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M.E. –Power System Engineering

I to IV Semester Curriculum and Syllabus

R-2017

M.E. – POWER SYSTEM ENGINEERING

SEMESTER I										
Sl. No.	**Course Code**	**Course Title**	**Category**	**L**	**T**	**P**	**C**	**CA**	**FE**	**Total**
1	PICM002	Applied Mathematics for Electrical Engineers	IIC	3	1	0	4	40	60	100
2	PPSC001	Advanced Power System Analysis	PC	3	0	1	4	40	60	100
3	PPSC002	Power System Control	PC	3	0	0	3	40	60	100
4	PPSC003	Analysis of Electrical Machines	PC	3	0	0	3	40	60	100
5	PPSC004	System Theory	PC	3	0	0	3	40	60	100
6	xxxxxxx	Professional Elective I	PE	3	0	0	3	40	60	100
7	PPSO001	Technical Seminar	TS	0	0	1	1	40	60	100
			Total	**18**	1	2	**21**			

SEMESTER II										
Sl. No.	**Course Code**	**Course Title**	**Category**	**L**	**T**	**P**	**C**	**CA**	**FE**	**Total**
1	PPSC005	Power System Dynamics	PC	3	0	0	3	40	60	100
2	PPSC006	Modelling of FACTS controllers	PC	3	0	0	3	40	60	100
3	PPSC007	Digital Power System Protection	PC	3	0	0	3	40	60	100
4	PPSC008	Power System deregulation and pricing	PC	3	0	0	3	40	60	100
5	xxxxxxx	Professional Elective II	PE	3	0	0	3	40	60	100
6	xxxxxxx	Professional Elective III	PE	3	0	0	3	40	60	100
7	PPSC009	Advanced Power System Simulation Laboratory	PC	0	0	2	2	40	60	100
8	PPSC010	Industrial Internship Training	IIT	0	0	1	1			
			Total	**18**	**0**	**3**	**21**			

SEMESTER III										
Sl. No.	**Course Code**	**Course Title**	**Category**	**L**	**T**	**P**	**C**	**CA**	**FE**	**Total**
1	xxxxxxx	Generic Elective I	GE	3	0	0	3	40	60	100
2	xxxxxxx	Professional Elective IV	PE	3	0	0	3	40	60	100
3	xxxxxxx	Professional Elective V	PE	3	0	0	3	40	60	100
4	PPSC301	Project work (Phase I)	FYP	0	0	6	6	60	40	100
			Total	**9**	**0**	**6**	**15**			

SEMESTER IV										
Sl. No.	**Course Code**	**Course Title**	**Category**	**L**	**T**	**P**	**C**	**CA**	**FE**	**Total**
1	PPSC401	Project work (Phase II)	FYP	0	0	12	12	60	40	100
			Total	**0**	**0**	**12**	**12**			

PROFESSIONAL ELECTIVE

Sl. No.	Course Code	Course Title	Category	L	T	P	C	CA	FE	Total
1	PPSE001	Power System Instrumentation	PE	3	0	0	3	40	60	100
2	PPSE002	Energy and Environment	PE	3	0	0	3	40	60	100
3	PPSE003	Power System Planning and Reliability	PE	3	0	0	3	40	60	100
4	PPSE004	Power quality issues and its mitigation methods	PE	3	0	0	3	40	60	100
5	PPSE005	Microcontroller based System design	PE	3	0	0	3	40	60	100
6	PPSE006	Transient over voltages in Power Systems	PE	3	0	0	3	40	60	100
7	PPSE007	Energy Management and Auditing	PE	3	0	0	3	40	60	100
8	PPSE008	Analysis and Design of Inverters	PE	3	0	0	3	40	60	100
9	PPSE009	Distributed Generation and Microgrid	PE	3	0	0	3	40	60	100
10	PPSE010	Solar and Energy Storage Systems	PE	3	0	0	3	40	60	100
11	PPSE011	Industrial Power System Analysis and Design	PE	3	0	0	3	40	60	100
12	PPSE012	Wind Energy Conversion Systems	PE	3	0	0	3	40	60	100
13	PPSE013	Smart Grid	PE	3	0	0	3	40	60	100
14	PPSE014	Bio-energy and Conversion systems	PE	3	0	0	3	40	60	100
15	PPSE015	Digital Control of Power Electronics	PE	3	0	0	3	40	60	100
16	PPSE016	SCADA Systems and Application Management	PE	3	0	0	3	40	60	100
17	PPSE017	System Identification and Adaptive Control	PE	3	0	0	3	40	60	100
18	PPSE018	Robust Control	PE	3	0	0	3	40	60	100
19	PPSE019	Power Electronics in HVDC	PE	3	0	0	3	40	60	100
20	PPSE020	Design of Substations	PE	3	0	0	3	40	60	100

GENERIC ELECTIVE

Sl. No.	Course Code	Course Title	Category	L	T	P	C	CA	FE	Total
1	PPSG001	Advanced soft computing techniques	GE	3	0	0	3	40	60	100
2	PPSG002	Advanced digital signal processing	GE	3	0	0	3	40	60	100
3	PPSG004	Optimization Techniques	GE	3	0	0	3	40	60	100

SEMESTER I

PICM002	APPLIED MATHEMATICS FOR ELECTRICAL ENGINEERS	L	T	P	C
		3	1	0	4

Course Objectives

- Able to introduce the concepts of Linear and Non-Linear Programming and Matrix Theory for formulating complex mathematical models in management science, industrial engineering and transportation science.
- Able to use calculus of variations to find the extremal of a functional.
- Able to find numerical solution of non-linear equations in a single variable.

Course Content

Advanced Matrix Theory

Matrix Norms – Jordan Canonical Form – Generalized Eigenvectors – Singular Value Decomposition – Pseudo Inverse – Least Square Approximation – QR Algorithm.

Calculus of Variation

Functional – Euler's equation – Variational problems involving one unknown function – Several unknown functions – Functional dependent on higher order derivatives – Several independent variables – Isoperimetric problems.

Linear Programming

Simplex algorithm – Two phase and Big-M method – Duality theory – Dual simplex method – Transportation and Assignment problems.

Non-Linear Programming

Formulation of non-linear programming problem – Constrained optimization with Equality constraints – Constrained optimization with inequality constraints – Kuhn-Tucker conditions with non-negative constraints.

Single Variable Optimization

Optimality criteria – Bisection method – Secant method – Newton Raphson method – Horner's method – Fibonacci search method – Golden section search method – Graeffe's Root Squaring method.

