# PROPOSED SYLLABUS

# MASTER OF TECHNOLOGY

# IN

# POWER SYSTEM


## DEPARTMENT OF ELECTRICAL ENGINEERING

**YMCA UNIVERSITY OF SCIENCE AND TECHNOLOGY**
**FARIDABAD-121006**

# DEPARTMENT OF ELECTRICAL ENGINEERING
# YMCA UNIVERSITY OF SCIENCE AND TECHNOLOGY, FARIDABAD

## MASTER OF TECHNOLOGY (ELECTRICAL ENGINEERING)
## POWER SYSTEMS

### SEMESTER-I

| CODE | COURSE TITLE | TEACHING SCHEDULE | | | | INT. | EXAMINATION | | TOTAL MARKS | Cr |
|---|---|---|---|---|---|---|---|---|---|---|
| | | L | T | P | TOTAL | | THEORY | PRACTICAL | | |
| EL-601 | Advanced in Power Electronics Converter | 4 | - | - | 4 | 40 | 60 | - | 100 | 4 |
| EL-603 | Advanced Power System Protection | 4 | - | - | 4 | 40 | 60 | - | 100 | 4 |
| EL-605 | EHV AC/DC Transmission | 4 | - | - | 4 | 40 | 60 | - | 100 | 4 |
| EL-607 | Computer Simulation in Power System | 4 | - | - | 4 | 40 | 60 | - | 100 | 4 |
| EL-609 | Power system Lab | - | - | 2 | 2 | 60 | - | 40 | 100 | 1 |
| EL-611 | MATLAB Programming Lab | - | - | 2 | 2 | 60 | - | 40 | 100 | 1 |
| EL-613 | Seminar | - | - | 2 | 2 | 50 | - | - | 50 | 1 |
| | **TOTAL** | **16** | **0** | **6** | **22** | **330** | **240** | **80** | **650** | **19** |

### SEMESTER-II

| CODE | COURSE TITLE | TEACHING SCHEDULE | | | | INT. | EXAMINATION | | TOTAL MARKS | Cr |
|---|---|---|---|---|---|---|---|---|---|---|
| | | L | T | P | TOTAL | | THEORY | PRACTICAL | | |
| EL-602 | Advanced Machine Drives | 4 | - | - | 4 | 40 | 60 | - | 100 | 4 |
| EL-604 | Power System Dynamics & Control | 4 | - | - | 4 | 40 | 60 | - | 100 | 4 |
| EL-606 | AI Techniques in Power System | 4 | - | - | 4 | 40 | 60 | - | 100 | 4 |
| EL-608 | Power System Operation and Control | 4 | - | - | 4 | 40 | 60 | - | 100 | 4 |
| EL-610 | AI Lab | - | - | 2 | 2 | 60 | - | 40 | 100 | 1 |
| EL-612 | Power System Simulation Lab | - | - | 2 | 2 | 60 | - | 40 | 100 | 1 |
| EL-614 | Seminar | - | - | 2 | 2 | 50 | - | - | 50 | 1 |
| | **TOTAL** | **16** | **0** | **6** | **22** | **330** | **240** | **80** | **650** | **19** |

# DEPARTMENT OF ELECTRICAL ENGINEERING
# YMCA UNIVERSITY OF SCIENCE AND TECHNOLOGY, FARIDABAD

## SEMESTER-III

| CODE | COURSE TITLE | TEACHING SCHEDULE | | | | INT. | EXAMINATION | | TOTAL MARKS | Cr |
|---|---|---|---|---|---|---|---|---|---|---|
| | | L | T | P | TOTAL | | THEORY | PRACTICAL | | |
| EL-701 | Flexible AC Transmission System | 4 | - | - | 4 | 40 | 60 | - | 100 | 4 |
| EL-703 | Recent Trends in Power System | 4 | - | - | 4 | 40 | 60 | - | 100 | 4 |
| | Elective-I | 4 | - | - | 4 | 40 | 60 | - | 100 | 4 |
| | Elective-II | 4 | - | - | 4 | 40 | 60 | - | 100 | 4 |
| | Minor Project | - | - | 4 | 4 | 120 | - | 80 | 200 | 4 |
| | **TOTAL** | **16** | **0** | **4** | **20** | **280** | **240** | **80** | **600** | **20** |

