ANNA UNIVERSITY: : CHENNAI - 25

FACULTY OF ELECTRICAL ENGINEERING

Approved Special Electives for

M.S. / Ph.D. Degree Programs

(upto 25th AC 02.05.2019)

ANNA UNIVERSITY : : CHENNAI – 600 025.

SPECIAL ELECTIVES FOR FACULTY OF ELECTRICAL ENGINEERING

COURSE CODE	COURSE TITLE	L	T	P	C
	Modelling and Simulation of FACTS Devices for Transient and Dynamic Stability Studies (5th AC)	3	0	0	3
	Evolutionary Computing (5th AC)	3	1	0	4
	Power System Optimization (5th AC)	3	1	0	4
	Coordination of Multiple FACTS devices using Linear / Non – Linear Control Technique (5th AC)	3	0	0	3
FE1911	DC – DC Converters	3	0	0	3
FE1912	Nano Electronics	3	0	0	3
FE1914	Application of Optimization Techniques to Power Systems	3	1	0	4
FE1915	Wind Electric Conversion System	3	0	0	3
FE1916	Modelling and Simulation of Facts Devices	3	1	0	4
FE1917	Power System Deregulation	3	0	0	3
FE1918	Network System Design Using Network Processors	3	0	0	3
FE1919	Smart Sensors: Analysis and Compensation	3	0	0	3
FE1920	Distributed Algorithms	3	0	0	3
FE1921	Support Vector Machine	3	0	0	3
FE1922	Interval System Analysis	3	0	0	3
FE1923	Loss Allocation in a Deregulated Power System	3	0	0	3
FE1924	Introduction to Nonlinear Systems	3	0	0	3
FE1925	Service Oriented Architecture	3	0	0	3
FE1926	Models And Measurements In Bio Mechanics	3	0	0	3
FE1927	Model Predictive Control	3	0	0	3
FE1928	Reinforcement Learning	3	0	0	3
FE1929	Modeling and Simulation of Wind Energy Conversion System	3	0	0	3
FE1930	Design of Electrical Machines – Electromagnetic Approach	3	0	0	3
FE1931	Application of Intelligent Controllers for Power Quality Improvement	3	0	0	3
FE1932	Fault Diagnosis in Electrical Machines	3	0	0	3
FE1933	Optimization Techniques for Power System Restoration	3	0	0	3
FE1934	Modelling and Simulation of DVR and its Controllers	3	0	0	3

FE1935	Modern Rectifiers and Resonant Converters	3	0	0	3
FE1936	EMC in Power Electronic Converters	3	0	0	3
FE1937	Modelling and Control of Hybrid Systems	3	0	0	3
FE1938	Design and Control of Switched Reluctance Machine for Automotive Applications	3	0	0	3
FE1939	Analysis, Design and Control of Stepping Motors	3	0	0	3
FE1940	Principles, Design and Fabrication of MEMS Devices	3	0	0	3
FE1941	Analysis and Control of Special Machines	3	0	0	3
FE1942	Intelligent Control Applications to BLDC Motors	3	0	0	3
FE1943	Voltage Source Converter Based HVDC Transmission	3	0	0	3
FE 9001	Advanced Optimal Control	3	0	0	3
FE 9002	Insulation Co-ordination of Gas Insulated systems	3	0	0	3
FE 9003	Statistical Techniques for High Voltage Engineering	3	0	0	3
FE 9004	Energy Efficient Illumination	3	0	0	3
FE 9005	Robust Control and Sliding Mode Control	3	0	0	3
FE 9006	Food Preservation Techniques	3	0	0	3
FE 9007	Web Based Embedded Systems	3	0	0	3
FE 9008	Advanced PID Control	3	0	0	3
FE 9009	Control of Power Converter	3	0	0	3
FE 9010	RTOS Based Embedded System Design	3	0	0	3
FE 9011	Intelligent Controller for Robotics	3	0	0	3
FE 9012	Experimental Stress Analysis Techniques	3	0	0	3
FE 9013	Finite Element Analysis on Boundary Value Problems	3	0	0	3
FE9014	Adaptive Control and Relay Feedback	3	0	0	3
FE9015	Recent Techniques for Reliable Distribution System	3	0	0	3
FE9016	Design of High Power Synchronous Generator	3	0	0	3
FE9017	Modeling and Simulation of Solar Energy Systems	3	0	0	3
FE9018	Sliding Mode and Adaptive Control	3	0	0	3
FE9019	Networking Wireless Sensors	3	0	0	3
FE9020	High Energy Radiation Effects on Polymers and High Voltage Testing of Power Apparatus	3	0	0	3
FE9021	Bifurcation Analysis of Power Systems	3	0	0	3
FE9022	Power Quality Analysis for Grid Integrated Renewable Energy	3	0	0	3

FE9023	Optimization Techniques in Design	3	0	0	3
FE9024	Matrix Converters	3	0	0	3
FE9025	Energy Technologies and Magnetic Energy Storage System	3	0	0	3
FE9026	Stability Analysis of Grid Integrated Wind Energy Conversion System	3	0	0	3
FE9027	Modern Optimization Techniques in Power System	3	0	0	3
FE9028	Marine Instrumentation and Underwater Technology	3	0	0	3
FE9029	CMOS Analog Mixed Signal Design	3	0	0	3
FE9030	Embedded Approaches for Micro Grid Application	3	0	0	3
FE9031	Energy Harvesting Technologies	3	0	0	3
FE9032	Electric Fields in Composite Dielectrics and Their Applications	3	0	0	3
FE9033	Embedded Processors and Embedded OS	3	0	0	3
FE9034	Virtual Instrumentation and Fault diagnosis of Induction motors	3	0	0	3
FE9035	Analysis and Design of a Special Machine for Flywheel Energy Storage Systems.	3	0	0	3
FE9036	Power Electronics for Photovoltaic Applications	3	0	0	3
FE9037	Advanced Power System Protection	3	0	0	3
FE9038	Design of Cable Fed Induction Motor Drive Systems – An Electromagnetic Approach	3	0	0	3
FE9039	Modeling and Analysis of Variable Speed Wind Energy Systems	3	0	0	3
FE9040	Power System Load Models, Identification & Application in Stability Studies	3	0	0	3
FE9041	Model Reduction for Control System Design	3	0	0	3
FE9042	Modelling and Simulation of Power Systems for SubSynchronous Resonance	3	0	0	3
FE9043	Demand Side Management for Distribution System	3	0	0	3
FE9044	Power System Restoration Techniques	3	0	0	3
FE9045	Real Time Optimization	3	0	0	3
FE9046	Android Based Embedded System	3	0	0	3
FE9047	Advance Chemical Reactor Theory	3	0	0	3

FE9048	Polymeric MEMS Devices	3	0	0	3
FE9049	Electric Propulsion	3	0	0	3
FE9050	Nuclear Reactor Engineering	3	0	0	3
FE9051	Control and Protection of Microgrid	3	0	0	3
FE9052	Power System Optimization	3	0	0	3
SEE001	Finite Element Analysis: Theory and Application Using ANSYS	3	1	0	4
FE9053	Synchronous Reluctance Motor and Drives	3	0	0	3
FE9054	Congestion Management With Renewable Energy Resources	3	0	0	3
SEE002	Research Methodology	3	0	0	3
FE9055	Demand Response In Smart Grid	3	0	0	3
FE9056	Transient Analysis and Fault Location In Electrical Machines	3	0	0	3
FE9057	Statistical Techniques for High Voltage Engineering	3	0	0	3
FE9058	State Estimation for Hybrid AC/DC Microgrids	3	0	0	3
FE9059	Image Analysis on Water Quality	3	0	0	3
FE9060	Digital Instrumentation for Offshore Grid	3	0	0	3
FE9061	Enhancement of Power Evacuation of Wind Energy Conversion System Using VSC MTDC Link	3	0	0	3

MODELLING AND SIMULATION OF FACTS DEVICES FOR TRANSIENT DYNAMIC STABILITY STUDIES

L T P C
3 0 0 3

This course will help to understand how FACTS controllers can be represented in power system simulation programs and how power studies can help to evaluate their applicability and performance characteristics.

INTRODUCTION TO FACTS 4

FACTS-Concepts and general system considerations, Types of FACTS controllers, Voltage source converters, Self and line commuted current sourced converters, Special purpose FACTS controllers, Generalized and multifunctional FACTS controllers. Types of computer analysis of power systems with FACTS controllers.

SIMULATION AND MODELING OF FACTS CONTROLLERS FOR TRANSIENT STABILITY STUDIES. 12

General comments on transient stability. Modeling and simulation of FACTS devices for transient stability programmes. Case studies using Eurostag.

SIMULATION AND MODELING OF FACTS CONTROLLERS FOR SMALL SIGNAL STABILITY STUDIES. 12

Introduction to small signal analysis. Simulation and modeling of FACTS controllers for small signal analysis. Comparison between dynamic and transient stability results.

FACTS CONTROLLERS FOR ELECTRO MAGNETIC TRANSIENTS 12

Introduction to EMTP. Steady state and time step solutions in EMTP and their uses. Models of synchronous machines. Modeling of FACTS controllers for power system studies using EMTP.

CUSTOM POWER DEVICES 5

Introduction to Custom Power Devices. Terms and definitions. Improvement of power quality by FACTS devices. Energy storage considerations. Control requirements.

REFERENCES:

1. H.W.Dommel “Electromagnetic Transients Program”, Reference manual prepared for Bonnerville Power Administration, U.S.A., August 1986.
2. Gyugyi L. “Unified power flow control concept for flexible AC Transmission”, IEEE Proceedings-C, Vol-139, No.4, July 1992.
3. Kundur P., “Power System Stability and control”, McGraw Hill, 1994.
4. Keri A.J.F., Meharban A.S.Etal “Unified Power Flow Controller: Modeling and Analysis “IEEE Trans on Power Delivery, Vol.14, No.2, April 1999.
5. Mohan Mathur. R. Rajiv K.Varma “Thyristor Based FACTS Controllers for Electrical Transmission Systems”, John Wiley and sons.
6. Narin G.Hingorani, L.Gyugi, “Understanding FACTS” IEEE press.
7. Padiyar K.R., Kulkarni A.M “Control design and simulation of Unified Power flow controllers” IEEE Trans on Power Delivery, Vol.13, No.4, Oct 1998.

EVOLUTIONARY COMPUTING

L T P C
3 1 0 4

UNIT I GENETIC ALGORITHM 10
Definition and concepts used in Genetic Computation, Theory of Genetic Algorithms, Genetic Algorithm Approach, and General Algorithm of Genetic Algorithms, Applications of Genetic algorithms to power systems. Genetic Algorithm for unit commitment, Load shedding.

UNIT II EVOLUTIONARY COMPUTATION 10
The evolution program for numerical optimization, Evolution program versus other methods. An evolution program the GENOCOP system, the GAFOC system.

UNIT III EVOLUTIONARY STRATEGIES 5
Evolution of evolution Strategies, Comparison of Evolution Strategies and Genetic Algorithms.

UNIT IV EVOLUTIONARY PROGRAMMING 10
Features of Evolutionary programming, Classical Evolutionary programming, Adaptive Evolutionary programming, object oriented analysis, design and implementation. Evolutionary programming. Object oriented testing.

UNIT V HYBRID EVOLUTIONARY ALGORITHMS 10
And Artificial Neural networks, an Evolutionary programming approach to reactive power planning, optimal reactive power dispatch using Evolutionary programming, Application of Neural networks and Evolutionary programming, to short term load forecasting

TEXT BOOK:
1. L.L.Lai, Intelligent system applications in Power Engineering.

REFERRENCES:
1. Z.Michalewiez, Genetic algorithms + Data Structures = Evolution Programmes
2. J.A.Momoh,Electric power system applications of optimization
3. D.E. Goldberg, Genetic algorithm in search, optimization and Machine learning.

Faculty of Electrical Engineering (Approved in 5th AC 18.11.2004)

POWER SYSTEM OPTIMISATION

L T P C
3 1 0 4

UNIT I OPTIMAL POWER FLOW 10
Introduction, Solution of Optimal power Flow, The Gradient method, Newton's method, Theorems on the Optimization of constrained functions, Procedure for the optimizing constrained problems, power systems applications. Examples, optimal dispatch of Generation, Fuel cost minimization, Power loss minimization, Optimum power flow – adding environmental constraints.

UNIT II LINEAR PROGRAMMING 10
Mathematical model and Nomenclature in Linear programming solution techniques. Duality in Linear programming, Mixed integer programming. Power system applications. Sensitivity methods for post optimization in linear programming. Examples.

UNIT III NON-LINEAR PROGRAMMING 10
Introduction, classification of non-linear programming problems, Sensitivity methods for solving non-linear programming variables, Algorithm for quadratic optimization, Barrier method for solving non-linear programming variables, Examples.

UNIT IV INTERIOR POINT METHOD 5
Introduction, Karmarkers algorithm. The projection scaling method. Extended interior point method for linear programming problems, Extended quadratic programming using interior point method, Illustrative examples.

UNIT V UNIT COMMITMENT & DYNAMIC PROGRAMMING 10
Formulation of unit commitment, modeling in unit commitment, Priority list unit commitment schemes, Different types, unit commitment of Thermal units using dynamic programming. Characteristics of Dynamic programming, Computational economy in Dynamic programming, Illustrative examples.

TEXT BOOKS
1. James A. Momoh, Electric power system applications of Optimization

REFERENCES
1. A.J.wood & B.F.Woolenberg, Power generation operation and control, John Wiley and sons,1996
2. Hadi Saadat, Power system Analysis, WCB/ Mcgraw Hill,1999
3. Nagrath, I.J.Kothari, Modern power system Analysis, Tata Mcgraw Hill, 1998
4. K.A.Gangadhar, Electric power systems, Khanna Publishers,1998.

COORDINATION OF MULTIPLE FACTS DEVICES USING LINEAR / NON-LINEAR CONTROL TECHNIQUE

L	T	P	C
3	0	0	3

UNIT I FUZZY LOGIC 7
Fuzzy sets – Fuzzy operation – Fuzzy arithmetic – Fuzzy relational equations – Fuzzy measure – Fuzzy functions – approximate reasoning – Fuzzy proposition – Fuzzy quantifiers-if-then rules.

UNIT II FUZZY LOGIC IN CONTROL 8
Structure of Fuzzy logic controller – Fuzzification models – database – rule base – inference engine – defuzzification modules – Non-Linear fuzzy control – PID like FLC – Sliding mode FLC – Sugeno FLC – adaptive fuzzy control applications – case studies.

UNIT III NEURAL NETWORKS IN CONTROL 8
Neural Network for Non-Linear systems – schemes of Neuro control-system identification forward model and inverse model – indirect learning neural network control applications – Case studies.

UNIT IV MODELING AND CONTROL OF FACTS DEVICES NEURAL AND FUZZY TECHNIQUE 10
FACTS-concept and general system considerations, types of FACTS devices – special purpose FACTS devices, generalized and multifunctional FACTS devices – General comments on transient stability programs.Neuro – Fuzzy based FACTS controller for improvement of Transient stability systems – GA for Adaptive fuzzy system – case study.

UNIT V STABILITY STUDIES UNDER MULTIPLE FACTS ENVIRONMENT 12

Introduction to small signal analysis – simulation and modeling of FACTS controllers for small signal analysis. Comparison between dynamic and transient stability results.

Introduction to EMTP – (Electromagnetic Transient programme / Package), Modeling of FACTS controllers for power system studies using EMTP.

REFERENCES:

1. KOSKO. B. "Neural Networks and Fuzzy systems", Prentice-Hall of India Pvt.Ltd., 1994.
2. Driankov, Hellendroon, "Introduction to Fuzzy control" Narosa Publisher.
3. Ronald R.Yager and Dimitar P.Filev "Essential of fuzzy modeling and control " John Wiley & Sons, Inc.
4. Enrique Acha, Claudio R.Fuerte-Esqivel, Hugo Ambriz-Perez, Cesar Angeles- Camacho" FACTS – Modeling and simulation in Power Networks" John Wiley & Sons.
5. Kundur P., "Power system stability and control", McGraw Hill, 1994.

Faculty of Electrical Engineering **(Approved in 8th AC – 18.03.2006) ITEM NO.8.5.7**

FE1911(Old Code PS 1901) DC – DC CONVERTERS

L	T	P	C
3	0	0	3

UNIT I INTRODUCTION 9

Historical review – Multiple – Quadrant Choppers – Pump Circuits Development of DC / DC conversion Techniques – Prototypes – DC / DC Converters family.

UNIT II VOLTAGE – LIFE CONVERTERS 9

Introduction – Self-lift converters – Positive output – Negative output – Modified output Luo converters.

UNIT III SUPER –LIFT CONVERTERS 9

Introduction – Main series – Additional Series, Enhanced series, Re-Enhanced series and multiple – Enhanced Series Luo Converters – Analysis, Modeling, Design, Simulation and control of super – Lift – Converters.

UNIT IV CASCADED BOOST CONVERTERS 9

Introduction – Main series, Additional Series and Multiple Series Cascaded Boost converters – Positive and Negative output cascaded – Boost converters – Modeling – Design, simulation and control of Boost converters.

UNIT V MULTIPLE QUADRANT OPERATION 9

Introduction – converter circuits – Mode A, Mode B, Mode C and Mode C and Mode D Operation – Modeling and Simulation.

TOTAL: 45 PERIODS

TEXT BOOK:

1. Dr.Fang Lin Luo and Dr. Hong YC, "Advance DC – DC Converters", CRC Press 2004.

REFERENCES:

1. Simon S.Ang, "Power Switching Converters", Marcel Dekker, Inc. Newyork, 1995.
2. M.H.Rashid, "Power Electronics Hand Book", Ed., Academic, Gan Diego, CA, August 2001.
3. John G.Kasskian, Martin, F.Schlect, George.C.Verghese, "Principles of Power Electronics", Addison Wesley Publication, 1991.
4. Ned Mohan, Tore M.Undeland, William,P.Robbins, "Power Electronics Converters, Applications and Design", John Wiley and Son, Inc., third Edition, 2002.
5. Fang Lin Luo, "Positive Output super-Lift Converters", IEEE Transaction on power Electronics Vol.18, No.1,pp. 105 –113, January, 2003.
6. Fang Lin Luo, "Negative Output Super-Lift Converters", IEEE Transaction on Power Electronics, Vol.18, No.5. pp 1113 – 1121, September, 2003.

Faculty of Electrical Engineering **(Approved in 9th AC – 02.12.2006)** **ITEM NO. FE 9.3**

FE1912 NANO ELECTRONICS 3 0 0 3

UNIT I NANOTECHNOLOGY 9

Introduction to Nanotechnology- history & recent trends- Application of Nanotechnology to Electrical engineering- Nanotechnology advantages and various issues.

UNIT II NANOELECTRONICS DEVICES: INTRODUCTION 9

Nanoelectronics Devices: Carbon nanotube, FINFET, Quantum transport devices- RTD, Super conducting Digital Electronics, Quantum computing using super conductors- Molecular electronics – Nanoelectronics Memories- nanoelectronics interfacing systems.

UNIT III FABRICATION &DEVICE MODELLING 9

Microelectronics & Nanoelectronics Fabrication methods- issues- nanoscale device modelling, micro and macro modelling of Nanodevices.

UNIT IV SINGLE ELECTRON TECHNOLOGY 9

Single electron transistor – Principle of operation- analytic I –V model ,SET logic gates- CMOS – C-SET, Programmable SET, SET Full Adder, threshold logic- Memories- SET analog Application-sensing systems- Single electron encoded logic-Applications.

UNIT V SIMULATION 9

Simulating single electron devices & circuits- Binary , Multiple valued and mixed mode logics- SET spice modelling- MAT LAB Modelling-SET CMOS Hybrid process.

TOTAL: 45 PERIODS

REFERENCES:

1. Wasshuber. C , SIMON - Simulation of Nano Structures: Computational Single-Electronics, Springer-Verlag, 2001.
2. Rainer waser, Nanoelectronics and information technology advanced electronic materials and novel devices, 2nd corrected edition , Willy –VcH verlag GmBh-KgaH,Germany, 2005.
3. Mark A.Reed and Takhee Lee,Molecular Nanoelectronics , American scientific publisher,California, 2003.
4. Takahashi.Y, A comparative study of single-electron memories, IEEE Trans. Electron Devices, 1998, pp. 2365–2371.
5. Ken Uchida,Junj Koga, Ryuji Ohba& Akira Toriumi, Programmable SET logic for future low power intelligent LSI, IEEE transaction on electron devices, July 2003,pp.1623.

FE1914 APPLICATION OF OPTIMIZATION TECHNIQUES TO POWER SYSTEMS

L	T	P	C
3	1	0	4

UNIT I INTRODUCTION 5

Necessity of optimization in power system, Types of optimization problem, Unconstrained problems, Constrained problems.

UNIT II UNCONSTRAINED OPTIMIZATION TECHNIQUES 10

Optimality criteria – Bracketing Method, Exhaustive search method, Bounding phase method – Region elimination method, Interval halving method, Fibonacci search method, Golden section method – Point estimation method, Successive quadratic estimation method. Gradient based method, Newton method, Bisection method, Secant method, Cubic search method – Root finding using optimization techniques – Simulation of power system optimization problems.

UNIT III CONSTRAINED OPTIMIZATION TECHNIQUES 10

Mathematical model and nomenclature in linear programming – Linear programming techniques – Duality in linear programming – Mixed Integer programming – Power system applications, Classification of Non Linear programming – Lagrange multiplier method – Karush – Kuhn Tucker conditions – Reduced gradient algorithms – Quadratic programming method – Penalty and Barrier method.

UNIT IV INTERIOR POINT METHODS 10

Karmarkar's algorithm – Projection Scaling method –Dual affine algorithm – Primal affine algorithm Barrier algorithm. Extended Quadratic programming using Interior point method to Economic Dispatch problem and Optimal Power Flow problems.

UNIT V DYNAMIC PROGRAMMING 10

Formulation of Multistage decision problem – Characteristics – Concept of sub optimization and the principle of optimality – Formulation of Dynamic programming – Backward and Forward recursion – Computational procedure – Conversion of final value problem into Initial value problem.

L = 45, T = 15. TOTAL = 60 PERIODS

TEXT BOOKS:

1. Kalyanmoy Deb, "Optimization for Engineering Design" Prentice Hall of India Pvt. Ltd, New Delhi 2005.
2. Ronald L.Rardin, "Optimization in Operation Research" Pearson Education Pvt. Ltd. New Delhi, 2005.
3. D.P.Kothari and J.S.Dhillon, "Power System Optimization" Prentice Hall of India, Pvt. Ltd., New Delhi 2004.
4. S.S.Rao, "Engineering Optimization Theory and Practice" 3rd edition, New Age International Pvt. Ltd., 1998.

REFERENCES:

1. wood, A.I.Woolwnberg, B.F. "Power Generation Operation and Control" Wiley Eastern Ltd. 4th reprint, 1993.
2. D.I.Sun, B.Ashley, B.Brewer, A.Hughes and W.F> Tinney, "Optimal Power Flow by Newton Approach," IEEE Transactions on Power Apparatus and Systems, Vol-PAS 103, pp 2864 – 2880. 1984.
3. Vargas L.S.Quintana V.H.Vannelli A.; " Tutorial Description of an Interior Point Method and its Application to Security – Constrained Economic Dispatch" IEEEPES 1992 Summer Meeting.

FE1915 WIND ELECTRIC CONVERSION SYSTEM L T P C
3 0 0 3

UNIT I THE WIND RESOURSES 9

The nature and geographical variation in the wind resources – long term wind speed variation-annual and seasonal variations – synoptic and diurnal variations, Turbulence, Gust wind Speeds – Extreme wind speeds – wind speed prediction and forecasting.

UNIT II AERODYNAMICS OF WIND TURBINES 9

The actuator disc concept – rotor disc theory – vortex cylinder model of the actuator disc- rotor blade theory – breakdown of the momentum theory – blade geometry – The effect of a discrete number of blades – calculated result for an actual turbines – the aerodynamics of a wind turbine in steady yaw – The method of acceleration potential – Stall delay – Unsteady Flow – Dynamic Inflow.

UNIT III WIND TURBINE PERFORMANCE AND DESIGN LOADS FOR WIND TURBINE 9

The performance curve – constant rotational speed operation – Comparison of measured with theoretical performance – variable speed operation – estimation of energy capture - wind turbine field testing – wind turbine performance measurement – aerodynamic performance assessment – basis for design loads – Extreme loads – fatigue loading – stationary blade loading – blade loads during operation – Hub and low speed shaft loading – Nacelle loading – Tower loading.

UNIT IV CONCEPTUAL DESIGN AND COMPONENT DESIGN OF WIND TURBINE 9

Rotor diameter – machine rating – rotational speed – number of blades – Teetering – Power control – Banking system – fixed and variable speed operation – types of generators – Design concept; blades, pitch bearing, rotor hub, gear box, generator, mechanical brakes, nacelle bedplate, yah drive, tower, foundation.

UNIT V WIND TURBINE CONTROLLER AND HARMONICS 9

Function of the wind turbine controller – Closed loop control; issues and objective, general techniques, analytical design methods, Pitch actuators control system implementation - Embedded wind generation – Power quality; voltage flicker, harmonics.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Tony Burton, David Shapre, Nick Jenkins, Ervin Bossanyi, “Wind Energy Hand Book”, John Wiley and sons Inc, Dec.2001.
2. Gray L.Johnson, “Wind Energy Systems”, Prentice Hall Inc., 1985.

REFERENCES:

1. Daniel, Hunt V, “Wind Power – A Handbook of WECS”, Van Nostrend Co., New York, 1981.
2. Freris L.L., “Wind Energy Conversion”, Prentice Hall (UK) Ltd.
3. Intelligent control of a class of wind energy conversion systems” – Chedid, R,Mrad, F,Basma, M,IEEE Transactions on Energy Conversion, Volume 14, Issue 4, Dec.1999 Page(s): 1597 – 1604.
4. Robust digital control of a wind turbine for rated – speed and variable – power operation regime” Camblong, H., Tapia, G,Rodriguez, M, IEE Proceedings – Control theory and application Volume 153, Issue I, 16 Jan.2006 Page(s): 81 – 91.

FE1916 MODELLING AND SIMULATION OF FACTS DEVICES **L T P C**
3 1 0 4

UNIT I INTRODUCTION 9
Basic concepts of FACTS controller – Unified power flow concept – Implementation of Unified Power Flow Controller – Matlab Simulation of UPFC Characteristics.

UNIT II STATCOM 9
Objectives of shunt compensation –mid – point voltage regulation – Voltage instability preventation – improvement of transient stability – power oscillation damping – control and implementation using Fuzzy and Neuro controller.

UNIT III SSSC 9
Concepts of series capacitive compensation – improvement of transient stability – power oscillation damping – model, control and implementation using fuzzy and Neuro controller.

UNIT IV MODELLING OF UPFC 9
Philips heffron model – power injection model – power frequency model – steady state and dynamic model – simulation analysis using Matlab and Pscad.

UNIT V CONROL AND IMPLEMENTATION OF UPFC 9
Modified decouple watt – var control – Radial basis control – Non-linear control – Real and Reactive Power coordination control – Comparative control analysis through PI, Fuzzy and Neuro controllers.

TOTAL: 60 PERIODS

REFERENCES:

1. N.G. Hingorani and L.Guygi " Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems, IEEE Press Publication, Newyork, 2000.
2. Mohan Mathur.R. Rajiv. K.Varma, "Thyristor – Based Facts Controllers for Electrical Transission Systems", IEEE press and John Wiley & Sons, Inc, 2002.
3. K.K.Sen and E.J.Stacey, "UPEC – Unified power flow controller: Theory, modeling, and application," IEEE Trans. Power Delivery, Vol.13, pp.1453-1460, Oct.1999.
4. P.K.Dash. S.Mishra, and G.Panda, "A radial basis function neural network controller for UPFC," IEEE Trans. Power Sys., vol. 15, pp.1293-1299, Now.2000.
5. I.Papic, P.Zunko, and D.Povh, "Basic control of unified power flow conroller," IEEE Trans. Power Syst. Vol.12, pp.1734-1739, Nov.1997.
6. K.S.Smith. L.Ran. and J.Penman, :Dynamic modeling of a unified power flow controller," IEE Proceedings Generation Transmission Distribution, Vol.144, No.1, p.2 – 12, January 1997.

FE1917 POWER SYSTEM DEREGULATION **L T P C**
3 0 0 3

UNIT I INTRODUCTION 9
Introduction – Deregulation – Different entities in Deregulated Electric markets – Background to deregulation and the current situation around the world – Benefits from competitive electricity market – After – effects of Deregulation – Review of Economic Load dispatch problem (ELD) – Recent development in ELD.

UNIT II MODELING 9

Optimal power flow (OPF) as a basic tool – OPF model, examples – characteristic features of OPF – Unit commitment (UC) – basic model, additional issues – Formation of power pools – The Energy Brokerage system.

UNIT III STRUCTURE OF DEREGULATED MARKET 9

Role of the independent system operator (ISO) – structure of UK and Nordic electricity sector deregulation – Operational planning activities of ISO – ISO in pool and bilateral markets – Operational planning activities of a Genco – Genco in pool and bilateral markets, Market participation issues – UC in Deregulated environment – Competitive bidding.

UNIT IV CONCEPT OF WHEELING 9

Power wheeling – Transmission open access – types of transmission services in open access – Cost components in transmission – Pricing of power transactions, and embedded cost based transmission pricing, incremental cost based transmission based transmission pricing – transmission open access and pricing mechanisms in various countries – United kingdom, Chile and Sweden.

UNIT V CONGESTION MANAGEMNET 9

Developments in international transmission pricing in Europe – security management in deregulated environment, scheduling of spinning reserves, interruptible load options for security management – Congestion management in deregulation, economic instruments for handling congestion.

TOTAL: 45 PERIODS

TEXT BOOK :

1. Kankar Bhattacharya, Math H.J.Bollen, Jaap E.Daader, Operation of restructured power systems, Kluwer academic publishers, USA, first Edition, 2001.

REFERENCES:

1. G.Zaccour, Deregulation of Electric utilities, Kluwar Academic Publisher, 1998.
2. Marjia Ilic, Francisco Galiana and Lester fink, Power systems restructuring engineering and economics, Kulwer academic Publishers, 1998.
3. A.J.Wood and B.F.Woolenberg, Power Generation, Operation and Control, John Wiley and sons, 1996

Faculty of Electrical Engineering (Approved in 10th AC 09.06.2007) **ITEM NO. FE 10.3(v)**

FE1918 NETWORK SYSTEM DESIGN USING NETWORK PROCESSORS 3 0 0 3

UNIT I REVIEW OF PROTOCOLS AND PACKET FORMATS

Introduction and Overview of Network Systems Engineering, Basic Terminology, Review of Protocols and Packet Formats.

UNIT II TRADITIONAL PROTOCOL PROCESSING SYSTEMS

Traditional Protocol Processing, Conventional Computer architecture, Basic Packet Processing Packet Processing functions, Protocol software on a Conventional Processor, Hardware architecture for Protocol Processing, Classification and Forwarding, Switching Fabrics.

UNIT III NETWORK PROCESSOR TECHNOLOGY

Network Processor; Motivation and purpose, Complexity of Network Processor Design, Network Processor Architecture, Issues in scaling a network Processor, Commercial Network Processor, Languages used for Classification, Design Tradeoffs and consequences.

UNIT IV NETWORK PROCESSORS

Overview of Intel Network Processor, Embedded RISC Processor, Packet Processing hardware, Reference System and Software Development Kit.

UNIT V PROGRAMMING MODELS

ACE. ACE Run – Time Structure and Strong ARM Facilities, Micro Engine Programming – I and II, Intel Second generation Processors.

TOTAL: 45 PERIODS

TEXT BOOK:

1. Douglas E. Comer, "Network System Design using Network Processor" Intel IXP version, Pearson Edition, 2003.

REFERENCES:

1. Franklin, mark. A, "Network Processor Design" Eleseiver PublicationsIntel IXP 2800
2. Network Processor Hardware Reference Manual", November 2003.

Faculty of Electrical Engineering **(Approved in 10th AC 09.06.2007) ITEM NO. FE 10.3(vi)**

FE1919 SMART SENSORS: ANALYSIS AND COMPENSATION 3 0 0 3

UNIT I ANALYSIS OF TRANSDUCERS AND ACTUATORS (9)

Characteristics and analysis of I and II order Transducers, Study of Electrical, Thermal, Mechanical and Magnetic Transducers and Electromagnetic Actuators.

UNIT II SENSOR COMPENSATION TECHNIQUES (9)

Software Techniques, Digital adaptive techniques, Analog adaptive techniques, and Kalman filtering.

UNIT III FAULT DETECTION AND ISOLATION (12)

Fault detection and localization using Decorrelation Matrix, Fault reconstruction form sensor and actuator failures, Covariance based Hardware selection, Observer architecture for failure detection and isolation.