References

1. A.Ravindran, Don T. Phillips, James J. Solberg, "Operations Research Principle and Practice", 2nd Edition, John Wiley and Sons (ASIA) Pvt. Ltd, 2014.
2. Taha, H.A., "Operations Research, An introduction", 10th edition, Pearson education, New Delhi, 2016.
3. A.S.Gupta, "Calculus of Variations with Applications", 12th Edition, PHI Learning Pvt. Ltd., 2015.
4. Richard Bronson, "Matrix Operation", Schaum's outline series, 2nd Edition, McGraw Hill, 2011.
5. Grewal, B.S., Higher Engineering Mathematics, 43rd edition, Khanna Publishers, 2012.
6. Richard Bronson, Gabriel B.Costa, "Linear Algebra", 6th Edition, Academic Press Publications 2011.

PPSC001	ADVANCED POWER SYSTEM ANALYSIS	L	T	P	C
		3	0	1	4

Course Objectives

- To Introduce various sparse matrix techniques for solving large scale power systems.
- To expose different methods of power flow analysis and obtain optimal power flow solution.
- To present about short circuit analysis and illustrate different numerical integration methods for stability analysis.
- To solve different power system problems and familiar various power system studies.

Course Content

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; Solution using Left and Right factors and L and U matrices.

Review of Newton Raphson and Fast Decoupled methods for Power Flow solution; Sensitivity factors for P-V bus adjustment. 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.

Symmetrical and unsymmetrical faults; Computer method for fault analysis using Z_{BUS} and sequence components. Solution of bus voltages, fault current and line currents. Power system stability, 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.

List of Experiments:

1. Power flow analysis by Newton-Raphson method with Large Sparse Jacobian Matrix.
2. Contingency analysis: Generator shift factors and line outage distribution factors.
3. Economic dispatch using lambda-iteration method.
4. Unit commitment: Priority-list schemes and dynamic programming.
5. Transient stability analysis of single machine-infinite bus system using classical machine model.

References

1. Allen J. Wood, Bruce F. Wollenberg, Gerald B. Shebl, “Power Generation, Operation and Control”, Third Edition, John Wiley & Sons, 2013.
2. TuranGonen, “Modern Power System Analysis”, Second Edition, CRC Press, 2013.
3. G W Stagg, A.H El. Abiad “Computer Methods in Power System Analysis”, McGraw Hill, 1983.
4. Xi-Fan Wang, Yonghua Song, Malcolm Irving, “Modern Power Systems Analysis”, Springer Science & Business Media, 2010.
5. Shreevardhan ArunchandraSoman, S.A. Khaparde, Shubha Pandit, “Computational Methods for Large Sparse Power Systems Analysis”, Springer Science & Business Media, 2012.

PPSC002	POWER SYSTEM CONTROL	L	T	P	C
		3	0	0	3

Course Objectives

- To familiarize students with various power system operations with different power plants.
- To understand the control techniques applied to power system for the normal operating condition.

Course Content

System load variation, Reserve requirements, Fundamentals of speed governing mechanism and modeling, Speed-load characteristics, Load sharing between two synchronous machines in parallel, concept of control area, LFC control of a single area system and two area system, Static and dynamic analysis of uncontrolled and controlled cases, Economic Dispatch Control, state variable model.

Hydrothermal scheduling problem, short term and long term mathematical model, algorithm. Dynamic programming solution methodology, optimization with pumped hydro plant, scheduling of systems with pumped hydro plant during off-peak seasons, Selection of initial feasible trajectory for pumped hydro plant, Pumped hydro plant as spinning reserve unit, Load management plant.

Statement of Unit Commitment (UC) problem, constraints in UC, solution methods: Priority-list methods, forward dynamic programming approach. Economic dispatch, solution by direct method and λ iteration method. Base point and participation factors, Economic dispatch controller added to LFC control. Load forecasting, techniques of forecasting, Energy control Centre, System hardware configuration, SCADA and EMS functions, state estimation, security analysis and control. Various operating states.

References

1. Olle. I. Elgerd, "Electric Energy Systems Theory – An Introduction, Tata McGraw Hill Publishing Company Ltd, New Delhi, Second Edition, 2003.
2. D.P. Kothari and I.J. Nagrath, Modern Power System Analysis, Third Edition, Tata McGraw Hill Publishing Company Limited, New Delhi, 2003.
3. L.L. Grigsby, "The Electric Power Engineering, Hand Book, CRC Press & IEEE Press, 2001.
4. Allen.J.Wood and Bruce F.Wollenberg, "Power Generation, Operation and Control", John Wiley & Sons, Inc., 2003.
5. P. Kundur, "Power System Stability & Control", McGraw Hill Publications, USA, 2007.

PPSC003	ANALYSIS OF ELECTRICAL MACHINES	L	T	P	C
		3	0	0	3

Course Objectives

To study the analysis and mathematical modelling of the AC and DC machines and to digitally simulate the models

Course Content

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.

Elementary DC machine and analysis of steady state operation - Voltage and torque equations, dynamic characteristics of permanent magnet and shunt DC motors, Time domain block diagrams - solution of dynamic characteristic by Laplace transformation, digital computer simulation of permanent magnet and shunt DC machines. Historical background, phase transformation and commutator transformation, transformation of variables from stationary to arbitrary reference frame, variables observed from several frames of reference.

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 variable, analysis of dynamic performance for load torque variations, digital computer simulation. Three phase synchronous machine and analysis of steady state operation voltage and torque equations in machine variables and rotor reference frame variables (Parks equations), analysis of dynamic performance for load torque variations, digital computer simulation.

References

1. Paul C.Krause, Oleg Wasyzczuk, Scott S, Sudhoff, "Analysis of Electric Machinery and Drive Systems", John Wiley, Second Edition, 2010.
2. P S Bimbhra, "Generalized Theory of Electrical Machines", Khanna Publishers, 2008.
3. A.E, Fitzgerald, Charles Kingsley, Jr, and Stephan D, Umanx, " Electric Machinery", Tata McGraw Hill, 5th Edition, 1992.
4. Ramakrishna, "Electric Motor drives: modelling, analyses and control", Prentice Hall, 2001.
5. B Gupta, "theory and performance of electrical machines", S.K. kataria& sons, 2009.Engineering", Dhanpat Rai & Sons., NewDelhi, 2008.

PPSC004	SYSTEM THEORY	L	T	P	C
		3	0	0	3

Course objectives

- To study the various advanced computational techniques to analyze the stability of linear and non-linear Control systems
- To expose the design methodology of controller for SISO and MIMO systems.