## SEMESTER-IV

| CODE | COURSE TITLE | TEACHING SCHEDULE | | | | INT. | EXAMINATION | | TOTAL MARKS | Cr |
|---|---|---|---|---|---|---|---|---|---|---|
| | | L | T | P | TOTAL | | THEORY | PRACTICAL | | |
| EL-702 | Dissertation | - | - | 24 | 24 | 300 | - | 200 | 500 | 12 |
| | **TOTAL** | **-** | **-** | **24** | **24** | **300** | **-** | **200** | **500** | **12** |

Instructions:

1. Sessional will be awarded by the teacher in marks only
2. Theory paper will be awarded in marks
3. Combining the theory and sessional marks university will compute percentage of marks in that subject
4. On the basis of combined percentage of marks in a particular paper, the grade will be allocated according to the minutes of the BOS meeting held on 2013

# DEPARTMENT OF ELECTRICAL ENGINEERING
# YMCA UNIVERSITY OF SCIENCE AND TECHNOLOGY, FARIDABAD

## LIST OF ELECTIVES

### ELECTIVE-I

| CODE | COURSE TITLE |
|---|---|
| EL-705 | Power Quality |
| EL-707 | Advanced Microprocessor and Microcontrollers |
| EL-709 | Power System Transient |
| EL-711 | Power Plant Instrumentation |

### ELECTIVE-II

| CODE | COURSE TITLE |
|---|---|
| EL-713 | Digital Signal Processing |
| EL-715 | Computer Communication and Networking |
| EL-717 | Solid State Controller of Drives |
| E-601-C | Modern Control System |
| E-607-C | Optimization Techniques |

**E-601-C** (Modern Control System) and **E-607-C** (Optimization Techniques) are common with Ist semester M.Tech Control and Instrumentation.

## EL-601 ADVANCED IN POWER ELECTRONIC CONVERTERS

| L | P | Cr | INTERNAL:40 |
|---|---|---|---|
| 4 | 0 | 4 | EXTERNAL:60 |
| | | | TOTAL:100 |

Switched mode power supply : Forward and flyback converter circuit , operation , Waveforms and design, transformer design for various power supplies , small signal analysis of DC-DC converters and closed loop control ; Resonant DC-DC converters ; operating principle , waveforms , switching trajectory and losses and control ; PWM inverter modulation strategies ; sine wave with third harmonic , space vector modulation and predictive current control techniques , Dynamic braking circuit , input side bidirectional power flow requirement for regeneration, Dual thyristor bridge and PWM rectifier ; Three level inverter ; Basic topology and waveforms , improvements in harmonics and high voltage application ; Resonant ac link/ dc link inverters ; cycloconveters : Circuit , operating principle , control , harmonics , power factor and application Non drive application of power electronic converters ; Back to Back HVDC transmission , induction heating , electronic blast , UPS , Static var compensators and active filters. Industrial PWM driver chips for power supplies such as UC3843 , 3825 or equivalent ; industrial gate driver chips for PWM voltage source inverters with isolation and protection circuits. Intelligent power modules

**REFERENCES BOOKS:**


1. N.Mohan , T.M. Undeland and W.P. Robbins , Power electronics ; converter, applications and design , Jhon wiley and sons 1989
2. R. Bausiere and G.Seguier, power electronics converters Springer - Verlag 1987
3. D.M.Mitchell , DC- DC switching regulator analysis Mc-Graw Hill 1987

## EL-603 ADVANCES IN POWER SYSTEM PROTECTION

| L | P | Cr | INTERNAL:40 |
|---|---|---|---|
| 4 | 0 | 4 | EXTERNAL:60 |
| | | | TOTAL:100 |

Introduction: Need for protective systems, Zones of protection, classification or protective relays and protective schemes, Current transformers and potential transformers, Advantages of static relays.

Comparators: general equation of comparators, Analysis for amplitude comparator, analysis for phase comparator, duality between amplitude and phase comparators, different types of amplitude and phase comparators.