UNIT IV BUSES AND SENSOR NETWORKS (6)

Smart Transducer Interface Module, Network Capable Application Processor, Transducer Electronic Data Sheet, IEEE 1451 Standards.

UNIT V ANALOG AND DIGITAL IMPLEMENTATION CASE STUDIES (9)

Application of analog adaptive filters of Dynamic Sensor Compensation, A 19 channel d.c. SQUID Magnetometer for Brain Research, Development of MOEMS Sun Sensor for Space Applications, Improvement of Sensory Information using Multi-Sensor and Model Based Sensor Systems, A Smart Thermal Environment Based on IEEE 1451.2 Standard for Global Networking.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. J.E. Brignell and N.M.White, " Intelligent Sensor Systems", London, U.K.; Institute of Physics, 1994.
2. Seippel Rober G, " Transducers, Sensors and Detectors", Reston Publishing Co., 1983.
3. Julian W.Gardner, Vijay K.Varadan, Osama O.Awadelkarim, "Microsensors, MEMS and Smart Devices", John Wiley sons, 2001.
4. Dr.S.Renganathan, "Transducer Engineering", Allied Publishers Ltd. May 1999.

Faculty of Electrical Engineering **(Approved in 10th AC 09.06.2007)** **ITEM NO. FE 10.3(vii)**

FE 1920 DISTRIBUTED ALGORITHMS 3 0 0 3

UNIT I SYNCHRONOUS NETWORK ALGORITHM

Introduction, Synchronous Network Model, Leader Election in Synchronous ring, Algorithms in general Synchronous Networks, Distributed Consensus with link failures Process failure, More Consensus problems.

UNIT II ASYNCHRONOUS ALGORITHMS

Asynchronous System Model, Asynchronous Shared Memory Model, Mutual Exclusion, Resource Allocation, Consensus, Atomic Objects.

UNIT III ASYNCHRONOUS NETWORK ALGORITHMS

Asynchronous Network Model, Basic Asynchronous Network Algorithms, Synchronizers, Shared Memory Vs Networks, Logical time.

UNIT IV RESOURCE ALLOCATION AND FAILURES

Global Snapshots and stable Properties, Network Resource Allocation, Asynchronous Networks with Process Failures, Data Link Protocols.

UNIT V PARTIALLY SYNCHRONOUS ALGORITHMS

Partially Synchronous System Models, Mutual Exclusion with Partial Synchrony,
Consensus with Partial Synchrony.

TEXT BOOK:

1. Nancy A. Lynch, "Distributed Algorithms" Morgan Kalyman Publishers, USA, 2005.

REFERENCES:

1. Bourkerche, Azzedine, "Handbook of Algorithms for wireless networking and Mobile Computing" CRC Press.

FE 1921 SUPPORT VECTOR MACHINE 3 0 0 3

UNIT I LEARNING AND SOFT COMPUTING
Examples of Applications in Diverse Fields – Basic Tools of Soft Computing: Neural Networks, Fuzzy Logic Systems, and Support Vector Machines – Basic Mathematics of Soft Computing – Learning and Statistical Approaches to Regression and Classification.

UNIT II GENERALIZATION AND OPTIMIZATION THEORY
Learning from examples and generalization – statistical learning theory – Empirical Risk minimization – key theorem – VC Dimension – Structural Risk Minimization.

UNIT III SUPPORT VECTOR MACHINE
Introduction – Optimal Hyper plane for linearly Separable Classes – Optimal Hyper plane for nearly non separable Classes – Kernel trick and Mercer Condition – Non linear SVM classifier.

UNIT IV KERNEL INDUCED FEATURE SPACE
Learning in Feature Space – The Imlicit Mapping into Feature Space – Making Kernels Kernels and Gaussian Processes – PCA.

UNIT V APPLICATION OF SVM
Principles of pattern Recognition – Support Vector machine for Pattern Recognition – Non linear Regression – Identification of processes using SVM – Fault diagnosis Using SVM – Modeling and Control, using Hybrid Intelligent Systems.

TOTAL: 45 PERIODS

TEXT BOOKS:
1. Nello Cristianini and John Shave – Taylor, An introduction to support vector machines and other kernel based learning methods, Springer.
2. Vladmir N. Vapnik, the Nature of statistical learning theory, 2nd Edition, Springer, 2000.
3. Bernhard Schlkopf, Alexander J.Smola, Learning with Kermels: Support Vector Machines, Regularization, Optimization and Beyond (Adaptive Computation and Machine Learning), Springer.
4. Vojislav Keeman, Learning and Soft Computing: Support Vector Machines, Neural Networks and Fuzzy Logic Models, Springer.

REFERENCES:
1. T.Hastie, R.Tibshirani, Friedman, The Elements of Statistical Learning, Springer.
2. Satish Kumar, Neural Network – A classroom approach, Tata McGraw Hill, 2004.
3. Simon Haykin, Neural Networks A comprehensive Foundation, 2nd Edition, Prentice Hall of India.
4. Richard O.Duda, Peter E.Hart and David G.Stork, Pattern Classification, 2nd Edition, Wiley Publication.

FE 1922 INTERVAL SYSTEM ANALYSIS 3 0 0 3

UNIT I

Basic properties of interval arithmetic: Motivation: Intervals: Rounded interval arithmetic" interval vectors and arithmetic expressions: Algebraic properties of interval: operations: Rules of Mid-point, radius and absolute value: distance and topology.

UNIT II

Enclosures for the range of function : Analysis of interval evaluation: inclusions algebras and recursive differentiation: The mean value form and other centered forms: interpolation forms.

UNIT III

Matrices and sub linear mappings: Basic facts: Norms and spectral radius: Distance and topology : Linear interval equations: sub linear mappings: M-Matrices and inverse positive matrices: H-Matrices.

UNIT IV

The solution of square linear systems of equations preconditioning: Krawezk's Method and quadratic approximation: interval Gasuss – Siedal interation: Linear fixed point equations: interval Gauss elimination.

UNIT V

Nonlinear systems of equations Existence and uniqueness: Interval interation: Set-Velued functions: Zeros of continuous functions: Local analysis of parameter dependent nonlinear systems: Global Problems Hull Computations.

TOTAL: 45 PERIODS

REFERENCES:

1. Ramon, E.Moore "Methods and applications of interval analysis" SIAM, Phildelphia, 1979.
2. Arnolod Neumaier "Interval methods for systems of equations" Cambridge University Press, 1st Edition, 1990.
3. Luc., Jaulin,Michel et.al,"applied interval analysis" Springer Verlag, Dec 2001.

FE1923 LOSS ALLOCATION IN A DEREGULATED POWER SYSTEM 3 0 0 3

UNIT I INTRODUCTION TO DEREGULATED POWER SYSTEM 8

Traditional organizational structure – Competitive organizational structure – Service unbundling – Power Exchange & Independent System Operator – Pool & Bilateral Market – Trading Entities – Transaction Networks – Classification of operation tasks in today's power industry – Meeting demand in the new industry – Primary electricity market – Contract specification – Spot Market – Sport market clearing process – Ex – post & Ex-ante electricity pricing.

UNIT II BILATERAL TRANSACTION 8

Transaction matrix – Frame work for analysis for power transaction – Load flow equation in terms of transaction matrices – Usage – based transmission flow pricing – Combined bilateral and pool dispatch with and without independent transmission flow pricing – Loss allocation with contracts – Incremental loss allocation formulae – Exact solution of the loss allocation formulae.

UNIT III TRANSMISSION LOSS ALLOCATION & ECONOMIC POWER SYSTEM OPERATION 12

Transmission Loss in power system operation – Transmission loss calculation from load flow analysis – Transmission loss expression Approximate loss formula – Economic power flow solutions Characteristics of loss allocation – Pro rata method – Pro rata method based on current and power injection – Incremental loss allocation method – Z-bus loss allocation method – Algorithm and characteristics of loss allocation methods – Comparison of loss allocation methods.

UNIT IV LOSS ALLOCATION IN BILATERAL MARKET 7

Transaction matrix – Loss allocation using pro rata method – Loss allocation using modified pro rata – Loss allocation by incremental transmission loss method – Time verification of contracts – Negative loss allocation and path dependence.

UNIT V LOSS ALLOCATION IN A COMBINED POWER POOL AND BILATERAL MARKET USING ANN 10

Incremental load flow approach – Real & reactive power loss allocation using incremental load flow approach – Back propagation algorithm – learning – weight update formula – Enhancement of convergence speed – optimum hidden neuron – Loss allocation with line failure – Transmission line outage – Inclusion of transmission line outage in loss allocation – Selection and grouping of line status to be used as inputs – case study.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Marija Ilic, Francisco Galiana, Lester Fink, "Power System Restructuring Engineering & Economics', Kluwer Academic Publishers, New Delhi 1198.
2. D.P.Kothari, J.S.Dhillon, 'Power System Optimization', Prentice Hall of India, 2003.
3. A.J.Conejo, J.M.Arroyo, N.Alguacil, A.L.Guijarro, "Transmission Loss Allocation: A Comparison Of Different Practical Algorithms", IEEE Trans. On Power Systems, Vol.17,no.3, pp.571-576, Aug.2002.
4. Francisco D.Galiana, Antonio J.Conejo, Ivana Kockar, "Incremental Transmission Loss Allocation Under Pool Dispatch", IEEE Trans. On Power Systems, Vol.17, no.1, pp.26-33, Feb.2002.
5. Antonio J.Conejo, D.Galiana, Ivana Kockar, "Z-Bus Loss Allocation", IEEE Trans, On Power Systems, Vol.16, no.1, pp.105-110, Feb.2001.

6. Francisco D.Galiana, Mark Phelan, “Allocation of Transmission Losses to Bilateral Contracts in a Competitive Environment”, IEEE Trans. On Power Systems, Vol.15, no.1, pp.143-150, Feb. 2000.

REFERENCES:

1. Rezaul Haque, N.Chowdhury, “An Artificial Neural Network Based Transmission Losses Allocation For Bilateral Contracts”, IEEE CCECE /CCGEL,pp.2203-2207,May.2005.
2. P.Cuervo Franco, F.D.Galiana, “ Transmission Loss Allocation Under Combined Pool And Bilateral Operation”, Revista Controle & Automacao, Vol14, no.3, pp.272-277, Julho, Agosto e Setembro.2003.

Faculty of Electrical Engineering **(Approved in 11th AC 05.01.2008) ITEM NO. FE 11.04(2)**

FE1924 INTRODUCTION TO NONLINEAR SYSTEMS 3 0 0 3

UNIT I INTRODUCTION TO NONLINEAR CONTROL 9

Nonlinear systems, Examples of nonlinear dynamics, Simple examples of nonlinear control, Basic notions of Euclidean and topological spaces, Illustrative examples.

UNIT II STABILITY OF NONLINEAR SYSTEMS 9

Definition of Stability, Lyapunov’s stability theorem, The Invariance Principle, Nonautonomous Systems and their Stability, Application examples.

UNIT III DIFFERENTIABLE MANIFOLDS – LOCAL THEORY 9

Differentiability Classes, Tangent Vectors, Smooth Maps and Their Differentials – Diffeomorphisms, Applications in Control.

UNIT IV INTRODUCTION TO FEEDBACK LINEARIZATION 9

Smooth Vector Fields, Input – Output Linearization, Relative DegreeNormal Form Zero Dynamics, Control examples.

UNIT V CONTROLLABILITY OF NONLINEAR SYSTEMS 9

Definition of a distribution, Lie brackets, Involutive distributions, Accessibility Applications in Control.

TOTAL: 45 PERIODS

REFERENCES:

1. Hassan K Khalil, Nonlinear Systems, Prentice Hall, 2002, Third Edition, 2002 ISBN 0-13-067389-7.
2. Henk Nimeijer, Nonlinear Dynamical Control Systems, Springer Verlag, New York, 1990
3. Alberto Isidori, Nonlinear Control Systems (3rd edition), Springer Verlag 1995.
4. http://www.nd.edu/~lemmon/courses/ee580/
5. http://www.control.aau.dk/~raf/NonLinear/Nonlinear.htm
6. http://www.control.aau.dk/~raf/NonLinear/JakubezykRespondek.pdf

FE1925 SERVICE ORIENTED ARCHITECTURE **L T P C**
3 0 0 3

UNIT I SOA FUNDAMENTALS 9
Entities – characteristics – development – life cycle and design – verification and validation.

UNIT II WEB SERVICES 9
Introduction – Web Services Implementation – Development – Benefits and standards.

UNIT III STANDARDS AND DIFFERENT MODELS 9
XML – XSD – Namespaces – SOAP – WSDL – UDDI – Soap messaging – processing models – describing web services – functional characteristics – developing web services – registries.

UNIT IV JAVA IMPLEMENTATION STANDARDS AND TOOLS 9
Java Based distributed applications - JAXB – JAXRPC – JAXR – JAXM – other distributed models (composition with web services) – RPC – CORBA – RMI – DCOM etc.

UNIT V APPLICATIONS AND PRACTICAL CONSIDERATIONS 9
Security – performance – transaction management – web services management – interoperability and WSI – dynamic web services – scalability and other standard BPEL.

TOTAL: 45 PERIODS

REFERENCES:
1. Newcomer, Lomow, " Understanding SOA with Web Services", Pearson Educaion, 2005.
2. Sandeep Chatterjee, James Webber, "Developing Enterprise Web Services, An Architect's Guide", Pearson Education, 2005.
3. Dan Woods and Thomas Mattern, "Enterprise SOA Designing IT for Business Innovation" O' REILLY, First Edition, 2006.

FE1926 MODELS AND MEASUREMENTS IN BIOMECHANICS **L T P C**
3 0 0 3

UNIT I INTRODUCTION TO BIOMECHANICS
Introduction to mechanics in medicine - stress, shear and strain, principal stresses and transformations, loading modes, shear rate, Newtonian and non- Newtonian laws - viscosity, viscoelasticity - biosolid and biofluid mechanics, composition and microstructure of blood vessels, mechanical properties of soft tissues.

UNIT II MATHEMATICAL MODELS IN BIOMECHANICS 12
Constitutive models and development of constitutive equations; pseudo elastic, randomly elastic, poroelastic and viscoelastic models, representation of the pseudo elastic stress – strain relationship, numerical models in biomechanics - generalized stochastic models.

UNIT III COMPUTATIONAL METHODS IN BIOMECHANICS 9
Models of structure and deformations, single layer and multi layer models, strain energy function - image based morphological modeling - measurement based physiological modeling - patient specific computational mechanical modeling.

UNIT IV INSTRUMENTATION IN BIOMECHANICS 9

Ultrasound imaging technique in biomechanics; instrument design, application in blood vessel structure and functions - MRI in biomechanics, 3D visualization - instrumentation in cardiovascular biomechanics.

UNIT V Experimental Biomechanics 9

Evaluation of structural and functional properties of bone - micro tensile tester for stress relaxation test - experimental investigation on the dynamics of vessel and vessel wall.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. J. D. Humphrey, S.L. Delange, 'An Introduction to Biomechanics, Solids and Fluids, Analysis and Design', Springer- Verlag, 2004, New York.
2. Y.C.Fung, 'Biomechanics, Mechanical Properties of Living Tissues', Springer- Verlag, 1993, New York, 2nd edition.

REFERENCES:

1. G.A. Holzapfel and R.W. Ogden (eds.), 'Biomechanics of Soft Tissue in Cardiovascular Systems', Springer – Verlag, 2003.
2. H.An.Yueheuei and R.A. Draughn (eds.), 'Mechanical testing of bone and the Bone – Implant interface', CRC Press, Boca Raton, 2000.
3. R.P. Vito and S.A. Dixon, 'Blood vessel constitutive models – 1995 – 2002', Annual review on Biomedical Engineering, 413 – 439, 2003.
4. G.A. Holzapfel and T.C. Gasser, 'A new constitutive framework for arterial wall mechanics and a comparative study of material models', Journal of Elasticity, 1-48, 2000.
5. R.C.P. Kerckhoffs, S.N. Healy, T.P. Usyk and A.D. McCulloch, 'Computational methods for cardio electromechanics', Proceedings of the IEEE, 769 – 783, 2006.

Faculty of Electrical Engineering **(Approved in 11th AC 05.01.2008) ITEM NO. FE 11.04(5)**

FE1927 MODEL PREDICTIVE CONTROL 3 0 0 3

UNIT I

Model Predictive Control - Introduction Model Predictive Control strategy – model predictive control elements – prediction model process model – objective function – control law – state space formulation.

UNIT II

Model predictive control schemesDynamic matrix control – model algorithmic control – predictive functional control -Formulation of generalized model predictive control – closed loops relationships.

UNIT III

Non-linear model predictive controlNon-Linear model predictive control Vs Linear model predictive control – Non-linear models – solution of non-linear model predictive control problem – techniques for non-linear model predictive control – stability of non-linear model predictive control.

UNIT IV
Methods for implementing model predictive control Model predictive control and multiparametric programming – implementation of model predictive control for uncertain systems – closed loop min-max model predictive control implementation of model predictive control and dead time consideration.

UNIT V
Case Study Model predictive control on a chip – FPGA implementation of MPC – FPGA implementation of MPC for a petrochemical process.

TOTAL: 45 PERIODS

REFERENCES:

1. Model Predictive Control, E.F.Camacho and C.Bordons, Springer, 2nd Edition, 2004.
2. A FPGA Implementation of Model Predictive Control, K.V.Ling, et.al.
3. Model Predictive Control: Theory and Practice – A Survey, Carlos E.Garcia et. al.

Faculty of Electrical Engineering **(Approved in 11th AC 05.01.2008) ITEM NO. FE 11.04(6)**

FE1928 REINFORCEMENT LEARNING 3 0 0 3

UNIT I Reinforcement Learning Introduction and Learning Problem
Introduction, elements of reinforcement learning, history, evaluative feedback, Rewards and returns, Markov Decision Processes, Value functions, optimality and approximation

UNIT II Dynamic Programming
Value iteration, policy iteration, asynchronous DP, generalized policy iteration, Monte-Carlo methods: policy evaluation, roll outs, on policy and off policy learning, importance sampling

UNIT III Temporal Difference learning
TD prediction, Optimality of TD(0), SARSA, Q-learning, R-learning, Games and after states Eligibility traces: n-step TD prediction, TD(lambda), forward and backward views, Q(lambda), SARSA(lambda), replacing traces and accumulating traces.

UNIT IV Function Approximation
Value prediction, gradient descent methods, linear function approximation, ANN based function approximation, lazy learning, instability issues
Policy Gradient methods: non-associative learning - reinforce algorithm, exact gradient methods, estimating gradients, approximate policy gradient algorithms, actor-critic methods

UNIT V Planning and Learning
Model based learning and planning, prioritized sweeping, heuristic search, trajectory sampling. Case studies: Elevator dispatching, Samuel's checker player, TD-gammon, Acrobot

TOTAL: 45 PERIODS

REFERENCES:

1. Reinforcement Learning - An Introduction. Richard S. Sutton and Andrew G. Barto. The MIT Press Cambridge, Massachusetts London, England
2. Neuro-dynamic programming. Dimitri P. Bertsikas and John N. Tsitsiklis.
3. Learning Automata - An Introduction. Kumpati S. Narendra and M. A. L. Thathachar. Prentice-Hall, Inc 1989

FE1929 MODELLING AND SIMULATION OF WIND ENERGY CONVERSION SYSTEMS

UNIT I : Introduction 5

Components of WECS – Major WECS schemes – Power obtained from wind – simple momentum theory – Sabinin's theory – with velocity components at blade element.

UNIT II : Wind turbines 10

Fixed speed – variable sped WT-HAWT – VAWT – Power developed – thrust – efficiency – rotor selection – rotor design considerations – No of blades – Blade profile – power regulation – yaw system – blade angle control – pitch angle control – Drop offset control – position speed estimation – filed weakening – modeling of Wind turbines for Power system studies.

UNIT III : Special Machines for WECS 10

Qualitative analysis of SFFIG – DFIG- BLDC machines PMSG : Airgap field distribution, emf – losses – circuit model – circuit model with AC & DC load – Autonomous PMSGs with Controlled Constant Speed and AC Load – Grid - Connected Variable – Sped PHSG System – Super – high speed PM generators – Testing of PMSG

UNIT IV : Modelling of PMSG 10

Traditional dq0 model – Embedded phase domain model for real time simulation –Model including magnetic saturation – Dynamic model including losses.

UNIT V : Grid Interconnection 10

Grid Interconnection Issues – Cost benefits – Grid side controllers – WECS in various countries – Simulation of PMSG based WEC.

REFERENCES

1. Ion Boldea, "Varible speed generators", Taylor & Francis group.
2. E.W.Golding "The generation of Electricity by wind power", Redwood burn Ltd., Trobridge, 1976.
3. L.L.Freis "Wind Energy conversion Systems", prentice hall, 1990.
4. S.Heir "Grid Integraton of WECS", Wiley 1998.
5. A.B.Dehkordi, A.M.Gole and T.L.Maguire "Permanent Magnet Synchronous Machine model for Real – time Simulation", IPST" 05 in Montreal, Canada on june 19-23, 2005.
6. Eleanor Denny and Mark O'Malley, "Quantifying th totl benefits of Grid Integrated Wind", IEEE Transactions on Power System, Vol.22, No.2, May 2007, pp 605-615.
7. Tomas Petru and Torbjorn Thiringer, "Modelling of Wind Turbines for Power System Studies", IEEE Transactions on Power Systems, Vol.17, No.4, November 2002, pp1132-1139.
8. Seul – Ki Kim and Eung – Sang Kim, "PSCAD / EMTDC – Based Modling and Analysis of a Gearless Variable speed Wind Turbine", IEEE Transactions on Energy Conversion, Vol.22, No.2, June 2007, pp 421 – 430.

FE1930 DESIGN OF ELECTRICAL MACHINES – ELECTROMAGNATIC APPROACH

UNIT I INTRODUCTION

Introduction – finite element methods – field problems with boundary conditions – classical method for the field problem Solution – Galerkin's method – rayleigh – ritz's method – application of finite element method to two dimensional fields – variational method – different boundary conditions.

UNIT II METHODS OF FIELD COMPUTATION

Computational Methods – Finite element model for electrical machines – equations for magnetic field and windings – transient time steeping simulation – direct coupling of field and circuit equations – coupling by the current output approach – circuit parameter approach.

UNIT III THERMAL ANALYSIS OF ELECTRICAL MACHINES

Recent advancement in thermal design of electric motors – Cylindrical magnetic devices – analytical study of the magnetic device – computation of the magnetic quantities – calculation of losses – eddy current analysis – determination of connection coefficient using CFD – temperature rise calculation.

UNIT IV FEA OF SYNCHRONOUS MACHINE

Finite element analysis of synchronous generator – computation of the no – load characteristic – computations after field solutions – flux linkage – induced emf – computation of direct axis inductance – solved structure – L_d by means of the magnetic energy – flux linkage – air gap flux density – computation of the quadracture axis inductance – saturation effect L_d and L_q with any current – computation of machine characteristics.

UNIT V MODELING OF MACHINES

Simulation – modeling of synchronous generator – circuit model – finite element model- commercial packages – magnetic energy and co-energy – apparent inductance and differential inductance – mechanical forces – electromagnetic forces.

REFERENCES:

1. Electrical Machine analysis using finite elements – Nicola Bianchi, T & F informa CRS press Boca Raton.NW, Suite 300 Reprint 2005.
2. Fields and Circuits in electrical Machines – N.Kesavamurthy and R.E.Bedford, Thacker Spink & Co. PVT LTD. 1993.
3. The analytical and Numercial solution of Electric and Magnetic Fields – K.J.Binns, P.Lawrenson, John Wiely & Sons, 1993.
4. An introduction to the Finite Element Method - J.N.Reddy, Tata McGraw – Hill publishing company Limited New Delhi Third Edition, 2005.

Faculty of Electrical Engineering (Approved in 12th AC 19.04.2008)

FE 1931 APPLICATION OF INTELLIGENT CONTROLLERS FOR POWER QUALITY IMPROVEMENT **3 0 0 3**

1. INTRODUCTION **9**

Control of Power Converters: Single Phase Inverter-Three Phase Inverter- Switching of Power Converters-High Voltage Inverters - Inverters for High Power and Voltage: Multi-Step / Multilevel / Chain Inverter. Open - Loop Voltage Control, Closed- Loop Switching Control, Second and Higher Order Systems. Classification of Electrical disturbances affects in power Quality.

2. INTRODUCTION TO CUSTOM POWER DEVICES 9

DSTATCOM Structure, DSTATCOM in Voltage control mode: State/ Output feed back control. DVR Structure: State/ Output Feed back Control. UPQC –Structure and Control of Right - Shunt /Left - Shunt UPQC.

3. SOLID STATE LIMITING, BREAKING AND TRANSFERRING DEVICES 9

Solid State Current Limiter (SSCL) - Current Limiter Topology, Operating principle. Solid State Breaker (SSB) - Issues in limiting and switching operations – Solid State Transfer Switch (SSTS) - Sag/Swell Detection algorithms: Algorithm based on Symmetrical Components/ Two- axis Transformation/ Instantaneous Symmetrical Components.

4. MODELLING AND SIMULATION TECHNIQUES FOR HARMONIC FILTERS 9

Real time – Digital time varying harmonic modeling and simulation techniques: Introduction – OFF LINE Harmonic modeling and simulation techniques-wave digital filters – discrete wavelet transform.

Design of discrete value passive filters: Introduction-Sequential approximation method – Optimal filter design problem using ANN - Examples – Results.

5. NEURO-FUZZY CONTROLLER FOR STATCOM 9

Introduction – adaptive critic designs – bench mark power system – ACD Neuro-fuzzy controller structure-controller Training – simulation results – Practical considerations.

TOTAL = 45PERIODS

TEXT BOOKS:

1. Arindam Ghosh, "Power Quality Enhancement Using Custom Power Devices", Kluwer Academic Publishers, Boston, 2002.
2. K. R. Padiyar, "FACTS Controllers in Power Transmission and Distribution",New Age International (P) Limited, Publishers, New Delhi, 2007.

REFERENCES

1. Inigo Monedero et.al., "Classification of Electrical Disturbances in real time using Neural Networks" IEEE Transactions on Power Delivery, Vol. 22, No.3, Pg. 1288-1295, July 2007.
2. Lof-Fu Pak et.al., "Real time digital time varying harmonic modeling and Simulation techniques" IEEE Transactions on Power Delivery, Vol.22, No.2, Pg. 1218-1227, April 2007.
3. Ying-Pin Chang et.al., "Optimal design of discrete value passive harmonic filters using sequential neural network approximation and orthogonal array" IEEE Transactions on Power Delivery, Vol.22, No.3, Pg.1813-1819, July 2007.
4. Salman Mohagheghi et.al, "Optimal Neuro-Fuzzy external controller for a STATCOM in the 12-Bus Benchmark Power system" IEEE Transactions on Power Delivery, Vol.22, No.4, Pg. 2548-2557, October 2007.

FE 1932 FAULT DIAGNOSIS IN ELECTRICAL MACHINES 3 0 0 3

UNIT I 9

Technology trends in fault diagnosis of Electrical Machines - a) Transformers b) Electrical machines - State Estimation methods for Electrical Machines modeling Simulation studies of transients in Electrical Machines (PSPICE, MATLAB).

UNIT II 9

Occurrence of faults in transformer and machines due to aging - Types of faults in transformer – insulation breakdown-winding breakdown - Types of faults in Machines – insulation, winding and mechanical breakdown.

UNIT III 9

Condition monitoring of Electrical machines - Acoustic monitoring of Core - Vibrations in Transformers and Bearing Noise in Machines - Study of faults in Inverter-fed Machines.

UNIT IV 9

Fourier transform and Wavelet Transforms for fault diagnosis - Model based prediction theory applied to fault detection in Electrical Machines - Discrete Event Systems approach for fault detection - Markov models for Fault diagnosis.

UNIT V 9

Behavior-Modulation Techniques for fault detection - Pattern Recognition applied to fault detection - Application of Artificial Intelligence tools like Fuzzy Logic, Neural Networks for fault diagnosis in Electrical Machines.

TOTAL: 45 PERIODS

REFERENCES:

1. Ronald N. Bracewell, “The Fourier Transform and its applications”, third edition, McGraw Hill,2000
2. Stephane Mallat, “A wavelet tour of signal processing”, second edition, Academic press, 1999.
3. Simon Haykin, “Neural Networks – A comprehensive foundation”, second edition, Pearson Education, 2001.
4. Timothy J. Ross, “Fuzzy logic with engineering applications”, second edition, John Wiley & sons Ltd, 2004.
5. John R. Jensen, “Introductory digital image processing – A remote sensing perspective”, second edition, Prentice Hall.
6. Anil K. Jain, “Fundamentals of Digital Image Processing”, Pearson Education,2003
7. BHEL, “Transformers”, second edition, Tata McGraw Hill, 2003
8. Irving L. Kosow, “Electric machinery and transformers”, second edition, Prentice Hall, 2007.
9. Anthanasios Papoulis, “Probability, Random Variables and Stochastic processes”, second edition, Tata McGraw Hill.

FE 1933 OPTIMIZATION TECHNIQUES FOR POWER SYSTEM RESTORATION 3 0 0 3

1. INTRODUCTION 06
Necessity of optimization in power system, Types of optimization problem, Unconstrained problems, Constrained problems.

2. UNCONSTRAINED OPTIMIZATION TECHNIQUES 10
Optimality criteria- Exhaustive search method, Bounding phase method – Region elimination method. Fibonacci search method, Golden section method – Point estimation method. Gradient based method. Newton method, Bisection method, Cubic search method – Root finding using optimization techniques.

3. CONSTRAINED OPTIMIZATION TECHNIQUES 10
Linear programming models- Mathematical formulation – Graphical solution of linear programming models- Simplex method – Artificial variable Techniques – Variants of Simplex method – Two phase and BigM techniques – Duality – dual simplex method.

4. NON LINEAR AND DYNAMIC PROGRAMMING 10
Non-linear programming – kuhn Tucker conditions. Dynamic programming- Formulation of dynamic Programming- Forward and Backward recursive equations.

5. CASE STUDY 09
Application of optimization techniques to power system restoration C.P.M and P.E.R.T for Project scheduling

TOTAL : 45 PERIODS

TEXT BOOKS
1.Kalyanmoy Deb. "Optimization for Engineering Design" Prentice Hall of India, Pvt Ltd., New Delhi 2005.
2.Hamdy A Taha, " An Introduction to Operations Research, Prentice Hall, Sixth Edition,2000.

REFERENCES
1.Ronald L. Randin, "Optimization in Operations Research", Pearson Education Pvt Ltd. New Delhi 2005.
2.D.P.Kothari and J.S. Dhillon, "Power system Optimization" Prentice Hall of India, Pvt Ltd., New Delhi 2004.
3.S.S.Rao, " Engineering Optimization Theory and Practice" 3rd edition, New Age International Pvt Ltd., 1998.

FE1934 MODELLING AND SIMULATION OF DVR AND ITS CONTROLLERS **L T P C**
3 0 0 3

UNIT I INTRODUCTION 6
Introduction to power quality – Over view of power quality phenomena – voltage sags – Characterization, Equipment behavior – Mitigation of voltage sags.

UNIT II ANALYSIS OF INVERTER 12
Voltage source inverters – Performance parameters – Voltage control of single phase inverters using PWM techniques – Various harmonic elimination techniques. Current source inverters – Operation of six step inverter – Load commuted inverter – Auto sequential current source inverter.

UNIT III DYNAMIC VOLTAGE RESTORER 9
Basic principles – Active power injection – Three phase series voltage controllers – Single phase series voltage controllers – Effect of voltage rating – effect Storage capacity – Interruptions – Various models DVR.

UNIT IV DVR CONTROLLERS 9
Micro controllers – Digital Signal processor – Artificial neural networks – Genetic algorithm – Fuzzy logic system – Tuning of controllers.

UNIT V APPLICATIONS OF DVR 9
Mitigation of voltage sags – Mitigation of voltage swells – Reduction of voltage harmonics – Minimum active power injection – Simulations with commercial software packages.

TOTAL: 45 PERIODS

REFERENCES:

1. Math H.J.Bollen, “Under standing Power Quality Problems voltage sags and interruptions” First Indian edition, Standard Publications, 2001.
2. Rashid M.H., “Power Electronics Circuits, Devices and Applications”, Prentice Hall India, New Delhi, 1995.
3. Haque M.H. “Voltage sag correction by Dynamic Voltage Restorer with minimum Power Injection”, IEEE Power Engineering Review, May 2001.
4. Zhan.C.et al, “Dynamic Voltage Restorer based on Voltage –Space-Vector PWM Control”, IEEE Transactions on Industry Application, Vol.37, No.6 Nov.2001.
5. Ghosh.A and Ledwich G, “Compensation of Distribution System Voltage using DVR”, IEEE Transactions on Power Delivery, Vol.17, No.4, Oct.2002.
6. Ngai-man Ho.C., et al, “Design and Implementation of a Fast Dynamic Control Scheme fro Capacitor – Supported Dynamic Voltage Restorers”, IEEE Transactions on Power Electronics, Vol.23, No.1, Jan.2008.