Course Content

Introduction- Concept of State, State equation for Dynamic Systems, Time invariance and linearity, Non uniqueness of state model, State Diagrams, Physical System and State Assignment. Existence and uniqueness of solutions to Continuous, time state equations, Solution of Nonlinear and Linear Time Varying State equations, Evaluation of matrix exponential, System modes-, Role of Eigen values and Eigenvectors.

Controllability and Observability, Stabilizability and Detectability, Test for Continuous time Systems, Time varying and Time invariant case, Output Controllability, Reducibility, System Realizations. Introduction, Equilibrium Points, Stability in the sense of Lyapunov, BIBO Stability-Stability of LTI Systems.

Time Autonomous Systems, Lyapunov Functions for Linear and Nonlinear Continuous Time Autonomous Systems, Krasovskii and Variable Gradient Method. SISO and MIMO Systems, effect of State Feedback on Controllability and Observability, Pole Placement by State Feedback for SISO and MIMO Systems, Full Order and Reduced Order Observers.

References

1. M. Gopal, “Modern Control System Theory”, New Age International, 2005.
2. K. Ogatta, “Modern Control Engineering”, PHI, 2002.
3. D. Roy Choudhury, “Modern Control Systems”, New Age International, 2005.
4. John J. DAzzo, C. H. Houpis and S. N. Sheldon, “Linear Control System Analysis and Design with MATLAB”, Taylor Francis, 2003.
5. Z. Bubnicki,”Modern Control Theory”, Springer, 2005.

SEMESTER II

PPSC005	POWER SYSTEM DYNAMICS	L	T	P	C
		3	0	0	3

Course Objectives

- To understand theoretical modeling concepts of various power system components
- To expose the stability analysis for both steady state and dynamic state of power system

Course Content

Schematic Diagram, Physical Description, Mathematical Description of a Synchronous Machine, dq0 Transformation, Per Unit Representations: L_{ad}-reciprocal per unit system and that from power-invariant form of Park's transformation; Equivalent circuits for direct and quadrature axes, Steady-state Analysis, Equations of Motion, Synchronous Machine Representation in Stability Studies, two-axis model with amortisseur windings neglected, classical model. Elements of an Excitation System, IEEE (1992) block diagram for simulation of excitation systems.

Turbine and Governing System Modeling of a hydroelectric plant, Steam turbine modeling, Fundamental Concepts of Stability of Dynamic Systems, Single-Machine Infinite Bus (SMIB) Configuration, Dynamics: synchronous machine, network and linearised system equations, block diagram representation with K-constants; expression for K-constants (no derivation), effect of field flux variation on system stability: analysis with numerical example.

Effects Of Excitation System, Multi-Machine Configuration: Equations in a common reference frame, equations in individual machine rotor coordinates, illustration of formation of system state matrix for a two machine system with classical models for synchronous machines Power System Stabilizer, Stabilizer based on shaft speed s-P Omega stabilizer, Frequency based stabilizers, Digital Stabilizer, Excitation control design, Exciter gain, Phase lead compensation, Stabilizing signal washout stabilizer gain, Stabilizer limits.

References

1. P. W. Sauer and M. A. Pai, "Power System Dynamics and Stability", Stipes Publishing Co, 2007
2. P.M Anderson and A.A Fouad, "Power System Control and Stability", Iowa State University Press, Ames, Iowa, 1978.
3. R.Ramunujam," Power System Dynamics Analysis and Simulation, PHI Learning Private Limited, New Delhi, 2009
4. Padiyar K.R., "Power System Dynamics, Stability & Control", 2nd Edition,B.S. Publications, Hyderabad, 2008.
5. P. Kundur, "Power System Stability & Control", McGraw Hill Publications, USA, 2007.

PPSC006	MODELLING OF FACTS CONTROLLERS	L	T	P	C
		3	0	0	3

Course Objectives

- To understand the utilization of several power electronic circuits in power system for its flexible operation and improved performance.
- To expose the modelling of various FACTS devices for both steady state and dynamic studies.

Course Content

Introduction to the control of power flow in AC transmission line- Analysis of uncompensated AC Transmission line, Need for FACTS controllers- types of FACTS controllers. Configuration of SVC, voltage regulation by SVC, Modelling of SVC for load flow analysis and for stability studies.

Design of SVC to regulate the mid-point voltage of SMIB system, Applications. Concepts of Controlled Series Compensation, Operation of TCSC and GCSC, Analysis and modelling of GCSC for load flow studies for stability studies, Applications. 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. Design of FACTS controller, approximate multi model decomposition, nonlinear variable structure control, Variable structure series capacitor control -Variable structure series resistor control.

References

1. NarainG.Hingorani, Laszio. Gyugyl, "Understanding FACTS Concepts and Technology of Flexible AC Transmission System", Standard Publishers, Delhi 2001.
2. V. K.Sood, "HVDC and FACTS controllers- Applications of Static Converters in Power System", 2004, Kluwer Academic Publishers.
3. Mohan Mathur, R., Rajiv. K. Varma, "Thyristor – Based Facts Controllers for Electrical Transmission Systems", IEEE press and John Wiley & Sons, Inc. 2002.
4. K.R.Padiyar," FACTS Controllers in Power Transmission and Distribution", New Age International (P) Ltd., Publishers New Delhi, Reprint 2008.
5. A.T.John, "Flexible AC Transmission System", Institution of Electrical and Electronic Engineers (IEEE), 1999.

PPSC007	DIGITAL POWER SYSTEM PROTECTION	L	T	P	C
		3	0	0	3

Course Objectives

- To get an overall idea of different types of static relays and its applications in the power system protection,
- To gain the knowledge about the modern techniques used in power system protection.

Course Content

General philosophy of protection, Qualities of relaying, Definitions, Characteristic Functions; Classification, analog, digital numerical; schemes and design-factors affecting performance zones and degree of protection; faults types and evaluation; Instrument transformers for protection.

Basic elements of digital protection, signal conditioning conversion, subsystems, relay units-sequence networks-fault sensing data processing units, FFT and Wavelet based algorithms, least square and differential equation based algorithms, travelling wave protection schemes.

Protection of power system apparatus, protection of generators, Transformer protection , magnetizing inrush current, Application and connection of transformer differential relays , transformer over current protection. Bus bar protection, line protection, distances protection, long EHV line protection, Power line carrier protection.

References

1. Badri Ram, Vishwakarma D N., “Power System Protection and Switchgear” Tata McGraw Hill Publishing House Limited, New Delhi, 2005.
2. Soni, M.L., Gupta, P.V., Bhatnagar, U.S. and Chakrabarti, A., “A Text Book on Power Systems Engineering”, Dhanpat Rai & Sons Company Limited, New Delhi, 2008.
3. Y.G. Paithankar and S.R. Bhide, “Fundamentals of Power System Protection”, Prentice Hall of India Pvt. Ltd., New Delhi–110001, 2003.
4. C.L. Wadhwa, “Electrical Power Systems”, Newage International (P) Ltd., 2000.
5. R.K.Rajput, “A Text book of Power System Engineering”, Laxmi Publications, First Edition Reprint 2007.

