Department of Electrical Engineering

National institute of Technology, Raipur

Master of Technology

In

Power System & Power Electronics

Scheme & Syllabus

Content

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NATIONAL INSTITUTE OF TECHNOLOGY, RAIPUR(CHHATTISGARH)													
Department of Electrical Engineering													
M.Tech. in Power System & Power Electronics													
Course of Study							**M.Tech: First Semester**						
Sn.	**Board of Studies**	**Subject Code**	**Subject Name**	**Periods/Week**			**Examination Schemes**					Total Marks	Credits L+(T+P)/2
				L	T	P	TA	FE	SE	ESE	PRACT ESE		
1	Electrical	EL311101EL	Modern Control Theory	3	1	-	20	15	15	100	-	150	4
2	Electrical	EL311102EL	FACTS in Power Transmission and Distribution	3		-	20	15	15	100	-	150	4
3	Electrical	EL311103EL	Electrical Drives and Control	3	1	-	20	15	15	100	-	150	4
4	Electrical	*	Elective-I	3	1	-	20	15	15	100	-	150	4
5	Electrical	*	Elective-II	3	1	-	20	15	15	100	-	150	4
6	Electrical	EL311401EL	Power System Laboratory-I	-	-	3	75	-	-	-	50	125	2
7	Electrical	EL311402EL	Electrical Dives Laboratory	-	-	3	75	-	-	-	50	125	2
Total				**15**	**5**	**6**	**250**	**75**	**75**	**500**	**100**	**1000**	**24**

List of Electives for First Semester		
Sn	**Subject Code***	**Subject Name**
1	EL311201EL	Extra High Voltage AC
2	EL311202EL	High Voltage DC
3	EL311203EL	System Identification
4	EL311204EL	Advanced Power Electronic
5	EL311205EL	Smart Grid Technology
6	EL311206EL	Power System Dynamics and Control
7	EL311207EL	Computer Aided Power System Analysis
8	EL311208EL	Energy Management System

NATIONAL INSTITUTE OF TECHNOLOGY, RAIPUR(CHHATTISGARH)													
Department of Electrical Engineering													
M.Tech. in Power System & Power Electronics													
Course of Study							**M.Tech: Second Semester**						
Sn.	**Board of Studies**	**Subject Code**	**Subject Name**	**Periods/Week**			**Examination Schemes**					**Total Marks**	**Credits L+(T+P)/2**
				L	T	P	TA	FE	SE	ESE	PRACT ESE		
1	Electrical	EL312101EL	Optimization in Engineering design	3	1	-	20	15	15	100	-	150	4
2	Electrical	EL312102EL	Advanced Power System Protection	3	1	-	20	15	15	100	-	150	4
3	Electrical	EL312103EL	Soft Computing Techniques	3	1	-	20	15	15	100	-	150	4
4	Electrical	**	Elective –III	3	1	-	20	15	15	100	-	150	4
5	Electrical	**	Elective-IV	3	1	-	20	15	15	100	-	150	4
6	Electrical	EL312401EL	Control System Laboratory	-	-	3	75	-	-	-	50	125	2
7	Electrical	EL312402EL	Power System Laboratory-II	-	-	3	75	-	-	-	50	125	2
Total				**15**	**5**	**6**	**250**	**75**	**75**	**500**	**100**	**1000**	**24**

List Of Electives for Second Semester		
S.No	**Subject Code****	**Subject Name**
1	EL312201EL	Digital Techniques of Power System & Electric Drives
2	EL312202EL	Advanced Electric Drives
3	EL312203EL	Power System Modeling
4	EL312204EL	Power Quality
5	EL312205EL	Renewable and Non-Conventional Energy System
6	EL312206EL	Advanced Instrumentation
7	EL312207EL	Nonlinear and Digital Control System
8	EL312208EL	Optimal Control System

NATIONAL INSTITUTE OF TECHNOLOGY, RAIPUR(CHHATTISGARH)													
Department of Electrical Engineering													
M.Tech. in Power System & Power Electronics													
Course of Study							**M.Tech: Third Semester**						
Sn.	**Board of Studies**	**Subject Code**	**Subject Name**	**Periods/Week**			**Examination Schemes**					**Total Marks**	**Credits L+(T+P)/2**
				L	T	P	TA	FE	SE	ESE	PRACT ESE		
1	Electrical	EL313501EL	Preliminary work on dissertation	-	-	24	100	-	-	-	200	300	12
2	Electrical	EL313502EL	Comprehensive Viva Voce & Seminar	-	-	-	-	-	-	-	200	200	4
			Total	**0**	**0**	**24**	**100**	**0**	**0**	**0**	**400**	**500**	**16**

NATIONAL INSTITUTE OF TECHNOLOGY, RAIPUR(CHHATTISGARH)													
Department of Electrical Engineering													
M.Tech. in Power System & Power Electronics													
Course of Study							**M.Tech: Fourth Semester**						
Sn.	**Board of Studies**	**Subject Code**	**Subject Name**	**Periods/Week**			**Examination Schemes**					Total Marks	Credits L+(T+P)/2
				L	T	P	TA	FE	SE	ESE	PRACT ESE		
1	Electrical	EL314501EL	Dissertation	-	-	32	200	-	-	-	300	500	16
			Total	**0**	**0**	**32**	**200**	**0**	**0**	**0**	**300**	**500**	**16**

National Institute of Technology, Raipur

Department of Electrical Engineering

M. Tech in Power System & Power Electronics

Semester: I **Code: EL311101EL**

SUBJECT: MODERN CONTROL THEORY

1. State Variable Modelling and Analysis

State Equations (continuous and discrete time), solution of state equations, system equivalence, Canonical forms, Stability , Linearization, MIMO(multi-input multi-output) system .

