NATIONAL INSTITUTE OF TECHNOLOGY, MIZORAM
M. Tech. Syllabus
Specialization: Power Electronics and Drives
Department of Electrical and Electronics Engineering

SEMESTER-I

EEL2101 ADVANCED POWER ELECTRONICS-I 3-0-0-6

Review of Power Electronics:
Concept of power electronics, application of power electronics, advantages and disadvantages of power electronics converters, Classification of power electronics converters, Power diode-Types, forward and reverse characteristics, switching characteristics-rating, uncontrolled converter. LECTURES-6

Semiconductor Power Devices:
Power BJT, power MOSFETs and IGBTs –construction, types, static and switching characteristics, steady state and dynamic models and switching loss computation and other advanced semiconductor devices. LECTURES-10

Gate Driver and Protecting Circuits:
Necessity of isolation, pulse transformer, Optocoupler, Gate drives circuit: SCR, MOSFET, IGBTs and base driving for power BJT, Over voltage, over current and gate protections; Design of snubbers, Heat sink types and design. LECTURES-8

Phase Controlled Converters:
Principle of operation of single phase and three phase half wave, half controlled, full controlled converters with R, R-L and RLE loads, effects of freewheeling diodes and source inductance on the performance of converters. External performance parameters of converters, techniques of power factor improvement, single phase and three phase dual converters. LECTURES-8

Analysis and Design of Basic DC-DC Converters:
Buck, Boost, Buck-boost and Cuk converters – topology, voltage transfer ratio, current and voltage waveforms, voltage and current ripple, modeling in the State Space Method.
LECTURES-8

Readings:

Prescribed Text Books

1. Ned Mohan, T.M. Undeland and William P.Robbins, Power Electronics: Converters,

Applications, 3rd Edition, John Wiley & Sons, 2009.
2. M. H. Rashid, Power Electronics-Circuits, Devices and Applications, 3rd Edition, PHI, 2005
3. C.W Lander, Power Electronics, McGraw-Hill book company, 1981

Additional Readings

1. M. D. Singh & K. B. Khanchandani, Power Electronics, McGraw Hill.
2. Undeland and Robins, Power Electronics – Concepts, applications and Design Mohan,
3. L. Umanand, Power Electronics, Essentials and Applications
4. Fundamental of Power Electronics,Robert W.erickson,Academic publisser

EEP2101 ADVANCED POWER ELECTRONICS LAB 0-0-3-3

1. Study of Single-phase half and full-wave uncontrolled rectifier with R and R-L load for continuous conduction modes.
2. Study of MOSFET, IGBT Characteristics
3. Study of Gate Driver circuit.
4. Study of Single phase half wave controlled rectifier with R and R-L load
5. Simulation of Single phase half wave controlled rectifier with R, R-L load and R-L-E load using MATLAB SIMULINK/PSPICE software
6. Study of Single phase semi converter with R and R-L load
7. Study of DC to DC converter with R and R-L load.
8. Simulation of Single Phase Semi-converter with R, R-L and R-L-E load using MATLAB SIMULINK/PSPICE software
9. Simulation of Single-phase full-converter with R, R-L and R-L-E loads for continuous and discontinuous conduction modes using MATLAB SIMULINK/PSPICE software.
10. Study of Single-phase full-converter with R and R-L load for continuous conduction modes.
11. Simulation of Three phase full-converter with R, R-L and R-L-E load using MATLAB SIMULINK/PSPICE software.
12. Simulation of Three phase semi converter with R, R-L and R-L-E Load using MATLAB SIMULINK/PSPICE software

Prescribed Text Books

1. Ned Mohan, T.M. Undeland and William P.Robbins, Power Electronics: Converters, Applications, 3rd Edition, John Wiley & Sons, 2009.
2. M. H. Rashid, Power Electronics-Circuits, Devices and Applications, 3rd Edition, PHI, 2005

EEL2102 MODELLING AND ANALYSIS OF ELECTRICAL MACHINES 3-0-0-6

Introduction:
Introduction to the theory of basic two pole machine applicable to DC machines, 3-ph induction machines and synchronous machine. Kron's primitive Machine. Need of modeling**,** Introduction to modeling of electrical machines, voltage and torque equations.
LECTURES-7

Concept of Transformation:
Change of variables & m/c variables and transform variables for arbitrary reference frames. Application to D.C. machine for steady state and transient analysis, and equation of cross field commutator machine, - linear transformation from 3-phase to 2-phase - transformation from rotating axes to stationary axes - power invariance - park's transformation for 3-phase synchronous and induction machines**.** LECTURES-7

Poly phase Induction Machines:
Voltage, torque equations, Equivalent circuit , Steady state analysis, Dynamic performance during sudden changes in load torque and three phase fault at the machine terminals.
LECTURES-7

Poly phase Synchronous Machine:
Voltage and Torque Equations in stator, rotor and air-gap field reference frames. Transformation and Transformed Equations. Parks Transformation Voltage and power equation for salient and non salient machines, their phasor diagrams, simplified equations of a synchronous machine with two damper coils. LECTURES-7

Dynamic Analysis of Interconnected Machines:
Machine Interconnection Matrices . Transformation of Voltage and Torque Equations using Interconnection Matrix . Large Signal Transient Analysis using Transformed Equations'.
LECTURES-7

Linearized Machine Equations:
Linearization of machine equations. Small displacement stability: Eigen values, Eigen values of typical induction machine and synchronous machine, Transfer Function Formulation. LECTURES-5

Readings:

Prescribed Text Books
1. P.C. Krause, Analysis of Electric Machinery, Wiley publication.
2. B. Adkins, The General theory of Electrical Machines, Chapman & Hall publication.
3. P.S. Bhimbra, Generalized theory of Electrical machines, Khanna publisher.

Additional Readings

1. B. Adkins & R.G. Harley, The General theory of AC Machines, Springer Natherland
2. Boldia & S.A. Nasar, Electrical Machine Dynamics, The Macmillan Press Ltd.

EEL2103 POWER SYSTEM ANALYSIS AND DYNAMICS 3-0-0-6

Load Flow Analysis:
Newton Raphson & Fast decoupled method(FDM) LECTURE-4

Optimum Power Flow (OPF):
Formulation of OPF, LP based gradient and Newton's method. Bus Incremental Cost (BIC). LECTURE-5

Introduction to Power System Stability:
Basic concept and definitions; rotor angle stability, voltage stability and voltage collapse, Mid term and long term stability; classification of stability. LECTURES-3

Analysis of Stability: Voltage Stability:
Basic concept, voltage collapse, prevention of voltage collapse mechanism, voltage stability analysis, effects of excitation system, power system stabilizer. LECTURE-6

Small Signal Stability:
Fundamental concept of stability of dynamic system, small signal stability of single machine infinite bus system, , small signal stability of multi machine systems, characteristics of small signal stability problems. LECTURES-6

Transient Stability:
Analysis using Numerical Integration Techniques, simulation of power system dynamics response, case study of a transient stability of a large system. LECTURES-5

Synchronous Machine Representation in Stability Studies:
Simplifications for large-scale studies; Simplified model with amortisseurs neglected; constant flux linkage models.

LECTURES-5

Modeling of Excitation and Prime Mover Systems:
Elements of Excitation System; Types of Excitation System; modeling of excitation system; Hydraulic turbine and Governing System Modeling; Steam turbine and governing systems.
LECTURES-6

Readings:

Prescribed Text Books

1. P.Kundur, Power System Stability and Control, McGraw Hill Inc, New York,1995.
2. K.R.Padiyar, Power System Dynamics, Stability & Control, 2nd Edition, B.S. Publications, Hyderabad, 2002.
3. Allen J Wood & Bruce Wollenberg, POWER GENERATION OPERATION & CONTROL, 2ND ED, wiley publisher

Additional Readings

1. P.Sauer & M.A.Pai, Power System Dynamics & Stability, Prentice Hall, 1997.

EEL2104 MODERN CONTROL SYSTEMS 3-0-0-6

State Variable Analysis and Design:
State space models, state space representation of simple electrical and mechanical systems, canonical forms, solution of state equation, state transition matrix, relation between transfer function and state variable representations; controllability and observability, pole-placement using state variable feedback; design of full order and reduced order observer, observer based and state feedback controller, optimal control concept, solution of linear quadratic regulator. LECTURES-12

Sample Data Control System:
Mathematical preliminaries- difference equations, Z Transform and properties; sampling quantization and reconstruction process, discrete time systems, system response, transfer function stability, bilinear transformation and the jury stability criterion, implementation of digital controllers and digital controllers for deadbeat performance. Root loci - Frequency domain analysis - Bode plots - Gain margin and phase margin - Design of Digital Control Systems based on Root Locus Technique, state space analysis of discrete system.
LECTURES-15

Nonlinear Control Systems:
Characteristics of nonlinear systems; linearization techniques; phase plane analysis, singular points, limit cycle vs closed trajectory; stability analysis using phase plane analysis- describing function (DF) of common nonlinearities, stability analysis using DF; stability in the sense of Lyapunov, Lyapunov's stability theorems for linear and nonlinear systems; effect of non-linearity in root locus and Nyquistplot. Introduction to Modern Nonlinear control system. Introduction to modern nonlinear control system.
LECTURES-13

Readings:

Prescribed Text Books

1. K. Ogata, Modern Control Engineering, Pearson Education, 2009
2. M. Gopal, Digital Control and State Variable Methods, Tata McGraw Hill, 2003
3. H.K.khalil, Non linear Systems, prentice, 3rd Edition.

Additional Readings

1. R. C. Dorf and R. H. Bishop, Modern Control Systems, Prentice Hall, 2010
2. B C. Kuo, Digital Control Systems, Oxford University Press, 1995
3. M. Gopal, Modern Control System Theory, New Age International, 1993

EEP2106 MODELLING AND SIMULATION LAB: 0-0-3-3

1.To design the gain parameters for a PI and PID controller for a SISO system in MATLAB-SIMULINK.

2. To design a Buck- Boost converter in continuous, discontinuous and critical conduction mode in PSPICE/PSIM.

3. To find the load flow parameters using Newton-Raphson Method in MATLAB.

4. To fast decoupled load flow in MATLAB.

5. To find DC load flow using ETAP.

6. To find economic dispatch problem considering transmission loss in MATLAB.

7. Study of limit cycle analysis of Non linear system.

8. To model an alternator in SIMULINK.

9. To design an overall system comprising generation transmission and distribution in SIMULINK.

10. Design of State feed back control of DC motor.

11. Design of State feedback control inverted pendulum and EMLS.

12. Transient Study of Induction Motor.

Prescribed Text Books

1. K. Ogata, Modern Control Engineering, Pearson Education, 2009
2. M. Gopal, Digital Control and State Variable Methods, Tata McGraw Hill, 2003
3. D.P. Kothari & J.S Dhillon, Power System Optimization, 2nd Edition, PHI, 2005.
4. M. H. Rashid, Power Electronics-Circuits, Devices and Applications, 3rd Edition, PHI, 2005
5. Mathwork, ETAP, ORCAD-PSPICE manual.

SEMESTER-II

EEL2201 ADVANCED POWER ELECTRONICS-II 3-0-0-6

Switching DC Power supplies:
Linear power supplies, overview of switching power supplies, DC-DC converters with Electrical isolation (Flyback, Forward, Push-pull, Half and Full bridge converter), Control of Switch Mode DC Power Supplies. LECTURES-8

DC-AC converters:
Single phase and three phase bridge inverters, PWM switching scheme, unipolar and bipolar switching scheme, space vector modulation (SVPWM), Reduction of harmonics, Output Voltage Control. LECTURES-6

AC-AC Direct Converter:
AC Voltage Controller with PWM Control, Single phase and three phase Cyclo-converters, Matrix Converter.

LECTURES-8

Resonant Converters:
Principle of soft switching – concept of zero current switching (ZCS) and zero voltage switching (ZVS). Series and parallel loaded resonant converter. LECTURES-6

Multilevel Converter:

Fundamental topologies ,neutral point clamped (NPC) ,flying capacitor converter, case cade multilevel converter,applications. LECTURES-6

Application of power electronic converters:
HVDC transmission, induction heating, electric welding, electronic ballast, UPS, static VAR compensators ,active filters. LECTURES-6

Readings:

Prescribed Text Books

1. Ned Mohan, T.M. Undeland and William P.Robbins, Power Electronics: Converters, Applications, 3rd Edition, John Wiley & Sons, 2009.
2. M. H. Rashid, Power Electronics-Circuits, Devices and Applications, 3rd Edition, PHI, 2005
3. C.WLander, Power Electronics, McGraw-Hill book company, 1981
4. Eacha, TJE miller, power electronics control of electrical system, newness
5. HW Whittington, switch mode power sypple, design and construction, research studies press.

Additional Readings

1. S. B. Dewan &A. Straughen, Power Semiconductor Circuits, John Wiley & Sons, 1975
2. B.K Bose, Modern Power Electronics and AC Drives, Pearson Education, 2003

EEL2202 ADVANCED ELECTRIC DRIVES 3-0-0-6

Characteristics of Electric Motors:
Characteristics of DC motors, 3-Phase induction motors and synchronous motors, Starting and braking of electric motors. Dynamics of Electric Drives, Mechanical system, Fundamental torque equations, components of load torques, Dynamic conditions of a drive system, Multi quadrant operation, Criteria for selection of motor for drives Energy loss in transient operations, Steady State Stability, Load equalization. LECTURES-8

Converter Control of DC Drives
Analysis of series and separately excited DC motor with single phase and three phase controlled rectifiers operating in different modes and configurations. Analysis of series and separately excited DC motors fed from different choppers for both time ratio control and current limit control, four quadrant control. Single quadrant variable speed chopper fed DC drives. Four quadrant variable speed chopper fed DC Drives. Single phase/ three phases - dual converter fed DC Drive, design of speed and current loop control. Different application. LECTURES-10

AC Motor Drives:
Induction Motor Drive**:** Variable voltage variable frequency drive, Slip power recovery, Static Scherbius and Cramer drives. CSI fed Induction motor drives. Synchronous Motor Drive: variable frequency drives, self control synchronous motor drives, LECTURES-12

Special Motor Drives: Brushless DC motor, Permanent magnet Synchronous motor, switched reluctance motor, stepper motor, linear induction and synchronous motor and other advanced drives. LECTURES-6

Advanced Control and Estimation of AC drives:
Small signal models, FOC control, sensor less control, DTC, model reference adaptive control, DSP, FPGA based implementation control and estimation technique. LECTURES-6

Readings:

Prescribed Text Books

1. M. H. Rashid, Power Electronics - Circuits, Devices and Applications, P.H.I Private Ltd. New Delhi.
2. B. K Bose, Modern Power Electronics and AC Drives, PHI
3. G.K. Dubey, Power Semiconductor controlled drives, Prentice Hall inc, A division of Simon and Schester England cliffs, New Jersey.
4. Sheperal, L.N. Wand Hully, Power Electronic and Motor control, Cambridge University Press Cambridge
5. R Krishnan, Electric Drives-Modelling Analysis and control,PHI publication.

Additional Readings

1. S. Dewan, B. Slemon, A.G.R Straughen, Power Semiconductor drives, John Wiley and Sons, New York.
2. P.C. Sen, Thyristor DC Drives, John Wiley and sons, NewYork.
3. V. Subramanyam, Electric Drives–Concepts and applications, TataMcGraw Hill Publishing Co., Ltd., New Delhi.
4. B.K. Bose, Power Electronics and Variable frequency drives, Standard Publishers Distributors

EEP2201 ADVANCED ELECTRIC DRIVES LABORATORY 0-0-3-3

1. Study of 1-phase fully controlled Converter fed DC motor drives
2. Simulation of 1-phase fully controlled Converter fed DC motor drives using MATLAB-SIMULINK/PSIM software
3. Simulation of Different Braking methods of Dc motor drives using MATLAB-SIMULINK/ PSIM software
4. Simulation of Different Braking methods of ac motor drives using MATLAB-SIMULINK/ PSIM software
5. Performance & Operation of a four quadrant Chopper fed D.C. Drive

6. Simulation of DC to DC Converter fed DC motor drives using MATLAB-SIMULINK/PSIM software
7. Performance & Operation of a four quadrant VSI fed D.C. Drive
8. Simulation of 3-phase VSI fed AC motor drives using MATLAB-SIMULINK/PSIM software
9. Simulation of 3-phase PWM VSI fed AC motor drives using MATLAB-SIMULINK/PSIM software
10. Simulation of 3-phase CSI fed AC motor drives using MATLAB-SIMULINK/PSIM software study of V/f control of Induction motor drives.
11. DSP & FPGA based AC and DC motor drives.

Prescribed Text Books

1. B. K Bose, Modern Power Electronics and AC Drives, PHI
2. G.K. Dubey, Power Semiconductor controlled drives, Prentice Hall inc, A division of Simon and Schester England cliffs, New Jersey.

EEL2103 FLEXIBLE AC TRANSMISSION SYSTEM (FACTS) 3-0-0-6

Introduction to Flexible Alternating Current Transmission System (FACTS):
Fundamentals of ac power transmission, transmission problems and needs, Emergence and advantages of FACTS technology in transmission system, Types of FACTS controller, Application of FACTS controllers in Distribution System. LECTURES-3

Power Flow Control:
Theory and implementation of Power Flow Control Concepts, Analysis of uncompensated AC Transmission line, Passive reactive power compensation: Effect of series and shunt compensation at the mid-point of the line on power transfer. LECTURES-6

Static VAR Compensation:
Analysis of SVC, Configuration of SVC, SVC Controller, Voltage Regulator Design, Harmonics and Filtering, Protection Aspects, Application of SVC LECTURES-6

Series and Shunt Compensation:
Principles of shunt compensation, Variable Impedance type & switching converter type-Static Synchronous Compensator (STATCOM) configuration, characteristics and control, Basic concepts of controlled series compensation, Principles and operation of static series compensation using GCSC, TCSC and TSSC, applications, Static Synchronous Series Compensator (SSSC) LECTURES-8

Static Voltage and Phase Angle Regulators:
Principles of operation-Steady state model and characteristics of a static voltage regulators and phase shifters power circuit configurations, Power-flow control and improvement of stability by phase angle regulator, Introduction to Thyristor Controlled Voltage and Phase Angle Regulators (TCVR and TCPAR) LECTURES-7

UPFC & IPFC
Principles of operation and characteristics, independent active and reactive power flow control, comparison of UPFC with the controlled series compensators and phase shifters, Applications of UPFC. Interline Power Flow Controller (IPFC), basic operating principles and characteristics, Applications of IPFC. LECTURES-5

Modeling of FACTS devices LECTURES-5

Readings:

Prescribed Text Books

1. Narain G. Hingorani, Laszlo Gyugyi, Concepts and Technology of Flexible AC Transmission Systems, Wiley, 2000.
2. K.R.Padiyar, FACTS controllers for transmission and Distribution systems, New Age international Publishers.
3. Y.H. Song and A. T. Johns, Flexible ac transmission systems (FACTS), Institution of Electrical Engineers Press, London.

Additional Readings

1. R. M. Mathur and R. K.Varma, Thyristor - based FACTS controllers for Electrical transmission systems, IEEE press, Wiley Inter science.

ELECTIVES

SUBJECT: RENEWABLE ENERGY SYSTEMS 3-0-0-6

Energy Resources:
World energy resources, Indian energy scenario, environmental aspects of energy utilization, renewable energy resources and their importance. LECTURES-4

Solar Energy:
Availability of solar energy, nature of solar energy, solar cell energy conversion, efficiency, characteristics, effect of variation of solar insolation and temperature, losses, components of PV systems , solar PV power plants, photo thermal systems, F chart method, φ–F chart method, utilizability modeling & simulation of solar energy systems, life cycle analysis of solar energy system. LECTURES-8

Wind Energy:
Wind resource assessment, power conversion technologies, wind power estimation techniques, principles of aerodynamics of wind turbine blade, wind mechanics, power content, class of wind turbines, various aspects of wind turbine design, wind turbine generators: induction, synchronous machine, constant V & f and variable V & f generations. LECTURES-8

Alternate Energy Sources:

Hydrogen as a renewable energy source, sources of hydrogen, fuel for vehicles. Classification of hydel plants, concept of micro hydel, MHP plants: components, design and layout, turbines, efficiency, status in India. Bio-Mass, Bio-Gas, Tide and Wave Energies Basic concepts and principles of operation. LECTURES-6

Distributed Generation Systems:
Benefits and limitations; classification of small generating systems, electric equivalent circuits of fuel cells, solar cells, micro-turbines, reciprocating engines, wind turbines and gas turbines, effects of renewable energy into the grid, supply guarantee, power quality, stability, intentional and unintentional islanding, power converter topologies for grid interconnection, inverter modelling, control of grid interactive power converters, synchronization and phase locking techniques, current control, and recent trends in DG interconnection. LECTURES-8

Readings:

Prescribed Text Books

1. Andrews J, Jelley N, Energy Science, Oxford University Press, 2010
2. Fang Lin Luo, Hong Ye, Renewable Energy Systems: Advanced Conversion Technologies and Applications, CRC Press, Taylor & Francis Group.
3. H Lee Willis, Walter G Scott, Distributed Power Generation, Planning & Evaluation, CRC Press Taylor & Francis Group.

Additional Readings

1. Remus Teodorescu, Marco Liserre, Pedro Rodr´ıguez, Grid Converters for Photovoltaic and Wind Power Systems, John Wiley & Sons.
2. B H Khan, Non-Conventional Energy Resources, Tata McGraw-Hill Education.

SUBJECT: SOFT COMPUTING TECHNIQUES AND APPLICATIONS 3-0-0-6

Introduction to Soft Computing:
Introduction, importance, main components, Fuzzy Logic, ANN, Evolutionary Algorithms, Hybrid Intelligent Systems. LECTURES-4

Artificial Neural Network and Supervised Learning:
Introduction, Comparison of Neural Techniques and AI, Artificial Neuron Structure, Adaline, ANN Learning, Back Propagation Learning, Properties & Limitations. LECTURES-5

Development of Generalized Neuron and Its Validation:
Existing Neuron Model, Development, Advantages, Learning Algorithm of a Summation Type Generalized Neuron, Benchmark Testing of Generalized Neuron Model, Generalization of GN model, Discussion. LECTURES-5

Introduction to Fuzzy Set Theoretic Approach:
Introduction, Uncertainty and Information., Types of Uncertainty, Fuzzy Logic-Introduction, development, Precisionand Significance, set, Operations, Union Intersection, Complement, Combination, Concentration, Dilation,Intensification, α-Cuts. Quantifier/Modifier/Hedges, Characteristics, Normality, Convexity, Cross Over Point, Singletone, Height, Cardinality, Properties of Fuzzy Sets, Fuzzy Cartesian Product, shape & defining Membership Functions, Defuzzification, Rule Based System. LECTURES-8

Applications of Fuzzy Rule Based System:

Introduction, Modeling and Simulation, approach, selection, Steady State D.C. Machine Model, Control ApplicationsAdaptiveControl, PID Control System, Transient Model of D.C. Machine, Fuzzy Control System, Power System Stabilizer Using Fuzzy Logic. LECTURES-4

Evolutionary & Metaheuristic search and optimization Algorithms:

GA-Selection, cross over & mutation, simple GA algorithm, elitism.
PSO- Particle swarm, velocity, mutation, selection, algorithm.
DE- Selection, cross over & mutation, algorithm, elitism.

LECTURES-6

Integration of Neural Networks, Evolution Algorithms and Fuzzy Systems:

Adaptive Neuro-Fuzzy Inference Systems,Neuro-Fuzzy Approachof Modeling.ANN – GA-Fuzzy Synergism and Its Applications Training of ANN, ANN Learning Using GA, Validation and Verification of ANN-GA Model.

LECTURES-4

Readings:

Prescribed Text Books

1. S N Sivanandam, S.N. Deepa, Principles of Soft Computing, Wiley.
2. Goldenberg, soft computing, Allied publisher.

Additional Readings

1. D K Chaturvedi, Soft Computing - Techniques and its Applications in Electrical Engineering, Springer

SUBJECT: OPTIMIZATION TECHNIQUES 3-0-0-6

Introduction:

Historical Development; Engineering applications of Optimization; Art of Modeling; Objective function; Constraintsand Constraint surface; Formulation of design problems as mathematical programming problems; Classification of optimization problems based on nature of constraints, structure of the problem, deterministic nature of variables, separability of functions and number of objective functions; Optimization techniques – classical and advanced techniques. LECTURES-8

Linear Programming:
Standard form of linear programming (LP) problem; Canonical form of LP problem; Assumptions in LP Models; Graphical method for two variable optimization problem; Examples; Simplex algorithm with equality and unequility constraints, integer programming. LECTURES-8

Optimization using Calculus:
Stationary points - maxima, minima and saddle points; Functions of single and two variables; Global Optimum; Convexity and concavity of functions of one and two variables; Optimization of function of single and multiple variables; Gradient vectors; Optimization of function of multiple variables subject to equality; Lagrangian function; Hessian matrix formulation; Kuhn-Tucker Conditions. LECTURES-7

Non Linear Programming Algorithms:
Unconstrained optimization techniques, Direct search methods, Descent methods, 2nd order methods, constrained optimization, Direct and indirect methods. LECTURES-10

Dynamic Programming:
Sequential optimization; Representation of multistage decision process;Concept of sub optimization and the principle of optimality; Computational procedure in dynamic programming (DP); curse of dimensionality in DP. LECTURES-8

Robust Optimization Techniques:

Limitation of conventional optimization techniques, robust techniques: Simulated annealing (SA), Genetic Algorithm (GA)

Readings:

Prescribed Text Books

1. S S Rao, Engineering Optimization: Theory and Practice, New Age International (P) Ltd.
2. Suresh Chandera, Jaydeva, Numerical Optimization with Applications, Narosa publisher.
3. David Edward Goldberg, Genetic Algorithms in Search, Optimization, and Machine Learning, Addison-Wesley Publishing Company.

Additional Readings

1. Edvin K P Chong, Stanislaw H Zak, An Introduction to Optimization, John Wiley.

2. Mohan C Joshi, Kannan M Moudgalya, Optimization Theory and Practice, Narosa publisher.

SUBJEC: SPECIAL ELECTRICAL MACHINES 3-0-0-6

Stepper Motors:
Constructional features, Principle of operation, Modes of excitation torque production in Variable Reluctance (VR) stepping motor, Dynamic characteristics, Drive systems and circuit for open loop control, closed loop control of stepping motor. LECTURES-7

Switched Reluctance Motors
Constructional features, Principle of operation. Torque equation, Characteristics, Control Techniques, Drive Concept. LECTURES-6

Permanent Magnet Synchronous Motors and Brushless DC Motors
Principle of operation, EMF, power input and torque expressions, Phasor diagram, Power Controllers, Torque speed characteristics, Self control, Vector control, Current control Schemes. 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, Controllers-Microprocessors based controller. LECTURES-12

Servomotors:
Servomotor – Types – Constructional features – Principle of Operation – Characteristics - Control –Microprocessor based applications. LECTURES-6

Linear Motors:
Linear Induction Motor (LIM) Classification – Construction – Principle of operation – Concept of Current sheet –Goodness factor – DC Linear Motor (DCLM) types – Circuit equation –DCLM control-applications
LECTURES-6

Some Other Electrical Motor:
Reluctance and hysteresis motor, Universal Motor. LECTURES-3

Readings:

Prescribed Text Books

1. Miller, T.J.E., Brushless Permanent Magnet and Reluctance Motor Drives, Clarendon Press, Oxford, 1989.
2. Kenjo, T, Stepping Motors and their Microprocessor control, Clarendon Press, Oxford,

1989.
3. K Venkataratam, Special Electrical Machines, University press.

Additional Readings

1. Naser A and Boldea I, Linear Electric Motors: Theory, Design and Practical Application, Prentice Hall Inc., New Jersey,1987
2. Floyd E Saner, Servo Motor Applications, Pittman USA, 1993.
3. Kenjo, T and Naganori, S, Permanent Magnet and brushless DC motors, Clarendon Press, Oxford, 1989.
4. P.S.Bimbra, Generalized Theory of Electrical Machines, Khanna publications-5th edition-1995

SUBJECT: HVDC TRANSMISSION 3-0-0-6

Introduction:
Introduction of DC power transmission technology, comparison of AC and DC transmission, description of DC transmission system, modern trends in DC transmission.

LECTURES-4

Analysis of HDVC converters:
Choice of converter configuration, simplified analysis of Graetz circuit, converter bridge characteristics, Characteristics of a twelve pulse converter, detailed analysis of converters.

LECTURES-8

Control of HVDC converter and systems:
Rectifier control, compounding of rectifiers, power reversal of DC link, voltage dependent current order limit(VDCOL) characteristics of the converter, inverter extinction angle control, pulse phase control, starting and stopping of DC link, constant power control, control scheme of HVDC converters. LECTURES-8

Harmonics and filters:
Generation of harmonics by converters, characteristics of harmonics on DC side, characteristics of current harmonics, characteristic variation of harmonic currents with variation of firing angle and overlap angle, effect of control mode on harmonics, non characteristic harmonic. Harmonic model and equivalent circuit, use of filter, filter configuration, design of band-pass and high pass filter, protection of filters, DC filters, filters with voltage source converter HDVC schemes.

LECTURES-10

Fault and protection schemes in HVDC systems:
Nature and types of faults, faults on AC side of the converter stations, converter faults, fault on DC side of the systems, protection against over currents and over voltages, protection of filter units. LECTURES-4

Multi-terminal HVDC systems:
Types of multi terminal (MTDC) systems, parallel operation aspect of MTDC. Control of power in MTDC. Multilevel DC systems. Power upgrading and conversion of AC lines into DC lines, Parallel AC/DC systems, FACTS and FACTS converters. LECTURES-6

Readings:

Prescribed Text Books

1. S. Kamakshaiah& V. Kamaraju, HVDC Transmission, Tata McGraw hill education.
2. K.R.Padiyar, HVDC Power transmission system, Wiley Eastern Limited.
3. J. Arrillaga, Peter Pregrinu, High Voltage Direct Current Transmission

Additional Readings

1. A. Chakraborty, D.P. Kothary, A.K. Mukhopadhyay,The Performance, Operation and Control of EHV Power Transmission Systems, Wheeler Pub.
2. Rakosh Das Begamudre, Extra High Voltage AC Transmission Engineering, New Age International (P) Ltd.
3. Colin Adamson and N.G.Hingorani, High Voltage Direct Current Power Transmission, Garraway Limited, London

SUBJECT: POWER QUALITY 3-0-0-6

Introduction to Power Quality:
Terms and definitions: Overloading - under voltage - over voltage. Concepts of transients – short duration variations such as interruption - long duration variation such as sustained interruption. Sags and swells - voltage sag - voltage swell - voltage imbalance - voltage fluctuation - power frequency variations, different standers of power quality. LECTURES-8

Voltage Sags and Interruptions:
Sources of sags and interruptions - estimating voltage sag performance. Thevenin's equivalent source - analysis and calculation of various faulted condition. Voltage sag due to induction motor starting. Estimation of the sag severity - mitigation of voltage sags, active series compensators. Static transfer switches and fast transfer switches. LECTURES-8

Overvoltages:
Sources of over voltages - Capacitor switching – lightning - ferro resonance. Mitigation of voltage swells - surge arresters - low pass filters - power conditioners. Lightning protection – shielding – line arresters - protection of transformers and cables. An introduction to computer analysis tools for transients, PSCAD and EMTP. LECTURES-8

Harmonics:
Harmonic sources from commercial and industrial loads, locating harmonic sources. Power system response characteristics - Harmonics Vs transients. Effect of harmonics - harmonic distortion - voltage and current distortion - harmonic indices - inter harmonics – resonance. Harmonic distortion evaluation - devices for controlling harmonic distortion - passive and active filters design. IEEE and IEC standards. LECTURES-8

Power Quality Improvement Scheme:
STATCOM, UPQC LECTURES-2

Power Quality EMI & EMC issues LECTURES-2

Power Quality Monitoring
Monitoring considerations - monitoring and diagnostic techniques for various power quality problems- modeling of power quality (harmonics and voltage sag) problems by mathematical simulation tools. Different power quality monitoring tools. LECTURES-8

Readings:

Prescribed Text Books

1. Roger. C. Dugan, Mark. F. McGranagham, Surya Santoso, H.WayneBeaty, 'Electrical Power Systems Quality' McGraw Hill, 2003.
2. C sankaran, Power Quality, CRC press

Additional Readings

1. G.T. Heydt, Electric Power Quality, 2nd Edition. (West Lafayette, IN, Stars in a Circle Publications, 1994).
2. M.H.J Bollen, Understanding Power Quality Problems: Voltage Sags and Interruptions, (New York: IEEE Press, 1999).
3. J. Arrillaga, N.R. Watson, S. Chen, Power System Quality Assessment', (New York: Wiley, 1999.

SUBJECT: SCADA SYSTEMS & APPLICATIONS 3-0-0-6

SCADA:
Data acquisition system, evaluation of SCADA, communication technologies, monitoring and supervisoryfunctions.PLC: Block diagram, programming languages, Ladder diagram, Functional block diagram, Applications, Interfacing of PLC with SCADA. LECTURES-12

SCADA System Components:
Schemes, Remote Terminal Unit, Intelligent Electronic Devices, Communication Network, SCADA server. LECTURES-6

SCADA Architecture:
Various SCADA Architectures, advantages and disadvantages of each system, single unified standard architectureIEC 61850 SCADA / HMI Systems. LECTURES-4

SCADA Communication:
Various industrial communication technologies- wired and wireless methods and fiber optics, open standard communication protocols. LECTURES-6

SCADA Applications
Utility applications, transmission and distribution sector operation, monitoring analysis and improvement. Industries, oil, gas and water, Automatic substation control, SCADA requirement and configuration in energy control systems, Energy management system, system operating states, system security.
LECTURES-6

Readings:

Prescribed Text Books

1. Stuart A Boyer, SCADA: Supervisory Control and Data Acquisition, ISA.
2. Gordan Clark, Deon Reynders, Practical Modem SCADA Protocols, Elsevier.

Subject: MODELING AND CONTROL OF POWER ELECTRONICS CONVERTERS 3-0-0-6

Overview of Power electronics converters:

Overview of basic and advanced Power electronics converters, various applications, basics of utility power conversion, isolated and non-isolated converter circuit, types of power converter models. LECTURES-4

Steady state analysis and Modeling of converters

Steady state converter analysis, Steady state modeling of power converters, DC transformer model, loss modeling. Dynamic modeling of power converters, AC modeling of converters, state space averaging, Transfer function and frequency domain analysis, Concept of controller design, stability analysis, non linear phenomenon. LECTURES-16

Modeling of PWM Converters

Pulse Width Modulation (PWM) control of power converters, voltage source and current source inverter. Feedback control design, voltage mode and current mode control, control of inverters and rectifiers. LECTURES-12

Application of DSP, FPGA for power electronics converter**,** practical converter design consideration. LECTURES-8

Readings:

Prescribed Text Books

1. Ned Mohan, T.M. Undeland and William P.Robbins, Power Electronics: Converters, Applications, 3rd Edition, John Wiley & Sons, 2009.
2. M. H. Rashid, Power Electronics-Circuits, Devices and Applications, 3rd Edition, PHI, 2005
3. C.WLander, Power Electronics, McGraw-Hill book company,1981

Additional Readings

1. S. B. Dewan &A. Straughen, Power Semiconductor Circuits, John Wiley & Sons, 1975
2. B.K Bose, Modern Power Electronics and AC Drives, Pearson Education, 2003

SUBJECT: EMBEDDED SYSTEMS 3-0-0-6

Introduction to Embedded systems:

Introduction, Features, microprossors, microcontrollers, mixed signal processor, digital signal processor, Application.

LECTURS-4

Embedded Systems Architectures:

Von Neumann,Havard,Modified Havard,Characteristics application,CISC and RISC,Instruction pipelineing,Microcontroller: characteristics and features,overview and architechtures of Atmel 89C52 and Microchip PIC16F877 and 18F452,Floating point and Fixed point prosser. LECTURES-8

PIC Microcontrollers:

16F877 Architechture and instruction set,External interrupts,Timers,watch-dog timer,I/O port Expansion,Analog to Digital converter,UART,12C and SPI bus for peripheral chips,Accessories and special features.

LECTURES-8

Software Architechture and RTOS:

Software Architechture:Round robin,Round robin with interrupts,Function queue,Scheduling,Architechture RTOS:Architechture-Tasks and taskstates-task and data-semaphores and shared data. LECTURES-8

Software development Tools and debugging Techniques:

Development tool: cross-complier,cross-assemblers,linker/locator,Programming Tool:PROM Programmers,ROM,Emulator,In-circuit Emulators,Debugging techniques and instruction set simulators. LECTURES-8

Basic Design using of Embedded system:

Overview,General,principles,Design of embedded system,Examples of embedded systems,case study. LECTURES-5

Readings:

Prescribed Text Books:

1. Raj Kamal, Embedded systems architechture,Programming and design,TMH.
2. D.E Simon, An Embedded software primer, Pearson Education.

Additional Reading:

1. J.B Peatman, Design with PIC Microcontrollers, Pearson Education.