PPSC008	POWER SYSTEM DEREGULATION AND PRICING	L	T	P	C
		3	0	0	3

Course Objectives

- To introduce the concepts of Deregulation in power industry through various market models.
- To impart learning about pricing and optimal power system expansion and it's planning.

Course Content

Deregulation of power industry, restructuring process, Issues involved in deregulation, Deregulation of various power systems. Fundamentals of Economics: Consumer behaviour, Supplier behaviour, Market equilibrium, Short and long run costs, various costs of production. Market models: Comparison of various market models, Market architecture, Congestion-Introduction, Importance and Features of congestion management, Classification and Types of congestion management method, Available Transfer Capability (ATC) and its calculation.

Locational marginal pricing– Lossless and 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.

Introduction and Types of ancillary services, Classification of Ancillary services, Voltage control and reactive power support devices, Black start capability service, Process to obtain ancillary services, Co-optimization of energy and reserve services, International comparison Transmission pricing: Principle, Classification methods and Types. Framework of Indian power sector, Reform initiatives, Availability based tariff, Electricity act 2003, Open access issues, Power exchange, Reforms in the near future.

References

1. Sally Hunt," Making competition work in electricity", John Willey and Sons Inc. 2002.
2. Steven Stoft," Power system economics: designing markets for electricity", John Wiley & Sons, 2002.
3. Mohammad Shahidehpour, MuwaffaqAlomoush, Marcel Dekker, "Restructured electrical power systems: operation, trading and volatility" Pub., 2001
4. Kankar Bhattacharya, Jaap E. Daadler, Math H.J. Boolen, "Operation of restructured power systems", Kluwer Academic Pub., 2001.

PPSC009	ADVANCED POWER SYSTEM SIMULATION LABORATORY	L	T	P	C
		0	0	2	2

Course Objectives

- To analyze the effect of various FACTS devices in improving the steady state stability.
- To have hands on experience on different wind energy conversion technologies.
- To expose the students on design of filter for harmonics mitigation.

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 an R-L load.
10. Design of active filter for mitigating harmonics.

References

1. TuranGonen, "Modern Power System Analysis", Second Edition, CRC Press, 2013.
2. P. W. Sauer and M. A. Pai, "Power System Dynamics and Stability", Stipes Publishing Co, 2007.
3. P. Kundur, "Power System Stability and Control", McGraw-Hill, 1993.
4. Allen J. Wood, Bruce F. Wollenberg, Gerald B. Shebl, "Power Generation, Operation and Control", Third Edition, John Wiley & Sons, 2013.
5. G W Stagg, A.H El. Abiad "Computer Methods in Power System Analysis", McGraw Hill, 1983.

PROFESSIONAL ELECTIVE

PPSE001	POWER SYSTEM INSTRUMENTATION	L	T	P	C
		3	0	0	3

Course Objectives

- To facilitate the students to understand the basic concepts of measurement techniques in power system.
- To understand the recent trends in measuring devices in power system in order to design proper protection technique.

Course Content

Measurement of large currents and voltages, current and voltage transformers, design equations and operational characteristics, error compensation schemes. Protective CTs and PTs, overload and transient performance, standard specification of instrument transformers.

DC current transformers, measurement of power and energy, torque equation of induction type energy meter, parasitic torques and their minimization, IS specifications, analog and digital KVA meters.

Tele-metering, remote terminal units, data acquisition systems, tri-vector meters, event and disturbance recorders. Thermal conductive type, paramagnetic type-Oxygen analyzer, hydrogen purity meter-chromatography-PH meter, fuel analyzer, pollution monitoring and control.

References

1. Cooper Helfrick, "Electrical Instrumentation and Measuring Techniques", Prentice Hall India, 2008
2. D. C. Nakra and K. K. Chowdhry, "Instrumentation, Measurement, and Analysis", Tata McGraw Hill Publishing Co., 2015.
3. S. K. Singh, "Industrial Instrumentation and Control", Mcgraw Hill Education, 201.
4. S. Mukhopadhyay, S. Sen, A. Deb, "Industrial instrumentation control and automation" Jaico pub, Mumbai.
5. J W Dally, W F Reley and K G McConnel, "Instrumentation for Engineering Meaasurements" (second edition), John Wiley & sons Inc New York, 1993.

PPSE002	ENERGY AND ENVIRONMENT	L	T	P	C
		3	0	0	3

Course Objectives

- To study the different energy sources with its impact on the ecosystems
- To expose the students about the environmental effects of energy extraction
- To familiarize the concept of global warming and its mitigation methods

Course Content

Energy sources: classification of energy sources, quality and concentration of energy sources; Overview of world energy scenario; Fossil fuel reserves - estimates, duration, overview of India's energy scenario, energy and development linkage, Ecological principles of nature; Concept of ecosystems; Different types of ecosystems; ecosystem theories; energy flow in the ecosystems; biodiversity.

Environmental effects of energy extraction, conversion and use, Sources of pollution; primary and secondary pollutants; Consequence of pollution and population growth; Causes of global, regional and local climate change; Pollution control methods; Environmental laws on pollution control.

Global warming; Green House Gas emissions, impacts, mitigation; Sustainability; Externalities; Future Energy Systems; Clean energy technologies; United Nations Framework Convention on Climate Change (UNFCC); Sustainable development; Kyoto Protocol; Conference of Parties (COP); Clean Development Mechanism (CDM); Prototype Carbon Fund (PCF).

References

1. Energy and Environment Set: Mathematics of Decision Making, Loulou, Richard; Waaub, Jean-Philippe; Zaccour, Georges (Eds.), 2005, XVIII, 282 p. ISBN: 978-0-387-25351-0
2. Energy and the Environment, 2nd Edition, John Wiley, 2006, ISBN: 9780471172482; Authors: Ristinen, Robert A. Kraushaar, Jack J. AKraushaar, Jack P. Ristinen, Robert A., Publisher: Wiley, Location: New York, 2006.
3. E H Thorndike, Energy & Environment: A Primer for Scientists and Engineers, Addison-Wesley Publishing Company
4. R Wilson & W J Jones, Energy, Ecology and the Environment, Academic Press Inc.
5. New Approaches on Energy and the Environment: Policy Advice for the President, by Richard D. Morgenstern, ISBN13: 9781933115016, ISBN10: 1933115017, Publisher: Resources for the Future, Publication Date: February 2005.

		L	T	P	C
PPSE003	**POWER SYSTEM PLANNING AND RELIABILITY**	**3**	**0**	**0**	**3**

Course Objectives

- To identify the objectives of Load forecasting and analyze the fundamentals of Generation system, transmission system and Distribution system reliability analysis.
- To illustrate the basic concepts of Expansion planning to meet the future demands in power system.

Course Content

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

Probabilistic generation and load models, Determination of LOLP and expected value of demand not served, Determination of reliability of ISO and interconnected generation systems. Deterministic contingency analysis, probabilistic load flow, Fuzzy load flow probabilistic transmission system reliability analysis, Determination of reliability indices like LOLP and expected value of demand not served.

Basic concepts on expansion planning, procedure followed for integrate transmission system planning, current practice in India, and capacitor placer problem in transmission system and radial distributions system. Introduction: Sub transmission lines and distribution substations, Design primary and secondary systems, distribution system protection and coordination of protective devices.

References

1. Roy Billinton& Ronald N. Allan “Reliability Evaluation of Power System”, Springer Publication.
2. R.L. Sullivan, “Power System Planning”, Tata McGraw Hill Publishing Company Ltd.
3. X. Wang & J.R. McDonald, “Modern Power System Planning”, McGraw Hill Book Company.
4. T. Gönen, “Electrical Power Distribution Engineering”, McGraw Hill Book Company.
5. B.R. Gupta, “Generation of Electrical Energy”, S. Chand Publications.

PPSE004	POWER QUALITY ISSUES AND ITS MITIGATION METHODS	L	T	P	C
		3	0	0	3

Course Objectives

- To study about the issues in power quality due to the unbalanced and nonlinear loads.
- To understand the concept of harmonics and its mitigation methods.

Course Content

Characterization of Electric Power Quality: Transients, short duration and long duration voltage variations, Voltage imbalance, waveform distortion, Voltage fluctuations, Power frequency variation, Power acceptability curves, power quality problems: poor load power factor, Non-linear and unbalanced loads, DC offset in loads, Notching in load voltage, Disturbance in supply voltage, Signalling Voltages, Radiated high –frequency Phenomena, Electro static discharge Phenomena, Nuclear electromagnetic pulses, Power quality standards.

Single phase linear and non- linear loads, single phase sinusoidal, non-sinusoidal source, three phase unbalanced and distorted source supplying non- linear loads, concept of pf. Principle of load compensation and voltage regulation – classical load balancing problem: open loop balancing, closed loop balancing, current balancing.

Harmonics – Sources–Definitions & standards – Impacts - Calculation and simulation – Harmonic power flow - Mitigation and control techniques – Filtering – Passive and active, Power quality conditioners. Shunt and series compensators, DStatcom, Dynamic voltage restorer, Unified power quality conditioners

References

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, 2002(2nd edition)
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PPSE005	MICROCONTROLLER BASED SYSTEM DESIGN	L	T	P	C
		3	0	0	3

Course objectives

- To expose the students to the fundamentals of microprocessor architecture.
- To introduce the advanced features in microprocessors and microcontrollers.
- To enable the students to understand various microcontroller architectures

Course Content

Role of microcontrollers, 8 bit microcontroller, architecture of 8031/8051/875, hardware description, memory organization, addressing mode, Boolean processing instruction set, simple programs. RTOS for 8051, RTOSLite, Full RTOS, Task creation, LCD, digital clock/thermometer using Full RTOS.

Introduction - PIC microcontroller, Architecture-memory organization, I/ O port, Reset circuits, Instruction set, compare/capture/PWM, Timers – Interrupts, I/O ports- I2C bus-A/D converter-UART, CCP modules, ADC, DAC Flash and EEPROM memories, Interfacing LCD Display, Keypad Interfacing, Generation of Gate signals for converters and Inverters, Motor Control, Controlling DC/ AC appliances, Measurement of frequency, Stand alone Data Acquisition System.

Stepper motor control, Real time clock, DC motor speed control, Generation of Gating Signals for Converters and Inverters, Advanced communication processor, Subscriber processor, Bluetooth Baseband controller.

References

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2. John Iovine, “PIC Microcontroller Project Book”, McGraw Hill 2000.
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5. Rajkamal, “Microcontrollers-Architecture, Programming, Interfacing& System Design”, 2nd, Pearson, 2012.

PPSE006	TRANSIENT OVERVOLTAGES IN POWER SYSTEMS	L	T	P	C
		3	0	0	3

Course objectives

- To effectively introduce the various forms of over voltages such as lightning strokes, surges and switching transients.
- To familiarize with some of the protection measures against Transient over voltages and to depict the necessity methods for grounding impulse voltages and current.

Course Content

Review of various types of power system transients, Lightning surges, Switching surges Inductive and Capacitive energy transient, Effect of transients on power systems. Lightning, Overview, Lightning surges, Electrification of thunderclouds, Simpson's theory of thunderclouds, Direct and Indirect strokes, Stroke to conductor. Conventional lightning protection technique: Collection Volume method (Dynasphere)

Wave equation, reflection and refraction, behavior of travelling waves at the line terminations, Lattice Diagrams, attenuation and distortion, multi conductor system and multi velocity waves. Classification of over voltages and insulations for insulation co-ordination, Characteristics of protective devices, applications, location of arresters, insulation co-ordination in AIS and GIS.

Modeling of power apparatus for transient studies, Closing and reclosing of lines, Load rejection, Fault initiation, Fault clearing, Short line faults, Ferro Resonance, Isolator switching surges, Temporary over voltages, Surges on an integrated system, Switching, Harmonics, Protection scheme.

References

1. Pritindra Chowdhari, "Electromagnetic transients in Power System", John Wiley and Sons Inc., Second Edition, 2009.
2. Allan Greenwood, "Electrical Transients in Power System", Wiley & Sons Inc. New York, 2012.
3. Rakosh Das Begamudre, "Extra High Voltage AC Transmission Engineering", (Second edition) Newage International (P) Ltd., New Delhi, 2006.
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PPSE007	ENERGY MANAGEMENT AND AUDITING	L	T	P	C
		3	0	0	3

Course Objectives

- To make the students realize the need for energy conservation.
- To familiarize to various Methods of energy management and energy auditing.
- To prepare the students for energy auditing and managing the energy demand.

Course Content

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

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, and Metering location vs. requirements, Metering techniques and practical examples

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

References

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

PPSE008	ANALYSIS AND DESIGN OF INVERTERS	L	T	P	C
		3	0	0	3

Course Objectives

- To provide knowledge about the different working modes of inverters and their operation.
- To equip with required skills to design power converters for various applications like UPS, Drives etc.,

Course Content

Introduction to self-commutated switches- MOSFET and IGBT, Principle of operation of half and full bridge inverters, Performance parameters, Voltage control of single phase inverters using various PWM techniques, various harmonic elimination techniques, forced commutated Thyristor inverters, Design of UPS.

180 degree and 120 degree conduction mode inverters with star and delta connected loads, voltage control of three phase inverters- single, multi pulse, sinusoidal, space vector modulation techniques, Application to drive system. Operation of six-step thyristor inverter, inverter operation modes, load commutated inverters, Auto sequential current source inverter (ASCI), current pulsations, comparison of current source inverter and voltage source inverters, PWM techniques for current source inverters.

Multilevel concept, diode clamped, flying capacitor, cascade type multilevel inverters, Comparison of multilevel inverters, application of multilevel inverters, PWM techniques for MLI, Single phase & Three phase Impedance source inverters. Series and parallel resonant inverters, voltage control of resonant inverters, Class E resonant inverter, resonant DC, link inverters.

References

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PPSE009	DISTRIBUTED GENERATION AND MICROGRID	L	T	P	C
		3	0	0	3

Course Objectives

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

Course Content

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. 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, Captive power plants ultra-capacitors, flywheels. 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.

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

References

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6. John Twidell and Tony Weir, "Renewable Energy Resources", Tyalor and Francis Publications, Second edition.

PPSE010	SOLAR AND ENERGY STORAGE SYSTEMS	L	T	P	C
		3	0	0	3

Course Objectives

- To study about solar modules and PV system design and their applications.
- To deal with grid connected PV systems.
- To discuss about different energy storage systems.

Course Content

Characteristics of sunlight, semiconductors and PN junctions, behavior of solar cells, cell properties, PV cell interconnection, Solar modules, storage systems, power conditioning and regulation, protection, standalone PV systems design, sizing

PV systems in buildings, design issues for central power stations, safety, Economic aspect, Efficiency and performance, International PV programs, Impact of intermittent generation, Battery energy storage, solar thermal energy storage

Application of pumped hydroelectric energy storage, Water pumping, battery chargers, solar car, direct drive applications, Space, Telecommunications.

References

1. Eduardo Lorenzo G. Araujo,"Solar electricity engineering of photovoltaic systems", Progensa, 1994.
2. Stuart R.Wenham, Martin A. Green, Muriel E. Watt and Richard Corkish, "Applied Photovoltaics", 2007, Earthscan, UK.
3. Frank S. Barnes & Jonah G. Levine, "Large Energy storage Systems Handbook", CRC Press, 2011.
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PPSE011	INDUSTRIAL POWER SYSTEM ANALYSIS AND DESIGN	L	T	P	C
		3	0	0	3

Course objectives

- To understand the issues related to operation of drives in the industries
- To expose the computer aided analysis of power quality issues in the industry
- To familiarize the students about the different grid grounding methodologies.

Course Content

Introduction- Evaluation Criteria, Starting Methods, System Data, Voltage Drop Calculations, Calculation of Acceleration time, Motor Starting with Limited, Capacity Generators-Computer-Aided Analysis, Conclusions. Introduction power factor correction, System Description and Modeling, Acceptance Criteria, Frequency Scan Analysis, Voltage Magnification Analysis, Sustained Over voltages.

Switching Surge Analysis, Back-to-Back Switching-Summary and Conclusions. Harmonic Sources, System Response to Harmonics, System Model for Computer, Aided Analysis, Acceptance Criteria-Harmonic Filters, Harmonic Evaluation. Case Study, Summary and Conclusions.

Sources of Flicker, Flicker Analysis, Flicker Criteria, Data for Flicker analysis, Case Study, Arc Furnace Load, Minimizing the Flicker Effects, Summary. Introduction Acceptance Criteria, Ground Grid Calculations, Computer, Aided Analysis, Improving the Performance of the Grounding Grids, Conclusions.

References

1. Ramasamy Natarajan,"Computer-Aided Power System Analysis", Marcel Dekker Inc., 2002.
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3. Glover Mulukutla, "Power System Analysis and Design", Cengage Learning; 2ND, international economy edition, 2012.
4. B.R. Gupta, "Power System Analysis and Design", A.H. Wheeler & co, New delhi, 1998.
5. M.A. Pai, "Supercomputer techniques in power system analysis", TMH, 2005.

PPSE012	WIND ENERGY CONVERSION SYSTEMS	L	T	P	C
		3	0	0	3

Course Objectives

- To expose the students the components and operation of Wind energy conversion systems
- To study the different generators employed in Wind energy conversion systems
- To familiarize with the grid connecting issues.

Course Content

Components of WECS-WECS schemes-Power obtained from wind, simple momentum theory, Power coefficient, Sabinins theory-Aerodynamics of Wind turbine, HAWT, VAWT, Power developed, Thrust, Efficiency, Rotor selection, Rotor design Considerations, Tip speed ratio, number of Blades, Blade profile, Power Regulation-yaw control, Pitch angle control-stall control-Schemes for maximum power extraction.

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. 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. 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.

References

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

PPSE013	SMART GRID	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.

Course Content

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. 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). 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.

Introduction of IoT, Basics of Networking, Communication Protocol, IoT controllers, Fog Computing, 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.

References

1. Vehbi C. Güngör,Dilan Sahin, Taskin Kocak, 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.
3. Stuart Borlase “Smart Grid: Infrastructure, Technology and Solutions”,CRC Press 2012.
4. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, “Smart Grid: Technology and Applications”, Wiley.
5. **Serpanos**, Dimitrios, **Wolf**, Marilyn, “Internet –of- Things (IoT) systems, Architectures,Algorithms,Methodolories” Springer, 2018.

PPSE014	BIO-ENERGY AND CONVERSION SYSTEMS	L	T	P	C
		3	0	0	3

Course Objectives

- To introduce different techniques for biomass assessment and application of remote sensing for forest assessment.
- To expose different methods biomass energy conversion schemes and their processes.
- To present about different methods useful for power generation from Biomass resources.

Course Content

Biomass: Biomass resources; classification and characteristics; Techniques for biomass assessment; Application of remote sensing in forest assessment; Biomass estimation. Thermochemical Conversion: Different processes, direct combustion, incineration, pyrolysis, gasification and liquefaction; economics of thermochemical conversion.

Biological Conversion: Biodegradation and biodegradability of substrate; biochemistry and process parameters of bio-methanation; chemical kinetics and mathematical modeling of biomethanation process, biogas digester types; digester design and biogas utilisation; economics of biogas plant with their environmental and social impacts; bioconversion of substrates into alcohol: methanol & ethanol production, organic acids, solvents, amino acids, antibiotics etc. Chemical Conversion: Hydrolysis & hydrogenation; solvent extraction of hydrocarbons; solvolysis of wood; biocrude; biodiesel production via chemical process; catalytic distillation; transesterification methods; Fischer-Tropsch diesel: chemicals from biomass.

Power generation: Utilisation of gasifier for electricity generation; operation of spark ignition and compression ignition engine with wood gas, methanol, ethanol & biogas; biomass integrated gasification/combined cycles systems. Sustainable co-firing of biomass with coal. Biomass productivity: Energy plantation and power programme. Economical impacts; food security and environmental impacts of biomass conversion to energy- energy from waste.

References

1. James J Winebrake, "Alternate Energy: Assessment & Implementation Reference Book", Springer January 2007.
2. Christian Stevens and Roland Verhe, "Renewable Bio resources - Scope and Modification for Non-Food Applications", John Wiley & Sons, 2004.
3. Alain A. Vertes, Nasib Qureshi, Hideaki Yukawa, Hans P. Blaschek, "Biomass to Biofuels: Strategies for Global Industries", John Wiley & Sons, 2011.
4. Hans Blaschek, Thaddeus Ezeji, Jürgen Scheffran, "Biofuels from Agricultural Wastes and Byproducts", John Wiley & Sons, 2010.
5. Anthony San Pietro, "Biochemical and Photosynthetic aspects of Energy Production", Academic Press, New York, 1980.

PPSE015	DIGITAL CONTROL OF POWER ELECTRONICS	L	T	P	C
		3	0	0	3

Course Objectives

- To analyze the methods used for implementing digital conversion to real time applications of Power Electronics

Course Content

Basic Mathematics of Digital Control Systems, Digital Signals and Coding, Shannon's sampling theorem, Sample-and-hold devices, Analog-to-Digital conversion, and Digital-to-Analog conversion. The Laplace transform (the s-domain),the z-transform (the z-domain)Mathematical modelling of digital Power Electronics, Digitally Controlled AC/DC Rectifiers–Introduction, Mathematical modelling for different AC/DC Rectifiers.

Digitally Controlled DC/AC Inverters–Mathematical modelling for DC/AC PWM inverters, Single phase half-wave, Single-phase full-bridge, Three Phase full-bridge, Three-phase full-bridge PWM CSI, Multistage PWM Inverter, Multilevel PWM inverter.

Digitally Controlled DC/DC Converters–Mathematical Modelling for power DC/DC converters, Open loop Control for Digital Power Electronics–Introduction, Stability analysis, Closed-Loop Control for Digital Power Electronics, PI control for Power Electronic systems.

References

1. Fang Lin Luo Hong,Ye Muhammad Rashid, "Digital Power Electronics and Applications", Elsevier Academic Press,2005.
2. J. Murphy and F.G.Turnbull, "Power Electronics Control of AC Motors", Paramon Press, 2010.
3. Power Electronic and motor control Shepherd, Hulley, Liang –II Edition, Cambridge University Press, 2011.
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5. Ogata, "Discrete time control systems", Pearson educational system, Singapore, 2002.

PPSE016	SCADA SYSTEMS AND APPLICATION MANAGEMENT	L	T	P	C
		3	0	0	3

Course Objectives

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

Course Content

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

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. 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.

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.

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.
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PPSE017	SYSTEM IDENTIFICATION AND ADAPTIVE CONTROL	L	T	P	C
		3	0	0	3

Course Objectives

- To introduce various model structures for system identification.
- To impart knowledge on non-linear identification, parametric and non-parametric identification techniques.
- To illustrate the identification and adaptive control techniques through case studies.

Course Content

Models of LTI systems: Linear Models-State space Models-OE model- Model sets, Structures and Identifiability, Models for Time-varying and Non-linear systems: Models with Nonlinearities, Non-linear state-space models-Black box models, Fuzzy models. Transient response and Correlation Analysis, Frequency response analysis, Spectral Analysis, Least Square, Recursive Least Square, Forgetting factor, Maximum Likelihood, Instrumental Variable methods.

Open and closed loop identification- Approaches, Direct and indirect identification, Joint input-output identification, Non-linear system identification, Wiener models, Power series expansions, State estimation techniques, Non linear identification using Neural Network and Fuzzy Logic.

Adaptive techniques, Uses, Auto tuning, Self Tuning Regulators(STR), Model Reference Adaptive Control (MRAC), Types of STR and MRAC, Different approaches to self- tuning regulators, Stochastic Adaptive control, Gain Scheduling. Inverted Pendulum, Robot arm, process control application: heat exchanger, Distillation column, application to power system, Ship steering control.

References

1. Ljung," System Identification Theory for the User", PHI, 1987.
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3. Astrom and Wittenmark," Adaptive Control ", PHI
4. William S. Levine, "Control Hand Book".
5. Narendra and Annasamy," Stable Adaptive Control Systems, Prentice Hall, 1989.

PPSE018	ROBUST CONTROL	L	T	P	C
		3	0	0	3

Course Objectives

- To introduce norms, random spaces and robustness measures.
- To educate on optimal control and estimation techniques.
- To familiarize students on synthesis techniques for robust controllers and illustrate through case studies.

Course Content

Norms of vectors and Matrices, Norms of Systems, Calculation of operator Norms, vector Random spaces, Specification for feedback systems, Co-prime factorization and Inner functions, structured and unstructured uncertainty, robustness. Linear Quadratic Controllers, Characterization of H2 optimal controllers, H2 optimal estimation, Kalman Bucy Filter, LQG Controller.

Formulation, Characterization of H-infinity sub-optimal controllers by means of Riccati equations, H-infinity control with full information, Hinfinity estimation, Formulation, Characterization of H-infinity sub-optimal controllers by means of LMI Approach – Properties of H-infinity sub-optimal controllers, H-infinity synthesis with pole- placement constraints

Synthesis of Robust Controllers, Small Gain Theorem, D-K iteration, Control of Inverted Pendulum, Control of CSTR, Control of Aircraft, Robust Control of Secondorder Plant, Robust Control of Distillation Column.

References

1. U. Mackenroth “Robust Control Systems: Theory and Case Studies”, Springer International Edition, 2010.
2. J. B. Burl, “Linear optimal control H2 and H-infinity methods”, Addison W Wesley, 1998
3. D. Xue, Y.Q. Chen, D. P. Atherton, "Linear Feedback Control Analysis and Design with MATLAB, Advances in Design and Control”, Society for Industrial and Applied Mathematics, 2007.
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PPSE019	POWER ELECTRONICS IN HVDC	L	T	P	C
		3	0	0	3

Course Objectives

- To understand how power conversion takes place between Ac to DC and vice versa and to deal with reactive power control of HVDC system

Course Content

Rectification: The 3-phase Bridge rectifier or Graetz circuit, Inversion, Kinds of D.C links, Paralleled and Series connection of thyristors, Power flow in HVDC transmission system. Converter Station: Major components of a converter station-converter unit, filters, reactive power source. Ground return and ground electrode.

Basic principles of DC link control: Converter control characteristics, firing angle control and extinction angle control. Parallel operation of DC link with AC transmission line.

Introduction to Multiterminal HVDC Systems and HVDC Circuit Breakers, Comparisonbetween AC and DC transmissions, break even distance for overhead transmission lines and underground cables.Application of HVDC transmission.

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References

1. K.R. Padiyar, HVDC Power Transmission System, Wiley EsternLimited,Second edition,2010
2. E.W. Kimbark EHV-AC and HVDC Transmission Engineering & Practice, Khanna Publishers,3rd Edition,2001
3. J. Arrillaga, "High Voltage Direct Current Transmission", 2nd Edition. IEE Power Engineering Series, 1998
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5. Ned Mohan, T.M Undeland and W.P. Robbin, "power electronics: converters, application and design", John Wiley & sons, Wiley India, edition 2006

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PPSE020	DESIGN OF SUBSTATIONS	L	T	P	C
		3	0	0	3

Course 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.

Course Content

Introduction to AIS and GIS, characteristics, comparison of Air Insulated Substation (AIS) and Gas Insulated Substation (GIS), main features of substations, Environmental considerations, Planning and installation, GIB / GIL. Major equipment of AIS and GIS, design features, equipment specification, types of electrical stresses, mechanical aspects of substation design, substation switching schemes, single feeder circuits.

Single or main bus and sectionalized single bus, double main bus-main and transfer bus main, reserve and transfer bus breaker and half scheme ring bus. Insulation coordination of AIS and GIS, stress at the equipment, insulation strength and its selection, standard BILs, Application of simplified method, Comparison with IEEE and IEC guides.

Grounding and shielding, definitions, soil resistivity measurement, ground fault currents, ground conductor, design of substation grounding system, shielding of substations, Shielding by wires and masts. Fast transients phenomenon in AIS and GIS, Disconnector switching in relation to very fast transients, origin of VFTO, propagation and mechanism of VFTO, characteristics of VFTO , Effects of VFTO.

References

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2. “Power Engineer’s handbook”, TNEB Association.
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4. AIEE Committee Report, “Substation One-line Diagrams,” AIEE Trans. on Power Apparatus and Systems, August 1953
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GENERIC ELECTIVES

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PPSG001	ADVANCED SOFT COMPUTING TECHNIQUES	L	T	P	C
		3	0	0	3

Course Objectives

- To provide adequate knowledge about feedback neural networks.
- To teach about the concept of fuzziness involved in various systems.
- To expose the ideas about genetic algorithm.

Course Content

Introduction of soft computing - various types- applications of soft computing, Artificial Neuron and its model, Neural network architecture- single layer and multilayer feed forward networks- different models, back propogation learning methods- factors affecting back propagation training- applications.

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.

Basic concept of Genetic algorithm and detail algorithmic steps-adjustment of free Parameters-Solution of typical control problems using genetic algorithm- Concept on some other search techniques like tabu search and ant colony search techniques for solving optimization problems. GA application to power system optimization problem- Case studies: Identification and control of linear and nonlinear dynamic systems using Matlab-Neural Network toolbox. Stability analysisof Neural Network interconnection systems- Implementation of fuzzy logic controller using Matlab fuzzy logic toolbox-Stability analysis of fuzzy control systems.

References

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2. Timothy J. Ross, “Fuzzy Logic with Engineering Applications” Wiley India.

3. Zimmermann H.J. "Fuzzy set theory and its Applications" Springer international edition, 2011.

4. David E.Goldberg, “Genetic Algorithms in Search, Optimization, and Machine Learning”, Pearson Education, 2009.

5. W.T.Miller, R.S.Sutton and P.J.Webrose, “Neural Networks for Control”, MIT Press, 1996.

PPSG002	ADVANCED DIGITAL SIGNAL PROCESSING	L	T	P	C
		3	0	0	3

Course Objectives

- To understand the concept of discrete random signal processing,
- To gain the knowledge about linear and power spectral estimation.

Course Content

Multirate Digital Signal Processing: Introduction of discrete random signal processing. Multirate Digital Signal Processing- Decimation by a Factor D, Interpolation by a Factor I, Sampling Rate Conversion by a Rational Factor I/D, Filter Design and Implementation for sampling rate Conversion, Applications of Multirate Signal Processing

Linear Prediction and Optimum Linear Filters: Innovations Representation of a Stationary Random Process, Forward and Backward linear prediction, Solution of the Normal Equations, Properties of linear prediction-Error Filter, AR Lattice and ARMA Lattice-Ladder Filter, Wiener filter for filtering and prediction, FIR and IIR wiener filter, Discrete Kalman filter

Power Spectral Estimation: Estimation of Spectra from Finite Duration Observations of a signal, the Periodogram, Use DFT in power Spectral Estimation, Bartlett, Welch and Blackman, Tukey methods, Comparison of performance of Non-Parametric Power Spectrum Estimation Methods. Parametric Methods for power spectrum estimation, Relationship between Auto-Correlation and Model Parameters, AR (Auto-Regressive) Process and Linear Prediction, Sequential Estimation, Moving Average(MA) and ARMA Models Minimum Variance Method.

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3. John G. Proakis, Dimitris G. Manolakis, “Digital Signal Processing”, Prentice Hall of India, New Delhi, 2005.
4. S. Kay,” Modern Spectrum Estimation Theory and Application”, prentice hall, Englewood cliffs, Nj, 1999.
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PPSG003	OPTIMIZATION 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.

Course Content

Definition, Classification of optimization problems, Classical Optimization Techniques, Single and Multiple Optimization with and without inequality constraints. Simplex method of solving LPP, revised simplex method, duality, constrained optimization, Theorems and procedure, Linear programming, mathematical model, solution technique, duality.

Steepest descent method, conjugates gradient method, Newton's Method, Sequential quadratic programming, Penalty function method, augmented Lagrange multiplier method., Multistage decision processes, concept of sub-optimization and principle of optimality, Recursive relations, Integer Linear programming, Branch and bound algorithm

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.

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