Static Relays: Over current relays: Instantaneous over current relays, definite time over current relays, directional over current relay, comparison with conventional relays, differential relays, operating and restraining characteristics, types of differential relays, comparison with conventional relays, distance relays, impedance relays, reactance relays, mho relay quadrilateral relays, elliptical relays, comparison with conventional relays.

Distance protection: Principle of distance relaying, time grading of distance relays, schemes of distance protection, distance protection by impedance, reactance and mho relays, Effect of power swings on the performance of distance relays.

Pilot relaying schemes: Pilot wire protection, carrier current protection.

Protection of Generators and Motors: Types of faults, Stator and rotor protection against various types of faults. Protection of Transformers: Types of faults, differential protection schemes, harmonic restraint relay, over flux protection, earthing transformer protection.

Bus Zone Protection: Types of Bus-bar faults, differential current protection frame leakage protection. Microprocessor based protective relays: Over current relay, impedance relay, reactance relay, mho relay, microprocessor based distance relaying.

Testing and maintenance of static relays

**REFERENCES:**


1. TSM Rao, "Power System Protection - Static Relays", Tata McGraw Hill.
2. S.P Patra, S.K Bl,lsu and S. Choudhary, "Power System Protection", Oxford IBH Pub.
3. S. Ravindernath and M. Chander, "Power System Protection and Switchgear", Wiley Eastern Ltd.
4. Badri Ram and Vishwakarma, Power System Protection and Switchgear, TAT A McGraw Hill.

## EL-605 EHV AC/DC TRANSMISSION

| L | P | Cr | INTERNAL:40 |
|---|---|---|---|
| 4 | 0 | 4 | EXTERNAL:60 |
| | | | TOTAL:100 |

EHV AC Transmission Bulk power transmission over long distance, need for EHV transmission problems of EHV transmission, Power Handling capacity and surge impedance loading. Current carrying capacity of conductor. Choice of economic voltage, standard transmission voltages. Bundled Conductors: Properties of bundled conductors, geometric mean radius of bundle, inductance and capacitance, Voltage gradients of conductors, maximum surface voltage gradients of bundled conductors, maximum surface electric fields for bundled and single conductor lines. Electrostatic fields of EHV lines. Effect of E.S. field on Humans, Animals and Plants. Series and Shunt compensation : Effect of series capacitors, location of series capacitors. Sub-synchronous resonance in series capacitor compensated lines and counter measures. Shunt compensation Variation of no load receiving end voltage, Static VAR Systems : TCRFC, TCR, TSCTCR and MSCTCR Schemes. HVDC Transmission Rectification: The 3phase Bridge rectifier or Graetz circuit, Inversion, Kinds of D.C links, Paralleled and Series connection of thyristors, Power flow in HVDC transmission system. Converter Station: Major components of a converter station converter unit, filters, reactive power source. Ground return and ground electrode. Basic principles of DC link control: Converter control characteristics, firing angle control and extinction angle control. Parallel operation of D.C. link with A.C. transmission line, Introduction to Multi-terminal HVDC Systems and HVDC Circuit Breakers, Comparison between AC and DC transmissions, break even distance for overhead transmission lines and underground cables, Application of HVDC transmission

**REFERENCES BOOKS :**


1. Rakosh Das Begamudre, “Extra High Voltage AC Transmission Engineering” Revised Second Edition, John Wiley.
2. K.R. Padiyar, “HVDC Power Transmission System”, Second revised Edition, New Age Int. 2012
3. S. Rao, “EHV-AC and HV DC Transmission Engineering Practice”, Khanna Publishers.
4. Arrillaga J “High Voltage Direct current Transmission” 2nd Edition (London) Peter Peregrinus, IEE, 1998.
5. Hingorani HG and Gyugyi L “Understanding FACTS-concepts and Technology of Flexible AC Transmissions Systems” New York, IEEE Press,2000.
6. Padiyar K R “FACTS controllers in Power Transmission and distribution” New Delhi, New Age Int. publishers 2007.