2. Controllability & Observability

Concept of controllability & observability, Grammian, controllability and observability tests for continuous -time systems, controllability and observability of discrete-time systems, canonical forms of state models.

3. State models and input-output descriptions

Input-output maps from state model and vice-versa, transfer matrix, output controllability, reducibility, Liapunov stability analysis.

4. State feedback control

Introduction, Effect of state feedback on controllability and observability, pole placement by state feedback; Integral state feedback, Full order observers, Reduced-order observers; constrained observer design.

5. Introduction to Robust Control

Modeling, Uncertainty and Robustness, Co-prime factorization, System Stabilities,
Sensitivity function, General regulator problem, Small-gain theorem

6. Fractional Order Controller

Fractional order calculus, Fractional order transfer function modelling, Frequency domain analysis of fractional order controller, Time domain analysis of time domain controller.

Reference Books

1) T Kailath, Linear Systems, Prentice Hall, 1980.

2) P J Antsaklis, A N Michel, Linear Systems, Springer, 2006.

3) D Xue, Y Q Chen and D P Atherton, Linear Feedback Control: Analysis and Design with MATLAB, SIAM 2007.

National Institute of Technology, Raipur

Department of Electrical Engineering

M. Tech in Power System & Power Electronics

Semester: I **Code: EL311102EL**

SUBJECT: FLEXIBLE AC TRANSMISSION SYSTEM

Introduction to Flexible AC transmission systems, Flow of power in AC system, Steady-state and dynamic problems in AC systems loading capability, controllable parameters, basic types of FACTS controllers, Basic realities & roles. Voltage Source Converters (VSC) Basic concepts of VSC, single-phase full wave bridge converter operation, single phase-leg operation, three-phase full wave bridge converter and its operation, transformer connections for 12-pulse, 24-pulse and 48-pulse operation. Current source converters (CSC) Basic concepts, three-phase CSCs, three-phase full wave rectifier, comparison of VSC and CSC. Static shunt compensators: basic concepts, method of controllable VAR generation: TCR, TSR, TSC, Static VAR Compensator (SVC), application of SVC in power systems. Shunt Compensators Introduction, mathematical model, working of STATCOM, V-I and V-Q characteristics, transient stability enhancement and exchange of real power using STATCOM, comparison of SVC and STATCOM, Merits of hybrid compensators. Series Compensators Objectives of series compensation, variable impedance type series compensation, GTO thyristor controlled series capacitors (GCSC), thyristor controlled series capacitor (TCSC), basic concepts of GCSC and TCSC, static synchronous series compensator (SSSC). Introduction to Unified Power Flow Controller (UPFC).

Reference Books

1. N.G. Hingorani and L.Gyugyi: Understanding facts, standard publishers, distributors, New Delhi, 1995.
2. R. Mohan Mathur And Rajiv K. Varma “Thyristor-based facts controllers for electrical transmission systems” IEEE press, 2002”.

National Institute of Technology, Raipur

Department of Electrical Engineering

M. Tech in Power System & Power Electronics

Semester: I **Code: EL311103EL**

SUBJECT: ELECTRICAL DRIVES AND CONTROL

Basic concept of electric drives, classification of electric drives, Requirement of electric drives, fundamental torque equation, speed torque conventions and multi quadrant operation, steady state stability of electrical drives

Speed control and, closed loop control of drives, current limit control, closed loop torque control, closed loop speed control, closed loop speed control of multi motor drives, phase locked loop controller (PLL), closed loop position control.

Speed torque characteristics of dc and induction motors,

Starting and speed control of Direct Current motors and induction motors

Breaking of industrial motors

Bidirectional Electric drive system and four quadrant Electrical drive systems

Single phase induction motors

Test books:

1. Electrical Machines and drives by G.K. Dubey
2. S. K. Pillai -A First Course on Electrical Drives

National Institute of Technology, Raipur

Department of Electrical Engineering

M. Tech in Power System & Power Electronics

Semester: I **Code: EL311201EL**

SUBJECT: EXTR HIGH VOLATGE A.C. TRANSMISSION

E.H.V. A.C. Transmission trends and preliminary aspects, standard transmission voltages – power handling capacities and line losses. Calculation of line resistance, inductance and capacitance calculation. Generation of High voltage AC, Impulse Volatge. Corona in EHV lines, corona loss formula, attenuation of travelling waves due to corona, Audio noise due to corona and characteristics. Power Frequency voltage control : Problems at power frequency, generalized constants, No load voltage conditions and charging currents, voltage control using synchronous condenser, cascade connection of components : Shunt and series compensation, sub synchronous resonance in series capacitor compensated lines.

Reference Books

1. High Voltage Engineering, M.S. Naidu and Kamaraju, 3 rd edition, Tata Mc.Grawhill, New Delhi, 2004
2. Extra High Voltage AC Transmission Engineering –Rakosh Das Begamudre, Wiley Eastem ltd., New Delhi–1987.
3. EHV Transmission line reference book – Edison Electric Institute (GEC) 1986.

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Department of Electrical Engineering

M. Tech in Power System & Power Electronics

Semester: I **Code: EL311202EL**

SUBJECT: HIGH VOLATGE DC TRANSMISSION

H.V.D.C. Transmission: General considerations, DC Versus AC transmission, power handling capabilities of HVDC lines, basic conversion principles, static converter configuration: 3-pulse, 6-pulse and 12-pulse converters, converter station and terminal equipment, commutation process, Rectifier and inverter operation, equivalent circuit for converter, control of HVDC Converters and systems: constant current, constant extinction angle and constant Ignition angle control. Individual phase control and equidistant firing angle control, Multi-terminal DC links and systems; series, parallel and series parallel systems, their operation and control.

Reference Books

1. E.W. Kimbark: Direct current Transmission, Wiely Inter Science – NewYork.
2. J.Arillaga: H.V.D.C.Transmission Peter Peregrinus ltd., London UK 1983
3. K.R. Padiyar: HVDC Power Transmission System, Wiely Eastern Ltd., New Delhi – 1992.
4. E.Uhlman : Power Transmission by Direct Current, Springer Verlag, Berlin Helberg – 1985.

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Department of Electrical Engineering

M. Tech in Power System & Power Electronics

Semester: I **Code: EL311203EL**

SUBJECT: SYSTEM IDENTIFICATION

Introduction to system identification, Parameter estimation using input-output data, Least squares algorithm, Generalized, weighted andrecursive least squares. Precision of parameter estimates, Cramer-Rao bound, Instrumental variable method, Autoregressive modelling (linear and nonlinear), Kalman filter, extended Kalman filter, LMS based adaptive filter, Likelihood functions and maximum likelihood estimation (MLE); Singular value decomposition (SVD); Stochastic approximation algorithm (STA); Order and structure determination, Yule-Walker equation; Multi-variable system representation, controllability and observability indices; Feedback system identification, Spectral estimation: parametric and non-parametric approaches, Use of optimization techniques in parameter estimation and system identification, Nonlinear system identification using soft computing techniques.

Reference Books

1. L Ljung, System Identification: Theory for the user, Prentice Hall, 1995.
2. O. Nellles, Nonliner System Identification, From classical approaches to neural networks and fuzzy models, Springer, 2001.
3. R. Pintelon and J. Schoukens, System Identification, A Frequency Domain Approach, Wiley-IEEE press, 2012

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Department of Electrical Engineering

M. Tech in Power System & Power Electronics

Semester: I **Code: EL311204EL**

SUBJECT: ADVANCED POWER ELECTRONICS

Solid State Power Semi-conducting Devices: Review of the thyristors, traic, GTO, transistor MOSFET, IGBT and other modem power devices, characteristics, ratings, commutation methods, protection and requirement of firing circuits.

Review of Phase Controlled Converters: Single and three-phase controlled converters, power factor improvement techniques.

Basic concepts of Switched Mode power converters. Analysis and design of DC to DC converters- Control of DC-DC converters. Isolated and non isolated DC-DC converter.

Single phase and Three phase inverters, Voltage source and Current source inverters, Voltage control and harmonic minimization in inverters. PWM techniques.

Single phase and three phase Cyclo-converters. Reduction in Output Harmonics. Matrix Converter

Multilevel Inverters and PWM modulation techniques

Reference books:

1. Rashid M. H., "Power Electronics Circuits, Devices and Applications", Prentice Hall India,Third Edition, New Delhi.
2. Mohan, Undeland and Robins, "Power Electronics – Concepts, applications and Design, John Wiley and Sons, Singapore.
3. B.W. Williams 'Power Electronics: Devices, Drivers, Applications and Passive Components,Tata McGraw Hill.
4. L. Umanand, Power Electronics, Essentials and Applications, Wiley India Pvt. Ltd.
5. Philip T Krein,' Elements of Power Electronics ',Oxford Press
6. B.K. Bose: Modern Power Electronics and AC Drives, Pearson Education Asia, 2002.
7. Robert Erickson and Dragon Maksivimovic, Fundamentals of Power Electronics

National Institute of Technology, Raipur

Department of Electrical Engineering

M. Tech in Power System & Power Electronics

Semester: I **Code: EL311205EL**

SUBJECT: SMART GRID TECHNOLOGY

Introduction to Smart Grid: Evolution of Electric Grid, Concept, Definitions, Need and Functions of Smart Grid, Opportunities & Barriers of Smart Grid, Difference between conventional & smart grid

Smart Grid Technologies: Smart Meters, Plug in Hybrid Electric Vehicles (PHEV), Smart Sensors, Home & Building Automation, Smart Substations, Substation Automation, Feeder Automation. Smart storage like Battery, SMES

Micro Grids and Distributed Energy Resources: Concept of micro grid, need & applications of micro grid, formation of micro grid, protection & control of micro grid.

Information and Communication Technology for Smart Grid: Advanced Metering Infrastructure (AMI), Home Area Network (HAN), Neighbourhood Area Network (NAN), Wide Area Network (WAN) Wireless Mesh Network, Basics of CLOUD Computing & Cyber Security for Smart Grid. Broadband over Power line (BPL). IP based protocols.

Reference Books:

1. Ali Keyhani, Mohammad N. Marwali, Min Dai “Integration of Green and Renewable Energy in Electric Power Systems”, Wiley, ISBN: 978-0-470-18776-0
2. Clark W. Gellings, “The Smart Grid: Enabling Energy Efficiency and Demand Response”, CRC Press.
3. Janaka Ekanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama, “Smart Grid: Technology and Applications”, Wiley
4. Jean Claude Sabonnadière, NouredineHadjsaïd, “Smart Grids”, Wiley Blackwell
5. Tony Flick and Justin Morehouse, “Securing the Smart Grid”, Elsevier Inc. (ISBN: 978-1-59749-570-7)
6. Peter S. Fox-Penner, “Smart Power: Climate Change, the Smart Grid, and the Future of Electric Utilities”.

National Institute of Technology, Raipur

Department of Electrical Engineering

M. Tech in Power System & Power Electronics

Semester: I **Code: EL311206EL**

SUBJECT: POWER SYSTEM DYNAMICS AND CONTROL

Introduction to Power System Stability: Power System Operation and Control, Stability Problems faced by Power Systems, Impact on Power System Operation and Control.

Analysis of Dynamical Systems: Concept of Equilibria, Small and Large Disturbance Stability, Example: Single Machine Infinite Bus System, Modal Analysis of Linear Systems, Analysis using Numerical Integration Techniques, Issues in Modeling: Slow and Fast Transients, Stiff Systems.

Stability Issues in Interconnected Power Systems: Single Machine Infinite Bus System, Multi-machine Systems, Stability of Relative Motion, Frequency Stability: Centre of Inertia Motion, Concept of Load Sharing: Governors, Single Machine Load Bus System: Voltage Stability, Torsional Oscillations.

Power System Stability Analysis Tools: Transient Stability Program, Small Signal Analysis Program, EMTP Programs, Real-Time Simulators.

Enhancing System Stability: Planning Measures, Stabilizing Controllers (Power System Stabilizers), Operational Measures- Preventive Control, Emergency Control.

Reference Books

1. K.R.Padiyar, Power System Dynamics, Stability & Control, 2nd Edition, B.S. Publications, Hyderabad, 2002.
2. P.Kundur, Power System Stability and Control, McGraw Hill Inc, New York, 1995.
3. P.Sauer&M.A.Pai, Power System Dynamics & Stability, Prentice Hall, 1997

National Institute of Technology, Raipur

Department of Electrical Engineering

M. Tech in Power System & Power Electronics

Semester: I **Code: EL311207EL**

SUBJECT: COMPUTER AIDED POWER SYSTEM ANALYSIS

UNIT-I:

Admittance Model and Network Calculations, Branch and Node Admittances, Mutually Coupled Branches in Y_{BUS}, An Equivalent Admittance Network, Modification of Y_{BUS}, Network Incidence Matrix and Y_{BUS}, Method of Successive Elimination, Node Elimination, Triangular Factorization, Sparsity and Near Optimal Ordering.

UNIT-II:

Impedance Model and Network Calculations, the BUS Admittance and Impedance Matrices, Thevenin's Theorem and Z_{BUS}, Algorithms for building Z_{BUS} Modification of existing Z_{BUS}, Calculation of Z_{BUS} elements from Y_{BUS}, Power Invariant Transformations, Mutually Coupled Branches in Z_{BUS}.

UNIT-III:

Gauss Seidel method, N-R Method, Decoupled method, fast decoupled method, comparison between power flow solutions. DC load flow.

UNIT-IV:

Z_{BUS} Method in Contingency Analysis, Adding and Removing Multiple Lines, Piecewise Solution of Interconnected Systems, Analysis of Single Contingencies, Analysis of Multiple Contingencies, Contingency Analysis of DC Model, System Reduction for Contingency and Fault Studies.

UNIT-V:

Fault Analysis: Symmetrical Faults-Fault calculations using Z_{BUS}- Fault calculations using Z_{BUS} equivalent circuits –Selection of circuit breakers-Unsymmetrical faults-Problems on various types of faults.

Reference Books

1. O.I.Elgerd, Electric Energy Systems Theory, McGraw Hill, 1971.
2. John J. Grainger and W. D. Stevenson, "Power System Analysis"- T.M.H. Edition
3. G.W.Stagg and A.H.El-Abiad, Computer Methods in Power System Analysis, McGraw Hill 1968.
4. G.L.Kusic, Computer Aided Power Systems Analysis, Prentice Hall, 1986.
5. I.J.Nagrath and D.P.Kothari, Modern Power Systems Analysis, Tata McGraw Hill, 1980.
6. A.J.Wood and B.F.Wollenberg, Power Generation, Operation and Control, John Wiley, 1984.

National Institute of Technology, Raipur

Department of Electrical Engineering

M. Tech in Power System & Power Electronics

Semester: I **Code: EL311208EL**

SUBJECT: ENERGY MANAGEMENT SYSTEMS (EMS)

Energy Efficiency, Optimization, Forecasting, Modeling and Analysis

Energy Efficiency in Industrial Utilities,

Energy Management Centers and Their Functions, Architectures, recent Developments

Characteristics of Power Generating Units and Economic Dispatch.

Unit Commitment (Spinning Reserve, Thermal, Hydro and Fuel Constraints); Solution techniques of Unit Commitment.

Generation Scheduling with Limited Energy.

Energy Production Cost – Cost Models, Budgeting and Planning, Practical Considerations.

Interchange Evaluation for Regional Operations, Types of Interchanges

Exchange Costing Techniques.

Methodology Development for a Comprehensive and Cost-Effective Energy Management in Industrial Plants, Energy Demand Analysis and Forecast

Reference Books

1. Handschin, E. “Energy Management Systems”, Springer Verlag, 1990.
2. Turner, W. C, “ Energy Management Handbook”, 5 th Edition, 2004.
3. P. GiridharKiniand Ramesh C. Bansal “Energy Management Systems” Intech Publication

National Institute of Technology, Raipur

Department of Electrical Engineering

M. Tech in Power System & Power Electronics

Semester: II **Code: EL312101EL**

SUBJECT: OPTIMIZATION IN ENGINEERING DESIGN

Module - 1

INTRODUCTION

Convex sets and functions, Least-squares, linear, and quadratic optimization, Formulation of objective function, Incorporating constraints in objective function.

Module -2

DYNAMIC PROGRAMMING

Discrete and Dynamic Programming with case studies

Module - 3

SINGLE-VARIABLE OPTIMIZATION ALGORITHM

Bracketing methods, Region elimination methods; Interval halving method, Fibonacci search method, Point-estimation method; Successive quadratic estimation method. Gradient-based methods : Newton-Raphson method, Bisection method, Secant method, Computer programmes.

Module - 4

MULTIVARIABLE OPTIMIZATION ALGORITHM

Optimality criteria, Unidirectional search, Direct search methods: Evolutionary optimization method, Simplex search method, Hooke-Jeeves pattern search method.

Module -5

CONSTRAINED OPTIMIZATION ALGORITHM

Kuhn Tucker Condition, Rosen's Gradient projection method, Penaltyfunction method.

Module - 6

NONTRADITIONAL AND EVOLUTIONARY OPTIMIZATION ALGORITHMS

Genetic Algorithm, Differential Evolution and Particle Swarm Optimization. Application of evolutionary optimization algorithms in power systems and power electronics.

Module-7

MULTIOBJECTIVE OPTIMIZATION

Formulation of optimization problem with multiple objectives, Pareto Optimality, NSGA (Non-sorted genetic algorithm).

Reference Books

1. S S Rao, Engineering Optimization- Theory and Practice, New Age International, 1996.
2. Kalyanmoy Deb, Optimization for Engineering Design, Algorithms and Examples, Prentice Hall, 1995.
3. KalyanmoyDeb, Multiobjective Optimization Using Evolutionary Algorithms, Wiley.

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Department of Electrical Engineering

M. Tech in Power System & Power Electronics

Semester: II **Code: EL312102EL**

SUBJECT: ADVANCED POWER SYSTEM PROTECTION

Digital Protection: Overcurrent, Fault Detection, Directional Relaying, Fault Classification, Differential and Distance Protection, Fault Location. Sequence networks & short circuit analysis; Relay coordination, Introduction to Current Transformer & Potential transformer; Introduction to computer aided relaying, Aliasing, Anti Aliasing, Phasor Estimation: Discrete Fourier transform (DFT), Half Cycle DFT, Full Cycle DFT, Least Square, Frequency Estimation, Transformer & Bus Bar Protection; Out-of-Step Relaying Introduction to adaptive relaying & wide area measurements. Numerical algorithms, Simulation of Transients, electromagnetic transient program (EMTP).

Reference Books

1. J. L. Blackburn, Protective Relaying: Principles and Applications, Marcel Dekker, New York, 1987.
2. S. H. Horowitz, and A.G. Phadke, Power System Relaying, John Wiley & Sons, New York, 2008.

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Department of Electrical Engineering

M. Tech in Power System & Power Electronics

Semester: II **Code: EL312103EL**

SUBJECT: SOFT COMPUTING TECHNIQUES AND ITS APPLICATIONS

Introduction of soft computing techniques, Artificial Neural Network: Introduction to Biological neural network and Artificial Neural Network: Evolution of ANN, Basic neuron modeling, comparison between ANN and human brain, characteristics, neuron models/ Architectures, activation functions, Learning (Supervised & Unsupervised) strategies, Back propagation network, Kohonen's Self organization map, competitive network, Applications of Neural network. Fuzzy Logic: Introduction to classical sets and operations, Fuzzy set theory and operations, Membership functions, Fuzzy rule base, fuzzification and defuzzification methods, fuzzy inference systems, Applications of fuzzy logic,. Genetic algorithm: Introduction, working principle, Basic operators and Terminologies like individual, gene, encoding, fitness function and reproduction, Genetic modelling: Significance of Genetic operators, cross over, mutation, GA optimization problems.

Reference Books

1. Neural Network Design, Martin T. Hagan, Howard B. Demuth, Mark H. Beale, PWS Publishing, 1999.
2. S.N. Shivnandam, "Principle of soft computing", Wiley India.
3. S.Rajasekaran, G.A.VijayalakshmiPai, "Neural Networks, Fuzzy Logic and Genetic Algorithms :synthesis and applications ", PHI, 2003

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Department of Electrical Engineering

M. Tech in Power System & Power Electronics

Semester: II **Code: EL312201EL**

SUBJECT: DIGITAL TECHNIQUES TO POWER SYSTEM AND ELECTRIC DRIVES

Review of basic microprocessors: Architecture and instruction set of 8085 microprocessor Evolution of advanced microprocessors**:** Introduction to 16, 32 and 64 bit microprocessors. architecture, working and applications of 8086 microprocessor.

Microcontrollers: Evolution of micro-controllers, comparison between micro processor and micro-controllers,Overview of various microcontroller architectures (e.g.8051, 8096 and PIC Serie) and their suitability for diverse applications.

Typical applications in the control of power electronic converters for power supplies and electric motor drive. PWM implementation, Implementation of P, PI and PID controllers. Implementation of digital controllers and filters, Power quality/power factor correction, Solar Power Conditioning (MPPT), microprocessor-based distribution relay applications etc.

References:

1. Ramesh Gaonkar' Microprocessor Architecture Programming and application with 8085',Penram International publishing private limited fifth edition.
2. Badri Ram, "Advanced microprocessors and interfacing", Tata McGrawhill, Twelth edition2006
3. Douglas V. Hall, 'Microprocessors and Interfacing – Programming and Hardware', Tata McGraw-Hill, Eleventh edition, 2003
4. Kenheth J. Hintz and Daniel Tabak, 'Microcontrollers – Architecture, Implementation and programming', McGraw Hill, USA, 1992
5. John B. Peatman, 'Design with microcontrollers', McGraw Hill International Ltd, 1997
6. John B. Peatman, 'Design with PIC microcontrollers', Pearson Education Inc., India,2005

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Department of Electrical Engineering

M. Tech in Power System & Power Electronics

Semester: II **Code: EL312202EL**

SUBJECT: ADVANCE ELECTRIC DRIVES

Generalized theory of synchronous machines : The ideal theory of synchronous machine, synchronous machine inductance, transformation to direct and quadrature axis variables, basic machine relation id *dq0* variables, steady state analysis using *dq0*, transient analysis, three-phase short circuit, transient power angle characteristics. Generalized theory of Inductance machines: The ideal induction machine, transformation to *dq*variables, basic machine relation in *dq*variables, steady state analysis using *dq0*, electrical transients in induction machine, power invariance. Modelling of electrical machines , reference frame theory. Control of Induction Motor Drive: Scalar control of induction motor, Principle of vector control and field orientation

Reference books:

1. R. Krishnan, “Electric Motor Drives: Modeling, Analysis and Control”, Prentice Hall.
2. P. S. Bhimbra, “Generalized Theory of Electric Machines”, Khanna Publication.
3. Advanced Electrical Drives Analysis, Modeling, Control by Rik De Doncker ,Duco, W.J. Pulle, André Veltman, Springer publication

National Institute of Technology, Raipur

Department of Electrical Engineering

M. Tech in Power System & Power Electronics

Semester: II **Code: EL312203EL**

SUBJECT: POWER SYSTEM MODELLING

Synchronous Machines Modelling: Per unit system and normalization , Park's transformation ,Flux –linkage equation , Voltage and current equations , Formulation of state space equations , Equivalent circuit , Sub-transient and transient inductance and time constant, Simplified models of synchronous machines.

Steady state equations and phasor diagram, Determination of machine parameters from manufacturer's data.

Linear model of single machine infinite bus system.

Load modelling of different types of load, transmission line modelling, modelling of Excitation and Prime movers controllers.

Reference Books:

1. Anderson P.M. and A.A. : " Power System control and stability", Galgotia Publication , 1981
2. Padiyar K.R.: " Power System Dynamics , Stability and Control", Interline Publishing Private Ltd. Banglore.
3. ArrilagaJ.and Arnold C.P. : " Computer Modelling of Electrical Power System", John Wiley and Sons.
4. Murthy P.S.R.: " Power System Operation and Control", TATA MCGRAW Hill Publisher, New Delhi.

National Institute of Technology, Raipur

Department of Electrical Engineering

M. Tech in Power System & Power Electronics

Semester: II **Code: EL312204EL**

SUBJECT: POWER QUALITY

Power Quality: What is power quality, power quality, voltage quality, and overview of power quality phenomena, - IEC and IEEE definitions, EMC standards, terms and definitions.

Voltage Sag and Interruptions: Motor –starting sags

Transient Overvoltage: Sources of transient overvoltage, principles of overvoltage protection, utility capacitor-switching transients, utility system lightning protection

Fundamentals of Harmonics: Harmonic distortion, harmonics versus transients, harmonic indices harmonic sources, effects of harmonic distortion, inter-harmonics, Standards of harmonics.

Long-Duration Voltage Variations: Principles of regulating the voltage, devices for voltage regulation. Flicker: sources and mitigation.

Power Quality Monitoring: Power quality monitoring standards

Reference Books:

1. Electrical Power Systems Quality; Dugan Roger.C. Santoso Surya, Mc Granaghan Marks, H. Wayne Beaty, TMH Ed.
2. Understanding Power Quality Problems: Voltage sags and interruptions, Bollen, M.H.J,IEEE Press, New York,
3. Power Systems Quality Assessment J.Arillaga, N.R.Watson, S.Clon, John Wiley
4. Power Quality by C. Sankaran CRC Press

National Institute of Technology, Raipur

Department of Electrical Engineering

M. Tech in Power System & Power Electronics

Semester: II **Code: EL312205EL**

SUBJECT: RENEWABLE AND NON CONVENTIONAL ENERGY SYSTEM

World energy use – Reserves of energy resources – Environmental aspects of energy utilisation – Renewable energy scenario in India – Potentials – Achievements – Applications. Introduction to renewable energy sources, wind, solar, hydrogen etc.

Wind Energy: Basics & Power Analysis, Wind resource assessment, Power Conversion Technologies and applications, Wind Power estimation techniques, Principles of Aerodynamics of wind turbine blade, Various aspects of wind turbine design, Wind Turbine Generators: Induction, Synchronous machine, constant V & F and variable V & F generations, Reactive power compensation Site selection, planning of wind farms - maintenance and operation - environmental assessment

Solar Energy & Environment, Present & Future Scope of Solar energy. Solar radiation - photo voltaic effect - types of PV cells. electrical properties . equivalent circuit - cell characteristics - effects of temperature variation, insolation level and tilt angle . peak power point operation - PV cell model - PV module, Grid connected systems: Technical and non-technical considerations – system size and module choice Stand-alone systems: Modules .Batteries . charge controllers, stand-alone inverters- sizing of PV arrays .

Hydrogen as a renewable energy source, Sources of Hydrogen, Fuel for Vehicles. Hydrogen Production: Direct electrolysis of water, thermal decomposition of water, biological and biochemical methods of hydrogen production. Storage of Hydrogen. Fuel cell – Principle of working, construction and applications.

Hybrid energy system, Hybrid wind energy systems - wind + diesel power, wind + conventional grid, wind + Photovoltaic system + fuel cell etc.

Reference books:

1. Non-Conventional Energy Sources /G.D. Rai, Khanna Publishers
2. Renewable energy sources and emerging technologies by D.P.Kothari,K.C.Singhal, P.H.I.
3. Renewable Sources of Energy and Conversion Systems: N.K.Bansal and M.K.Kleeman.
4. Wind electrical systems, S.N.Bhadra, D.Kastha and S. Banerjee, Oxford University Press, 2005.
5. Wind and Solar Power Systems, Mukund R. Patel, CRC Press, 1999.
6. Wind Energy Systems for Electrical Power Generation, Manfred Stiebler, Springer, 2008.
7. Wind Energy System, Gary L. Johnson, Prentice hall Inc., Englewood Cliffs, New Jersey, 1985.
8. Wind energy conversion system, L. Lfreris, Prentice hall (U.K) Ltd., 1990.
9. Solar Electricity: Engineering of Photovoltaic systems, E. Lorenzo , Earthscan Publications Ltd, 1994.
10. Solar Energy Handbook: Kreith and Kreider (McGrawHill)
11. Photovoltaic systems Engineering, Roger A Messenger and Jerry Ventre, second edition, CRC Press, 1997.
12. Handbook : Batteries and Fuel cell – Linden (Mc.Graw Hill)

National Institute of Technology, Raipur

Department of Electrical Engineering

M. Tech in Power System & Power Electronics

Semester: II **Code: EL312206EL**

SUBJECT: ADVANCED INSTRUMENTATION

Measurement of force torque, velocity

Electric balance – different types of load cells – magnets – elastics load cell-strain gauge load cell-different methods of torque measurement, strain gauge, relative regular twist-speed measurement-revaluation counter- capacitive tacho-drag up type tacho D.C and A.C tacho generators – stroboscope.

Measurement of acceleration, vibration and density

Accelerometers – LVDT, piezo- electric, strain gauge and variable reluctance type accelerometers – mechanical type vibration instruments – seismic instrument as an accelerometer and vibrometer – calibration of vibration pick ups – units of density, specific gravity and viscosity used in industries – Baume scale API scale – pressure head type densitometer – float type densitometer – ultrasonic densitometer Bridge type gas densitometer.

Pressure measurement

Units of pressure – manometers – different types – elastic type pressure gauges – Bourde type bellows – diaphragms – Electrical methods – elastic elements with LVDT and strain gauges – capacitive type pressure gauge – piezo resistive pressure sensor –resonator pressure sensor – measurement of vacuum – McLeod gauge – thermal conductivity gauges – Ionization gauge cold cathode and hot cathode types – testing and calibration of pressure gauges–dead weight tester.

Temperature measurement

Definitions and standards – primary and secondary fixed points – calibration of thermometers different types of filled in system thermometer – sources of errors in filled in systems and their compensation – Bimetallic thermometers – Electrical methods of temperature measurement – signal conditioning of industrial RTDs and their characteristics–3 lead and 4 lead RTDs, Thermocouples and pyrometers.

Measurement of viscosity, humidity and moisture

Viscosity terms – say bolt viscometer – rotameter type viscometer – industrial consistency meters – humidity terms – dry and wet bulb psychrometers – hot wire electrode type hygrometer –dew cell – electrolysis type hygrometer – commercial type dew point meter – moisture terms – different methods of moisture measurement – moisture measurement in granular materials, solid penetrable materials like wood, web type material.

Electrical type flow meter

Principle and constructional details of electromagnetic flow meter – different types of excitation – schemes used – different types of ultrasonic flow meters – laser doppler anemometer systems – rortex shedding flow meter – target flow meter – solid flow rate measurement – guidelines for selection of flow meter.

Level measurement

Gauge glass technique coupled with photo electric readout system – float type level indication – different schemes – level switches level measurement using displacer and torque tube – bubbler system. Boiler drum level measurement – differential pressure method – hydra step systems – electrical types of level gauges using resistance, capacitance, nuclear radiation and ultrasonic sensors

Text books

1. D.Patranabis, Principles of Industrial Instrumentation Tata McGraw Hill Publishing Co., New Delhi, 1999
2 .R.K.Jain, Mechanical and Industrial Measurements, Khanna Publishers, New Delhi 1999.
3. Ernest O.Doebelin, Measurement systems Application and Design, InternationalStudent Edition, IV Edition, McGraw Hill Book Company, 1998.

References

1. Patranabis, Principles of Industrial Instrumentation Tata McGraw Hill Publishing Co., New Delhi, 1999
2. A.K.Sawhney, A course in Electrical and Electronic Measurement and Instrumentation – DhanpatRai and Sons, New Delhi, 1999.
3. EckmanD.P.Industrial Instrumentation – Wiley Eastern Limited, 1990.
4. Liptak B.G. Instrument Engineers Handbook (Measurement), Chilton Book Co., 1994.
5. P.Holman, Experimental Methods for Engineers International Student Edition, McGraw Hill Book Company, 1971.
6. B.C.Nakra and K.K.Chaudary, Instrumentation Measurement and Analysis, Tata McGraw Hill Publishing Company Ltd., New Delhi, 1985.

National Institute of Technology, Raipur

Department of Electrical Engineering

M. Tech in Power System & Power Electronics

Semester: II **Code: EL312207EL**

SUBJECT: NON LINEAR AND DIGITAL CONTROL SYSTEM

Introduction to digital control: Introduction, Discrete time system representation, Mathematical modelling of sampling process, Data reconstruction. Modelling of discrete time systems by pulse transfer function: Revising z-transform, Mapping of s-plane into z-plane, Pulse transfer function, Pulse transfer function of closed loop system, Sampled signal flow graph. Stability analysis of discrete time systems: Jury stability test, Stability analysis using bilinear transformation. Time response of discrete-time systems: Transient and steady state responses, Timeresponse parameters of a prototype second order system. Design of sampled data systems: Root locus method, Controller using root locus, Nyquist stability criterion, Bode plot, and Lead, Lag, and Lag-lead compensator design using Bode plot. Deadbeat response design: Design of digital control systems with deadbeat response, Practical issues with deadbeat response design, Sampled data control systems with deadbeat response. Discrete space state model: Introduction of state variable model, Various canonical forms, Characteristic equation, State transition matrix, Solution of discrete state equation, and controllability, observability and stability of discrete state space models. State feedback design: Pole placement design, Full order tracking controller, Reduced-order observer. Output feedback design: Theory and applications.

Text Books:

1. M. Gopal, Digital Control and State Variable Methods, Tata McGraw Hill, 2003.
2. Franklin, Gene F., J. David Powell, and Michael L. Workman. Digital Control of Dynamic Systems. 3rd ed. Upper Saddle River, NJ: Prentice Hall, 1997.
3. K. J. Astrom and B. Wittenmark, Computer-Controlled Systems: Theory and Design, 1996, ISBN 13: 978-0133148992.
4. N.S. Nise, Control System Engineering, 3rd edition, Wiley & Sons, ISBN 0-471-36601-3, 2000.
5. M. Morari and E. Zafirou: Robust process control, Prentice Hall, 1989, ISBN 0-137-82153-0.
6. S. J. Elliott: Signal Processing for Active Control, Academic Press, 2001, ISBN 0-12-237085-6.

Reference Books:

1. C. L. Phillips and H. T. Nagle, Digital Control System Analysis and Design, 1998, ISBN 0-13-317729-7.
2. K. Ogata, Discrete Time Control systems, Prentice Hall, Second Edition, 2003.

National Institute of Technology, Raipur

Department of Electrical Engineering

M. Tech in Power System & Power Electronics

Semester II **Code EL312208EL**

SUBJECT: OPTIMAL CONTROL SYSTEM

Optimization overview, flow chart of linear optimal control technique, Parameter optimization. Minimization problem. Tracking problem, Regulator problem. Calculus of variation. Derivation of Eular-Lagrange equation. Lagrange, Mayer and Bolza Optimal problems. Optimal Control Systems and Performance Indices.

Pontryagins maximum principle, Hamilton – Jacobi Equation, Application of variation approach to control problem.

Optimal Control of Linear systems with Quadratic Performance Index, statement of LQR problem, solution of finite time and infinite time regulator problem, solution of Riccati equation. Frequency domain interpretation of LQR design, Stability & robustness properties of LQR design., Linear Quadratic Gaussian (LQG) Control.

Linear Programming, Dynamic Programming, Multistage decision process, Concept of sub-optimization and principle of optimality, Recurrence relationship, computational procedure in dynamic programming.

Adaptive Control System: Adaptive Controllers, Identifications, Decision making, Modification, Application, Classification: Passive, Active, Dynamic Adaptive Control Systems, Adaptive PI controller for D.C. drive, learning machine.

Reference Books:

1. Optional control system- D.S. Naidu, CRS Press, 2003
2. Introduction to optimum design – Jasbir S. Vora- Elsevier 2006
3. Optimal Control, Linear Quadratic Methods, Prentice- Hall International Inc.,