FE1935 MODERN RECTIFIERS AND RESONANT CONVERTERS

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UNIT I POWER HARMONICS & LINE COMMUTATED RECTIFIERS 9

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

UNIT II PULSE WIDTH MODULATED RECTIFIERS 9

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

UNIT III RESONANT CONVERTERS 9

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

UNIT IV DYNAMIC ANALYSIS OF SWITCHING CONVERTERS 9

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

UNIT V CONTROL OF RESONANT CONVERTERS 9

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

TOTAL: 45 PERIODS

REFERENCES:

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

FE1936 EMC IN POWER ELECTRONIC CONVERTERS 3 0 0 3

UNIT I DC-DC CONVERTERS AND SMPS 9

DC- DC, Converters - principle of operation, analysis and design of buck, boost, buck-boost Converters - Modeling of the above converters using state averaging techniques. Switched Mode Power Supply: Forward and flyback converter circuit, Analysis and design- Design of switched mode power supplies

UNIT II CONTROL TECHNIQUES 9

Industrial PWM driver chips for power supplies such as UC3843,3825 or equivalent- voltage mode control – current mode control- one step control – SMC controller.

UNIT III EMI IN POWER ELECTRONIC EQUIPMENT 9

EMI from power semiconductors – EMI from controlled Rectifier circuits – EMI calculation for semiconductor Equipments – Predicting EMI from a power supply with Rectifiers – EMI Prediction and design of filters- EMI Prediction for switching power supplies.

UNIT IV SPREAD SPECTRUM TECHNIQUE 12

Direct Sequence Spread Spectrum : BPSK ,QPSK,MSK Direct sequence spread spectrum. Frequency Hop Spread Spectrum : Coherent slow frequency Hop spread spectrum – Non-coherent slow frequency hop spread spectrum – Non coherent fast frequency hop spread spectrum. Binary shift-Register sequences for spread spectrum systems: Definitions-Finite-Field Arithmetic-Sequence generator fundamentals – State Machine Representation of shift Register Generators.

UNIT V APPLICATION 6

Application of frequency hop spread spectrum technique into Buck converter through simulation.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Simon.S.Ang, Alexandro Oliver , “Power-Switching converters”, Taylor and Francis
2. Laszlo Tihanyi, “Electromagnetic Compatibility in Power Electronics, J.K Eckert& Company, Sarasota, Florida, U.S.A.
3. Roger L. Peterson, Rodger.E.Zimer, David.E.Borth ,“Introduction to Spread Spectrum Communications”, Prentice-Hall –U.S.A -1995.

REFERENCES:

1. Ned Mohan, Undeland and Robbin, “Power Electronics: Converters, Application and Design” John Wiley and sons. Inc, Newyork, 1995.
2. Rashid M.H.,”Power Electronics Circuits, Devices and Applications” Prentice Hall India, New Delhi,1995.

FE1937 MODELLING AND CONTROL OF HYBRID SYSTEMS **L T P C**
3 0 0 3

UNIT I HYBRID SYSTEMS AND THEIR REPRESENTATION 9
Hybrid dynamical system structure – Hybrid P henomena – Classification of Hybrid System models – Hybrid automata – Example of Hybrid systems: Thermostat control, Water level control, Two tank system.

UNIT II MODELING OF HYBRUID SYSTEMS (Conventional approach) 9
Piecewise – Affine mode(PWA) – Mixed Logic Dynamical mode (MLD) – Linear Complementarity Systems (LC) – Extended Linear Complementarity systems (ELC) – Max – Min – Plus Scaling Systems (MMPS) – Equivalence of MLD, LC, ELC, PWA and MMPS systems – Timed Automata Timed Petri Net.

UNIT III MODELLING USING PETRINETS 9
Petri Net structure – Petri net graphs – Petri Net markings – Execution rules for Petri Nets – Petri spaces – Hybrid Petri Net – Differential Predicate transition Net – Object Oriented Differential Predicate Transition net – Fuzzy Petri Net – Adaptive Petri Net.

UNIT IV TOOLS FOR MODELLING HYBRID SYSTEMS 12
Tools for Simulation and design : Simulink and Stateflow – Syntax – Simulink Data Model – Stateflow Data model – Examples – Modelica – Modelica language syntax – Modelica language semantics – Examples.

UNIT V CONTROL OF HYBRID SYSTEMS 6
Switched Control : Stabilization of switched linear systems – Time – controlled switching & pulse width modulation – sliding mode control – stabilization by switching control.Optimization – Based Control : optimal Control of Hybrid systems – MPC for MLD and PWA systems – MPC for MMPS and continuous PWA systems.

TOTAL: 45 PERIODS

TEXT BOOKS:
1. John Lygeros, Shankar Sastry, and Claire Tomlin “The Art of Hybrid Systems” July 29, 2001.
2. B.Hruz and M.C. Zhou “Mpdelling and Control of Discrete – Event Dynamics Systems with Petri nets and other tools” Springer –Verlag, 2007.
3. “Modelling and control of Hybrid systems” Lecture notes
4. James L.Peterson “Petri Net theory and the Modelling of Systems” Prentice Hall INC, Englewood Cliffs, N.J.
5. Emilia Villani, Paulo E.Miyagi and Robert Valette” Modelling and Analysis of Hybrid Supervisory systems – A Petri Net Approach” Springer – Verlag,2007
6. John Lygeros, “Lecture Notes on Hybrid Systems” Department of Electrical and Computer Engineering, University of Patras, Rio, Patras, GR-26500, Greece.
7. Luca Carloni, Maria D.Di Benedetto, “Modeling Techniques, Programming Languages, Design Toolsets and Interchange Formats for Hybrid Systems “Project IST – 2001-38314 COLUMBUS report, March 19, 2004.

FE1938 DESIGN AND CONTROL OF SWITCHED RELUCTANCE MACHINE FOR AUTOMOTIVE APPLICATIONS **L T P C 3 0 0 3**

UNIT I DESIGN OF SWITCHED RELUCTANCE MACHINE 09

Introduction – Output equation – Selection of Dimensions – Design verification – operational limit – number of phases – number of poles – ratio of pole arc to pole pitch – selection of pole arcs – effect of air gap measurement of inductance – calculation of torque.

UNIT II CONVERTERS FOR SWITCHED RELUCTANCE MACHINE DRIVES 09

Converter configurations – asymmetric bridge converter – single switch per phase converter – (q+1) switch and diode configurations – C-dump converter – design procedure – two – stage power converter.

UNIT III CONTROL OF SWITCHED RELUCTANCE MACHINE DRIVES 09

Introduction – control principle – closed – loop speed controlled SRM drive – design of current controllers – rotor position measurement and estimation methods – sensor less rotor position estimation – observer – based rotor estimation – intelligent – control – based estimation.

UNIT IV FEA OF SWITCHED RELUCTANCE MACHINE MOTORS 09

Introduction - assumptions – derivation of partial differential equations – boundary conditions – thermal analysis of SRM – modal analysis of SRM.

UNIT V NOISE AND VIBRATION OF SWITCHED RELUCTANCE MACHINE 09

Introduction – numerical models of SRM stator modal analysis – FE results of stator modal analysis – design selection of low vibration SRM 's – effects of smooth frame on resonant frequencies – modeling and parameter identification of SRM – SR drive automotive applications.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Hand book of Automotive Power Electronics and Motor Drives, Ali Emadi, CRC press, 2005.
2. Switched Reluctance Motor Drives, R.Krishnan, CRC press, 2001.

FE1939 ANALYSIS, DESIGN AND CONTROL OF STEPPING MOTORS 3 0 0 3

UNIT I INTRODUCTION 9

Constructional features, principles of operation, permanent magnet – variable reluctance motor – Hybrid motor – Modes of excitation – single – phase stepping motors – specification of stepping motor characteristics.

UNIT II THEORY OF ELECTROMAGNETICS & DYNAMIC CHARACTERISTICS 9

Mechanism of static torque production in a VR stepping motor – Theory of torque produced in hybrid stepping motor – Tooth structure, number of teeth, steps per revolution, and number of poles. Fundamental equations – Transfer functions of stepping motors – single-step response – Torque vs. speed characteristics –Resonances and instabilities – mechanical dampers

UNIT III OPEN LOOP & CLOSED LOOP CONTROLLER OF STEPPING MOTOR **9**

Drive system – Logic sequencers – Motor driver – Input controller – Acceleration and deceleration by a Microprocessor Limitations of open-loop operation and need for closed loop operation – The concept of lead angle – A closed-loop operation system using a microprocessor – Direct-drive servomotor - Development of integrated circuits for closed-loop operation – Switched reluctance drive – Use of current waveforms as a position sensor.

UNIT IV CONVERTERS **9**

Control of Stepping motor using Converter, Inverter, Chopper - Implementation of PWM techniques

UNIT V CASE STUDY **9**

Application of stepping motors in Robotics

TOTAL: 45 PERIODS

REFERENCES :

1. Takashi Kenjo and Akira Sugawara, "Stepping Motors and Their Microprocessor Controls", Second Edition, Oxford Science Publications.
2. IEEE papers

FE1940 PRINCIPLES, DESIGN AND FABRICATION OF MEMS DEVICES 3 0 0 3

UNIT I FUNDAMENTALS OF MEMS DEVICES **9**

Scaling of MEMS devices –Scaling of Mechanical systems - MEMS architecture - Electromagnetic and its application for MEMS devices – Classical mechanics and its application – Newtonian mechanics – Lagrange equations of motions – Hamilton equations of motion – Atomic structures and quantum mechanics – Thermo analysis and heat equation.

UNIT II BIO-MEMS: SENSORS AND ACTUATORS **9**

Scaling in micro fluidics - Flow physics – Liquid flows in micro channels – Micro fluidic simulation models – Physics of thin liquid films – Biomems materials - Bio-sensors – Micro valves

UNIT III PRESSURE, VIBRATION AND TEMPERATURE SENSORS **9**

Piezo resistive pressure Sensor – Capacitive Pressure sensor - Accelerometer - Magnetic sensors – Micro actuators – Electro static –Electro magnetic – Thermal-Piezo electric.

UNIT IV DESIGN, FABRICATION AND PACKAGING OF MEMS DEVICES **9**

Fabrication of cantilever beams- Modeling of micro-electro mechanical systems - Micro pump applications in BIOMEMS – Packaging

UNIT V BIO-MEMS APPLICATIONS **9**

Lab on a chip based on BIO-MEMS - System on a chip model of a micro pump – MEMS piezoresistive pressure sensor for biomedical applications - MEMS viscometric sensor for continuous glucose monitoring.

TOTAL: 45 PERIODS

REFERENCES :

1. Chang Liu, "Foundation of MEMS", Pearson Edition, 2006

2. Stephen Beeby, Graham Ensell, Michael Kraft, Neil White, “MEMS Mechanical Sensors”, Artech House Publishers, 2004
3. Tai-Ran Hsu, “MEMS & Microsystem Design & Manufacture”, McGraw-Hill, Boston, 2002
4. Wanjun Wang , Steven A. Soper, “Bio-MEMS Technologies and Applications”CRC Press, 2007
5. Sergey Edward Lyshevski, “Nano- And Microelectromechanical Systems” CRC Press, 2001
6. Julian W. GardnerVijay, K.Varadan, Osama , Awadelkarim “Microsensors, MEMS, and Smart Devices”, John Wiley & Sons, Ltd, 2001.

FE1941 ANALYSIS AND CONTROL OF SPECIAL MACHINES 3 0 0 3

UNIT I SWITCHED RELUCTANCE MOTOR (9)

Principle of operation of SRM – steady state performance – method of inductance calculation – Design of SRM – Derivation of output equation – Energy conversion principle – Selection of dimensions, Poles, Phases and pole ares.

UNIT II CONVERTERS (9)

Converters for SRM drives – Asymmetric bridge converters – Single switch per phase – Two phase power converters- Resonant converter circuits.

UNIT III CONTROL STRATEG (9)

Control of SRM drive – Closed loop speed controlled SRM – Design of current controller flux linkage controller Torque control and speed control – Modeling of SRM noise control in SRM

UNIT IV STEPPER MOTORS (9)

Introduction – historical survey – classification of stepping motors – modes of excitation single phase stepping motor – Theory of electro-magnetics – Theory of torque produced in VR stepping motor – Hybrid motor – Dynamic characteristics of stepping motor.

UNIT V DRIVE SYSTEM (9)

Drive system and circuitry for open loop control system – Driver system – Logic sequence motor drive input controller – Closed loop control of stepping motor – Concept of lead angle – Closed loop operation system – Direct drive servo motor – Switched reluctance drive.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. R.Krishnan,”Switched reluctance motor drives modeling simulation analysis design and application,” Prentice Hall India, 2002.
2. T.J.E.Miller, “Switched reluctance motor and their control”, CRC Press.
3. Takashi Kenjo, Akira Sugawara, “Stepping motor and their microprocessor controls” Oxford University Press.

REFERENCES :

1. Paul C Krause, Olegwasyzezuk, Scott D Sudhoff, “Analysis of electric machinery and drive system”, IEEE Press, Second Edition.
2. A.E.Fitzgerald, “Electric Machinery”, Wiley Eastern publishers.

FE1942 INTELLIGENT CONTROL APPLICATIONS TO BLDC MOTORS 3 0 0 3

UNIT I GENETIC ALGORITHM 9
Basic concept of Genetic algorithm and detail algorithmic steps, adjustment of free parameters. Solution of typical control problems using genetic algorithm.

UNIT II ARTIFICIAL NEURAL NETWORKS 9
Concept of Artificial Neural Networks and its basic mathematical model, McCulloch-Pitts neuron model, simple perceptron, Adaline and Madaline, Feed-forward Multilayer Perceptron. Learning and Training the neural network. Hopfield network, Self-organizing network and Recurrent network. Neural Network based controller

UNIT III FUZZY LOGIC SYSTEM 9
Introduction to crisp sets and fuzzy sets, basic fuzzy set operation and approximate reasoning. Introduction to fuzzy logic modeling and control. Fuzzification, inferencing and defuzzification. Fuzzy knowledge and rule bases. Fuzzy modeling and control schemes for nonlinear systems. Self-organizing fuzzy logic control. Stability analysis of fuzzy control systems.

UNIT IV PERMANENT MAGNET BRUSHLESS DC MOTORS 9
Commutation in DC motors, Difference between mechanical and electronic commutators, Hall sensors, Optical sensors, Multiphase Brushless motor, Square wave permanent magnet brushless motor drives - Torque and emf equation, Torque-speed characteristics - Mathematical Model Controller design.

UNIT V APPLICATIONS TO MOTION CONTROL 9
GA application to motor control optimisation problem, Identification and control of linear and nonlinear dynamic systems using Neural Network. Implementation of fuzzy logic controller for DC motor speed control.

TOTAL: 45 PERIODS

REFERENCES :

1. Jacek.M.Zurada, "Introduction to Artificial Neural Systems", Jaico Publishing House, 1999.
2. KOSKO,B. "Neural Networks And Fuzzy Systems", Prentice-Hall of India Pvt. Ltd., 1994.
3. KLIR G.J. & FOLGER T.A. "Fuzzy sets, uncertainty and Information", Prentice-Hall of India Pvt. Ltd., 1993.
4. S.N.Sivanandam, S.N.Deepa, "Introduction To Genetic Algorithms", Springer Verlag,2007.
5. Kalyanmony Deb, "Multiobjective Optimization using Evolutionary Algorithms", John Wiley & Sons, First Edition, USA, 2003.
6. Miller, T.J.E. " Brushless permanent magnet and reluctance motor drives ", Clarendon Press, Oxford, 1989.
7. Kenjo, T and Naganori, S " Permanent Magnet and brushless DC motors ", Clarendon Press, Oxford, 1989.
8. R.Krishnan, " Electric Motor Drives – Modeling, Analysis and Control", Prentice-Hall of India Pvt. Ltd., New Delhi, 2003.

FE1943 VOLTAGE SOURCE CONVERTER BASED HVDC TRANSMISSION 3 0 0 3

UNIT I HVDC OPTIONS 9

Developments in line commutated High Voltage Direct Current Schemes (HVDC) schemes – STATic COMpensator (STATCOM) aided DC transmission – comparison of Line Commutated Converter (LCC) link and Voltage Source Converter (VSC) link – frequency cross modulation across LCC.

UNIT II TOPOLOGIES FOR DC TRANSMISSION 9

VSC based transmission using Insulated Gate Bipolar Transistor (IGBT) – dynamic model – phase and amplitude control of VSC – Pulse Width Modulation (PWM) converter – 3 level neutral point clamped VSC – 4 level floating capacitor VSC – 5 level diode clamped VSC – merits and demerits of multilevel VSC configurations – combined PWM multilevel converters – continuously tuned filters – DC filters for VSC based transmission – VSC HVDC cable technology.

UNIT III VSC HVDC FOR WIND POWER EVACAUTION 9

VSC HVDC (light) link control – coordination – control capability limits – inter area decoupling and local area damping – need for grid strengthening for wind power evacuation – calculation of SCR for wind power infeed points – grid strengthening using VSC HVDC link – inherent STATCOM functionality – assistance during grid restoration.

UNIT IV HYBRID SCHEMES 9

Basic Current Source Converter (CSC) operation – modulated tripole DC transmission – hybrid VSC and CSC transmission – hybrid VSC and LSC transmission – power transfer characteristics - current relationships – harmonics – comparison of various multilevel topologies.

UNIT V MODELLING AND SIMULATION 9

AC-DC (light) load flow – inclusion of HVDC light model in Small Signal Stability (SSS) algorithm – inclusion of HVDC light model in transient stability algorithm – variation of P, Q, V and f at Point of Common Coupling (PCC) for major faults – outages and for different wind power penetration levels – validation

TOTAL: 45 PERIODS

REFERENCES :

1. Jos Arrillaga, “AC DC Power System Analysis”, IEE Power Engg. Series, 1997.
2. Jos Arrillaga, Liu Y.H. and Neville R.Watson, “Flexible Power Transmission: The HVDC Options”, Wiley Publishers, 2007.
3. Mohan N., Undeland T.M. and Robbins W.P. “Power Electronics Converters Applications and Design”, John Wiley and Sons Inc, 1995.
4. Sood V.K. “HVDC and FACTS Controllers: Application of FACTS Converters in Power System”, Bosten M A Kluwer, 2004.
5. Farque M.O., et al, “Detailed modeling of CIGRE HVDC Benchmark System Using PSCAD/EMTDC and PSB/SIMULINK”, IEEE Transactions on Power, Vol.21, No.1, 2006, PP.378-387.
6. Schettler F., et al, “HVDC Transmission Systems using Voltage Sourced Converters Design and Applications”, IEEE Conference, 2000, pp.715-720.
7. Ervin Spahic, et al, “Impact of the VSC HVDC Connection of large Offshore Wind Farms on Power System Stability and Control”, IEEE Conference, 2007, pp.207-212.

8. Weixing Lu, et al, “Simultaneous inter area decoupling and local area damping by voltage source HVDC”, IEEE Conference, 2001, pp. 1079 – 1084.

FE 9001 ADVANCED OPTIMAL CONTROL 3 0 0 3

1. THE CALCULUS OF VARIATIONS 9

Problem formulation – Mathematical model – Physical constraints - Performance measure - Optimal control problem. Formulation of optimal control - Selection of performance measure. Fundamental concepts. Functionals. Piecewise – smooth extremals Constrained extreme. Variational approach to optimal control problems – Necessary conditions for optimal control – Linear regulator problems - Linear tracking problems - Pontryagin’s minimum principle and state inequality constraints.

2. DYNAMIC PROGRAMMING 9

Optimal control law – Principle of optimality. A recurrence relation of dynamic programming – computational procedure. Characteristics of dynamic programming solution. Hamilton – Jacobi – Bellman equation - Discrete linear regulator problems.

3. THE MINIMUM (MAXIMUM) PRINCIPLE 9

Minimum control – effort problems. Singular intervals in optimal control problems. Numerical determination of optimal trajectories – Two point boundary – valve problems. Methods of steepest decent, variation of extremals. Quasilinearization. Gradient projection algorithm.

4. OPTIMAL CONTROL SYSTEM DESIGN 9

LQR design method, kalman filter technique, LQG design method. Robust optimal control system design using loop transfer recovery technique. Implementation of optimal controller and its related issues.

5. ON-LINE OPTIMIZATION AND CONTROL 9

Model based predictive controllers, MPC elements-prediction model, objective function, control law. DMC, algorithmic control, predictive functional control, generalized predictive control. Simple implementation of GPC for industrial process.

TOTAL : 45 PERIODS

REFERENCES :

1. Donald E. Kirk, Optimal Control Theory: An Introduction, Prentice-Hall Networks series, 2004.
2. B. D. O. Anderson, J. B. Moore, Optimal control linear Quadratic methods, Prentice Hall of India, New Delhi, 1991
3. A. P. Sage, C. C. White, Optimum Systems Control, Second Edition, Prentice Hall, 2001.
4. E.F. Camcho and C. Bordons, Model Predictive Control, Springer, 2004.

FE9002 INSULATION CO-ORDINATION OF GAS INSULATED SYSTEMS 3 0 0 3

1. SOURCES OF VERY FAST TRANSIENT OVERVOLTAGES 9

Type of over voltage stresses imposed on Gas Insulated substations (GIS) - Temporary over voltages, lightning over voltages, switching over voltages - Principle of over voltage propagation in GIS - Origin and severity of over voltages entering the GIS.

2. GAS INSULATED SUBSTATIONS 9

Layout of Gas Insulated switchgear - Enclosure configuration - Enclosure material - SF6 Insulating Gas Pressure - Components of GIS - New Trends in GIS Design - Compressed Gas Insulated Cables - Dimensioning of compressed gas enclosure - Condensation threshold - Spacer Flashover - Heat dissipation considerations.

3. FACTORS AFFECTING INSULATION STRENGTH AND ON-SITE TESTING 9

Effect of electrode material – Conductor conditioning and surface roughness – problems associated with solid spacers – Particle contamination in GIS – Particle initiated breakdown – Particle control Techniques – Conductor coating –Breakdown of GIS at low temperature – Electromagnetic compatibility in GIS Substations-High Voltage on-site testing – Diagnostics of micro discharges in GIS - Environmental Considerations –SF_6 Green house Effect .

4. EFFECT OF VFTO ON POWER APPARATUS 9

Withstand strength of GIS and on switchgear, transformers, surge arresters -Influence of substation and line parameters - interaction between line parameters on over voltages stressing GIS insulation – Equipment insulation -Different means to limit the over voltages.

5. INSULATION CO-ORDINATION 9

Insulation Co-ordination of GIS using Surge Arresters- Selection and location - Conventional method based on specified Incoming over voltages - Probabilistic Method - Economical aspects of insulation level.

TOTAL: 45 PERIODS

REFERENCES:

1. Klaus Ragaller, “Surges in High Voltage Networks”, Plenum Press, New York, 1980.
2. Mazen Abdel-salam , Hussein Anis , Ahdab El-Morshedy ,Roshdy Radwan ,” High – Voltage Engineering Theory and Practice “, Second Edition, Marcel Dekkar Inc, 2000 .
3. Kunio Nakanishi ,” Switching Phenomena in High-Voltage Circuit breakers “, Marcel Dekkar Inc ,1991.
4. Insulation Coordination related to internal insulation of gas insulated systems with SF6 and N2/SF6 gas mixtures under AC condition, Working Group C4.302, October 2008.

FE 9003 STATISTICAL TECHNIQUES FOR HIGH VOLTAGE ENGINEERING 3 0 0 3

1. REVIEW OF FUNDAMENTALS 9

Basic concepts of Probability theory -Distribution functions – concept and properties, Empirical distributions functions - Parameter Estimation - Discrete Variate - Continuous Variate - Mixed Distributions – Fundamental of correlation and regression

2. STOCHASTIC NATURE OF BREAKDOWN 9

Statistical features of breakdown - Weibull Distribution and other statistical distributions - Effect of voltage and time on the failure statistics

3. STOCHASTIC MODELS OF BREAKDOWN 9

Statistical and physical connections - Fluctuation model - Fractal description of breakdown - Cumulative defect models of breakdown - Differences and similarities in model statistics

4. TEST METHODS 9

Distribution Tests - Graphical Methods, Mathematical methods - F test - Double-t test - U test - Test of independence of realizations - laboratory tests - constant stress test, progressive test tests, effect of voltage on lifetime

5. STATISTICAL DESCRIPTION OF INSULATION CAPACITY 9

Choice of Variate - Air, Compressed-gas, Liquid and Solid insulation - uniform and Non Uniform insulation - Statistics of partial discharges

TOTAL: 45 PERIODS

REFERENCES:

1. Hauschild.W, Mosch.W, "Statistical Techniques for high voltage engineering", IEE Press,1992
2. Dissado.L.A, Fothergill.J.C, “Electrical degradation and breakdown in polymers”, IEE Press, 1992
3. Peyton Z.Peebles , “ Probability, Random variables and Random Signal Principles” Mc-Graw Hill Publishing Company Limited ,New Delhi,1993.

FE 9004 ENERGY EFFICIENT ILLUMINATION 3 0 0 3

GREEN ENGINEERING: CHOICE OF LIGHTING TECHNOLOGIES 9

Lighting upgrade- Green Benefits-Energy Savings-Green House Gas Emission- Social Prospective- Deferred from Mercury- Clean disposal options-Discount-Rational Economic Factor- Pay Back Formula. Cost of Light- Energy Cost –Usage hours- Replacement Cost. Trade –off among alternative technology-Daily Lighting Load Curves- Annual Cost of White LED’s-Better investment.

TRANSISION TO SOLID STATE LIGHTING 9

Technical Prospective Lighting Upgrade- Comparative Study of Lights- Edison’s bulb- Fluorescent Tubes- CFL- Solid State Lighting- Key Characteristics- Efficiency- Life Time-Spot Replacement - Group Replacement- Colour- Co-related Colour Temperature- Black Body Radiator- RF Noise and Flicker.

RETROFIT ECONOMICS 9

Efficiency: Visible Spectrum- Luminous Flux- Human Eye- Photopia Spectral Eye Sensitivity Curve- Device Efficacy, Source and Driving Circuit Losses- System Efficacy with minimum Fixture Loss. Useful Life- Lamp Lumen Depreciation- Junction Temperature- Heat Sink- Fixture Reflectance Depreciation- Optics Cleaning- Maintenance Factor- Coefficient of Utilization-Causes of Failure.

LUMINAIRE FIXTURE **9**

Definition-Thermal-Electrical-Mechanical Design and Testing-Lamp Holder- wiring- Control Gear- Driving Circuit-Housing. Optics-Light control elements: Reflectors-Lenses and Refractors-Diffuser- Filters- Screening devices- Mirror Louver. Specula reflector-Plane- Optical Gain-Uses-Parabolic- Curved-Circular- Faceted- Trough versions. Accurate beam Control- Control of spill light- practical uses-Combined Spherical and Parabolic reflectors- Elliptical reflectors-Hyperbolic reflector- Spread reflector- Moderate beam control- Diffuse reflector- Materials- Lenses and refractors

LIGHT FITTINGS **9**

Focusing Lours for flood lighting-Shielding angle- Cut-off angle- Barn doors- colour filters- Light Distribution- Symmetric- and Asymmetric- Diffused and Focussed- Direct and Indirect Beam spread classification- Batwing light distribution

TOTAL: 45 PERIODS

REFERENCES :

1. Craig Delouse-"The Lighting Management Hand Book"- The FAIRMONT PRESS.
2. Ines Lima Azededo, M. Granger Morgan and Fritz Morgan "The Transition to Solid State Lighting" IEEE Proceedings, Vol97, No.3.March 2009.
3. A.R. Bean and R. H. Simons-"Lighting Fittings".

FE 9005 **ROBUST CONTROL AND SLIDING MODE CONTROL** **3 0 0 3**

1. INTRODUCTION TO ROBUST CONTROL AND H_∞ NORM **9**

Elements of Robust Control Theory – Design Objectives – Shaping the Loop Gain – Signal Spaces – Computation of H_∞ norm- All Pass Systems – Factorization of polynomial matrices and standard forms.

2. PARAMETRIZATION AND ROBUST STABILIZATION **9**

Well – posedness and internal stability – Youla parameterization approach – State space realization – Sensitivity minimization Design limitations due to Right Half Plane Zeros – plant uncertainty and robustness – Robust stabilizing controllers – Balanced realization.

3. H_2 AND H_∞ OPTIMIZATION **9**

Separation principle – Algebraic Riccati Equation - Solution of LQG problem – H_∞ optimization techniques – Parameterization of stabilizing controllers for G_{22} - Reduction to the standard problem – From standard form to model matching – LQG control – Full information problem – Kalman filter – Parameterization of controllers – output feedback – state space formulation of H_∞ control - H_∞ filter.

4. INTRODUCTION TO SMC, PASSIVITY AND FLATNESS **9**

Dynamics in the sliding mode – linear system, non-linear system, chattering phenomenon – sliding mode control design – reachability condition, robustness properties – application to boost dc-dc converters- flatness, passivity properties through flatness, non – minimum phase output stabilization, trajectory planning.

5. STABILITY AND STABILIZATION 9

Introduction – Notation – Generalized regular form – Obtaining the regular form – Effect of perturbations on the regular form – Estimation of initial sliding motion – Problem formulation – Sliding domain and initial domain of sliding motion – Application – Stabilization. development

TOTAL: 45 PERIODS

REFERENCES:

1. P.C.Chandrasekharan., "Robust Control of Linear Dynamical Systems, Academic Press Limited, San Diego.1996.
2. Doyle J.C. Francis B.R., and Tannenbaum A.R. "Feedback control theory", New York: Macmillan, 1992.
3. Jean Pierre Barbot., "Sliding Mode Control In Engineering" Marcel Bekker, 2002.
4. Stanislaw H. Zak, "Systems and Control" Oxford University press. 2003.
5. Green M. and Limebeer /D.J.N. "Linear Robust Control", Englewood cliffs, NJ: Prentice Hall, 1995.

Faculty of Electrical Engineering (**Approved in 15th AC 13.02.2010**) **ITEM NO. FE 15.02 (6)**

FE9006 FOOD PRESERVATION TECHNIQUES 3 0 0 3

1. DRYING & THERMAL PROCESSING 9

Recent developments in drying including spray drying, freeze drying, foam mat drying and other newer drying processes; newer methods of concentration and evaporation; freeze concentration design aspects; membrane filtration for recovery of low concentration products; applications of ultra-filtration and reverse osmosis.

Use of electric current for thermal processing of foods; relationship of conductance and heating of foods; Ohmic heating: principle & applications.

2. NON-THERMAL METHODS 9

Chemical preservatives - Food additives, functional chemical additives applications. Chemical preservatives and antibiotics; Preservation by ionizing radiations- technology aspects of the radiations, pasteurization of foods; public health aspects, microbiology of irradiated foods; Ultrasonics, high pressure, fermentation, curing, pickling, smoking, membrane technology. Hurdle technology.

3. RADIATION PROCESSING 9

Generation of irradiation by different techniques including gamma rays and electron acceleration; Safety and effect of radiation doses; Radiation processing of cereals & grains, meat, fish & poultry products, spices & herbs etc. Control of ripening of fruits by irradiation; Infra-red heating**:** interaction of infra-red (IR) radiation with penetration properties, equipment; dairy and food application, advantages and disadvantages of IR heating.

4. PULSED ELECTRIC FIELDS 9

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

5. APPLICATION OF PEF TECHNOLOGY IN FOOD PRESERVATION 9

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

TOTAL: 45 PERIODS

TEXT BOOKS

1. Majumdar, Arun S. "Dehydration of Products of Biological Origin", Oxford & IBH Publication, 2004.
2. Gopala Rao, Chandra "Essentials of Food Processing Engineering", BS
3. Smith, P.G. "Introduction to Food Process Engineering" Springer, 2005. Publications, 2006.
4. Das, H. "Food Processing Operations Analysis", Asian Books, 2005.

REFERENCES :

1. Fellows, P.J. "food Processing Technology : Principles and Practice", Wood head
2. Publishing, 1997. Rahman, M.S. "Handbook of Food Preservation", Marcel Dekker, 1999.
3. Toledo, R.M. "Fundamentals of Food Process Engineering", 3rd Edition, Springer, 2007.
4. G.V. Barbosa –Canovas , "Pulsed electric fields in food processing:Fundamental aspects and applications" CRC Publisher Edition March 1 2001.
5. H L M Lelieveld and Notermans.S,et.al., "Food preservation by pulsed electric fields: From research to application", Woodhead Publishing Ltd. October 2007.

Faculty of Electrical Engineering **(Approved in 15th AC 13.02.2010) ITEM NO. FE 15.02(7)**

FE9007 WEB BASED EMBEDDED SYSTEMS 3 0 0 3

1. EMBEDDED SYSTEMS 9

Embedded System – Hardware Architecture - Software Components –– Communications - Embedded Development Environment – Embedded Computing Platform – Distributed Embedded System Design - Embedded Design Techniques

2. EMBEDDED NETWORKING 9

Introduction – Principles of Networking, Networking for Embedded systems – Network Technology Standard ,Protocols -TCP/IP, Architecture Implementation, Embedding TCP/IP – Embedded Networking with Java - Networking software for Embedded Systems, CAN networks.

3. ROUTING METHODOLOGIES 9

Introduction – Hubs, Bridges, Routers, Routing protocols, Routing Security, Switch based routing , unicast, multicast routing, embedded routing - Routing components, Routing levels, routing protocols Web based routing - Routing components, protocols, Types of routing.

4. WEB BASED CLIENT- SERVER COMMUNICATION 9

Introduction – A client-Sever approach, Methods of communication , Components – HTTP protocol, web browsers, web servers, Languages - HTML and its extension, Java applets - Interaction with server using CGI and alternatives – server side programming and control – Design of web pages using client-side scripting-Web security

5. CASE STUDIES 9

Web-based Embedded Computing - Design of a web based monitor system for embedded applications – Web based control applications.

TOTAL: 45 PERIODS

REFERENCES:
1. William Stallings"High speed Networks TCP/IP and ATM Design Principles" Prentice Hall, New York, 1998.
2. M. Steen Strub "Routing in Communication networks" Prentice Hall International New York, 1995
3. Designing embedded Internet devices by Dan Eisen Reich, Brian DeMuth
4. Embedded networking with CAN and CAN open by Copperhill Technologies Corporation' Olay Pfeiffer, Andrew Ayre, Christian Keydel
5. A methodology for client/server and web application development by Roger Fournier
6. The Internet directory by Eric Eugene Braun.

Faculty of Electrical Engineering **(Approved in 15th AC 13.02.2010) ITEM NO. FE 15.02(8)**

FE9008 ADVANCED PID CONTROL 3 0 0 3

1. INTRODUCTION 9

Feedback fundamentals, PID controller-Two degree freedom controller- Issues related to implementation- integral windup. Stability, sensitivity functions, robustness to process variations, requirements and specifications.

2. PID STABILIZATION 9

PI, PID stabilization – characterization and computation.

3. PID CONTROLLER DESIGN 9

ZN & related methods, rule based empirical tuning, pole placement, lambda tuning, algebraic design, optimization methods, robust loop shaping, and frequency response methods. IMC based PID tuning. Design for disturbance rejection.

4. ROBUST PERFORMANCE AND PERFORMANCE ASSESSMENT 9

Modeling uncertainty, performance in the presence of uncertainty, robust pole placement, design for robust performance. PID controller performance assessment.

5. ADAPTIVE PID CONTROL 9

Autotuning, Adaptive Technique-model based methods-rule based methods, Multimodel based PID Controller design, nonlinear PID Controller design.

TOTAL: 45 PERIODS

REFERENCES:
1. Karl J. Astrom and Tore Haggland, Advanced PID Control, ISA Publications, 2005.
2. G.J. Silva, Aniruddha datta, SP.Bhattacharyya, PID control for time delay systems, Springer, 2005.
3. Q.G. Wang, Z. Ye, W.J. Cai, C.C. Hang, PID control for Multivariable Process, Springer, 2008.

Faculty of Electrical Engineering **(Approved in 15th AC 13.02.2010) ITEM NO. FE 15.02(9)**

FE9009 CONTROL OF POWER CONVERTER 3 0 0 3

UNIT I REVIEW OF SWITCH-MODE DC –DC CONVERTERS 9

Modeling and analysis of Converters: Buck, Boost, Buck-Boost, Cuk , Sepic , Flyback , Forward Converters . Continuous and discontinuous operation.

UNIT II STATE -SPACE AVERAGED MODEL 9
State Space Averaging - Converter Transfer Function – Formation of averaged models and averaged circuit model – Small signal analysis. Voltage-mode and Current-mode controls.

UNIT III SLIDING MODE CONTROL AND HYSTERIS CONTROL 9
Introduction – Principles of Sliding Mode Control – Constant Frequency Operation , Steady State Error Elimination in Converters With Control Inputs , Hysteris control for Power converters.

UNIT IV FUZZY LOGIC CONTROL 9
Introduction Fuzzy Set Theory, Fuzzification, Defuzzification, Fuzzy Logic Controller, Systhesis. Case study for Power electronic circuits.

UNIT V STABILITY ANALYSIS OF POWER CONVERTERS 9
Stability –Routh Hurwitz Criterion – Root Locus Construction – Frequency Domain – Bode Plots – Nquist Plots- Stability analysis in d-q frame - Stability analysis for dc-dc converters – Cascade DC-DC Converter Systems – Case study

TOTAL: 45 PERIODS

REFERENCES:

1. Fang lin Luo "Advanced dc –dc converters "volume 1-power electronics and application series , CRC press -2004
2. Phili T. Krein " Elements of Power electronics" Oxford university press , First Indian edition, 2008.
3. Muhammad H.Rasid "Power Electronics handbook- devices ,circuits and applications" academic press 2007 -2 edition
4. Bimal K.Bose "Modern power electronics evolution , technology , and applications Institute of Electrical and Electronics Engineers, 1992.
5 M.Gopal " control system " TATA MCGRAW HILL 2 –edition.

Faculty of Electrical Engineering **(Approved in 15th AC 13.02.2010) ITEM NO. FE 15.02(10)**

FE9010 RTOS BASED EMBEDDED SYSTEM DESIGN 3 0 0 3

UNIT I OPERATING SYSTEM 9
Real Time Systems - Embedded Operating Systems, Task Management- Scheduling, Multi-Tasking, Interrupts, IPC Synchronization, Components of Embedded Hardware, Writing Software for Embedded System.

UNIT II REAL TIME DEVICE DRIVERS 9
Mechanism and Policy, Device Drivers Using UNIX, Complex Real Time Device Drivers, Real Time Serial Line, Real Time Parallel Ports, Real Time Networking

UNIT III STUDY OF EXISTING EMBEDDED OPERATING SYSTEM 9
Linux based Real Time and Embedded Operating Systems: RTlinux, Real Time Application Interface, Uclinux , Etlinux. Non Linux Real Time Operating System: ADIOS, Nano Kernel, E-Cos, RT-Ems, Jaluna, Wonka+Oswald, Fiasco And Drops, Real Time Micro Kernel , Kiss Real Time Kernel

UNIT IV RTOS DESIGN AND IMPLEMENTATION 9
Design Principles, Pattern and Frame Work, Cross Compilation Debugging and Tracing, Design Example

UNIT V CASE STUDY **9**

Study of Commercial RTOS, Case Studies of Programming with RTOS.

TOTAL: 45 PERIODS

REFERENCES:

1. Rajkamal " Embedded systems Architecture, Programming and Design" Tata McGraw-Hill Publishing Company Limited , NewDelhi,2005.
2. Real-Time and Embedded Guide by Herman Bruyninckx K.U.Leuven, Mechanical Engineering Leuven Belgium www.Herman.Bruyninckx@mech.kuleuven.ac.be

Faculty of Electrical Engineering **(Approved in 15th AC 13.02.2010) ITEM NO. FE15.02(11)**

FE9011 INTELLIGENT CONTROLLER FOR ROBOTICS **L T P C**
3 0 1 4

1 ARM ARCHITECTURE AND PROGRAMMING **12**

RISC Machine – Architectural Inheritance – Core & Architectures -Registers – Pipeline - Interrupts – ARM organization - ARM processor family – Co-processors. Instruction set – Thumb instruction set – Instruction cycle timings - The ARM Programmer's model – Interrupts – Interrupt handling schemes- Firmware and boot loader.

2 TRANSPORT AND APPLICATION LAYERS **9**

TCP over Adhoc Networks – WAP – Architecture – WWW Programming Model – WDP – WTLS – WTP – WSP – WAE – WTA Architecture – WML – WML scripts.

3 . ONE DIMENSIONAL RANDOM VARIABLES **12**

Random variables - Probability function – moments – moment generating functions and their properties – Binomial, Poisson, Geometric, Uniform, Exponential, Gamma and Normal distributions – Function of a Random Variable. – Random processes – classification – time averages – ergodic , markov, poisson , binomial processs.

4 COMMUNICATION WITH BUSES FOR DEVICES NETWORKS **12**

I/O devices: timer and counting devices , serial communication using I2C, CAN, USB, Buses: communication using profi bus, field bus, arm bus, interfacing with devices/ serial port and parallel ports ,device drivers.

5 ARM APPLICATION DEVELOPMENT **15**

ARM Development tools – ARM Assembly Language Programming and 'C'compiler program; Introduction to DSP on ARM –FIR Filter – IIR Filter – Discrete fourier transform; TUTORIAL & Experiments -with Arm processor for sensor & Motor Interface, communication and Bus protocol using ARM /microcontroller.

REFERENCES :

1. Steve Furber, 'ARM system on chip architecture', Addision Wesley
2. Andrew N. Sloss, Dominic Symes, Chris Wright, John Rayfield 'ARM System Developer's Guide Designing and Optimizing System Software', Elsevier 2007.
3. Dananjay V. Gadre 'Programming and Customizing the AVR microcontroller', McGraw Hill 2001
4. Charles E. Perkins, " Adhoc Networking", Addison-Wesley, 2001.
5. Siva Ramamurthy and B.B. Manoj, 'Ad Hoc wireless network Architectures and protocols'
6. R. E. Walpole, R. H. Myers, S. L. Myers, and K. Ye, Probability and Statistics for Engineers & Scientists, Asia, 8th Edition, (2007).

7. P.kandasamy, K.Thilagavathy, K.Gunavathi, ‘ Probability statistics and queueing theory.
8. N.Mathivanan, ‘Microprocessors, PC Hardware and Interfacing , PHI, second Printing 2003.

Faculty of Electrical Engineering **(Approved in 15th AC 13.02.2010) ITEM NO. FE 15.02(12)**

FE9012 EXPERIMENTAL STRESS ANALYSIS TECHNIQUES 3 0 0 3

UNIT 1 9

Normal stress, Normal strain, Poisson’s ratio, Young’s Modulus, Shear Strain, Shear stress, Shear modulus, Stress-strain diagram for various materials, Principal planes, Stress strain Transformation for different cases, Mohr’s circle, Beam bending, Shear force and bending moment diagrams, Deflection of beams, Thermal stresses, Stress tensor, Strain tensor, Compatibility conditions, Plane stress, Plane strain, Bi-harmonic equation, Airy’s stress function.

UNIT 2 9

Electrical properties of the strain gauges, Strain sensitivity, Materials used for strain gauges, Carrier materials, Adhesive materials, Bonding procedure, Different configuration of strain gauges, Study of change in resistance with strain for various strain gauge materials, Gauge factor, Cross sensitivity factor, Response of a strain gauge.

UNIT 3 9

Strain measuring circuits, Potentio meter circuit, Effect of non-linear term, Sensitivity of circuit, Temperature compensation, Measuring strain in beams and bar, Effect of resistance ratio, Power calculation, Disadvantage of potentiometer, Importance of filter circuit, Dynamic strain measurements.

UNIT 4 9

Wheatstone bridge circuit, Balancing, Sensitivity of circuit, Temperature compensation, measuring strain in beams and bar, Effect of resistance ratio, Power calculation, Advantages of Wheatstone bridge circuit, Total strain measurements, Static and Dynamic strain measurements, Full bridge circuit, Half bridge circuit, Quarter bridge circuit.

UNIT 5 9

Calibration of strain measuring circuits, Rosettes, Rectangular rosettes, Delta rosettes, T- rosettes, Stress gauges, Applications of strain gauges and stress gauges.

TOTAL: 45 PERIODS

TEXT BOOK:

1. Experimental Stress Analysis *by* *James W. Dally*, *William F. Riley*, Publisher: McGraw-Hill Higher Education Pub. Date: January 1978.

REFERENCES:

1. Experimental Stress Analysis by Sadhu Singh, Khanna Publishers, New Delhi,1996.
2. Experimental Stress Analysis by L.S.Srinath, Tata McGraw-Hill Company, New Delhi 1984

FE9013 FINITE ELEMENT ANALYSIS OF BOUNDARY VALUE PROBLEMS 3 0 0 3

UNIT 1 9

Revision of analytical methods for solving ordinary differential equations: variable separable method, Bernoulli's method; initial conditions and boundary conditions, finite difference methods, under standing the difference between numerical methods and classical methods, polynomial type approximate solutions and trigonometric type approximate solutions, essential boundary conditions, natural boundary conditions, domain residue, boundary residue, classification of classical methods.

UNIT 2 9

Weighted residual methods: Least square method, collocation methods, sub domain method, method of moments, Galerkine method, and modified Galerkine method.
Variational method: Elementary study on calculus of variation, and Rayleigh Ritz method.

UNIT 3 9

Different coordinate systems: Global coordinate system, local coordinate system, natural coordinate system. Interpolation functions for linear and quadratic elements, h-approximation, p-approximation, solving boundary value problems using classical methods with different elements (linear elements and quadratic elements), solving boundary value problems in different coordinate systems, element stiffness matrix, element load vector, global stiffness matrix, global load vector, reduced stiffness matrix, Gauss elimination procedure.

UNIT 4 9

Study of one dimensional structural mechanics problems: bar, truss, beam,column Study of one dimensional potential problems: heat transfer, fluid flow, current flow Different 2-d elements, Lagrangian Interpolation, shape functions for 2-d elements, iso-parametric, sub-parametric, super-parametric elements, Serendipity elements, Jacobian, EICJ and EILJ, constant strain triangle elements, linear strain triangle elements, Two dimensional boundary value problems.

UNIT 5 9

Numerical Integration, Gaussian Integration (one point, two points, three points), Finite element analysis on: time dependent, Eigen value and initial value problems convergence criteria, Banded symmetric matrix, Finite Element analysis software.

TOTAL: 45 PERIODS

TEXT BOOKS

1. An Introduction To The Finite Element Method by J.N. Reddy,Hardcover, McGraw-Hill College (December 2004).
2. Concepts and Applications of Finite Element Analysis,by Robert Davis Cook (Editor), David S. Malkus, Michael E. Plesha, Robert Davis
3. Concepts and Applications of Finite Element Analysis Cook (Editor), Robert Davis Cook (Editor), Robert D. Cook, Robert J. Witt. Hardcover, John Wiley & Sons Inc **(October 2001)**

REFERENCES :

1. Introduction to Finite Elements in Engineering, by Tirupathi R. Chandrupatla, Ashok D. Belegundu, Other, Prentice Hall (March 2002).
2. Fundamental Finite Element Analysis And Applications: With Mathematical and MATLAB Computations, by M. Asghar Bhatti,Hardcover, John Wiley & Sons Inc (February 2005).

FE9014 ADAPTIVE CONTROL AND RELAY FEEDBACK L T P C
3 0 0 3

1. ADAPTIVE CONTROL AND REALTIME PARAMETER ESTIMATION 9
Linear feedback – Effects of process variations – Adaptive schemes – Adaptive control problem – Least squares and regression models – Estimating parameters in dynamical systems – Experimental conditions – Simulation of recursive estimation.

2. DETERMINISTIC, STOCHASTIC AND PREDICTIVE SELF TUNING REGULATOR 9
Pole placement design – Indirect self tuning regulator – Direct self tuning regulator- Design of minimum variance and moving average control stochastic self tuning regulator – Unification direct self tuning regulator – Linear quadratic self tuning regulator- Adaptive predictive control.

3. MRAC ADAPTIVE SYSTEM 9
MIT rule – Determination of adaptive gain – Lyapunov theory – BIBO stability – Applications to adaptive control – Non-linear dynamics – Adaptation of feed forward gain – Averaging – Application of averaging techniques- Robust adaptive controllers.

4. DESCRIBING FUNCTION AND STATE SPACE BASED PROCESS IDENTIFICATION 9
Basics of process identification – Characteristics of relays – Existence and stability of limit cycles- Identification using describing function – Parallel relay with controller-State space method – Existence of limit cycles in unstable processes – SOPDT dynamics identification

5. ONLINE TUNING AND GAIN SCHEDULING 9
Online tuning of controllers – Model based and model free tuning –Principle and design of gain scheduling controllers – Nonlinear transformations – Applications of gain scheduling – Robust high gain feedback control – Self oscillating adaptive systems.

TOTAL: 45 PERIODS

TEXT BOOKS

1. Astrom and Wittenmark,” Adaptive Control ”, PHI.
2. Somanath Majhi ., “ Advanced Control Theory A relay Feedback Approach”, Cengage Learning, 2009.

REFERENCES

1. William S. Levine, “Control Hand Book”, CRC Press
2. Narendra and Annasamy,” Stable Adaptive Control Systems, Prentice Hall, 1989.

Faculty of Electrical Engineering (Approved in 15th AC 13.02.2010) ITEM NO. FE 15.02(15)

FE9015 RECENT TECHNIQUES FOR RELIABLE DISTRIBUTION SYSTEMS 3 0 0 3

UNIT I ADAPTIVE COTROL AND ADAPTATION TECHNIQUES 9
Introduction – 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.

UNIT II HARMONIC ANALYSIS 9

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

UNIT III FLICKER ANALYSIS 9

Sources of Flicker-Flicker Analysis-Flicker Criteria-Data for Flicker analysis- Case Study-Arc Furnace Load-Minimizing the Flicker Effects-Summary.

UNIT IV ELECTRICITY PRICING - VOLATILITY, RISK AND FORECASTING 9

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

UNIT V SUPPORT VECTOR MACHINES 9

Introduction – An overview – Classification – Pattern Classification - Linear Support Vector Machines – Non Linear Support Vector Machines.

TOTAL: 45 PERIODS

TEXT BOOKS

1. G.W.Stagg, A.H.El.Abiad “Computer Methods in Power System Analysis”, McGraw Hill, 1968.
2. Astrom and Wittenmark,” Adaptive Control”, PHI
3. Narendra and Annasamy,” Stable Adaptive Control Systems, Prentice Hall, 1989
4. Ramasamy Natarajan, ”Computer-Aided Power System Analysis”, Marcel Dekker Inc., 2002.

REFERENCES :

1. M.K. Jain, N.D.Rao, G.J.Berg, “Improved Area Interchange Control Method for use with any Numerical Technique”, I.E.E.E. P.E.S Winter Power Meeting 1974.
2. J.P.Britton, “Improved Area Interchange Control for Newton’s method Load Flows”, Paper 69 TP 124-PWR presented at IEEE Winter Power Meeting, NewYork, Jan 26-31, 1969.
3. William S. Levine, “Control Hand Book”.
4. K.Zollenkopf, “Bi-Factorization: Basic Computational Algorithm and Programming Techniques; pp: 75-96; Book on “Large Sparse Set of Linear Systems” Editor: J.K.Rerd, Academic Press, 1971.
5. “Support vector machines “Steinwart, Ingo; Christmann, Andreas.

Faculty of Electrical Engineering **(Approved in 15th AC 13.02.2010) ITEM NO. FE 15.02(16)**

FE9016 DESIGN OF HIGH POWER SYNCHRONOUS GENERATOR 3 0 0 3

UNIT I INTRODUCTION TO DESIGN OF RADIAL FLUX PMSG AND STUDY OF VARIOUS TOPOGRAPHIES 9

Construction of PMSG - Principle of operation - Types of PMSG - Surface mounted, surface inset permanent magnet and interior permanent magnet machines - Types based on flux path[6] - Modeling of PMSG [1]- Introduction to design - Design requirements of PMSG - Basic design choices - Factors affecting the design of PMSG[4]

UNIT II OPTIMUM STATOR DESIGN FOR MAXIMUM EFFICIENCY 9

Stator modeling - Types of stator winding - Concentrated & distributed, single layer & double layer[5] - Winding factor[2] – MMF waves - Stator losses - Output power coefficient and basic stator

Geometry[5] - Number of stator Slots - Design of stator winding[2] - Design of stator core for 1 MW machine.

UNIT III OPTIMUM ROTOR DESIGN FOR MAXIMUM EFFICIENCY 9

Armature reaction and demagnetization calculation - Selection of rotor topology - Rotor design -Main materials selection - Lamination thickness selection[3] - Influence of the permanent magnet length on the generator magnetic excitation flux- Influence of the rotoric slot opening on the generator magnetic excitation flux[7] – Design of Rotor Core for 1 MW machine

UNIT IV PERFORMANCE SIMULATION STUDIES OF RADIAL FLUX PMSG 9

Performance characteristics of radial flux PMSG using MAGNET software - Comparison of performance characteristics of various configurations - Saturation characteristics - Flux distribution – Losses – Thermal equivalent circuit[5] - Case Study for 1 MW machine

UNIT V TESTING, COMMISSIONING AND COMPARISON OF TEST RESULTS WITH SIMULATION RESULTS 9

Acceptance test - Performance test - Parameter test under steady state – Sub-transient and transient parameter test - Standstill frequency response tests - Comparison of test results with simulation results[5] – Case Study for 1 MW machine

TOTAL: 45 PERIODS

REFERENCES:

1. Belakehal. S., Benalla H. and Bentounsi A (2009), 'Power Maximization Control of Small Wind System using Permanent Magnet Synchronous Generator', Revue des Energies Renouvelables, Vol. 12, No. 2, pp. 307 – 319
2. Cros J., Viarouge P (2002), 'Synthesis of High Performance PM Motors With Concentrated Windings', IEEE Transactions on Energy Conversion, Vol. 17, No. 2, pp. 248-253
3. Nagorny A.S., Dravid N.V., Jansen R. H., Kenny B.H. (2005), 'Design Aspects of a High Speed Permanent Magnet Synchronous Motor/Generator for Flywheel Applications' IEEE International Conference on Electric Machines and Drives, San Antonio, Texas, USA, pp. 635-641
4. Hendershot J.R. and Miller T.J. (1994), E. Miller, "Design of Brushless Permanent Magnet Motor", Oxford University Press, UK
5. Boldea I. (2006), 'The Electric Generators Hand Book - Synchronous Generators' CRC Press, Taylor & Francis Group, USA
6. Krishnan R. (2009), 'Permanent Magnet Synchronous and Brushless DC Motor Drives' CRC Press, Taylor & Francis Group, USA
7. Ghita C., Chirila A.-I,Deaconu I.-D., and Ilina D.-I, 'Wind turbine permanent magnet synchronous generator magnetic field study' ICREPQ'07 conference

Faculty of Electrical Engineering (Approved in 16th AC (Ad hoc) 02.12.2010) ITEM NO. FE 16.02(1)

FE 9017 MODELING AND SIMULATION OF SOLAR ENERGY SYSTEMS

L	T	P	C
3	0	0	3

UNIT I SOLAR RADIATION AND COLLECTORS 9

Solar angles - day length, angle of incidence on tilted surface - Sunpath diagrams -shadow determination - extraterrestrial characteristics - measurement and estimation on horizontal and tilted surfaces - flat plate collector thermal analysis - heat capacity effect - testing methods-evacuated tubular collectors - concentrator collectors – classification - design and performance parameters - tracking systems - compound parabolic concentrators - parabolic trough concentrators - concentrators with point focus - Heliostats – performance of the collectors.

UNIT II APPLICATIONS OF SOLAR THERMAL TECHNOLOGY 9

Principle of working, types - design and operation of - solar heating and cooling systems - solar water heaters – thermal storage systems – solar still – solar cooker – domestic, community – solar pond – solar drying.

UNIT III SOLAR PV FUNDAMENTALS 9

Semiconductor – properties - energy levels - basic equations of semiconductor devices physics. Solar cells - p-n junction: homo and hetro junctions - metal-semiconductor interface - dark and illumination characteristics - figure of merits of solar cell - efficiency limits - variation of efficiency with band-gap and temperature - efficiency measurements - high efficiency cells - preparation of metallurgical, electronic and solar grade Silicon - production of single crystal Silicon: Czokralski (CZ) and Float Zone (FZ) method - Design of a complete silicon – GaAs- InP solar cell - high efficiency III-V, II-VI multi junction solar cell; a-Si-H based solar cells-quantum well solar cell - thermophotovoltaics.

UNIT IV SOLAR PHOTOVOLTAIC SYSTEM DESIGN AND APPLICATIONS 9

Solar cell array system analysis and performance prediction- Shadow analysis: reliability - solar cell array design concepts - PV system design - design process and optimization - detailed array design - storage autonomy - voltage regulation - maximum tracking - use of computers in array design - quick sizing method - array protection and trouble shooting - centralized and decentralized SPV systems - stand alone - hybrid and grid connected system - System installation - operation and maintenances - field experience - PV market analysis and economics of SPV systems.

UNIT V SOLAR PASSIVE ARCHITECTURE 9

Thermal comfort - heat transmission in buildings- bioclimatic classification – passive heating concepts: direct heat gain - indirect heat gain - isolated gain and sunspaces - passive cooling concepts: evaporative cooling - radiative cooling - application of wind, water and earth for cooling; shading - paints and cavity walls for cooling - roof radiation traps - earth air-tunnel. – energy efficient landscape design - thermal comfort - concept of solar temperature and its significance - calculation of instantaneous heat gain through building envelope.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Sukhatme S P, Solar Energy, Tata McGraw Hill, 1984.
2. Kreider, J.F. and Frank Kreith, Solar Energy Handbook, McGraw Hill, 1981.
3. Goswami, D.Y., Kreider, J. F. and & Francis., Principles of Solar Engineering, 2000.

REFERENCES:

1. Garg H P., Prakash J., Solar Energy: Fundamentals & Applications, Tata McGraw Hill, 2000.
2. Duffie, J. A. and Beckman, W. A., Solar Engineering of Thermal Processes, John Wiley, 1991.
3. Alan L Fahrenbruch and Richard H Bube, Fundamentals of Solar Cells: PV Solar Energy Conversion, Academic Press, 1983.
4. Larry D Partain, Solar Cells and their Applications, John Wiley and Sons, Inc, 1995.
5. Roger Messenger and Jerry Vnetre, Photovoltaic Systems Engineering, CRC Press, 2004.
6. Sodha, M.S, Bansal, N.K., Bansal, P.K., Kumar, A. and Malik, M.A.S. Solar Passive Building, Science and Design, Pergamon Press, 1986.
7. Krieder, J and Rabi, A., Heating and Cooling of Buildings: Design for Efficiency, McGraw-Hill, 1994.

FE9018 SLIDING MODE AND ADAPTIVE CONTROL L T P C
3 0 0 3

UNIT I INTRODUCTION TO SMC, PASSIVITY AND FLATNESS 9
Dynamics in the sliding mode – linear system, non-linear system, chattering phenomenon – sliding mode control design – reachability condition, robustness properties –application – flatness, passivity properties through flatness, non-minimum phase output stabilization, trajectory planning.

UNIT II STABILITY AND STABILIZATION 9
Introduction – Notation- Generalized regular form – Obtaining the regular form – Effect of perturbations on the regular form – Estimation of initial sliding motion –Problemformulation – Sliding domain and initial domain of sliding motion – Application- Stabilization.

UNIT III DETERMINISTIC, STOCHASTIC AND PREDICTIVE SELF TUNING REGULATOR 9
Pole placement design – Indirect self tuning regulator – Direct self tuning regulator- Design of minimum variance and moving average control stochastic self tuning regulator – Unification direct self tuning regulator – Linear quadratic self tuning regulator- Adaptive predictive control- MIT rule.

UNIT IV DESCRIBING FUNCTION AND STATE SPACE BASED PROCESS IDENTIFICATION 9
Basics of process identification – Characteristics of relays – Existence and stability of limit cycles-Identification using describing function – Parallel relay with controller-State space method – Existence of limit cycles in unstable processes – SOPDT dynamics identification

UNIT V ONLINE TUNING AND GAIN SCHEDULING 9
Online tuning of controllers – Model based and model free tuning –Principle and design of gain scheduling controllers – Nonlinear transformations – Applications of gain scheduling – Robust high gain feedback control – Self oscillating adaptive systems.

TOTAL: 45 PERIODS

TEXT BOOKS
1. Astrom and Wittenmark,” Adaptive Control ”, PHI.
2. Somanath Majhi ., “ Advanced Control Theory A relay Feedback Approach”, Cengage Learning, 2009.
3. Jean Pierre Barbot .,” Sliding Mode Control In Engineering” Marcel Bekker, 2002.

REFERENCES
1. William S. Levine, “Control Hand Book”, CRC Press
2. Narendra and Annasamy,” Stable Adaptive Control Systems, Prentice Hall, 1989.

Faculty of Electrical Engineering (Approved in 16th AC (Ad hoc) 02.12.2010) ITEM NO. FE 16.02(3)

FE9019 NETWORKING WIRELESS SENSORS L T P C
3 0 0 3

UNIT I INTRODUCTION 8
Wireless sensor networks – Networked wireless sensor devices – Wireless characteristics - Applications of wireless sensor networks – Design challenges – Network deployment.

UNIT II LOCALIZATION AND TIME SYNCHRONIZATION 10
Localization – Overview – Coarse grained node localization using minimal information – Fine grained node localization using detailed information – Network-wide localization – Theoretical analysis of

localization techniques – Time synchronization - Overview –key issues – Fine grained clock synchronization – Coarse grained clock synchronization

UNIT III MEDIUM ACCESS WITH SLEEP SCHEDULING 9

MAC protocols - Overview – Traditional MAC protocols – Energy efficiency in MAC protocols – Asynchronous sleep techniques – Sleep scheduled techniques – Contention free protocols – Sleep based topology control – Constructing topology for connectivity – Constructing topologies for coverage – Set K cover algorithms –Cross layer Issues

UNIT IV ROUTING & DATA CENTRIC NETWORKING 9

Energy efficient and robust routing- Overview – Metric based approaches – Routing with diversity – Multi path routing – Lifetime maximizing energy aware routing – geographical routing – Routing to mobile sinks –Data centric routing – Data gathering and compression – Querying – Data centric storage and retrieval – Database perspective on sensor networks

UNIT V CASE STUDIES 9

Discrete event simulation of Medium Access Control (MAC) protocols and routing protocols for wireless sensor networks – Study on Power aware protocols- Empirical analysis of Time Synchronization, RSSI based Localization and Transmission power control –Application of Wireless sensor networks in Electrical and Instrumentation engineering

TOTAL: 45 PERIODS

TEXT BOOKS

1. Bhaskar Krishnamachari, 'Networking Wireless Sensors', Cambridge University Press, New York

REFERENCES:

1. Ivan Stojmenovic, 'Handbook of sensor networks Algorithms and Architectures', A JOHN WILEY & SONS, INC., PUBLICATION 2005
2. MOHAMMAD ILYAS AND IMAD MAHGOUB, 'Handbook of sensor Networks: Compact wireless and wired sensing systems', CRC Press,2005
3. Jagannathan Sarangapai "Wireless Adhoc and sensor networks" CRC Press

Faculty of Electrical Engineering **(Approved in 16th AC (Ad hoc) 02.12.2010) ITEM NO. FE 16.02(4)**

FE9020 HIGH ENERGY RADIATION EFFECTS ON POLYMERS AND HIGH VOLTAGE TESTING OF POWER APPARATUS

L T P C
3 0 0 3

UNIT I GENERATION OF DIRECT, ALTERNATING, IMPULSE VOLTAGES AND MEASUREMENT OF HIGH VOLTAGES AND CURRENTS 9

Generation of High AC and DC Voltages- Generation of High Frequency High AC voltages-Generation of rectangular, square wave pulses-measurement techniques and study of equipments.

UNIT II TESTING TECHNIQUES FOR ELECTRICAL EQUIPMENT 9

Type and nature of testing- Basic Insulation Level(BIL) of Power system- National and International Standards on Testing- Atmospheric Conditions and Correction factors-Testing of insulators, bushings, air break switches, isolators, circuit breakers, power transformers-voltage transformers-current transformers, surge diverters ,cables –testing methodology-recording of oscillograms – interpretation of test results.

UNIT III NUCLEAR TECHNOLOGY AND AGEING 9

Artificial Pollution tests- salt-fog method, solid layer method-Ageing problems associated with nuclear power plants-radiation effects in polymers- condition monitoring- cable failure mechanisms-prediction of life of polymers- qualification of cables-study of standards (IEEE)-Nuclear ageing of cables-Ageing of polymers and electrical equipments-radiation induced degradation in NBR, SR and EPDM rubbers-prediction of life duration of polymers.

UNIT IV GAMMA RAY IRRADIATION EFFECTS ON POLYMERS 9

Study of gamma ray irradiation inhibiting surface charge accumulation on polymers-Nuclear technology and ageing studies –Analysis of electrical and mechanical properties of polymers and their blends.

UNIT V ELECTRON BEAM IRRADIATION ON POLYMERS 9

Study of di-electric and mechanical properties of electron beam irradiated polymer insulation materials-Study of electron beam irradiation effects on morphologic properties of the PET/PP/PE/EVA polymeric blends.

TOTAL: 45 PERIODS

REFERENCES :

1. Kuffel, E., Zaengl, W.S. and Kuffel J., “High Voltage Engineering Fundamentals”, Elsevier India Pvt. Ltd, 2005.
2. Dieter Kind, Kurt Fusser, “High Voltage Test Techniques”, SBA Electrical Engineering Series, New Delhi, 1999.
3. Naidu M S and Kamaraju V, “High Voltage Engineering”, Tata McGraw-hill Publishing Company Ltd., New Delhi, 2004.
4. Gallagher, T.J., and Permain, A., “High Voltage Measurement, Testing and Design”, John Wiley Sons, New York, 1983.
5. R.Mazen Abdel-Salam, Hussein Anis, Ahdab El-Morshedy, Roshdy Radwan, “High Voltage Engineering Theory and Practice” Second Edition, Revised and Expanded, Marcel Dekker, Inc., New York, 2000.
6. N.H.Malik, A.A.Al_Arainy, M.I.Qureshi, “ Electrical Insulation in Power Systems”, marcel Dekker,Inc., New York 1988.
7. Adolf J. Schwab, “High Voltage Measurement Techniques”, M.I.T Press, 1972.
8. IS, IEC and IEEE standards for “Dielectric Testing of High Voltage Apparatus” W.Nelson, Applied Life Data Analysis, John Wiley and Sons, New York, 1982.
9. B.X.Du and Y.Gao, Gamma-ray Irradiation inhibiting surface charge accumulation on polyethylene”, IEEE Transactions on Dielectrics and Electrical Insulation, Vol 16, No 3, pp 876-881,June 2009.
10. H.M. Ban ford and R.A.Fouracre,”Nuclear Technology and ageing” IEEE Electrical Insulation Magazine, Vol15, No 5,pp 19-27,Sep/Oct 1999.
11. Chung Lee, Ki-Yup Kim , Boo-Hyung Ryu and Kee-Joe Lim, “Radiation effects of electrical and mechanical properties of γ –ray irradiated LDPE/EVA blends”, Conference record of 2006 IEEE International Symposium on electrical insulation, Toronto, pp447-450.
12. Katsuyoshi Shinyama, Makoto Baba and Shigetaka Fujita, Dielectric properties of electron beam irradiated polymer insulating material”, Proceedings of International symposium on electrical insulating materials,B2-2, PP 387-391, oyohashi,Japan,Sept 27-30,1998.
13. Edvaldo L. Rossini, Helio Wiebeck and Leonardo G. Andrade e Silva, Study of electron beam irradiation effects on morphologic properties of the PET/PP/PE/EVA polymeric blends’’, International nuclear atomic conference-INAC 2009, Rio de Janerio, RJ Brazil, Sep 27-Oct-2,2009.
14. IEEE – 383, 1974-Type test of class 1E Electric cables, Field Splices and Connections for nuclear power generating stations.
15. IEEE – 323, 1983 – Qualifying Class 1E equipment for nuclear power generating stations.

16. R.Raja prabu, S.Usa, K.Udayakumar, M.abdullah Khan and S.S.M.Abdul Majeed , '' Electrical Insulation Characteristics of Silicone and EPDM Polymeric Blends- Part-I" IEEE Transactions on Dielectrics and Electrical Insulation, Vol 14, No.5, October 2007.
17. W.Kennedy, "Recommended Dielectric Tests and Test Procedures for Converter Transformer and Smoothing Reactors", IEEE Transactions on Power Delivery, Vol.1, No.3, pp 161-166, 1986.
18. IEC – 60270, "HV Test technique – Partial Discharge Mechanism", 3rd Edition December 2000.
19. M.D Judd, Liyang, Ian BB Hunter, "P.D Monitoring of Power Transformers using UHF Sensors",IEEE Electrical Insulation Magazine, Vol.21, No.2, pp5-14, 2004.

Faculty of Electrical Engineering **(Approved in 16th AC (Ad hoc) 02.12.2010)** **ITEM NO. FE 16.02(5)**

FE9021 BIFURCATION ANALYSIS OF POWER SYSTEMS **L T P C**
3 1 0 4

UNIT I INTRODUCTION TO BIFURCATION [1] 5

Introduction to bifurcation, Types of bifurcation SNB, HB, CFB, PDB, SIB, Torous and Intermittency. Mathematical background - Differential Equations (qualitative theory)- Differential-Algebraic systems- Multiple-time scales.

UNIT II MODELING OF POWER SYSTEM COMPONENTS FOR BIFURCATION ANALYSIS [3,4] 10

Modeling of Synchronous Generators (Type 0, 1B, 1A, 2B, 2A), excitation systems, transformer, transmission line, PSS, LTC, and FACTS Controllers- Different types of wind turbine generators SCIG, DFIG and PMSG - Modeling of Grid integrated solar conversion system and other Grid integrated Renewable energy sources.

UNIT III METHODS AND TOOLS FOR BIFURCATION ANALYSIS OF NON-AUTONOMOUS SYSTEM [1, 2, 4] 10

Algorithm for tracing local and global bifurcation diagrams for ODE systems with single variations. Bifurcation diagrams: time response plot, Phase plane and Poincare maps.

UNIT IV METHODS AND TOOLS FOR BIFURCATION ANALYSIS OF AUTONOMOUS SYSTEM [1, 2, 4] 10

Algorithm for tracing local and global bifurcation diagrams for ODE and DAE systems with single and multi-parameter variations- Bifurcation diagrams: time response plot, Phase plane and Poincare maps. PB Theorems.

UNIT V CASE STUDY [2,4,5,6,7] 10

Simulation of the single parameter Bifurcation diagram: ODE and DAE power systems - Analysis with the use of simulation software packages - coding for the sample power system.

L= 45 T =15 TOTAL = 60 PERIODS

REFERENCES

1. L.O.Chua, C.A.Desoer, and E.S.Kuh, "Linear and Nonlinear Circuits", MCgraw hill, 1987.
2. L.O.Chua and Lin P.M "Computer aided analysis of electronics circuits", Printice Hall Inc-USA.
3. R.Ramanujam, "Power System Dynamics: Analysis and Simulation" Prentice Hall India
4. R.Saravanaselvan, Kassim-Al-Anbari, Padma Subramanian, "Ph.D.Thesis".
5. http://www.bifurcation.de/,. and http://www.dynamicalsystems.org/tu/tu/

6. http://www.egwald.ca/nonlineardynamics/bifurcations.php and http://www.staff.science.uu.nl/~kouzn101/NBA/index.html
7. www.matcont.ugent.be/

Faculty of Electrical Engineering **(Approved in 16th AC (Ad hoc) 02.12.2010) ITEM NO. FE 16.02(6)**

FE9022 POWER QUALITY ANALYSIS FOR GRID INTEGRATED RENEWABLE ENERGY **L T P C 3 0 0 3**

UNIT I RENEWABLE ENERGY 9
Solar Photovoltaic Systems – Geothermal Electric Power Plants – Wind Energy Farms and Energy Conversion Systems – Biomass Energy Technology – Ocean Energy Technology – Tidal Energy Conversion.

UNIT II ENERGY STORAGE SYSTEMS 9
Energy Storage & Renewable Energy - Lead Acid Battery cells – Nickel Cadmium Battery – Lithium-Ion Battery – NaS Battery – Electrochemical Capacitors – CAES+Gas ESS – AFES - Flow Batteries – VRB-ESS – SMES – Hydrogen for Energy Storage, Transport and Reconversion.

UNIT III GRID INTEGRATION OF RENEWABLE ENERGY 9
Renewable Power and Grid Stability - Connection and Operational Requirements (Grid Codes) - Integration in Existing Grid / Barriers - Decentralized Generation / Future Integration - Advanced Renewable Energy Technology Solutions for Grid Integration

UNIT IV POWER QUALITY ISSUES 9
Renewable Energy and Power Quality – Harmonic Distortion – Blackouts – Under and Over Voltages – Sags and Surges – Flicker - Interharmonics - Transients – Power Quality Benchmarking – Power Quality Monitoring.

UNIT V MITIGATION TECHNOLOGIES 9
Utility - Customer interface – Harmonic filters: passive, Active and hybrid filters –Custom power devices: Network reconfiguring Devices, Load compensation using DSTATCOM, Voltage regulation using DSTATCOM, protecting sensitive loads using DVR

L: 45+T:15 = 60 PERIODS

REFERENCES:

1. Arindam Ghosh “Power Quality Enhancement Using Custom Power Devices”, Kluwer Academic Publishers, 2002
2. G.D.Rai, “Non-conventional Energy sources”, Khanna Publishers, 1997
3. S.Heir, “Grid Integration of WECS”, Wiley 1998.

Faculty of Electrical Engineering **(Approved in 16th AC (Ad hoc) 02.12.2010) ITEM NO. FE 16.02(7)**

FE9023 OPTIMIZATION TECHNIQUES IN DESIGN **L T P C 3 0 0 3**

UNIT I INTRODUCTION 5
Problem formulation, degree of freedom analysis, objective functions, constraints and feasible region, Types of optimization problem.

UNIT II UNCONSTRAINED OPTIMIZATION TECHNIQUES 10

Introduction to optimum design - General principles of optimization – Problem formulation & their classifications - Single variable and multivariable optimization, Techniques of unconstrained minimization – Golden section, Random, pattern and gradient search methods – Interpolation methods.

UNIT III CONSTRAINED OPTIMIZATION TECHNIQUES 10

Optimization with equality and inequality constraints - Direct methods – Indirect methods using penalty functions, Lagrange multipliers - Geometric programming

UNIT IV MULTI OBJECTIVE OPTIMIZATION 10

Weighted Sum of Squares method, Epsilon constrains method, Goal attainment Examples. Introduction to optimal control and dynamic optimization

UNIT V ADVANCED OPTIMIZATION TECHNIQUES 10

Multi stage optimization – dynamic programming; stochastic programming; Multi objective optimization, Genetic algorithms and Simulated Annealing techniques; Neural network & Fuzzy logic principles in optimization.

TOTAL : 45 PERIODS

REFERENCES:

1. Rao, Singaresu, S., "Engineering Optimization – Theory & Practice", New Age International (P) Limited, New Delhi, 2000.
2. Johnson Ray, C., "Optimum design of mechanical elements", Wiley, John & Sons, 1990.
3. Kalyanamoy Deb, "Optimization for Engineering design algorithms and Examples", Prentice Hall of India Pvt. 1995.
4. Goldberg, D.E., "Genetic algorithms in search, optimization and machine", Barnen, Addison-Wesley, New York, 1989.

Faculty of Electrical Engineering **(Approved in 16th AC (Ad hoc) 02.12.2010)** **ITEM NO. FE 16.02(8)**

FE9024 MATRIX CONVERTERS

L	T	P	C
3	0	0	3

UNIT I AC – AC CONVERTERS 9

Introduction-AC-AC Voltage Controllers,Cycloconverters – single phase ,three phase,Control scheme,Cycloconverter harmonics & I/P current, Power quality Issues, Forced commutated cycloconverter,Matrix Converter.

UNIT II MATRIX CONVERTERS 9

Basic circuit, Bidirectional switches, single phase, three phase, mathematical modelling ,Switching algorithm,Commutation methods, I/P filter and O/P filter, Unbalanced supply and Load conditions.

UNIT III MODULATION TECHNIQUES 9

Operation and modulation techniques of Matrix Converter-Venturini – Modified Venturini -, SVPWM-Indirect Transfer function - scalar modulation algorithm, protection Issues. Power regulation – Control of reactive power.

UNIT IV CONTROLLER DESIGN & APPLICATIONS 9

PID controller, Neuro controller,Fuzzy controller,Neuro fuzzy ,PR controller.

Applications – For Induction motor drives,Hybrid vehicle applications,Frequency changing power supply applications,aircraft applications,Renewable Energy applications.

UNIT V MATRIX CONVERTER FOR WIND ENERGY CONVERSION SYSTEMS 9

Introduction ,Advantages of MC applied to Wind Energy Conversion Systems(WECS),Comparison of WECS technologies,Modelling and simulation of wind energy systems with matrix converters – PMSG wind turbine system ,DFIG wind turbine system,SCIG wind turbine system.

TOTAL : 45 PERIODS

REFERENCES:

1. Mohammed H Rashid ,"POWER ELECTRONICS HANDBOOK",2nd edition,Academic Press,2007.
2. S.N.Bhadra "WIND ELECTRICAL SYSTEMS", Oxford University Press,2005
3. Marian P.Kazmier kowski,R.Krishnan,Frede Blaabjerg,"Control in Power Electronics – Selected Problems"Academic Press,2002.
4. P.Thoegersen,F.Blaabjerg "Adjustable Speed Drives in the next Decade-The next step in Industry & Academia" Proc.PCIM'00,Intelligent Motion,pp 95-104,2000.
5. A.Guoliang Yang, B.Huiguang Li "Application of a Matrix Converter for PMSG Wind Turbine Generation System"Proc. IEEE General Meeting, pp 619 – 623,August 2009.
6. Roberto Cardenas, Ruben Pena, Jon Clare " Control of the Reactive Power Supplied by a matrix Converter"IEEE Transactions on Energy Conversion, Vol 24,No 1, pp 301-303, March 2009.
7. J.Jeong, Y.Ju,B.Han "Wind Power System using Doubly- Fed induction Generator and Matrix Converter with Simple Modulation Scheme" Proc.IEEE General Meeting,Sep.2009.
8. Dr.Saul Lopez Arevalo ,"Matrix converter for frequency changing power supply applications",PhD Thesis,University of Nottingham,UK,2008)
9. Dr.M.Imayavaramban ,"Avoiding Regeneration with Matrix converter Drive",Ph.D Thesis,Universiy of Nattingham,UK,2009.

Faculty of Electrical Engineering **(Approved in 16th AC (Ad hoc) 02.12.2010)** **ITEM NO. FE 16.02(9)**

FE9025 ENERGY TECHNOLOGIES AND MAGNETIC ENERGY STORAGE SYSTEM **L T P C**
3 0 0 3

UNIT I INTRODUCTION 9

Development in the field of superconductivity, Basic parameters of superconductivity, Types of superconductors, BCS theory, Meissner Effect, Josephson effect in Superconductors. High Tc Superconductors, Cuprate Superconductors; La, Y, Bi, Tl and Hg based superconductors, Intermetallic MgB2 superconductor crystal structure and superconducting properties, conduction mechanism.

UNIT II SYNTHESIS OF HIGH TC SUPERCONDUCTORS 9

Introduction, Different methods of synthesis of High Tc superconductors; electro deposition, electrophoretic method, spray pyrolysis technique, solid state reaction method, screen printing, Pulse laser deposition method (PLD), Powder in tube method (PIT), combustion method, sol -gel method, Electro deposition of alloys; DC electrode position, Mechanism of lectrodeposition, Post deposition treatments.

UNIT III APPLICATIONS OF SUPERCONDUCTORS IN ENERGY 9

Superconducting wires and their characteristics, High field magnets for production of energy by magnetic fusion, Energy generation - Magneto hydrodynamics (MHD), energy storage, electric generators and role of superconductors.

UNIT IV MAGNETIC AND ELECTRIC ENERGY STORAGE SYSTEMS 9

Superconducting Magnet Energy Storage (SMES) systems; Capacitor and Batteries: Comparison and application; Super capacitor: Electrochemical Double Layer Capacitor EDLC), principle of working, structure, performance and application, role of activated
Carbon and carbon nano-tube.

UNIT V EXPERIMENTAL TECHNIQUES 9

Low temperature resistivity measurements; Four probe and Vander Paw resistivity technique, AC and DC susceptibility measurements, SQUID measurements, Different types of cryostat, Closed cycle refrigerators system.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Introduction to Superconductivity: Second Edition (Dover Books on Physics) by Michael Tinkham, Publisher: Dover Publications; 2 edition (June 14, 2004)
2. Preliminary investigation of small scale superconducting magnetic energy storage (SMES) systems by J. Schwartz, Publisher: US Army Corps of Engineers, Construction Engineering Research Laboratories National Technical Information Service, distributor

REFERENCES:

1. Superconductivity of Metals and Alloys (Advanced Book Classics) by Pierre-Gilles de Gennes, Pierre-Gilles De Gennes, P. G. de Gennes, Publisher: Westview Press (March 31, 1999)
2. The Theory of Superconductivity in the High-Tc Cuprate Superconductors by P. W. Anderson, Publisher: Princeton University Press; First Edition edition (August 4, 1997)
3. Global Superconducting Magnetic Energy Storage Systems (SMES) Market 2008-2012 by TechNavio, Publisher: Infiniti Research Limited.

Faculty of Electrical Engineering **(Approved in 17th AC (Ad hoc) 27.04.2012)** **ITEM NO. FE 17.02(1)**

FE 9026 STABILITY ANALYSIS OF GRID INTEGRATED WIND ENERGY CONVERSION SYSTEM

L T P C
3 0 0 3

UNIT I INTRODUCTION 9

Classification of Stability-Types of WECS- Fixed speed wind generator -Variable speed wind generator - FACTS- Basic concepts- Static Var Compensator (SVC), Static Synchronous Compensator (STATCOM), Thyristor Switched Series capacitor (TCSC), Static Series Synchronous Compensator (SSSC) and Unified power flow controller (UPFC).

UNIT II MODELLING OF WIND FARMS FOR LOAD FLOW ANALYSIS 9

Aggregated modelling of wind farms for load flow analysis-Different types of aggregation-Simulation.

UNIT III MODELLING OF WECS AND FACTS FOR STABILITY 9

Modelling of synchronous generators (Type 0, 1B, 1A)-Modelling of Wind turbine, Squirrel cage Induction generator (SCIG), Doubly Fed Induction Generator (DFIG) –Introduction to vector control-Modelling of SVC, STATCOM-TCSC.

UNIT IV SMALL SIGNAL STABILITY ANALYSIS 9

Small Signal stability analysis of WSCC 9 Bus system- SCIG-DFIG-Enhancement of Small Signal Stability –SVC-STATCOM-TCSC-Simulation.

UNIT V TRASIENT STABILITY ANALYSIS 9

Transient stability analysis of WSCC 9 Bus system- SCIG-DFIG-Enhancement of Transient Stability – SVC-STATCOM-TCSC--Simulation.

TOTAL: 45 PERIODS

REFERENCES :

1. S.Heir “Grid Integration of WECS”, Wiley 1998.

2. P. Kundur, "Power System Stability and Control", McGraw-Hill, 1993.
3. P.M Anderson and A.A Fouad, "Power System Control and Stability", Iowa State University Press, Ames, Iowa, 1978.
4. R.Ramanujam, "Power System Dynamics: Analysis and Simulation" Prentice Hall India.
5. R.Mohan Mathur, Rajiv K.Varma, "Thyristor – Based Facts Controllers for Electrical Transmission Systems", IEEE press and John Wiley & Sons, Inc.
6. Narain G. Hingorani, "Understanding FACTS -Concepts and Technology of Flexible AC Transmission Systems", Standard Publishers Distributors, Delhi- 110 006
7. Modeling of Wind
8. Load flow analysis for variable speed offshore wind farms by M.Zhao et al.,
9. Small signal stability analysis of large scale variable speed wind turbines integration by Xiangi Li et.al,
10. Modeling and performance of fixed-speed induction generators in power system oscillation stability studies by Jian Zhang et al.,
11. Small Signal stability analysis of Wind Turbines with Squirrel Cage Induction Generators by Yuri Ullianov Lopez et al.,
12. Ph.d Thesis," On the Use of Wind Power for Transient stability Enhancement of Power systems" by Katherin Elkington, Royal Institute of Technology,
13. Ph.d Thesis," Small signal modeling and Analysis of DFIG in wind power application" by Francoise Mei, University of London,
14. Ph.d Thesis, "Analysis, Modeling and control of DFIG for wind turbines" by Andreas Petersson, Chalmers University of technology,Sweden.
15. Doubly Fed Induction Generator Model for Transient Stability Analysis by Peblo Ledesma and Julio Usaola,IEEE Trans. On energy Conversion, June2005.
16. Aggregated Wind Park Models for Analyzing Power system dynamics by Markus Poller and Sebastian Achilles.
17. Initialization of Wind turbine models in Power system Dynamic Simulation by Slootweg et.al.,, IEEE conference.

Faculty of Electrical Engineering **(Approved in 17th AC (Ad hoc) 27.04.2012)** **ITEM NO. FE 17.02(2)**

FE 9027 MODERN OPTIMISATION TECHNIQUES IN POWER SYSTEM **L T P C**
3 0 0 3

UNIT I INTRODUCTION **6**

Power system optimisation-Emerging optimisation techniques and its application in Power system-Simulated annealing applications-Multi-objective optimisation-Constrained and Unconstrained Optimization problems.

UNIT II CONVENTIONAL METHODS **9**

Lagrangian relaxation-Augmented Lagrangian decomposition-Short-term hydro-thermal co-ordination and Long-term hydro-thermal co-ordination problem-Unit Commitment- Optimal Power Flow - Interior point methods –IPM application in Power Systems- Case study on IPM based spot pricing algorithm

UNIT III GENETIC ALGORITHM **9**

Genetic Algorithm- Genetic Algorithm for Unit Commitment-Problem formulation- Generator maintenance scheduling using Genetic Algorithm-Transmission Network Planning problem- Genetic Algorithm model for Transmission Network Planning-Ant colony search algorithms -Tabu search-Particle Swarm Optimization technique

UNIT IV ARTIFICIAL NEURAL NETWORK AND FUZZY BASED

OPTIMISATION TECHNIQUES **12**

Introduction–Hopfield networks for optimisation-Hopfield networks applied to the Economic Dispatch and Unit Commitment problem-Augmented Hopfield network(AHN)-Network Architecture and Dynamics-Application of AHN to the scheduling problem-Fuzzy sets-Fuzzy multiple objective decision-Application of Fuzzy set to Power system –Decision making in a deregulated power environment based on Fuzzy set.

UNIT V CASE STUDIES **9**

Application of Different Optimization techniques: Load flow - Optimal power flow - Economic Discpatch- Security constrained optimal power flow-State Estimation- Deregulated Power Systems.

TOTAL: 45 PERIODS

REFERENCES :

1. Yong-Hua Song , “Modern Optimisation techniques in Power systems “- Kluwer Academic Publisher, 1999.
2. Ashok D.Belegundu and Chrandrapatla T. R “ Optimization Concept and Application in Engineering “ Prentice Hall, 1999.
3. Laurence Fausett “Fundamentals of Neural Networks” – Prentice Hall, 1994.
4. David E.Goldberg “Genetic Algorithm” – Pearson Education, 2007.
5. Timothy J.Ross “Fuzzy Logic with Engineering Applications”-Tata McGraw-Hill, 1997.

Faculty of Electrical Engineering **(Approved in 17th AC (Ad hoc) 27.04.2012)** **ITEM NO. FE 17.02(3)**

FE9028 MARINE INSTRUMENTATION AND UNDERWATER TECHNOLOGY **L T P C 3 0 0 3**

UNIT I OCEANOGRAPHIC AND MARINE SURVEY INSTRUMENTATION **9**

Basic studies on Ocean profilers – conductivity – salinity – temperature - depth and pressure sensors / instruments - sampling system for deep sea water - current meter - sea bed system - Echo sounder, multibeam sonar - sub bottom profiler - side scan sonar.

UNIT II PHYSICAL OCEANOGRAPHY **9**

Properties of Seawater – Coastal landforms – Ocean dynamics and upwelling Oceanographic instruments and methods – heat budget – General ocean circulation – Regional oceanography – waves, tides, sea level.

UNIT III UNDER WATER SYSTEM BASIC DESIGN PROCESS **9**

Introduction - overall perspective - input to submersible system design - basic design of manned submersible - Electrical power distribution systems and lighting systems for underwater application

UNIT IV OCEAN ENVIRONMENT AND VEHICLE SUPPORT SYSTEMS **9**

Introduction - physical properties of sea water - dynamical processes - The geography of the world’s ocean basins - Transportation systems - Navigation and position aids - Motion compensation techniques - General safety consideration of underwater system - Design of control systems,

UNIT V CONTROL AND REGULATION ELEMENTS **9**

Direction flow and pressure control valves-Methods of actuation, types, sizing of ports-pressure and temperature compensation - Overlapped and underlapped spool valves-operating characteristics-electro hydraulic servo valves-Different types-characteristics and performance.

TOTAL : 45 PERIODS

REFERENCES:

1. E.Eugene Allmendinger , submersible vehicle systems a design , The society of naval architects and marine engineers , 1st edition (1990).
2. Jane's , Underwater technology , Janes information group, 1st edition (1998-99).
3. Antony Esposito, Fluid Power Systems and control Prentice-Hall, 1988
4. Herbert R. Merritt, Hydraulic control systems, John Wiley & Sons, Newyork, 1967
5. W.Bolton, Mechatronics, Electronic control systems in Mechanical and Electrical Engineering Pearson Education, 2003.
6. Garrison, T., Oceanography: An Invitation to Marine Science, 5th Edition, Brooks, 2007.
7. Gross, M.G. Principles of Oceanography, 7th Edition, Prentice-Hall, 1995.
8. Gross, M.G., Oceanography: A View of the Earth, 3rd Edition Prentice Hall, 2008

Faculty of Electrical Engineering **(Approved in 17th AC (Ad hoc) 27.04.2012) ITEM NO. FE 17.02(4)**

FE 9029 CMOS ANALOG MIXED SIGNAL DESIGN **L T P C**
3 0 0 3

UNIT I TRANSISTOR MODELS FOR ANALOG DESIGN 9

Long channel and short channel MOSFETs; The square law equations for nMOS and pMOS; Threshold voltage and body effect; Transconductance; AC Analysis; Transient analysis; Transition frequency; Temp effects; MOSFET noise modeling.

UNIT II CMOS INVERTER AND CURRENT MIRRORS 9

Inverter DC characteristics and switching characteristics; Noise Margins for inverter VTC; Inverter transistor sizing for large loads; Basic current mirrors; Biasing and referencing current mirrors for both long channel and short channel transistors; Cascoding the current Mirror for wide swing; Biasing circuits for long channel and short channel transistors.

UNIT III CMOS AMPLIFIERS AND DIFFERENTIAL AMPLIFIERS 9

Gate-Drain connected Transistor loads; Current source loads; Common source Amplifier-Miller compensation, Pole splitting, cancelling RHP zero; Cascode Amplifier; Source follower; Push pull Amplifier; Source coupled Differential Amplifier; Source cross coupled Diff Amplifier; Cascode and wide swing Diff Amplifier; DC operation; AC operation; CMRR; Slew rate limitations; Input signal range and Noise performance.

UNIT IV OPERATIONAL AMPLIFIERS 9

Two stage op-Amp; Buffered Amplifier output; Operational Transconductance Amplifier; Gain Enhancements, CMRR, PSRR, Gain Margin, Phase Margin, Input Common-Mode voltage range, Bandwidth; Biasing op-Amp for power and speed; Common mode feedback Amplifier.

UNIT V DATA CONVERTERS – BASICS AND ARCHITECTURE 9

ADC,DAC Basics – Analog Vs Discrete Time signals; Sample and Hold circuits; Differential Nonlinearity, Integral nonlinearity, offset, Gain error, latency, SNR, Dynamic rang, aliasing; DAC architectures- Digital input code, R-2R ladder network, Current steering, pipeline DAC; ADC Architecture – Flash, Two step flash, pipeline ADC, SAR ADC, oversampling ADC.

TOTAL: 45 PERIODS

TEXT BOOK:

1. Jacob Baker, "CMOS circuit design, layout and simulation", IInd Edition, Wiley-IEEE press, Nov 2004.

REFERENCES:

1. Mohammed Ismail, Terri Fiez, "Analog VLSI signal and Information Processing ", McGraw-Hill International Editons, 1994.
2. Malcom R.Haskard, Lan C.May, "Analog VLSI Design - NMOS and CMOS ", Prentice Hall, 1998.
3. Randall L Geiger, Phillip E. Allen, " Noel K.Strader, VLSI Design Techniques for Analog and Digital Circuits ", Mc Graw Hill International Company, 1990.
4. Jose E.France, Yannis Tsividis, "Design of Analog-Digital VLSI Circuits for Telecommunication and signal Processing ", Prentice Hall, 1994

Faculty of Electrical Engineering **(Approved in 17th AC (Ad hoc) 27.04.2012)** **ITEM NO. FE 17.02(5)**

FE 9030	**EMBEDDED APPROACHES FOR MICRO GRID APPLICATION**	**L T P C** **3 0 0 3**

UNIT I INTRODUCTION TO MICRO GRID 9

Introduction- Concept of Microgrid - Island operation mode - Grid connected mode. Microgrid Control: Voltage vs. Reactive Power (Q) Droop - Power Vs Frequency Droop - SOA for Microgrid.

UNIT II MULTIAGENT SYSTEMS 9

Introduction, agents and objects - Agents and distributed systems - Intelligent Agents, Benefits of Multiagent systems - Hierarchical Multi Agent System - Multiagent Systems for power engineering applications.

UNIT III INTERACTION LANGUAGES 9

Ontology Languages: Agent Communication Languages, KQML, the FIPA Agent Communication Language. ZEUS tool kit.

UNIT IV WIND AND SOLAR PHOTOVOLTAIC SYSTEM 9

Introduction: Components, Electrical load matching. System Design Features. Modeling: Solar Photo voltaic systems, Wind energy system.

UNIT V CASE STUDIES MICRO GRID 9

Simulation on Stand-Alone System, Hybrid systems using MATLAB, LABVIEW and ZEUS.

TOTAL: 45 PERIODS

REFERENCES

1. Clark W. Gellings, "The Smart Grid : Enabling Energy Efficiency And Demand Response", The Fairmont Press, 2009.
2. Brendan Fox, Damian Flynn et al., "Wind Power Integration Connection and System Operational

Aspects", The Institution of Engineering and Technology, London, United Kingdom,2007.
3. Mukund R. Patel, "Wind and solar power systems" CRC Press, 2009.
4. Micheal Wooldridge, "An Introduction to MultiAgent Systems", Second Edition, John Wiley and Sons Ltd, 2009.
5. Zeus agent development toolkit. Available online: http://www.upv.es/sma/plataformas/zeus/Zeus-TechManual.pdf

Faculty of Electrical Engineering **(Approved in 17th AC (Ad hoc) 27.04.2012)** **ITEM NO. FE 17.02(6)**

FE 9031 ENERGY HARVESTING TECHNOLOGIES L T P C
3 0 0 3

UNIT I PIEZOELECTRIC ENERGY HARVESTING 9
Physics and Characteristics of Piezoelectric Effects, Materials, and Mathematical Description of Piezoelectricity Effect ,Piezoelectric Parameters, and Modeling Piezoelectric Generators, Power Electronic Interfaces for Piezoelectric Energy Harvesting, Piezoelectric Energy Harvesting Applications.

UNIT II ELECTROMAGNETIC ENERGY HARVESTING 9
Linear Generators, Physics, Mathematical Models, and Structures, Recent Applications and Projects on Electromagnetic Energy Harvesting, Hybrid Piezoelectric-Electromagnetic Energy Harvesting.

UNIT III ENERGY HARVESTING CIRCUITS AND ARCHITECTURES 9
One-dimensional Electromechanical Analytic Model, Power Optimization Optimality of the Parallel-RL Circuit, The Purely Resistive Circuit The Parallel-RL Circuit, The Series-RL Circuit, Optimality Results for Series RL-Circuit , Energy Harvesting using Non-linear Techniques-Introduction to Nonlinear Techniques and their Application to Vibration Control.

UNIT IV THERMOELECTRIC ENERGY HARVESTING 9
Harvesting Heat ,Thermoelectric Generators, Design of a Thermo electric Energy Harvester, General Considerations, Thermoelectric Efficiency Matched Thermal Resistance, Heat Flux, Matching Thermo electrics to Heat Exchangers, Thin Film Devices.

UNIT V APPLICATIONS OF ENERGY HARVESTING SYSTEMS 9
Harvesting Energy from the Straps of a Backpack Using Piezoelectric materials, Piezoelectric Energy Harvesting for Bio-MEMS Applications, Energy Harvesting for Active RF Sensors and ID Tags.

TOTAL: 45 PERIODS

REFERENCES:
1. Priya Shashank, Inman Daniel J., "Energy harvesting technologies" , Springer; 2009.
2. Tom J. Ka´zmierski · Steve Beeby, "Energy Harvesting Systems Principles, Modeling and Applications", Springe Science+Business Media, LLC 2011.
3. Alroza KhalighOmar G. Onar Energy, Power Electronics, and Machines Series , "ENERGY HARVESTING Solar, Wind, and Ocean Energy Conversion Systems" 2010 by Taylor and Francis Group.

FE 9032 ELECTRIC FIELDS IN COMPOSITE DIELECTRICS AND THEIR APPLICATIONS **L T P C 3 0 0 3**

UNIT I BASIC PROPERTIES OF ELECTRIC FIELDS IN COMPOSITE DIELECTRICS 9

Background – Fundamentals of Composite Dielectric Fields- Effect of Conduction – Outline of Field Behavior near a Contact Point.

UNIT II ELECTRIC FIELD BEHAVIOR FOR A FINITE CONTACT ANGLE 9

Analytical Treatment – Numerical Treatment – Effect of Volume and Surface Conduction

UNIT III ELECTRIC FIELD FOR A ZERO CONTACT ANGLE 9

Stressed Conductor in Contact with a Solid Dielectric – Uncharged Spherical Conductor Under a Uniform Field – Stressed Conductor on a Solid Dielectric of Finite Thickness – Other Basic Configurations – Effect of Volume and Surface Conduction.

UNIT IV ELECTRIC FIELD BEHAVIOR FOR THE COMMON CONTACT OF THREE DIELECTRICS 9

Contact of Straight Dielectric Interfaces – Perpendicular Contact of a Solid Dielectric with Another Solid – Numerical Analysis of Field Behavior.

UNIT V ELECTRIC FIELD IN HIGH VOLTAGE EQUIPMENT 9

Finite Contact Angle: Prevention of Field Singularity near a Contact Point – Zero Contact Angle in Gas Insulated Equipment – Common Contact of Three Dielectrics – Application of High Field Emission Devices.

TOTAL: 45 PERIODS

REFERENCES

1. Tadasu Takuma, Boonchai Techaumnat, " Electric Fields in Composite Dielectrics and their Applications", Springer (2010).
2. Kowalik, J., Osborne, M.R., " Method for Unconstrained Optimization Problems", Elsevier, New York (1968).
3. Takuma, T., Kawamoto, T.: "Field enhancement at a triple junction in arrangements consisting of three media", IEEE Trans. Dielectr. Electr. Insul. 14(3), 566 – 571 (2007).

FE 9033 EMBEDDED PROCESSORS AND EMBEDDED OS **L T P C 3 0 0 3**

UNIT I ARM PROCESSOR 9

ARM Processor Fundamentals, Introduction to the ARM Instruction set, Efficient C Programming, Digital Signal Processing, Memory Management Units, Simple Interface programs.

UNIT II OMAP PROCESSOR 9

Introduction, architecture, instruction set, addressing modes, applications –Interface to I/O.

UNIT III OMAP AM/DM 37x PROCESSOR 9

Functional block diagram, Key features, Memory and I/O Mapping, I/O Interface, Power Module, Case study.

UNIT IV UBUNTU OPERATING SYSTEM 9

Introduction, Features , Building a Ubuntu Linux host under Virtual-box, Configuring Virtual Machine, Installing Ubuntu on the Virtual machine, Sharing files between Ubuntu and windows. Configuring a Proxy in Ubuntu, Case study

UNIT V ANDROID 9

Introducing Android, Key Concepts, Designing the User Interface, Multimedia, Storing local data, case study

TOTAL: 45 PERIODS

REFERENCES

1. Andrew.N.Sloss, Dominc Symes, Cris Wright "ARM Systems Developers Guide - Designing and optimizing system software", Morgan Kauffmann Publishers, Fifth Edition, 2009.
2. OMAP Reference manual from Texas instruments, 2006.
3. AM37x Evaluation Module – Hardware User Guide, 2009.
4. AM37x EVM SDK 4.00 Release Notes, 2010.
5. Ed Burnette "Hello, Android" Shroff Publishers &Distributors Pv.t Ltd. Third Edition, 2011.

Faculty of Electrical Engineering **(Approved in 17th AC (Ad hoc) 27.04.2012)** **ITEM NO. FE 17.02(9)**

FE 9034	VIRTUAL INSTRUMENTATION AND FAULT DIAGNOSIS OF INDUCTION MOTORS	L T P C 3 0 0 3

UNIT I 9

Types of faults in Induction motors, Condition monitoring of Induction motors, Study of faults in Inverter-fed Machines

UNIT II 9

Technology trends in fault diagnosis of Induction motors, State Estimation methods for induction motor modeling, MATLAB Simulation studies of transients in Induction motors.

UNIT III 9

Fourier transform and Wavelet Transforms for fault diagnosis – Model based prediction theory applied to fault detection in Induction motors – Discrete Event Systems approach for fault detection – Markov models for Fault diagnosis. Behavior-Modulation Techniques for fault detection – Pattern Recognition applied to fault detection.

UNIT IV **9**

Use of Analysis tools, Fourier transforms, power spectrum, correlation methods, windowing and filtering. Application of VI in process control designing of equipments like oscilloscope, Digital multi meter, Design of digital Voltmeters with transducer input Virtual Laboratory.

UNIT V **9**

Distributed I/O modules – Application of Virtual Instrumentation: Development of process database management system, Simulation of systems using VI, Development of Control system, Image acquisition and processing, Development of Virtual Instrument using GUI.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. L.H. Chiang, E.L. Russell and R.D.Braatz, "Fault Detection and diagnosis in Industrial Systems" – Springer – Verlag-London 2001.
2. Irving L.Kosow, "Electric machinery and transformers", second edition, Prentice Hall, 2007
3. 3. Ronald N. Bracewell, "The Fourier Transform and its applications", third edition, McGrew Hill,2000
4. Stephane Mallat, "A wavelet tour of signal processing", second edition, Academic press, 1999.
5. Gary Johnson, LabVIEW Graphical Programming, Second edition, McGraw Hill, Newyork, 1997.

REFERENCES:

1. Anthanasios Papoulis, "Probability, Random Variables and Stochastic processes", second edition, Tata McGraw Hill.
2. Lisa K. wells & Jeffrey Travis, Lab VIEW for everyone, Prentice Gall, New Jersey, 1997.

Faculty of Electrical Engineering **(Approved in 17th AC (Ad hoc) 27.04.2012)** **ITEM NO. FE 17.02(10)**

FE 9035 **ANALYSIS AND DESIGN OF A SPECIAL MACHINE FOR FLYWHEEL ENERGY STORAGE SYSTEMS** **L T P C 3 0 0 3**

UNIT I ELECTROMAGNETIC ENERGY CONVERSION **9**

General expression of stored magnetic energy, Co-energy and force/torque – Calculation of air-gap MMF and per phase machine inductance using physical machine data – Reference frame theory.

UNIT II SPECIAL ELECTRICAL MACHINES **9**

Principle of operation of Stepper motors - Switched Reluctance Machines - Brushless DC Machines - Axial Flux Permanent Magnet Machines

UNIT III PRINCIPLES OF AXIAL FLUX PERMANENT MAGNET MACHINES **9**

Introduction – Magnetic circuits – Windings – Torque production – Losses and efficiency – Sizing equations – AFPM motor – AFPM generator – Materials and Fabrication

UNIT IV CHARACTERISTICS OF AFPM MACHINES AND CONTROL **9**

AFPM machines with iron core – without stator core – without stator and rotor cores - Control

UNIT V COOLING AND HEAT TRANSFER OF AFPM MACHINE 9

Importance of thermal analysis – Heat transfer modes – Cooling of AFPM machines – Lumped parameter thermal model – Machine duties.

TOTAL: 45 PERIODS

REFERENCES

1. Paul C. Krause, OlegWasyzczuk, Scott S, Sudhoff, "Analysis of Electric Machinery and Drive Systems", IEEE Press, Second Edition
2. Jacek F.Gieras, Rong-Jie wang, Maarten J Kamper, "Axial Flux Permanent Magnet Brushless Machines", Springer,2005
3. A.E, Fitzgerald, Charles Kingsley, Jr, and Stephan D, Umanx, " Electric Machinery", Tata McGraw Hill, 5th Edition, 1992
4. Slobodan N Vukosavic , "Digital Control of Electric Drives", Springer, 2007.
5. R. Krishnan, "Electric Motor Drives, Modeling, Analysis and Control" , Prentice Hall of India, 2002

Faculty of Electrical Engineering **(Approved in 17th AC (Ad hoc) 27.04.2012) ITEM NO. FE 17.02(11)**

FE 9036	POWER ELECTRONICS FOR PHOTOVOLTAIC APPLICATIONS	L T P C
		3 0 0 3

UNIT I Introduction to Solar 9

Semiconductor – properties - energy levels - basic equations of semiconductor devices physics - Basic characteristics of sunlight - Solar angles - day length - angle of incidence on tilted surface – Sun path diagrams – Equivalent circuit of PV cell , PV cell characteristics (VI curve, PV curve) - Maximum power point, Vmp, I_{MP}, V_{oc}, I_{SC} – types of PV cell - Block diagram of solar photo voltaic system, PV array sizing.

UNIT II DC-DC Converter 9

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

UNIT III Charge Controllers 9

Direct Energy transmission, Impedance Matching, Maximum Power Point Tracking (MPPT) - Function of MPPT, P&O method, INC Method, Fractional Open circuit voltage method, Fractional short circuit current method**,** parasitic capacitance and other MPPT techniques.

UNIT IV Battery 9

Types of Battery, Battery Capacity – Units of Battery Capacity-impact of charging and discharging rate on battery capacity-Columbic efficiency-Voltage Efficiency, Charging – Charge Effieciency,Charging methods, State of Charge, Charging Rates, Discharging - Dept of discharge-Discharge Methods, Battery Management System (BMS), selection of Battery.

UNIT V Simulation of PV Module & Converters 9

Simulation of PV module - VI Plot, PV Plot, finding V_{MP}, I_{MP}, V_{oc}, I_{sc} of PV module .Simulation of DC to Dc converter -buck, boost, buck-boost and Cuk converters. Simulation of solar photo voltaic system.

TOTAL: 45 PERIODS

REFERENCES:
1. Tommarkvart, Luis castaner, "Solar cells; materials, manufacture and operation ", Elsevier, 2005.
2. S.P.Sukhatme, J.K.Nayak, "Solar Energy: Principles of Thermal Collection and Storage, Tata McGraw Hill, 2008.
3. G.D .Rai, "Solar energy utilization ", Khanna publishes, 1993
4. Ned Mohan, Undeland and Robbin, "Power Electronics: converters, Application and Design" John Wiley and sons.Inc, Newyork, 1995.
5. Rashid M.H., "Power Electronics Circuits, Devices and Applications", Prentice Hal India, New Delhi, 1995.
6. Rashid .M. H "power electronics Hand book", Academic press, 2001.
7. Valer Pop, Henk Jan Bergveld" Battery Management Systems" springer publication, 2008.
8. H. A. Kiehne," Battery Technology Handbook", Second Edition, Expert Verlag, Renningen Malsheim, Germany 2003.

Faculty of Electrical Engineering **(Approved in 17th AC (Ad hoc) 27.04.2012)** **ITEM NO. FE 17.02(12)**

FE 9037 ADVANCED POWER SYSTEM PROTECTION L T P C
3 0 0 3

UNIT I STATIC RELAYS 9

Introduction - advantages and disadvantages - classification logic circuits - smoothing circuits - voltage regulator - square wave generator - time delay circuits - level detectors - summation device - sampling circuit - zero crossing detector - output devices. COMPARATORS: Replica Impedance - mixing transformers - general equation of phase and amplitude comparator - realization of ohm, impedance and off set impedance characteristics - duality principle, static amplitude comparators - coincidence circuit - Hall effect devices - Magneto receptivity - zener diode, phase comparator, multi input comparators.

UNIT II NUMERICAL RELAYS AND ITS APPLICATION 9

Introduction - principles of numerical relay - fault locators - protection and coordinated control-numerical relaying, algorithm for over current, distance and differential protection with application to Generator, transmission system, transformers and bus bar protection.

UNIT III ISLANDING PROTECTION OF DISTRIBUTION SYSTEMS WITH DISTRIBUTED GENERATORS 9

Introduction – loss of grid protection – objective and requirement – different techniques for LOG detection -active technique – passive technique – other techniques – Islanding protection – DG Protection Requirements.

UNIT IV GRID PROTECTION USING COMMUNICATION – ASSISTED DIGITAL RELAYS 9

Introduction - protection scheme - a new model for high impedance faults - micro grid –smart grid-application system - simulation study.

UNIT V RECLOSER ALLOCATION FOR IMPROVED RELIABILITY OF DG-ENHANCED DISTRIBUTION NETWORKS 9

Introduction - problem description - current regulations - calculating the composite reliability Index of a DG -enhanced feeder - genetic algorithm for the optimal allocation of DGs and protection devices in a non-radial feeder- parameters of a genetic algorithm- test results.

TOTAL: 45 PERIODS

TEXT BOOKS

1. T S M Rao, "Digital/Numerical relays",– Tata Mc-Graw Hill Pub,2005.
2. T S Madhava Rao,"Power System Protection static relays with microprocessor application",– McGraw Hill companies,2008.
3. Y. G. Paithankar,S. R. Bhide, "Fundamentals of power system protection", - Eastern Economy Edition,2010

REFERENCES

1. Eric Sortomme, S. S. Venkata and Joydeep Mitra "Microgrid Protection Using Communication-Assisted Digital Relays," IEEE transactions on power delivery, vol. 25, no. 4, page 2789-2796, October 2010
2. Aleksandar Pregelj, "Recloser Allocation for Improved Reliability of DG-Enhanced Distribution Networks" IEEE transactions on power systems, vol. 21, no. 3,Page 1442-1450 august 2006
3. E. O'Neill-Carrillo, G. T. Heydt, E. J. Kostelich, S. S. Venkata, and A. Sundaram "Nonlinear deterministic modelling of highly varying loads," IEEE Trans. Power Del., vol. 14, no. 2, page. 537–542, Apr. 1999.
4. Vinicius F. Martins and Carmen L. T. Borges, "Active Distribution Network Integrated Planning Incorporating Distributed Generation and Load Response Uncertainties", IEEE transactions on power systems, VOL. 26, NO. 4, page 2164-2172, 2011.

Faculty of Electrical Engineering **(Approved in 18th AC 09.08.2014) ITEM NO. FE 18.03 (01)**

FE9038 DESIGN OF CABLE FED INDUCTION MOTOR DRIVE SYSTEMS – AN ELECTROMAGNETIC APPROACH

L	T	P	C
3	0	0	3

UNIT I INTRODUCTION

Introduction – finite element methods – field problems with boundary conditions – classical method for the field problem Solution – Galerkin's method – rayleigh – ritz's method – application of finite element method to two dimensional fields – variational method – different boundary conditions

UNIT II METHODS OF FIELD COMPUTATION

Computational Methods – Finite element model for electrical machines – equations for magnetic field and windings – transient time steeping simulation – direct coupling of field and circuit equations – coupling by the current output approach – circuit parameter approach

UNIT III FEA OF INDUCTION MACHINE

Finite element analysis of synchronous generator – computation of the no – load characteristic – computations after field solutions – flux linkage – induced emf – computation of direct axis inductance – solved structure – Ld by means of the magnetic energy – flux linkage – air gap flux density – computation of the quadracture axis inductance – saturation effect Ld and Lq with any current – computation of machine characteristics

UNIT IV HIGH FREQUENCY MODEL OF INDUCTION MACHINES AND CABLES

Design of high frequency induction motor parameter - induction capacitances of windings and frame (Csf) - stator windings and rotor (Csr) - rotor and frame (Crf) and bearings (Cb) in induction motors - based on the finite element technique - common mode - differential mode- Determination of self and mutual inductance - capacitance between conductors of three phase cable - Variation of parameters as a function of frequency – FEM approach

UNITV STRESS GRADING

Transient Finite Element Analysis of Stress Grading of winding insulation under Fast Rise Time Pulses for Conductive Armor Tape (CAT) - Semi conductive Stress-Grading Tapes (SSGT) of medium and high voltage induction motor.

TOTAL: 45 PERIODS

REFERENCES

1. Sheppard Joel Salon- Finite element analysis of electrical machines-Kluwer Academic publisher group-1995
2. Electrical Machine analysis using finite elements – Nicola Bianchi, T & F informa CRSpress Boca Raton.NW, Suite 300 Reprint 2005.
3. Fields and Circuits in electrical Machines – N.Kesavamurthy and R.E.Bedford,Thacker Spink & Co. PVT LTD. 1993.
4. The analytical and Numercial solution of Electric and Magnetic Fields – K.J.Binns, P.Lawrenson, John Wiely & Sons, 1993.
5. An introduction to the Finite Element Method - J.N.Reddy, Tata McGraw – Hill publishing company Limited New Delhi Third Edition, 2005.
6. By Joao Bastos, Bastos/Sadowski, Nelson Sadowski, Marcel Dekker (Firma comercial) Electromagnetic modeling by finite element methods
7. High Performance AC Drives: Modelling Analysis and Control By Mukhtar Ahmad
8. Electrical Machine analysis using finite elements – Nicola Bianchi, T & F informa CRS press Boca Raton.NW, Suite 300 Reprint 2005
9. High-frequency cable and motor modeling of long-cable-fed induction motor drive systems Liwei Wang; Ho, C.N.M.; Canales, F.; Jatskevich, J.; Energy Conversion Congress and Exposition (ECCE), 2010 IEEE Digital Object Identifier: 10.1109/ECCE.2010.5617906 Publication Year: 2010 , Page(s): 846 - 852
10. Effectiveness of stress grading coatings on form wound stator coil groundwall insulation under fast rise time pulse voltages Espino-Cortes, F.P.; Cherney, E.A.; Jayaram, S.; Energy conversion, IEEE Transactions on Volume: 20 , Issue: 4 Digital Object Identifier: 10.1109/TEC.2005.853745 Publication Year: 2005 , Page(s): 844 - 851.

Faculty of Electrical Engineering **(Approved in 18th AC 09.08.2014)** **ITEM NO. FE 18.03 (02)**

FE 9039	MODELING AND ANALYSIS OF VARIABLE SPEED WIND ENERGY SYSTEMS	L T P C 3 0 0 3

UNIT I VARIABLE SPEED WIND ENERGY SYSTEMS 9

Need for variable speed systems-Power-wind speed characteristics- DFIG: Review of reference theory fundamentals-principle of operation and analysis-Grid side converter control-Rotor side converter control- Crow bar control.

UNIT II REDUCED ORDER MODELLING OF WIND TURBINES 9

Introduction-Power system dynamics simulation-Current wind turbine types-Modelling Assumptions-Model of a wind turbine with DFIG: Model structure-Rotor model-Generator model-Converter model-Protection system model-Rotor speed controller model-Pitch angle controller model – Terminal voltage controller model- Model Validation.

UNIT III SLIDING MODE CONTROL OF DFIG 9

Introduction-Characteristics of VSC-VSC for linear systems: Basic Definitions – Switching schemes-Reaching conditions and reaching mode- Control law – VSC for Non-linear systems-Reaching mode design and control law-Design of SMC based controller for active and reactive power regulation of DFIG

UNIT IV MODEL PREDICTIVE CONTROL OF DFIG 9

Basic structure of MPC-MPC with linear models: Target Calculation- Receding Horizon Regulator-State Estimation MPC with non-linear models: State feedback- Control problem formulation- Design of MPC based controller for active and reactive power regulation of DFIG.

UNIT V IMPACT OF WIND POWER ON POWER SYSTEM DYNAMICS 9

Introduction-Power system dynamics- Actual Wind Turbine Types- Impact of wind power on Small signal stability: Eigenvalue- frequency domain analysis- analysis of the impacts of wind power on small signal stability- simulation results- Preliminary conclusions.

TOTAL: 45 PERIODS

REFERENCES

1. B. M. Nomikos and C. D. Vournas, “Investigation of Induction Machine Contribution to Power System Oscillations”, *IEEE Trans. Power Systems 2005,* vol. 20,pp.916-925.
2. Ahmadreza Tabesh and Reza Iravani, “Small-Signal Dynamic Model and Analysis of a Fixed-Speed Wind Farm—A Frequency Response Approach”, *IEEE Trans. Power Delivery 2006,* vol. 21,pp.778-787.
3. B.C. Pal F. Mei “Modelling adequacy of the doubly fed induction generator for small-signal stability studies in power” ,IET Renew. Power Generation., 2008, Vol. 2, No. 3, pp. 181–190.
4. Amir Ostadi, Amirnaser Yazdani and Rajiv K. Varma , “Modeling and Stability Analysis of a DFIG-Based Wind-Power Generator Interfaced With a Series-Compensated Line ”, *IEEE Trans. Power Delivery*,2009, VOL. 24, NO. 3, pages 1504-1514 .
5. Georgios Tsourakis, Basil M. Nomikos, and Costas D. Vournas, “Contribution of Doubly Fed Wind Generators to Oscillation Damping” *IEEE Transactions On Energy Conversion*, 2009 VOL. 24, NO. 3.
6. Shan-Ying Li, Yu Sun, Tao Wu, Qun-Ju Li, Hui Liu, “Analysis of Small Signal Stability of Grid-Connected Doubly Fed Induction Generators” *Power and energy Engineering Conference* (APPEEC),2010 Asia Pacific .
7. Li Wang, Ying-Hao Lin, “Dynamic Stability Analyses of a Photovoltaic Array Connected to a Large Utility Grid”, IEEE Conference 2000.
8. S.J. Lee, H.S. Bae, B.H. Cho, “Modeling and Control of the Single-Phase Photovoltaic Grid-Connected Cascaded H-Bridge Multilevel Inverter” ,IEEE Conference 2009.
9. Adria-Junyent Ferre,Oriol Gommis–Bellmunt, Andreas Sumper, Marc Sala, Montserrat Matta,“Modelling and Control of doubly fed induction generator wind turbine.” 2010,Simulation modeling practice and theory Vol 18 pp 1365-1381.
10. W. Du, H. F. Wang, and R. Dunn ,“Power System Small-Signal Oscillation Stability as Affected by Large-scale PV Penetration”, IEEE Conference2008
11. HaifengLiu,LichengJin,David Le,A.A.Chowdhury, “Impact of High Penetration of Solar Photovoltaic Generation on Power System Small Signal Stability "International Conference on Power System Technology 2010.

12. Alfeu J. Sguarezi Filho, Milton E. de Oliveira Filho, and Ernesto Ruppert Filho, "A Predictive Power Control for Wind Energy" IEEE Transactions on sustainable energy, Vol. 2, No. 1, January 2011,pp 97-105.
13. Etienne Tremblay, Sergio Atayde, and Ambrish Chandra, "Comparative Study of Control Strategies forthe Doubly Fed Induction Generator in Wind Energy Conversion Systems: A DSP-Based Implementation Approach",IEEE Transactions on sustainable energy, Vol. 2, No. 3, July 2011.
14. Alvaro Luna, Francisco Kleber de Araujo Lima, David Santos,Pedro Rodríguez, Edson H. Watanabe and Santiago Arnaltes, "Simplified Modeling of a DFIG for Transient Studies in Wind Power Applications" IEEE Transactions on Industrial Electronics, Vol. 58, No. 1, January 2011pp 9-20.
15. Thomas Ackerman, "Wind Power in Power Systems", John Wiley & Sons, Ltd 2005.

Faculty of Electrical Engineering **(Approved in 18th AC 09.08.2014) ITEM NO. FE 18.03 (03)**

FE 9040	**POWER SYSTEM LOAD MODELS, IDENTIFICATION & APPLICATION IN STABILITY STUDIES**	**L T P C** **3 0 0 3**

UNIT I LOAD MODELLING 9

Concept of aggregate load models and their significance, Types of load models: Static models-Constant Impedance, Current and Power (ZIP) models – linear ,exponential and polynomial modeling approach. Dynamic models - Composite models with Induction motor model of 1st and higher orders considering rotor & stator flux dynamics. Model Dependency on Voltage and Frequency. Component Based and Measurement Based approaches.

UNIT II EFFECT ON STABILTY STUDIES 9

Effect of different load models on power system transient stability, small- signal stability and voltage stability analysis and issues related to their application to transient stability calculations.

UNIT III MODEL IDENTIFICATION & VALIDATION TECHNIQUES 9

System Identification Techniques: Artificial Neural Networks, Genetic algorithm, Evolutionary Programming approaches for parameter estimation. Time series models using Black-Box approach-AR, ARMA and ARMAX (Auto Regressive Moving Average with eXogenous inputs) models. Suitability and stability of these models for dynamic studies.

UNIT IV PERFORMANCE COMPARISON OF LOAD MODELS 9

Comparing the performance of simulated power system dynamics for various load models under different faults- symmetrical and unsymmetrical faults, small disturbances and major transients. Detailed analysis.

UNIT V STABILITY OF LOAD MODELS & THEIR APPLICATION ISSUES 9

Difficulties in establishing the range of load model parameters that may be used for different transient conditions. Issues with load-mix and ways of dealing with it.

REFERENCES:

1. "Load representation for dynamic performance analysis of power systems," IEEE Transactions on Power Systems, vol. 8, pp. 472-482, 1993.
2. "Bibliography on load models for power flow and dynamic performance simulation,", IEEE Transactions on Power Systems, vol. 10, pp. 523-538, 1995.
3. "Standard Load Models for Power Flow and Dynamic Performance Simulation", IEEE Transactions on Power Systems Vol.10. No.3. 1995
4. "Development of a Dynamic ZIP-motor load model from on-line field measurements", *Electrical Power & Energy Systems,* Vol. 19, No. 7, 1997.
5. "Measurement-based Load Modelling- Model structure", He Renmu, J.H.Shi 2003 Power Tech conference.
6. "Modelling of Load During and After System Faults Based on Actual Field Data", IEEE 2003
7. "Power System Stability and Control", P.Kundur, McGraw Hill, 1994.
8. "An Interim dynamic Induction Motor Model for stability studies in the WSCC", IEEE Transactions on Power Systems, vol. 17, N0.4,Nov 2002
9. "Application of Different Load Models for the Transient stability Calculation", He Renmu, Zhang Hongbin, 2002.
10. New Load Modeling Approaches Based on Field Tests for Fast Transient Stability Calculations," Q. Ai, D. Gu, and C. Chen*, IEEE Transactions on Power Systems,* vol. 21, pp. 1864-1873, 2006
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13. "Slow Voltage recovery Response of Several Load Models: Evaluation study", Hongbin wu, Hsiao-Dong Chiang, fellow, IEEE, Byoung-kon Choi, Power and Energy Society General Meeting 2008 IEEE
14. "Simulating voltage collapse dynamics for power system with constant power load models", S.G. Abhyankar, A.J. Flueck, IEEE Member, Power and Energy Society 2008 IEEE
15. "The Modeling Requirements for Short-Term Voltage Stability Studies", Jhon A. Diaz de Leon, and Bud Kehrli, Power System conference and Exposition,2006, IEEE PES.
16. "Identification of ARMAX model for Short term Load Forrecasting: An Evolutionary Programming Approach", Hong- Tzer, Chao Ming Huang, Ching-Lien Huang, IEEE Transactions on Power Systems Feb 1996
17. "A New Short- Term Load Forecasting Approach Using Self- Organizing Fuzzy ARMAX Models", Hong- Tzer, Chao Ming Huang, Ching-Lien Huang, IEEE Transactions on Power Systems Feb 1998
18. "A Multistage Algorithm for Identification of Nonlinear Aggregate Power System Loads" , Pouyan Jazayeri, William Rosehart, David T. Westwick, IEEE Transactions on Power Systems Aug 2007
19. "Multivariate Time Series Model Applied to the Assessment of Energy Storage Systems", Bernd Klockl, Verbund Austrian Power Grid, Vianna, Austria 2008

20. “Non-Linear Load Modeling – Requirements and Preparation for Measurement” K. Rudion, H. Guo, H. Abildgaard, A. Styczynski, IEEE Power and Energy Meeting 2009
21. “Significance of Load Modeling in Power System Dynamics”, Ian A. Hiskens, University of Wisconsin-Madison, USA
22. “Load Modeling in Power System studies: WECC Progress Update”, Dmitry Kosterev, anatoliny Meklin, Jhon Undrill, IEEE Power and Energy Meeting 2008
23. “Uncertainity Analysis of Load Models in Dynamic Stability” HAN Dong, MA Jin, HE Renmu, SUPERGEN’09, International Conference 2009
24. “Validation of Measurement-based Load Modeling for Large-scale Power Grid”, Xu Yanhui, He Renmu, Han Dong, IEEE Power and Energy Meeting 2008
25. “ A Real Application of Measurement- based Load Modeling in Large- Scale Power Grid and its Validation” dong Han, Jin Ma, Renmu He, Zhao-yang Dong, IEEE Transactions on Power Systems Nov 2009
26. “Load Modeling During Asymmetric Disturbance in a Metropolitan Power Grid”, wei-Hua Xu, Chen chen, Qian Ai, Wei Wang, Xia0-Bo Ling, IEEE Transactions on Power Systems Aug 2009
27. “Study of Voltage Collapse Cases of a Large Power System Using Static and Dynamic Approaches”, Power System conference and Exposition,2009, IEEE PES
28. “Time- domain Simulation Investigates Short-Term Voltage Stability with dynamic Loads”, Peng Li, Baohui Zhang, Chenggen Wang, Jin Shu, Asia-Pacific Power and Energy Engineering Conference, APPEEC2009
29. “Slow Voltage Recovery Response of Several Load Models: Evaluation Study”, Hongbin wu, Hasia0-dong Chiang, Buoung-Kon Choi, IEEE Power and Energy Meeting 2008
30. “Devlopment of Load Models for Fault Induced Delayed Voltage Recovery Response”, IEEE Power and Energy Meeting 2008
31. “Effects of Stochastic Load Model on Power System Voltage Stability Based on Bifurcation Theory”, Y. Qui, J.Zhao, H.D. Chiang, Transmission and Distribution conference & Exposition 2008, T&D, IEEE PES
32. “Dynamic Load Models for Power Systems- Estimation of Time-varying Parameters During Normal Operation”, PhD Thesis, Ines Romero Navarro, Lund University, Sweden
33. “Analog Methods for Power System and Load Modeling”, PhD Thesis, Anthony Steven Deese, Drexel University, Philadelphia, USA

Faculty of Electrical Engineering **(Approved in 18th AC 09.08.2014) ITEM NO. FE 18.03 (04)**

FE9041 MODEL REDUCTION FOR CONTROL SYSTEM DESIGN L T P C
3 0 0 3

UNIT I LINEAR METHODS FOR REDUCTION 9

Block diagram of reduced order and full order model control-Linear reduction of dynamical system - transfer function, Stability, Passivity-Approximation methods- Approximation by projection- Taylor Series- Pade Approximations- Lagrange Polynomials-Moment matching methods: Asymptotic waveform evaluation AWE-Lanczos-Pade via Lanczos PVL -Arnoldi and PRIMA algorithm - introduction to krylov projection techniques-hankel norm approximation and TBR

UNIT II NON-LINEAR METHODS FOR REDUCTION 9

Introduction to model and controller reduction model reduction by truncation-singular perturbation-Linearization method- Quadratic method-Piece-wise-linear method -Balancing technique -Proper orthogonal decomposition POD method

UNIT III MULTIPLICATIVE APPROXIMATION 9

The multiplicative approximate problem: Balanced stochastic truncation, theory and extension-multiplicative Hankel norm approximation

UNIT IV LOW ORDER CONTROL DESIGN 9

Approaches to the design of lower order controllers-controller and plant reduction via frequency weighted approximation- frequency weighted balanced truncation- frequency weighted Hankel norm reduction- frequency weighted reduction using partial fraction

UNIT V MODEL AND CONTROLLER REDUCTION BASED ON COPRIME FACTORIZATION 9

Coprime factorization: definition and use- coprime fractional description-reducing controller dimension using coprime fractions-controller reduction via coprime fraction and frequency weighting-controller reduction via multirelative coprime factor approximation

TOTAL: 45 PERIODS

TEXT BOOKS

1. Goro Obinata and Brian D.O. Anderson," Model reduction for control system design", Springer 2000.

REFERENCE BOOKS

1. Kasra Mohaghegh,"Linear and Nonlinear Model Order Reduction for Numerical Simulation of Electric circuits"
2. Wilhelmus H. Schilders, Henk A. van der Vorst, Joost Rommes," Model Order Reduction: Theory, Research Aspects and Applications", 2008
3. Zu-Qing Qu , "Model Order Reduction Techniques: With Applications in Finite Eement analysis", Springer 2004.

Faculty of Electrical Engineering **(Approved in 18th AC 09.08.2014)** **ITEM NO. FE 18.03 (05)**

FE9042 MODELLING AND SIMULATION OF POWER SYSTEMS FOR SUBSYNCHRONOUS RESONANCE

L T P C
3 0 0 3

UNIT I SUBSYNCHRONOUS OSCILLATIONS AND SUBSYSNCHRONOUS RESONANCE (SSR) 9

Review of Subsynchronous oscillations and SSR – Turbine Generator Torsional Characteristics: Shaft system model – Torsional Interaction with Power System Controls: Interaction with generator excitation controls – Interaction with speed governors – Subsysnchronous Resonance (SSR): Characteristics of series –Compensated transmission systems – Self-excitation due to induction generator effect – Torsional interaction resulting in SSR - Analytical Methods Frequency scanning method, Modal analysis, and Time domain simulation

UNIT II MODELLING AND SIMULATION OF SSR FOR SYNCHRONOUS GENERATOR 9

Modelling: Synchronous generator, Network and Turbine generator model –Analysis of induction generator effect and Torsional Interaction:Eigen value analysis-digital time-domain simulation of IEEE first benchmark model (FBM) and IEEE second benchmark model (SBM).

UNIT III MODELLING AND SIMULATION OF SSR FOR GRID INTEGRATED WECS 9

Squirrel cage induction Generator (SCIG) and Doubly fed induction generator (DFIG) model – Network model – Two mass model – Induction generator effect and Torsional interaction - Time domain using PSCAD and frequency domain simulation of modified IEEE FBM and SBM .

UNIT IV MODELLING OF FACTS CONTROLLER FOR SSR ANALYSIS 9

Modelling of Static Var Compensator (SVC) and Static synchronous compensator (STATCOM) for SSR analysis – Time domain simulation of SVC and STATCOM for modified IEEE FBM and SBM system using PSCAD

UNIT V COUNTERMEASURES FOR SSR 9

Subsynchronous damping controller (SSDC) for SVC and STATCOM - Filters – Time domain simulation using PSCAD and Frequency scanning method.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. P. Kundur, Power System Stability and Control, McGraw-Hill, 1993.
2. R. Ramanujam, Power System Dynamics Analysis and Simulation, PHI Learing Pvt. Ltd., 2009
3. K.R.Padiyar, Analysis of subsynchronous resonance in power systems Kulwer Academic Publishers, 1999.
4. P.M. Anderson et al., Subsynchronous Resonance in power systems, IEEE press1990

REFERENCES:

1. H. W. Dommel, EMTP THEORY BOOK, Microtran Power System Analysis Corporation, Second Edition, 1996.
2. R. K. Varma, and A. Moharana, Subsynchronous resonance single cage self excited induction genersator based wind farm connected to series compensated line, IET Gen., Trans., Distrib. Vol 5 (12) pp. 1221-1232, 2011.
3. R. K. Varma et al., Mitigation of SSR in a series compensated wind farm using FACTS controllers, IEEE Trans., on power delivery, Vol 23 (3), 2008.
4. Lingling Fan et al., Modelling of DFIG based wind farms for SSR analysis, IEEE Trans., on power delivery, Vol 25 (4), 2010.
5. Lingling Fan et al., Mitigation of SSR using DFIG based wind generation,, IEEE Trans., on sustainable Energy Future Issue.

Faculty of Electrical Engineering (Approved in 18th AC 09.08.2014) **ITEM NO. FE 18.03 (06)**

FE9043 DEMAND SIDE MANAGEMENT FOR DISTRIBUTION SYSTEM

L T P C
3 0 0 3

UNIT I INTRODUCTION TO SMART GRID

Need of Smart Grid, Concept of Smart Grid, Functions of Smart Grid components, Opportunities Barriers of Smart Grid, Difference between conventional & smart grid, Smart grid Architectural design, smart grid communication and measurement technology.

UNIT II LOAD MANAGEMENT

Electric Energy Efficiency in Power Production- Space Conditioning and Domestic Water Heating, Efficiency in Power Delivery, Conservation Voltage Reduction Delivery, Distribution Transformer Efficiency, Using a Smart Grid to Evolve Perfect Power System-the IntelliGrid Architecture for the Smart Grid.

UNIT III SMART GRID –ENABLING DEMAND RESPONSE (DSM)

Smart Energy Efficient End-Use Devices, Smart Distributed Energy Resources, Advanced Whole-Building Control Systems, Integrated Communications Architecture, Demand Response Role of

Technology in Demand Response Current Limitations and Scope for Dynamic Energy Management Distributed Energy Resources ,Overview of a Dynamic Energy Management System Operation From an Integrated Perspective Key Characteristics of Smart Energy-Efficient End-use Devices and Distributed Energy Resources Key Characteristics of Advanced Whole-building Control Systems, Key Features of a Dynamic Energy Management System

UNIT IV DISTRIBUTED ENERGY RESOURCES (DER)

Introduction-Distributed generation plants- Combined heat and power plants , Renewable energy generation -Small-scale hydro generation, Wind power plants, Offshore wind energy , Solar photovoltaic generation, Distributed generators and their connection to the system , Distributed generators Synchronous generators Induction generators , Doubly fed induction generator, Full power converter (FPC) connected generators- Integration of distributed generation in electricity system planning- Pricing of distribution networks with distributed generation- Distributed generation and future network architectures

UNIT V DEMAND-SIDE PLANNING AND EVALUATION

Introduction- Critical Issues to the Demand-side, Type of Demand-side, Activities Alternatives That Are Most Beneficial, Levels of Analysis ,Transferability Data Requirements, Cost/Benefit Analysis ,Non-monetary Benefits & Costs, Program Interaction, Dynamic Systems, Estimating Future Market Demand & Customer Consumer & Market Research Customer Adoption Techniques Program Implementation Issues. Monitoring and Evaluation Approaches, Issues in Program Monitoring and Evaluation.

TOTAL: 45 PERIODS

REFERENCES

1. The smart grid: enabling energy efficiency and demand response by Clark W. Gellings, The Fairmont Press 2009
2. The Advanced Smart Grid Edge Power Driving Sustainability by Andres Carvallo &John Cooper, Artech house 2011
3. Smart Grid Fundamentals of Design and Analysis by James Momoh, John Wiley & Sons 2012
4. Integration of Green and Renewable Energy in Electric Power Systems Ali Keyhani, Mohammad N. Marwali, Min Dai, John Wiley & Sons 2010
5. Integration of Demand Side Management, Distributed Generation, Renewable Energy Sources and Energy Storages State of the art report Vol 1: Main report
6. ‘Load management,’ S.N.Talukar, IEEE press publications
7. Distributed Generation, N. Jenkins, J.B. Ekanayake and G. Strbac IET Renewable Energy Series 1, 2010.

Faculty of Electrical Engineering **(Approved in 18th AC 09.08.2014) ITEM NO. FE 18.03 (07)**

FE9044 POWER SYSTEM RESTORATION TECHNIQUES L T P C
3 0 0 3

UNIT I RESTORATION OVERVIEW 9

Analytical Tools – System Operation Challenges – Restoration Issues and onsiderations – New approaches – Plant Start up and control – AGC implementation for islanding and restoration – Analytical Tools – Restorations following major breakdowns.

UNIT II RESTORATION TECHNIQUES 9

Cold load pickup – Black start utilization – Over voltage control during restoration – Reactive capability limitations of synchronous machines – Standing phase angle reduction – Optimising generator reactive power resources – Asymmetry issues – Energising HV and EHV lines during restoration- restoration based on wide area measurement systems.

UNIT III SYSTEM RESTORATION PLANNING AND RESTORATION TRAINING 9

Roll of interactive control computers – Systematic methods PS restoration planning – Estimating Restoration Duration – Dispatcher training simulators and their use for system restoration – Bulk Power System restoration – System restoration guidelines - Distribution System Restoration.

UNIT IV KNOWLEDGE BASED SYSTEMS 9

Knowledge Based System for restoration and bulk power Systems – Use of Real-Time expert systems in load dispatch Centres – Power System restoration by expert systems and mathematical programming approach – Generation capability dispatch and tie-line utilisation during restoration.

UNIT V NON LINEAR AND DYNAMIC PROGRAMMING TECHNIQUES FOR RESTORATION 9

Non-linear programming – Kuhn Tucker conditions – Dynamic programming – Formulation of dynamic programming – forward and backward recursive equations.

TOTAL: 45 PERIODS

TEXTBOOKS:

1. M.M. Adibi, Editor, Power System Restoration – Methodologies and Implementation Strategies, IEEE Press Series on Power System Engineering, 2000.
2. Kalyanmoy Deb “Optimization for Engineering Design”, Prentice Hall of India Pvt Ltd, New Delhi 2005
3. D. P. Kothari and J.S. Dhillon, “Power System Optimization “, Prentice Hall of India Pvt Ltd, New Delhi 2004

REFERENCES:

1. Nezam Sarmadi, S.A.; Dobakhshari, A.S.; Azizi, S.; Ranjbar, A.M.”A Sectionalizing Method in Power System Restoration Based on WAMS”, IEEE Transactions on Smart Grid, Volume: 2 , Issue: 1, Page(s):190 – 197, 2011.
2. Barkans J., Zalostiba D., “Protection against blackouts and self-restoration of power systems, RTU publishing house, Riga, 2009.

Faculty of Electrical Engineering (Approved in 18th AC 09.08.2014) **ITEM NO. FE 18.03 (08)**

FE 9045 REAL TIME OPTIMIZATION L T P C
3 0 0 3

COURSE OBJECTIVES

To impart knowledge on

i. the formulation and solution of real time optimization problem.
ii. real time iteration schemes, optimization and control problems.
iii. concepts of model predictive method and SQP method.

UNIT I INTRODUCTION 9

Basic requirements in Real Time Operation – The Formulation and Solution of RTO Problem – Unconstrained Optimization – Linear Programming – Quadratic and Nonlinear Programming.

UNIT II CONSTRAINED OPTIMAL FEEDBACK CONTROL 9

Differential Algebraic Equation Systems – Nonlinear Model Predictive Control – Direct Multiple Shooting for DAE – Standard Real-Time Iteration Scheme – Real-Time Iteration Variants with Inexact Jacobians.

UNIT III REAL-TIME IMPLEMENTATION OF NON LINEAR MODEL PREDICTIVE CONTROL 9

Discrete-Time Nonlinear Model Predictive Control – The Real-Time Iteration Scheme – Local Convergence of Newton-Type Optimization – Numerical Experiments: Distillation Control.

UNIT IV LEAST-SQUARES FINITE ELEMENT METHOD FOR OPTIMIZATION AND CONTROL PROBLEMS 9

Quadratic Optimization and Control Problems in Hilbert Spaces with Linear Constraints – Least-Squares Formulation of the Constraint Equations – Methods Based on Constraining by the Least-Squares Functional – Examples for Optimization Problems.

UNIT V GENERALIZED SQP METHODS WITH PARAREAL TIME DOMAIN DECOMPOSITION 9

Parareal Time-Domain Decomposition – Time-Domain Decomposition of the Optimal Control Problem – A Generalized SQP Method – Application of the Generalized SQP Method with Parareal Solvers.

TOTAL: 45 PERIODS

REFERENCE BOOKS

1. Lorenz T. Biegler, 'Real-Time PDE-Constrained Optimization', Society for Industrial and Applied Mathematics,1st Edition, 2007.
2. Kartik B. Ariyur & Miroslav Krstic, 'Real-Time Optimization by Extremum-Seeking Control', John Wiley & Sons,1st Edition, 2003.
3. Dale E. Seborg, Duncan A. Mellichamp, Thomas F. Edgar & Francis J. Doyle, 'Process Dynamics and Control', John Wiley & Sons, 2nd Edition, 2010.
4. Asadi I. & Asadi E. 'Investigation on effect of real time optimization(RTO) on reducing energy consumption in the gas sweetening plant in Iran', Proceedings of the 2011 3rd International Youth Conference on Energetics (IYCE).

FE 9046 ANDROID BASED EMBEDDED SYSTEM

L	T	P	C
3	0	0	3

AIM

To expose the students to the fundamentals of Android for embedded system design.

OBJECTIVES

To impart knowledge on

1. Fundamentals of Android
2. Android Native Development
3. Android Application Development
4. How to build Android based Embedded Systems

UNIT I ANDROID COMPONENTS AND BIG PICTURE 9

Four kinds of Android components-Android Platform-Different layers of Android OS-Building on the Linux kernel-Running in the DVM-Android SDK-Creating an Android Application-Understanding activities and views-Exploring the Activity life cycle-Working with resources.

UNIT II ANDROID SYSTEM DEVELOPMENT AND ANDROID NATIVE DEVELOPMENT 9

Android source code organization and the folder structure-Android porting code modification-Compiling Android Source-Preparing Android Root File System- Writing C/C++ modules and Android make files-Debugging the native code using GNU Remote Debugging-Building the JNI library-Small JNI based project-Building Android applications in C-Solving the problem with dynamic linking-Day Time Server-Day Time Client.

UNIT III ANDROID APPLICATION DEVELOPMENT 9

Android UI components-Android database-Broadcast Receivers-Services.-Android Content Providers-Location Manager-Phone Accessing-Advanced Android application development.

UNIT IV ANDROID POWER MANAGEMENT TECHNIQUES 9

Android power management architecture- power management at the application level-Power management from Linux kernel to Android-Android Linux device driver development-Power management at the device driver level-Tools for power measurement and optimization.

UNIT V BUILDING ANDROID BASED EMBEDDED SYSTEMS 9

Introduction to Beagle board Xm-Building Boot Loader-Building X-Loader and Kernel for Beagle Board Xm-Building Android File System-Porting Android OS onto the Beagle Board Xm-Porting Android Application to the Beagle board-

TOTAL: 45 PERIODS

REFERENCES

1. W.Frank Ableson, Robi Sen, Chris King, “Android in Action”, Second Edition, Dreamtech Press, 2011.
2. Dynamic Power Management for Embedded Systems, IBM and MontaVista Software, Version 1.1, November 19, 2002.
3. Collin Walls, “Android Development for Embedded Systems Beyond Mobile”
4. TI Android GingerBread 2.3 DevKit 1.0 Developers Guide
5. Reto Meier, “Professional TM Android Application Development”, Wiley Publishing, Inc.

Faculty of Electrical Engineering **(Approved in 18th AC 09.08.2014)** **ITEM NO. FE 18.03 (10)**

FE 9047 ADVANCE CHEMICAL REACTOR THEORY

L	T	P	C
3	0	0	3

UNIT I 9

Overview of Chemical reaction engineering: Classification of Reactions, variables affecting the rate of reaction, definition of rate of reaction, kinetics of homogeneous reaction. Interpretation of batch reactor data: constant volume batch reactor, irreversible unimolar type first order, bimolecular type second order, trimolecular type third order reaction. Zero order reaction, irreversible parallel homogeneous catalyzed reaction, autocatalytic & reversible reactions,

UNIT II 6

Reaction Engineering overview- reactor design- ideal reactor design equations- single & multiple reactions, instantaneous and overall yields. Design of parallel reactors, Plug flow, batch reactors.

UNIT III **9**

Mass & Energy balance in stirred batch, semi-batch and continuous vessels- energy balance in plug flow vessels - optimal design for exothermic reversible reactions - stability and multiplicity of steady states in CSTR.

Design of packed tubular reactors- Gas solid reactions, shrinking core model, pseudo steady state hypothesis for ash layer control, gas solid reactions in rotary kiln and fluid beds.

UNIT IV **12**

Non ideal flow, RTD of ideal vessels, modeling non ideal flow, conversion from RTD theory, tanks in series model, dispersion model -catalyst deactivation, design for deactivating catalysts.

Introduction to population balance, application to RTD of CSTR, application to gas solid reactions in Rotary kiln and fluid beds, performance of reactor regenerator system from PBE modeling.

UNIT V **9**

Design for Immobilized cell reactor, design for fermentation alcohol, design for polymerization reactors, biological waste water treatment- flow and reaction through porous media, acid leaching of rocks-liquid liquid reactions-gas liquid reactions , applications in CO2 capture and global warming.

TOTAL: 45 PERIODS

TEXT BOOKS

1. Chemical Reaction Engineering – Octave Levenspiel, 3rd Edition, John Wiely & Sons, 1999

REFERENCE BOOKS

1. Chemical Engineering Kinetics – J M Smith, 3rd Edition, Mc Graw Hill, 1981
2. Modelling of Chemical Kinetics and Reactor design – Coker AK, Gulf Professional publishing, 2001
3. Chemical reactor analysis and design – Froment GB, K G Bischoff, 2nd Ed., Wiely, 1990

Faculty of Electrical Engineering **(Approved in 18th AC 09.08.2014)** **ITEM NO. FE 18.03 (11)**

FE9048	Polymeric MEMS Devices	L T P C
		3 0 0 3

UNIT I Foundations of Polymer MEMS **9**

Introduction of MEMS Technology, Introduction to polymers, UV curing of polymers, Polymers and their synthesis, Polymeric sensors and actuators, Deposition techniques for polymer thin films

UNIT II Polymer Properties for MEMS **9**

Properties of polymers, Chemical structures of polymers; Thermodynamic properties of polymers; (e.g. melting, glass transitions, molecular weight); Properties of polymers suspended in solvents; Surface and wetting properties of polymers; Methods of measuring polymer properties; Micro/nanostructure; (block copolymers, folding, cross-linking) Visco-elastic properties; Elastic and mechanical properties; Adding electronic and optical properties to polymers

UNIT III Polymer Materials for MEMS **9**

Parylene, polyimide, acrylics, Poly methyl methacrylate (PMMA), photopatternable epoxy, polydimethylsiloxane (PDMS), SU-8, elastomer liquid crystal polymer (LCP), liquid crystal elastomer (LCE), biodegradable polymers, functional hydrogels, Polyurethane, Nanocomposite elastomers, Paraffin, piezoelectric polymers, fluorocarbon thin films, and conductive polymers

UNIT IV Polymeric MEMS Fabrication Techniques 9

Rapid prototyping; microstereolithography, micromolding of polymeric 3D structures, Incorporation of metals and ceramics by polymeric processes, electrochemical fabrication (EFAB); combined silicon and polymer structures

UNIT V Polymer MEMS devices 9

Polymer based RF MEMS Devices, Polymer based Phase shifters, Microvalves and Micropumps, Polymer Microlenses, Flow Cytometer, PDMS based microchip, Comb-drive Electrostatic Micro-Actuator, Vertical Comb-drive Micro-Mirror, Micro Thermal Actuator, Electrostatic Micro-Accelerometer.

TOTAL: 45 PERIODS

REFERENCES:

1. Smart Material Systems and MEMS: Design and Development Methodologies, Wiley publications, Vijay K. Varadan, K. J. Vinoy , S. Gopalakrishnan}, 2006.
2. MEMS Materials and Processes Handbook, Reza Ghodssi and Pinyen lin, Springer.
3. RF MEMS and their Applications, Wiley publications, Vijay. K. Varadan, K.J.Vinoy, K.A.Jose.

Faculty of Electrical Engineering **(Approved in 18th AC 09.08.2014)** **ITEM NO. FE 18.03 (12)**

FE9049 ELECTRIC PROPULSION

L	T	P	C
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OUTLINE:

Upon completion of the course, students will learn the governing physics of electric propulsion, working and performance of electro-thermal, electrostatic and electromagnetic thrusters.

UNIT I INTRODUCTION TO THE BASIC PHYSICS OF ELECTRIC PROPULSION SYSTEMS 9

Historical outline - Definition of Electric Propulsion - High impulse Space Missions - Exhaust velocity and specific impulse - Power supply penalty – Electric charges and Electrostatic fields - Currents and Magnetic interactions - Time dependent fields and Electromagnetic wave propagation - Application to ionized gas flows

UNIT II PHYSICS OF IONIZED GASES 6

Atomic structure of gases - Ionization processes - Particle collisions in an ionized gas - Electrical conductivity of an ionized gas - Kinetic Theory

UNIT III ELECTRO-THERMAL PROPULSION 9

One dimensional model - Enthalpy of high temperature gases - Frozen flow efficiency - Resistojets - Electrical discharges - Arcjets - Operation and Analysis - Materials - Advantages and Disadvantages

UNIT IV ELECTROMAGNETIC PROPULSION 12

The Lorentz force - Magnetogasdynamic channel flow - Ideal steady flow acceleration - Thermal and viscous losses - Geometry considerations - Self induced fields - Sources of the conducting gas - The magnetoplasmadynamic arc - Magneto- plasmadynamic (MPD) thrusters - Pulsed plasma acceleration - Pulsed plasma thrusters (PPT) - Quasi steady acceleration - Pulsed inductive acceleration - Traveling wave acceleration

UNIT V ELECTROSTATIC PROPULSION 9

One dimensional space-charge flows - Basic relationships - The acceleration- deceleration concept - Ion engines - Design and Performance - Hall effect – Hall thrusters - Field emission electric propulsion (FEEP) - Colloid thrusters

TOTAL: 45 PERIODS

REFERENCES

1. Robert G. Jahn, "Physics of Electric Propulsion", McGraw-Hill Series, New York, 1968.
2. George W. Sutton, "Engineering Magnetohydrodynamics", Dover Publications Inc., New York, 1965
3. George P. Sutton & Oscar Biblarz, "Rocket Propulsion Elements, John Wiley & Sons Inc., New York, 2001.

Faculty of Electrical Engineering **(Approved in 18th AC 09.08.2014) ITEM NO. FE 18.03 (13)**

FE 9050 NUCLEAR REACTOR ENGINEERING

L	T	P	C
3	0	0	3

UNIT I INTRODUCTION TO NUCLEAR REACTOR 9

Nuclear Energy Fundamentals – Nuclear Fission – Nuclear Reactions and Radiation – Reactor Kinetics – Basics of Power Plant – Nuclear Reactor Safety.

UNIT II COMPONENTS OF NUCLEAR REACTOR 9

Fermi pile – Reactor Core – Coolant – Control Rods – Moderator – Containment – Steam Generator – Turbine Generator – Steam / Water System – Fuel Handling – Spent Fuel Cooling – Emergency Core Cooling.

UNIT III TYPES OF NUCLEAR REACTOR 9

Boiling Water Reactor – Pressurized Water Reactor – Pressurized Heavy Water Reactor – Fast Breeder Reactor.

UNIT IV MODELING OF NUCLEAR REACTOR 9

Derivation of Multipoint Kinetics Modeling of Large Nuclear Reactor – Selection of Suitable Nodalization Scheme – Application to the AHWR – Thermal Hydraulics Model – Coupled Neutronics – Thermal Hydraulics Model – Transient Response – Reactor Stability Analysis.

UNIT V CONTROL OF NUCLEAR REACTOR 9

General features of Reactor Control – Methods of Control – Control loops – Effectiveness of Control Rods – Output Feedback Control Design – Multi parameter Singular Perturbation of Linear Optimal Regulators – Direct Block Diagonalization and Composite Control of Three -Time -Scale Systems – Design of Fast Output Sampling Controller for Three-Time-Scale Systems.

TOTAL: 45 PERIODS

REFERENCES:

1. S.Glasstone and A.Selsonske, Nuclear Reactor Engineering, 4th Edition, CBS Publishers & Distributors Pvt. Ltd, 2004.
2. S.R.Shimjith, A.P.Tiwari and B.Bandyopadhyay, Modeling and Control of a Large Nuclear Reactor, Springer-Verlag Berlin Heidelberg, 2013.
3. Dr.G.Vaidyanathan, Nuclear Reactor Engineering, 1st Edition, S.Chand & Company Pvt.Ltd, 2013.

Faculty of Electrical Engineering (Approved in 18th AC 09.08.2014) **ITEM NO. FE 18.03 (14)**

FE9051 CONTROL AND PROTECTION OF MICROGRID

L	T	P	C
3	0	0	3

COURSE OBJECTIVES

- To familiarize the power quality management issues in microgrid.
- To Discuss about different energy storage systems
- To study the concepts behind economic analysis and Load management.
- To illustrate the concept of distributed generation
- To analyze the impact of grid integration.
- To study concept of Microgrid and its configuration

UNIT I DISTRIBUTED ENERGY RESOURCES 9

Introduction - Combined heat and power (CHP) systems - Micro-CHP systems - Wind energy conversion systems (WECS) - Wind turbine operating systems - Solar photovoltaic (PV) systems - Types of PV cell - Small-scale hydroelectric power generation - Other renewable energy sources - Storage devices - Island mode of operation - Problem of power quality.

UNIT II VOLTAGE AND CURRENT CONTROL IN DISTRIBUTED GENERATION SYSTEMS 9

Distributed energy system description - DGS control requirements - Distributed generation system modeling - Control system design- Load sharing control algorithm - Power converter system - control theory: perfect control of robust servomechanism problem - discrete-time sliding mode control - control system development - step-by-step control flow explanations.

UNIT III PROTECTION ISSUES FOR MICROGRIDS 9

Introduction - Islanding: separation from utility - Different islanding scenarios - Major protection issues of stand-alone Microgrid - Microgrid distribution system protection - Protection of microsources - Microgrids and active distribution networks - NEC requirements for distribution transformer protection - Neutral grounding requirements.

UNIT IV IMPACT OF DG INTEGRATION ON POWER QUALITY AND RELIABILITY 9

Introduction - Power quality disturbances - Transients - Voltage sags and swells - Over-voltages and under-voltages - Outage - Harmonic distortion - Voltage notching - Flicker -

Electrical noise - Power quality sensitive customers - Existing power quality improvement technologies - Alternative power supply technologies - Power-conditioning technologies - Impact of DG integration - Simple standby generation scheme - Secondary DG system with power quality support - Primary DG system with power quality support to priority loads - Soft grid-connected DG with power quality support to priority loads - DG with intermittent solar PV within power quality environment - DG with intermittent wind generator within power quality environment - Ultra-high reliability scheme using dual link DC bus - Issues of premium power in DG integration.

UNIT V POWER FLOW CONTROL OF A SINGLE DISTRIBUTED GENERATION UNIT 9

Introduction - Real and reactive power control problems - Conventional integral control - Stability problem - Newton–Raphson parameter estimation and feedforward control Newton–Raphson parameter identification - Harmonic power control.

TOTAL: 45 PERIODS

TEXT BOOKS

1. S. Chowdhury, S.P. Chowdhury and P. Crossley, 'Microgrids and Active Distribution Networks', The Institution of Engineering and Technology, 2009.
2. Ali Keyhani Mohammad N. Marwali Min Dai, 'Integration of Green and Renewable Energy in Electric Power Systems', John Wiley & Sons, 2010.

REFERENCES

1. Farhad Shahnia, Ritwik Majumder , Arindam Ghosh, Gerard Ledwich, and Firuz Zare, 'Operation and control of a hybrid microgrid containing unbalanced and nonlinear loads', Electric Power Systems Research, Vol. 80, Issue 8, August 2010, Pages 954–965.
2. Yang Wang, Peng Zhang, Wenyuan Li, Weidong Xiao and Ali Abdollahi,'Online Overvoltage Prevention Control of Photovoltaic Generators in Microgrids', IEEE Transactions on Smart Grid, Vol. 3, No. 4, December 2012, Pages 2071 – 2078.
3. Amir H. Etemadi, Member, IEEE, and Reza Iravani,'Overcurrent and Overload Protection of Directly Voltage-Controlled Distributed Resources in a Microgrid', IEEE Transactions on Industrial Electronics, Vol. 60, No. 12, December 2013, Pages 5629 – 5638.
4. Seon-Ju Ahn, Jin-Woo Park, Il-Yop Chung, Seung-Il Moon, Sang-Hee Kang, and Soon-Ryul Nam, 'Power-Sharing Method of Multiple Distributed Generators Considering Control Modes and Configurations of a Microgrid', IEEE Transactions on Power Delivery, Vol. 25, No. 3, July 2010, Pages 2007 – 2016.

Faculty of Electrical Engineering **(Approved in 5th AC** 18.11.2004**)**

FE 9052 POWER SYSTEM OPTIMISATION L T P C
3 0 0 3

UNIT I OPTIMAL POWER FLOW 10

Introduction, Solution of Optimal power Flow, The Gradient method, Newton's method, Theorems on the Optimization of constrained functions, Procedure for the optimizing constrained problems, power systems applications. Examples, optimal dispatch of Generation, Fuel cost minimization, Power loss minimization, Optimum power flow – adding environmental constraints.

UNIT II LINEAR PROGRAMMING 10

Mathematical model and Nomenclature in Linear programming solution techniques. Duality in Linear programming, Mixed integer programming. Power system applications. Sensitivity methods for post optimization in linear programming. Examples.

UNIT III NON-LINEAR PROGRAMMING 10

Introduction, classification of non-linear programming problems, Sensitivity methods for solving non-linear programming variables, Algorithm for quadratic optimization , Barrier method for solving non-linear programming variables, Examples.

UNIT IV INTERIOR POINT METHOD 5

Introduction, Karmarkers algorithm. The projection scaling method. Extended interior point method for linear programming problems, Extended quadratic programming using interior point method, Illustrative examples.

UNIT V UNIT COMMITMENT & DYNAMIC PROGRAMMING 10

Formulation of unit commitment, modeling in unit commitment, Priority list unit commitment schemes, Different types, unit commitment of Thermal units using dynamic programming. Characteristics of Dynamic programming, Computational economy in Dynamic programming, Illustrative examples.

TOTAL : 45 PERIODS

TEXT BOOKS

1. James A. Momoh, Electric power system applications of Optimization

REFERENCES

1. A.J.wood & B.F.Woolenberg, Power generation operation and control, John Wiley and sons,1996
2. Hadi Saadat, Power system Analysis, WCB Mcgraw Hill,1999
3. Nagrath, I.J.Kothari, Modern power system Analysis, Tata Mcgraw Hill, 1998
4. K.A.Gangadhar, Electric power systems, Khanna Publishers,1998.

SEE001 FINITE ELEMENT ANALYSIS: THEORY AND APPLICATION USING ANSYS **L T P C 3 1 0 4**

OBJECTIVE:
To develop a thorough understanding of the basic principles of finite element analysis techniques with an ability to effectively use ANSYS for solving practical problems in engineering design

UNIT I INTRODUCTION 6
Engineering problems – Numerical Methods-History- Basic Steps-Direct Formulation - Weighted residual formulations- - Need of FEM- different FEM methods –Basic concepts of FEM- Derivation of stiffness matrix equation- Types of analysis that can be done using ANSYS- Advantages of the Finite Element Method- Limitations of FEA.

UNIT II ONE-DIMENSIONAL AND TWO-DIMENSIONAL ELEMENTS 9+3
One-Dimensional-Linear elements-Quadratic elements-Cubic elements-Iso-parametric Elements-Numerical Integration-Analysis-Heat transfer problems-Two Dimensional- Rectangular elements-quadratic quadrilateral elements-Linear Triangular elements-Quadratic Triangular Elements-Iso-parametric Elements-Two-Dimensional Integrals-Analysis of two-dimensional heat transfer problem-unsteady heat transfer.

UNIT III DYNAMIC PROBLEMS AND THREE DIMENSIONAL ELEMENTS 10+4
Review of dynamics-Review of vibration of Mechanical and structural systems- Lagrange's Equations Three-Dimensional Element-The four-Node Tetrahedral Element-Analysis-Basic solid modeling ideas Design and Material selection-Design optimization.

UNIT IV FUNDAMENTALS OF ANSYS 10+4
About ANSYS Inc., ANSYS Products, Fundamentals of ANSYS- Organization, File Structure-Menus and Windows-n. Introduction to the ANSYS GUI- Operation Modes of ANSYS-p- Product Launcher-q. Launcher Tasks- Custom Memory Settings-Launcher Menu - ANSYS GUI-Selection Logic- Plotting-Pan-Zoom-Rotate- Picking-Coordinate Systems- Select Logic- Solid Modeling- An Overview of Solid Modeling Operations- Working with Boolean operations- Working Plane-Importing of 3D models-Meshing- Free meshing or Mapped meshing- Setting Element Attributes-. Selecting Element Type-Shape Function- Defining Element Types-Real Constants- Defining Section Properties- Assigning Element Attributes before meshing- Mesh Controls-ANSYS Mesh Tool- Smart sizing- Meshing-Free Meshing-Mapped Meshing- Hybrid meshing- Mesh Extrusion- Volume Sweeping

UNIT V ANSYS SOLUTION AND POST PROCESSING 10+4
Material Properties-Material Library-Specifying properties-Loading and Boundary Conditions- Types of Loads- Applying loads –Solvers- Types of Solvers- Solver Setup- Load Step Options- Solving Multiple Load Steps- Post Processing- Contour Plot Viewing--Path Operations-Estimating Solution Error-Time History Postprocessor- Report Generator-Introduction to Non-Linear Analysis- Static Structural Analysis-Case Studies- Modal Analysis Case Studies-Thermal Analysis-Case Studies.

T=15, TOTAL: 60 PERIODS

REFERENCES
1. Saeed Moaveni ," Finite Element Analysis: Theory and Application with ANSYS", Pearson Education India. 2011.
2. Tadeusz Stolarski, Y. Nakasone, S. Yoshimoto. "Engineering Analysis with ANSYS Software" Elsevier Butterworth-Heinemann, Burlington, 2006.

3. Erdogan Madenci, Ibrahim Guven ," The Finite Element Method and Applications in Engineering Using ANSYS" Springer Science & Business Media,LLC, 2006.
4. Paleti Srinivas, Sambana Krishna Chaitanya Datti Rajesh Kumar, "Finite Element Analysis Using Ansys 11.0" PHI Learning Pvt. Ltd.. New Delhi. 2010.

FE9053 SYNCHRONOUS RELUCTANCE MOTOR AND DRIVES **LT P C**
3 0 0 3

OBJECTIVES:

- To understand the working principles and fundamentals of Synchronous Reluctance Motor (SynRM).
- To acquire the knowledge of SynRM design aspects through Analytical and Finite Element Modeling (FEM).
- To analyse the Dynamic performance of Synchronous Reluctance Motor Drive.
- To study the various control methods used for Synchronous Reluctance Motor.

UNIT I BASICS OF SYNCHRONOUS RELUCTANCE MOTOR 9
Basic theory – Equivalent circuit – Main performance characteristics (Flux linkage, Inductance, Iron Losses, Torque and Power factor) – Magnetization characteristics(saturation, cross coupling and slotted stator) – Classification of rotor(TLA and ALA) - Comparison with Induction Motor.

UNIT II SYNCHRONOUS RELUCTANCE MOTOR ANALYTICAL DESIGN ASPECTS 9
Four quadrant operation - Servo drive design aspects – Two quadrant operation - Power drive design aspects – Stator and Rotor core design - Parameter Classification and Description of TLA rotor .

UNIT III SYNCHRONOUS RELUCTANCE MOTOR FINITE ELEMENT DESIGN ASPECTS 9
Inductance (Ld & Lq) analysis – Effect of cross saturation – Effect of Iron losses – Max torque - Power factor - Rotor position effect – Influence of flux barrier width, barrier location, barrier numbers – Influence of pole span and pitch – Influence of mechanical strutting (radial and tangential rib).

UNIT IV DYNAMIC MODEL OF SYNRM 9
1-Phase and 3-Phase - Mathematical model of SynRM in the machine variables - Mathematical model of SynRM in the rotor and synchronous reference frames – Matlab/Simulink model and analysis of 3-phase SynRM.

UNIT V DRIVE CONTROL WITH AND WITHOUT MOTION SENSORS 9
Basic control strategies – Torque Production in SynRM – dq current angle control - Constant i_d control – Torque vector control –bipolar two level current control – State estimator for closed loop sensor less control – Open loop sensor less control - Maximum Power Factor Control (MPFC) - Maximum Efficiency Control(MEC) – Hybrid method.

TOTAL : 45 PERIODS

OUTCOMES:

- Through understanding about theory of Synchronous Reluctance Motor(SynRM)
- Ability to design and analyse the SynRM through Analytical and Finite Element Modeling
- Ability to model and analyse the Dynamic behavior of SynRM Drive using various control methods.

TEXT BOOK:

1. Ion Boldea, 'Reluctance Synchronous Motor and Drives', Oxford University Press, 1996.

REFERENCE BOOKS:

1. S. A. Nasar, I. Boldea, L. E. Unnewehr, 'Permanent magnet, reluctance, and self-synchronous motors', CRC Press, 1993.
2. Jacek F. Gieras, Zbigniew J. Piech, Bronislaw Tomczuk, 'Linear Synchronous Motors: Transportation and Automation Systems', CRC Press, 2011.
3. Nicola Biyanchi, "Electrical Machine analysis using Finite Elements", Taylor and Francis Group, CRC Publishers, 2005.
4. Sergey Edward Lyshevski, 'Electromechanical Systems, Electric Machines, and Applied Mechatronics', CRC Press, 1999.
5. Ion Boldea, Syed A. Nasar, 'Vector Control of AC Drives', CRC Press, 1992.

Faculty of Electrical Engineering **(Approved in 22nd AC 26.07.2017) ITEM NO. FE22.04 (02)**

FE9054 CONGESTION MANAGEMENT WITH RENEWABLE ENERGY RESOURCES

	L	T	P	C
	3	0	0	3

Course Objectives:

- To Study Photovoltaic and Wind Energy Conversion System.
- To impart knowledge on concepts of congestion management in presences of renewable energy resources
- To understand the concept of different energy storage systems.
- To apply various optimization techniques for Hybrid power system.

UNIT I INTRODUCTION 9

Recent trends in energy consumption - World energy scenario - Energy sources and their availability - Qualitative study of different renewable energy resources: Solar, Wind, Ocean, Biomass, Fuel cell, Hydrogen energy systems and Hybrid renewable energy systems. Introduction to Restructuring of Power System-Market Models-Comparison of Market Models-Definition of Congestion, reasons for transfer capability limitation, Importance of congestion management, Features of congestion management

UNIT II PHOTOVOLTAIC AND WIND ENERGY SYSTEM 9

Photovoltaic Energy Conversion: Principle of operation, Solar radiation and measurement, solar cells and their characteristics - Switching devices for solar energy conversion, Grid connection Issues; Wind Energy Conversion Systems(WECS): Basic principle of wind energy conversion system, components of a wind energy system, Factorsinfluencing wind. Hybrid systems - safety and environmental aspects, economic aspects.

UNIT III OPERATION OF POWER SYSTEM WITH WIND AND SOLAR ENERGY SYSTEMS 9

Interface requirement – synchronizing with grid – operating limit –load scheduling – utility resource planning – electrical performance – voltage, current and power efficiency – component design for maximum efficiency – static bus impedance and voltage regulation – quality of power – renewable capacity limit – Plant economy.

UNIT IV CONGESTION MANAGEMENT WITH RENEWABLE ENERGY RESOURCES 9

Congestion Management Methods – Calculation of ATC - Non – market methods – Market methods – Nodal pricing – Inter zonal and Intra zonal congestion management – Price area congestion management – Capacity alleviation method- Locational marginal pricing– Lossless DCOPF model for LMPcalculation – Loss compensated DCOPF model for LMP calculation – ACOPF model for LMPcalculation – Financial Transmission rights.

UNIT V STORAGE SYSTEM AND OPTIMIZATION 9

Energy Storage System: Necessity – Types – comparison of energy storage technologies; Battery: Fundamental concept-Types of batteries; Alternate Storage Systems Principles and Methods:Flywheel, Super capacitors, Compressed air Energy storage, Concept of Hybrid Storage: social, economic and technicalproblems.Optimization of Hybrid solar energy sources and wind turbine systems integraed with energy storage system under pool/bilateral/hybrid electricity market.

TOTAL : 45 PERIODS

REFERENCES:

1. Rai ,G.D., “Non- conventional resources of energy”, Khanna publishers ,Fourth edition , 2010.
2. Kankar Bhattacharya, Jaap E. Daadler, Math H.J. Boolen,” Operation of restructured powersystems”, Kluwer Academic Pub., 2001.
3. SolimanAbdel Hady,Abdel Aal Hassan Mantawy, “Modern optimization techniques with applications in Electric Power Systems”, Springer,2012.
4. Bansal N K, Kleeman and Meliss, “Renewable energy sources and conversion Techniques”, Tata McGraw hill, 1990.
5. Electrochemical technologies for energy storage and conversion, Ru-shiliu, Leizhang,Xueliang sun, Wiley publications, 2012.
6. Kalyanmoy Deb, “Optimization for Engineering Design”,Prentice hall of India first edition,1988.
7. Mohammad Shahidehpour, Muwaffaq Alomoush, Marcel Dekker, “Restructured electricalpower systems: operation, trading and volatility” Pub., 2001
8. P. R. Shukla, T. K. Moulik, S. Modak and P. Deo; Strategic Management ofEnergy Conservation,Oxford & IBM Publishing Co., 1993.
9. M. Mohammadi, S.H. Hosseinian, G.B. Gharehpetian “Optimization of hybrid solar energy sources/wind turbine systems integrated to utility grids as microgrid (MG) underpool/bilateral/hybrid electricity market using PSO”, Elsevier-Solar Energy 86 (2012) 112–125.

SEE002 RESEARCH METHODOLOGY

L	T	P	C
3	0	0	3

UNIT I OBJECTIVES AND TYPES OF RESEARCH 9

Meaning of Research ,Objectives of Research ,Motivation in Research ,Types of Research ,Research Approaches, Significance of Research ,Research Methods versus Methodology , Research and Scientific Method ,Importance of Knowing How Research is Done, Research Process , Criteria of Good Research ,Problems Encountered by Researchers in India.

UNIT II RESEARCH PROBLEM AND DESIGN 9

Define Research Problem , Selecting the Problem ,Necessity of Defining the Problem ,Technique Involved in Defining a Problem , Research Design- Meaning of Research Design ,Need for Research Design, Features of a Good Design, Important Concepts Relating to Research Design, Different Research Designs ,Basic Principles of Experimental Designs .

UNIT III MEASUREMENT AND SCALING TECHNIQUES 9

Measurement in Research ,Measurement Scales ,Sources of Error in Measurement, Tests of Sound Measurement, Technique of Developing Measurement Tools, Scaling, Meaning of Scaling, Scale Classification Bases, Important Scaling Techniques, Scale Construction Techniques.

UNIT IV TESTING OF HYPOTHESES-I (PARAMETRIC OR 184 STANDARD TESTS OF HYPOTHESES) 9

Define Hypothesis, Basic Concepts Concerning Testing of Hypotheses, Procedure for Hypothesis Testing, Flow Diagram for Hypothesis Testing, Measuring the Power of a Hypothesis Test, Tests of Hypotheses ,Important Parametric Tests, Hypothesis Testing of Means, Hypothesis Testing for Differences between Means, Hypothesis Testing for Comparing Two Related Samples.

UNIT V INTERPRETATION AND REPORT WRITING 9

Meaning of Interpretation , Interpretation, Technique of Interpretation-Precaution in Interpretation ,Significance of Report Writing, Different Steps in Writing Report, Layout of the Research Report, Types of Reports , Oral Presentation , Mechanics of Writing a Research Report, Precautions for Writing Research Reports.

TOTAL : 45 PERIODS

REFERENCES

1. Garg, B.L., Karadia, R., Agar wal, F. and Agarwal, U.K., 2002. An introduction to Research Methodology , RBSA Publishers.
2. Kothari, C.R., 1990. Research Methodology: Methods and Techniques . New Age International. 418p.
3. Sinha, S.C. and Dhiman, A.K., 2002. Research Methodology , Ess Ess Publications. 2 volumes.
4. Trochim, W.M.K., 2005. Research Methods: the concise knowledge base, Atomic Dog Publishing. 270p.
5. Wadehra, B.L. 2000. Law relating to patents, trademarks, copyright designs and geographical indications . Universal Law Publishing. Additional reading.

FE9055 DEMAND RESPONSE IN SMART GRID L T P C
3 0 0 3

COURSE OBJECTIVES:

- To introduce the restructured power industry and market models.
- To impart knowledge on concepts on fundamental concepts of Demand Response.
- To analyse the system level benefits and the socioeconomic aspects of Demand Response.
- To look forward in filling up the gaps and enable widespread Demand response deployment .

UNIT I RESTRUCTURING OF POWER INDUSTRY 9

Introduction: Deregulation of power industry, Restructuring process, Issues involved inderegulation, Deregulation of various power systems –Market models: Market models based on Contractual arrangements,Comparison of various market models, Electricity vis – a – vis other commodities, Marketarchitecture, Case study. Reforms in Indian Power Sector: Framework of Indian power sector – Reform initiatives - Availability based tariff –Electricity act 2003 – Open access issues – Power exchange – Reforms in the near future.

UNIT II DEMAND RESPONSE 9

Introduction about DR – Need for DR – Advantages and Dis-advantages – Concepts of Arbitrage – Arbitrage in Power Markets – Arbitrage Examples in Power Markets – Power Wheeling- Transmission Open Access - Pricing of Pwer Transaction - Transmission Open Access and Pricing Mechanisms inCountries – Security Management and Congestion Management.

UNIT III STRATEGIC METHODS FOR DR 9

Introduction- Need for Algorithm – Modeling : Optimal Demand Response: Competitive Equlibrium – Iterative Supply Function Bidding – Strategic Demand Response: Game theoretic Equilibrium – Nash Equilibrium – Online Load Scheduling Learning – Stackelberg Equilibrium – Programs: Incentive Based DR – Price Based DR – Comparative Analysis of DR Algorithm.

UNIT IV THE SMART GRID-ENABLING DEMAND RESPONSE-THE DYNAMIC ENERGY SYSTEMS CONCEPT 9

Smart Energy Efficient End-Use Devices – Smart Distributed Energy Resources – Advanced Whole-Building Control Systems – Integrated Communicaation Architecture – Energy Management Today: Demand Side Management and Demand Response – Role of Technology in Demand Response – Dynamic Energy Management: Current Limitation and Scope – Overview of a Dynamic Energy Management – Key Characteristics: Smart Energy Efficient End-Use Devices and Distributed Energy Sources – Advanced Whole Building Control Systems – Dynamic Energy Management Systems.

UNIT V FUTURE APPLICATION AND OUTLOOK OF SMART GRID 9

Introduction and History – Information Modeling – Communication Services - Technology Mapping – Profiles - Security – Power Domain – Specific Data Modeling - Market Communication and the Need for IT Standards - IT Standards and Standards Developing Organizations for Market Communication - The Future of Smart Grid Communications and Standardization.

REFERENCE BOOKS

1. Mohammad Shahidehpour, MuwaffaqAlomoush, Marcel Dekker, “Restructured electricalpower systems: operation, trading and volatility” Pub., 2001.

2. Clark W. Gellings,P.E, “The Smart Grid: Enabling Energy Efficiency and Demand Response” CRC Press., 2009.

3. Mathias Uslar, Michael Specht, Christian Dänekas, JörnTrefke, Sebastian Rohjans, José M. González, Christine Rosinger, and Robert Bleiker, “Standardization in Smart Grids: Introduction to IT-Related Methodologies,Architectures and Standards” , Springer Pub., 2013.

4. Farshid Shariatzadeh, Paras Mandal, Anurag K. Srivastava, Demand response for sustainable energy systems: A review, application and implementation strategy, Renewable and Sustainable Energy Reviews, Volume 45, 2015, Pages 343-350, ISSN 1364-0321,

5. HaiderTarishHaider, Ong Hang See, WilfriedElmenreich, A review of residential demand response of smart grid, Renewable and Sustainable Energy Reviews, Volume 59, 2016, Pages 166-178, ISSN 1364-0321.

6. Ijaz Hussain, SajjadMohsin, Abdul Basit, Zahoor Ali Khan, Umar Qasim, Nadeem Javaid, A Review on Demand Response: Pricing, Optimization, and Appliance Scheduling, Procedia Computer Science, Volume 52, 2015, Pages 843-850, ISSN 1877-0509,

FE9056 TRANSIENT ANALYSIS AND FAULT LOCATION IN ELECTRICAL MACHINES **LT P C 3 0 0 3**

OBJECTIVE:

- To give an overview on modelling of transformer and rotating machines for transient analysis.
- To impart knowledge on SFRA technique and its applicability for Fault location

UNIT I BASIC METHODS FOR ANALYSIS OF HIGH FREQUENCY TRANSIENTS IN POWER APPARTUS WINDING 9

Introduction- Models for windings of power apparatus- Calculation of internal voltage distribution –Multiconductor transmission line model-Lumpedparameter models-Terminal models-Black box models - Single-input Single-output model,Multiple-input Multiple-Output model-Terminal models for very fast front transients-Resonance in windings.

UNIT II TRANSIENT ANALYSIS OF TRANSFORMER WINDINGS 9

Analysis methods of winding frequency characteristics-Transfer functions of transmission line and capacitive ladder network-Frequency characteristics of transformer windings and Equivalent circuits - Applications of winding frequency characteristics-Models for internal voltage distribution calculation-Simulation tools-Parameter determination.

UNIT III TRANSIENT ANALYSIS OF ROTATING MACHINES 9

Analysis methods of winding frequency characteristics-generator stator windings-Two main modes of pulse propagation along generator stator windings-Synchronous machine transient model-Mechanical model (shaft torque equation)-Induction machine transient model-Electromagnetic model (electrical circuit equations)-Fast transient model forgeneral rotating machines-Machine winding model.

UNIT IV FAULT DETECTION AND LOCATION IN WINDINGS 9

Frequency response of windings -Impulse response method,Swept frequency method-Diagnosis of transformer faults by FRA,Art of diagnosing electrical and mechanical faults by FRA -Mathematical and statistical methods-Failure modes sensitive to FRA-Influence of material characteristics on FRA-Standardization of FRA-Partial discharge location based on terminal measurements.

UNIT V Z-TRANSFORM MODELS 9

Conventional transformer and rotating machine models for terminal transient analysis-Z-transform model -Synthesis of surge impedance in frequency domain and in time domain-Z-transform model for impulse response analysisand gain functions-Lightning protection of substations using Z-transform models-Transformer terminal voltage prediction for impulse voltage tests.

TOTAL: 45 PERIODS

REFERENCES

1. Charles Q. Su, “Electromagnetic transients in transformer and rotating machine windings” Information Science Reference (an imprint of IGI Global).
2. Chowdhuri, P. “Electromagnetic transients in power systems (2nd ed.)” New York, NY: Re-search Studies Press - John Wiley,2004.
3. Gustavsen B. “A hybrid measurement approach for wideband characterization and modelling of power transformers”, IEEE Transactions on Power Delivery, 25(3), 1932–1939. doi:10.1109/TPWRD.2010.2043747,2010.
4. Major, S., &Su, Q. “Development of a frequency dependent model for the examination of impulse propagation along generator stator windings”. Proceedings of AUPEC’94, Adelaide, (pp. 405-410), 1994.
5. International Council on Large Electric Systems. “Mechanical-condition assessment oftransformer windings using frequency response analysis (FRA)”. WG A2.26,2008.
6. Tushar Gulabrao Vilhekar,Makarand Sudhakar Ballal and Bhimrao S. Umre. “Application of Sweep Frequency Response Analysis for the Detection of Winding Faults in Induction Motor”, IECON 2016, IEEE conference publications in Industrial Electronics society,2016.
7. N. Hashemnia, A. Abu-Siada, and S. Islam, "Improved powertransformer winding fault detection using FRA diagnostics:axial displacement simulation", IEEE Transactions on Dielectrics and Electrical Insulation, vol. 22, pp. 556-570, 2015.
8. Bahar Mohseni ,Naser Hashemnia ,Syed Islam, “Application of Online Impulse Technique to DiagnoseInter-turn Short Circuit in Transformer Windings”,AUPEC2016,IEEE,2016.

FE9057 STATISTICAL TECHNIQUES FOR HIGH VOLTAGE ENGINEERING L T P C
3 0 0 3

OBJECTIVE

- To study various statistical techniques from both applied and theoretical points of view.
- To expose the student with various Statistical methods for evaluation of breakdown studies and Overvoltages

UNIT I REVIEW OF FUNDAMENTALS 9

Basic concepts of Probability theory – Distribution function - concept and properties, Empirical distributions functions – Parameter Estimation _Discrete Variate – Continuous Variate – Mixed Distributions – Fundamental of correlation and regression

UNIT II STOCHASTIC NATURE OF BREAKDOWN 9

Statistical features of breakdown – Weibull Distribution and other statistical distributions – Effect of voltage and time on the failure statistics

UNIT III STOCHASTIC MODELS OF BREAKDOWN 9

Statistical and physical connection – Fluctuation model – Fractal description of breakdown - Cumulative defect models of breakdown – Differences and similarities in model statistics

UNIT IV STATISTICAL DESCRIPTION OF INSULATION CAPACITY 9

Choice of Variate – Air, Compressed-gas, Liquid and Solid insulation – uniform and Non Uniform insulation – Statistics of partial discharges

UNIT V WAVELET TRANSFORM 9

Review of digital signal processing-CWT, DW, Discretisation in steps, Discretisation of Time and Space

TOTAL: 45 PERIODS

REFERENCES

1. Hauschild.W, Mosch.W, “Statistical Technique for high voltage engineering”, IEE Press, 1992.
2. Dissado.L.A, Fothergill.J.C, “Electrical degradation and breakdown in polymers”, IEEE Press, 1992.
3. Hamza A.H., Samy M. Ghania, Ahmed M.Emam, “Statistical Analysis of Switching Overvoltages and Insulation Coordination For a 500 kV Transmission Line”, Third International Conference on Advances in Electrical, Electronics, Information, Communication and Bio-Informatics (AEEICB17), 2017.
4. K. P. Soman, K. I. Ramachandran, "Insight Into Wavelets - From Theory to Practice", Prentice Hall of India, Eastern Economy Edition, Prentice Hall of India Private Limited, M-97, New Delhi, 2004.
5. Narayani A., WilljuiceIruthayarajan M., Bakrutheen M., “A Statistical Study on the AC Breakdown Voltage of Corn Oil and Mineral Oil for Liquid Insulation”, Third International Conference on Advances in Electrical, Electronics, Information, Communication and Bio-informatics (AEEICB17), 2017.
6. Peyton Z.Peebles, “Probability, Random variables and Random Signal Principles” Mc-Graw Hill Publishing Company Limited, New Delhi, 1993.

FE9058 STATE ESTIMATION FOR HYBRID AC/DC MICROGRIDS

L	T	P	C
3	0	0	3

UNIT I INTRODUCTION TO STATE ESTIMATION 9

Introduction: State Estimation – Need for State Estimation –Comparison of power flow and state estimation problems – Measurements – Redundancy – Noise – Measurement Functions – Weighted Least Square Errors – Measurement Jacobian Matrix – Weights – Gain Matrix – Bad Data Detection and Removal

UNIT II POWER SYSTEM STATE ESTIMATION 9

Building model for power system components - Mean - Standard deviation - Maximum likelihood estimation - Measurement equations - WLS State Estimation - Measurement Jacobian matrix - Gain matrix - Cholesky decomposition - Forward and backward substitutions - State estimation algorithm - Decoupled formulation of WLS state estimation - DC State estimation.

UNIT III DECENTRALIZED STATE ESTIMATION 9

Centralized State Estimation: Limitations - Decentralized State Estimation: Lagrangian Relaxation Approach – Decomposition Theory: Dual Decomposition approach and application –Primal Decomposition approach and application – Indirect and Hierarchical Decomposition.

UNIT IV LINEARIZED STATE ESTIMATION 9

General Architecture – Measurement models - State vector in rectangular coordinates - State vector in polar coordinates - Simultaneous SE formulation - Sequential SE formulation - Reference bus issues –Multi area State Estimation using Synchronized Phasor Measurements.

UNIT V STATE ESTIMATION FOR HYBRID AC/DC GRID 9

Overview of Power Management Strategies – Energy Management and Operation Modelling of Hybrid AC/DC grid and its co-ordination control – Linear State Estimation formulation for Distribution Systems – Fully Distributed State Estimation for WAMS.

TOTAL : 45 PERIODS

REFERENCES:

1. Monticelli. A, State Estimation in Electric Power Systems: A Generalized Approach, Springer, 1999.
2. A. Abur, A. Gomez-Exposito, Power System State Estimation: Theory and Implementation, MarcelDekker, April 2004.
3. Grainger J J and Stevension W D, “Power System Analysis”, McGraw-Hill, Inc., 1994.
4. Mukhtar Ahmad, “Power System State Estimation”, Lap Lambert Acad Publishers, 2013.
5. Naim Logic, “Power System State Estimation” , LAP Lambert Acad. Publ., 2010.
6. http://ewh.ieee.org/soc/pes/dsacom/testfeeders/

FE9059 IMAGE ANALYSIS ON WATER QUALITY L T P C
3 0 0 3

COURSE OBJECTIVES:

- To gain knowledge about various types of water borne contaminants
- To have an exposure to measurement and data acquisition related to water quality
- To understand the basic concepts of Image Processing
- To gain in-depth knowledge on few algorithms for Image analysis relating to water quality
- To realize ways in which Image analysis can be utilized in certain real world applications

UNIT I CONTAMINANTS AFFECTING WATER QUALITY 9

Chemical contaminants: Organic – Synthetic Organic – Toxic – Nano particles – Oil - Inorganic – Suspended Solids and Sediments – Thermal pollutants – Pathogens – Algae – Odour and Color forming compounds

UNIT II SENSORS FOR WATER QUALITY ANALYSIS 9

Types – Instrumentation – Performance Characteristics – Operational Lifetimes - Water Quality Parameters: ORP - BOD – COD – TOC – TSS – pH – Dissolved Organic Nitrogen – Turbidity - Bio Sensors – Smart Sensors

UNIT III INTRODUCTION TO IMAGE ANALYSIS 9

Elements of visual perception, brightness, contrast, hue, saturation, Image Transform: 1D DFT, Image Enhancement: Spatial Domain Filtering, Image Segmentation: Edge Detection, Basics of Morphological Image processing – Image Compression: Need, Run length encoding

UNIT IV IMAGE ANALYSIS FOR WATER QUALITY 9

Empirical Mode Decomposition - K – Means clustering – 2D Matched Filter method – Threshold Probing – Color Analysis methods for Water - Color Image Analysis: Color Space models – Color Difference Calculations

UNIT V CASE STUDY 9

Computer Vision Platform Based Virtual Instrument - Flow measurements based on image analysis - Controlled image acquisition systems - Quality and Safety Inspection of Food and Agricultural Products - Multivariate Image Regression (MIR)

TOTAL : 45 PERIODS

REFERENCES

1. Lloyd, J.W. and Heathcote, J.A., Natural inorganic chemistry in relation to Groundwater resources, Oxford University Press, Oxford, 1988.
2. Bhatia S.C. , "Hand Book of Environmental Microbiology", Part 1 and 2, Atlantic Publisher 2. Gabriel Bitton, Wastewater Microbiology, 2nd Edition.
3. *Global Trends & Challenges in Water Science, Research and Management, IWA Specialist Groups, Published by International Water Association (IWA), Second Edition, 2016*
4. Rafael C. Gonzalez, Richard E. Woods, “Digital Image Processing”, Pearson Education, Inc., Second Edition, 2004
5. Sid Ahmed, M.A., “Image Processing Theory, Algorithms and Architectures”, McGrawHill, 1995.
6. Milan Sonka et al, “Image Processing, Analysis and Machine Vision”, Brookes/Cole, Vikas Publishing House, 2nd edition, 1999.

FE9060 DIGITAL INSTRUMENTATION FOR OFFSHORE GRID

L	T	P	C
3	0	0	3

COURSE OBJECTIVES

- To study on operation and performance of Offshore Wind Energy System(WES).
- To Model various types of Electrical faults in grid connected WES (its Electrical Machines)
- To model the instrumentation module for WES condition monitoring.
- To understand the choice of specific of sensors.
- To develop wireless protocol for data routing specific to WES.

UNIT I DIAGNOSIS OF FAULTS IN ELECTRICAL MACHINE 9

Technology trends in fault diagnosis of Electrical Machines - Types of faults in transformer and grid connected Electrical machines – insulation breakdown-winding breakdown – electrical and mechanical breakdown - Signal processing based instrumentation methods for Electrical Machines modelling and characterisation.

UNIT II MODELLING OF FAULTS IN ELECTRICAL MACHINES 9

MATLAB Simulation studies of transients in transformer and grid connected Electrical machines - Signal analysis using Transform techniques - Pattern Recognition applied to fault detection in electrical machines. Simulation studies of transients in Electrical Machines using MATLAB and LabVIEW.

UNIT III WIND ENERGY ROTOR SYSTEM ISSUES 9

Introduction to WES - Fixed speed – variable sped WT-HAWT – VAWT – Power developed – thrust – issues on efficiency – rotor design considerations and possible disturbances – damages to blades – Blade characteristics to speed – power regulation – yaw system – faults in blade angle control – pitch angle control – Drop offset control – position speed estimation – field weakening – modelling of Wind turbines for Power failure studies.

UNIT IV OCEANOGRAPHIC INSTRUMENT SENSORS 9

Properties of Seawater -Basic studies on conductivity – salinity – temperature - role of depth and pressure sensors, Different configuration of strain gauges sensors , Study of change in resistance with strain for various strain gauge materials - Response of a strain gauge- Bonding procedure, Gauge factor, Cross sensitivity factor - instrumentation issues -sampling system for sea water meters-sea bed system for WES installation - Ocean dynamics and upwelling Oceanographic instruments and methods for WES– heat budget – General ocean circulation effects– waves, tides, sea level.

UNIT V WIRELESS INSTRUMENTATION FOR POWER QUALITY ISSUES 9

Renewable Energy machine Power Quality issues– Harmonic Distortion – Blackouts – Under and Over Voltages – Sags and Surges – Flicker due to electrical and mechanical stress- Interharmonics - Transients – Power Quality Benchmarking – Power Quality Monitoring-classical methods, Wireless protocols for instrument data routing.

TOTAL: 45 PERIODS

REFERENCES:
1. Irving L. Kosow, “Electric machinery and transformers”, second edition, Prentice Hall, 2007.
2. L.L.Freis “Wind Energy conversion Systems”, prentice hall, 1990.
3. Jagannathan Sarangapani, “Wireless Ad Hoc and Sensor Networks”, CRC Press, 2007.
4. C. Britton Rorabaugh, “Simulating Wireless Communication Systems”, Pearson Education, 2006.
5. Krzysztof Iniewski, “Smart Grid Infrastructure & Networking”, Tata McGraw-Hill Edition, 2006.
6. Bent Sorensen, “Renewable Energy”, Elsevier, Third Edition, 2006.
7. Arindam Ghosh “Power Quality Enhancement Using Custom Power Devices”, Kluwer Academic Publishers, 2002
8. A.B.Dehkordi, A.M.Gole and T.L.Maguire “Permanent Magnet Synchronous Machine model for Real– time Simulation”, IPST” 05 in Montreal, Canada on june 19-23, 2005.
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Faculty of Electrical Engineering **(Approved in 25th AC 02.05.2019) ITEM NO. FE25.04**

FE9061	**ENHANCEMENT OF POWER EVACUATION OF WIND ENERGY CONVERSION SYSTEM USING VSC MTDC LINK**	**L T P C** **3 0 0 3**

OBJECTIVES:
- To impart comprehensive understanding of VSC MTDC system operation and controller design
- To impart comprehensive understanding of DFIG operation and controller design.
- To analyze the impact of unbalanced and distorted grid voltage on DFIG wind turbine
- To enable the student to develop coordinated controller to enhance LVRT capability of the system.

UNIT I INTRODUCTION TO VSC MTDC SYSTEMS 9
VSC based HVDC transmission - LCC based HVDC Transmission- Comparison with respect to Control of power flow, harmonics, need for filters, converter transformer, communication channel, fault infeed, DC breaker , protection - VI plot-Modes of control-Interaction with weak AC system- Impact of Short Circuit Ratio (SCR)- Power flow analysis of VSC HVDC Link-Hybrid VSC-LCC DC Transmission-modelling of VSC HVDC link in phasor domain and instantaneous domain- Case Study

UNIT II VSC-MTDC LINKS - DC GRID AT SUBTRANSMISSION LEVEL 9
MTDC configurations- Series, Ring and Radial topologies - Coordinated control of MTDC links-phasor modeling-instantaneous domain-time domain analysis and State space model without droop control - Need for droop regulation-V_{dc}-P droop, V_{dc}-I droop and Q-V_{PCC} - distributed DC slack bus concept-droop incorporation in Load Flow Analysis-Coordinated droop controller gain parameters optimization for steady state power penetration – dynamic optimization of droop settings for varying power penetrations into DC grid-impact of droop regulation on AC /DC system - V_{dc}, V_{AC} bus voltages-AC DC line flows.

UNIT III MODELING AND CONTROL OF DFIG and PMSG 9

Steady-State Equivalent Circuit of a DFIG and PMSG- Dynamic Model of a DFIG and PMSG - Modeling of the Converter -Start-Up Process of the DFIG System drive train modelling-application of vector control for PMSG and DFIG- Grid-Side Converter control- Rotor-Side Converter - Control-Mode Switching- DFIG behavior during voltage recovery-under recurring grid faults- -simulation of impact of faults on onshore PCC-offshore PCC-Study of LVRT grid codes of various countries- FRT strategies on literatures.

UNIT IV OPERATION OF DFIG UNDER DISTORTED AND UNBALENCED GRID VOLTAGE 9

Influence on GSC under distorted grid voltage- Influence on DFIG and RSC - stator flux vector orientation, Discussion on Different Controller Parameters- Discussion on Different Power Scales , influence of inner current control dynamics- Dynamics of Phase locked loop-Resonant Control of DFIG under Grid Voltage Harmonics Distortion - Stator Current Control using Resonant Controllers- Design and Optimization of Current Controller, DFIG under unbalanced grid voltage - Control Limitations Under Unbalanced Grid Voltage-Negative sequence controller design.

UNIT V COORDINATED CONTROL OF DFIG AND VSC MTDC SYSTEM 9

Various FRT strategies of DFIG, Power Hardware inloop simulation of FRT capability of various control strategies- control mode switching between inertia support and LVRT support of DFIG controllers - control mode switching between inertia support and LVRT support of VSC-MTDC controllers-Coordinated control of DFIG converters and VSCs of MTDC system- Tradeoff between Frequency and LVRT support during various disturbances. Case Study .

TOTAL : 45 PERIODS

OUTCOMES:

- The student will have a comprehensive understanding of VSC MTDC system operation and controller design
- The student will have a comprehensive understanding of DFIG operation and controller design
- The student will be able to develop coordinated controller to enhance LVRT capability of the system.

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