## EL-607 COMPUTER SIMULATION IN POWER SYSTEM

| L | P | Cr | INTERNAL:40 |
|---|---|---|---|
| 4 | 0 | 4 | EXTERNAL:60 |
| | | | TOTAL:100 |

Review of matrix operations, graph theory and various circuit incidence matrices, primitive network and matrix, formation of various network matrices by singular transformation interrelations. Building algorithm for bus impedance matrix, modification of bus impedance matrix for change of reference bus for network changes, formation of bus admittance matrix and modification, gauss elimination, node elimination (kron reduction), LU Factorization, schemes of ordering sparsity, calculation of Z-bus element for Y-bus. Load flow studies, its importance. Classification of busses, load flow techniques, interactive solutions and computer flow charts using Gauss-Siedel and Network-Raphson methods, decoupled and fast decoupled load flow solution, representation of regulation and off nominal ration transformers, tie-line control, comparison of methods.

Introduction to AC-DC load flow problems: formation and solutions

Power system security, contingency analysis using Z bus using sensitivity factors, Introduction to state estimation, maximum likelihood weighted least square error estimation, state estimate of an AC network.

Short circuit studies symmetrical and unsymmetrical faults, algorithm for calculating system condition after the occurrence of fault, short circuit studies using bus admittance matrix, direct short circuit, comparison between symmetrical components and phase coordinate method.

**REFERENCES**


1. G.W. Stagg and A.H EI-Abaid, "computer methods in power system analysis" , McGraw Hill, New York. G.L Kusic, "computer aided power system analysis", Prentice Hall of India, New Delhi.
2. John J. Grainger and W.D Stevenson, "Power System Analysis", McGraw Hill, New York, 1994.
3. A.J Wood and W.F Wollenberg, "Power Generation, operation and control", 2nd Edn, John and sons, New York, 1996
4. O.I Elgerd, "Electric Energy Systems Theory: an introduction", McGraw Hill , New York, 1982. J.Arrillaga, C.P. Arnold and Harker, " computer modeling of electrical power systems "John Wiley and sons.

## EL-609 POWER SYSTEMS LABORATORY

| L | P | Cr | |
|---|---|---|---|
| 0 | 2 | 1 | INTERNAL:60 |
| | | | EXTERNAL:40 |
| | | | TOTAL:100 |

1. Determination of Sub-Transient Reactance of a Salient Pole Machine.
2. Determination of Sequence Impedances of a Cylindrical Rotor Synchronous Machine.
3. Fault Analysis of
    i) LG Fault
    ii) LL Fault
    iii) LLG Fault
    iv) LLLG Fault
4. Power Angle Characteristics of a Salient Pole Synchronous Machine.
5. Equivalent Circuit of a Three Winding Transformer.
6. Characteristics of IDMT Over Current Relay (Electro Magnetic Type).
7. Characteristics of Static Negative Sequence Relay.
8. Characteristics of Over Voltage Relay.
    i) Electromagnetic Type
    ii) Microprocessor Type
9. Characteristics of Percentage Biased Differential Relay.
    i) Electromagnetic Type
    ii) Static Type
10. Simulation of 220KV Transmission line model.
    i) Ferranti Effect
    ii) Transmission line parameter
    iii) Surge Impedance loadings
    iv) Voltage control methods
11. Transformer Oil Testing.

## EL-611 MATLAB PROGRAMMING LAB

| L | P | Cr | INTERNAL:60 |
|---|---|---|---|
| 0 | 2 | 1 | EXTERNAL:40 |
| | | | TOTAL:100 |

1. Basics of MATLAB matrices and vectors, matrix and array operations, Saving and loading data, plotting simple graphs, scripts and functions, Script files, Function files, Global Variables, Loops, Branches, Control flow, Advanced data objects, Multi-dimensional matrices, Structures, Applications in linear algebra curve fitting and interpolation. Numerical integration, Ordinary differential equation.
2. **Simulink:** Idea about simulink, problems based on simulink.
3. Formulation of Bus Incidence matrices, A,B,C using MATLAB
4. Formulation of Ybus with matrix A and using direct approach/Formulation of Jacobian matrix.
5. Formulation of Zbus using Zbus building algorithm
6. Short circuit studies using Zbus

## EL-602 ADVANCED MACHINE DRIVES

| L | P | Cr | INTERNAL:40 |
|---|---|---|---|
| 4 | 0 | 4 | EXTERNAL:60 |
| | | | TOTAL:100 |

Separately Excited D.C motor Drive, Operating limits using armature voltage control and field control technique, Dynamic model(Armature voltage control only) of machine and converters (continues conduction only), open loop dynamic performance, starting and reversal time, energy consumption, closed loop control using single (speed) and loops (speed ,current), implementation using circulating current type, three phase dual converter and four quadrant transistorized chopper state feedback control and sliding mode control of separately excited D.C machine, modeling and control of separately excited D.C machine in field weakening region and discontinuous converter conduction mode, control of D.C series machine .Review of variable frequency of three phase symmetrical induction machine, scalor control methods(constant V/f and air-gap flux control),vector control of induction machine, methods of flux sensing/estimation. Implementation of IRFO scheme using current controlled PWM VSI, implementation of DSFO scheme using GTO CSI, effect of machine parameter variation on the performance of vector controlled permanent magnet machine control. Introduction to speed control of switched reluctance machine .Induction motor drive, speed sensor less control, flux observation, DTC, speed control of wound rotor induction motors: static rotor resistance control, static scherbius drive using line commutated converter cascade , harmonic and power factor, vector control of wound rotor IM using self commutated converter cascade and improvement in power factor, introduction to variable speed constant frequency generation: control of wound field synchronous machine: constant V/f control, scalar self control (commutator less motor) , vector control: control of permanent magnet synchronous machine: Brushless D.C machine, surface permanent machine and interior.

**REFRENCES**


1. G.K. Dubey " Electric drives"
2. Electric Drives by De And Den ; PHI
3. DC Drives by P.C.Sen

## EL-604 POWER SYSTEM DYNAMICS AND CONTROL

| L | P | Cr | INTERNAL:40 |
|---|---|---|---|
| 4 | 0 | 4 | EXTERNAL:60 |
| | | | TOTAL:100 |

Introduction Basic Concepts, Definitions and Classification of Power System Stability

Synchronous machine modeling for stability studies: Basic equations of a synchronous machine, the dq0 transformation, per unit representation, equivalent circuits for direct and quadrature axes, steady state analysis, transient performance, magnetic saturation', equations of motion, swing equation, simplified model with ammortisseurs neglected, constant flux linkage model.

Excitation and prime mover controllers: Elements of excitation systems, types of excitation system, DC AC and static excitation systems, system representation by block diagram and state equations, prime mover control system.

Small signal stability of power systems: Fundamental concepts of stability of dynamic systems, Eigen properties of the state matrix, small signal stability of a single machine infinite bus system, effects of excitation system, power system stabilizers, system state matrix with amortisseurs, small signal stability of multi machine systems. Use of PSS to improve small signal stability

Transient stability: Equal area criterion, numerical integration methods, simulation of power system dynamic response, direct methods of transient stability analysis - description of transient energy function approach, limitations of the direct methods. Methods of improving transient stability

Voltage stability: Basic concepts related to voltage stability, voltage collapse, voltage stability analysis static and dynamic analysis, the continuation power flow analysis, prevention of voltage collapse.

**REFERENCE BOOKS:**


1. P.M. Anderson and A.A.Found, "Power system control and stability", the Iowa State Univ Press, 1977.
2. R.T.Byerly and E. W.Kimbark, "Stability of large electric power system", IEEE Press, 1974.
3. V.A.Venikov, "Transient process in electrical power system" Mir Publishers, Moscow, 1977.
4. Y.N.Yu, "Electric power system dynamics", Academic press 1983.
5. M.A. Pai, "Power system stability analysis by direct method ofliapunov", 1981.
6. M.Payella and P.G. Murphy, "Transient stability from theory to practice" John Wiley, New York, 1993.
7. K.R. Padyar, "power system dynamics, stability and control", John Wiley, Singapore, inbrlie publishing, Bangalore.

## EL-606 AI APPLICATIONS IN POWER SYSTEMS

| L | P | Cr | INTERNAL:40 |
|---|---|---|---|
| 4 | 0 | 4 | EXTERNAL:60 |
| | | | TOTAL:100 |

**UNIT-I-**

**Artificial Intelligence:** Definition, problem solving methods, searching techniques, knowledge representation, reasoning methods, predicate logic, predicate calculus, multivalue logic

**UNIT-II**

**Fuzzy Logic:** