP) 9

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

UNIT III NON LINEAR PROGRAMMING 9

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

UNIT IV DYNAMIC PROGRAMMING (DP) 9

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

UNIT V GENETIC ALGORITHM 9

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

Attested

DIRECTOR
Centre For Academic Courses
Anna University, Chennai-600 025.

TOTAL : 45 PERIODS

TEXT BOOKS:

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

REFERENCE BOOKS:

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

PS8253 FLEXIBLE AC TRANSMISSION SYSTEMS LT P C
3 0 0 3

COURSE OBJECTIVES

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

UNIT I INTRODUCTION 9

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

UNIT II STATIC VAR COMPENSATOR (SVC) 9

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

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

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

UNIT IV VOLTAGE SOURCE CONVERTER BASED FACTS CONTROLLERS 9

Static synchronous compensator(STATCOM)- Static synchronous series compensator(SSSC)- Operation of STATCOM and SSSC-Power flow control with

STATCOM and SSSC- Modelling of STATCOM and SSSC for power flow and transient stability studies –operation of Unified and Interline power flow controllers(UPFC and IPFC)- Modelling of UPFC and IPFC for load flow and transient stability studies-Applications.

UNIT V CONTROLLERS AND THEIR COORDINATION 9

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

TOTAL : 45 PERIODS

TEXT BOOKS

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

REFERENCES:

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

PS8077 WIND ENERGY CONVERSION SYSTEM L T P C
3 0 0 3

COURSE OBJECTIVES

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

UNIT I INTRODUCTION 9

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

UNIT II WIND TURBINES 9

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

UNIT III FIXED SPEED SYSTEMS 9

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

UNIT IV VARIABLE SPEED SYSTEMS 9

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

TEXT BOOKS

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

REFERENCES

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

PS8074 HIGH VOLTAGE DIRECT CURRENT TRANSMISSION L T P C
3 0 0 3

COURSE OBJECTIVES

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

UNIT I DC POWER TRANSMISSION TECHNOLOGY 6

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

UNIT II ANALYSIS OF HVDC CONVERTERS AND HVDC SYSTEM CONTROL **12**

Pulse number, choice of converter configuration – Simplified analysis of Graetz circuit - Converter bridge characteristics – characteristics of a twelve pulse converter- detailed analysis of converters.

General principles of DC link control – Converter control characteristics – System control hierarchy - Firing angle control – Current and extinction angle control – Generation of harmonics and filtering - power control – Higher level controllers.

UNIT III MULTITERMINAL DC SYSTEMS **9**

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

UNIT IV POWER FLOW ANALYSIS IN AC/DC SYSTEMS **9**

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

UNIT V SIMULATION OF HVDC SYSTEMS **9**

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

TOTAL: 45 PERIODS

TEXT BOOKS

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

REFERENCES

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

PE8351 POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS LT P C
3 0 0 3

OBJECTIVES :

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

UNIT I INTRODUCTION 9

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

UNIT II ELECTRICAL MACHINES FOR RENEWABLE ENERGY CONVERSION 9

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

UNIT III POWER CONVERTERS 9

Solar: Block diagram of solar photo voltaic system : line commutated converters (inversion-mode) - Boost and buck-boost converters- selection Of inverter, battery sizing, array sizing.

Wind: three phase AC voltage controllers- AC-DC-AC converters: uncontrolled rectifiers, PWM Inverters, Grid Interactive Inverters-matrix converters.

UNIT IV ANALYSIS OF WIND AND PV SYSTEMS 9

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

UNIT V HYBRID RENEWABLE ENERGY SYSTEMS 9

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

TOTAL : 45 PERIODS

TEXT BOOK

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

REFERENCES:

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

CO8002 CONTROL OF ELECTRICAL DRIVES L T P C
3 0 0 3

COURSE OBJECTIVES

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

UNIT I POWER ELECTRONIC CONVERTERS FOR DRIVES 9

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

UNIT II CONTROL OF DC DRIVES 9

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

UNIT III ANALYSIS AND MODELLING OF INDUCTION MOTOR DRIVE 9

Basics of induction motor drive-classification – equivalent circuit- torque Vs slip characteristics-steady state performance- Dynamic modeling of induction motor, Three phase to two phase transformation-stator, rotor, synchronously rotating reference frame model

UNIT IV CONTROL OF INDUCTION MOTOR DRIVE 9

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

UNIT V EMBEDDED CONTROL OF DRIVES 9

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

TOTAL : 45 PERIODS

REFERENCES

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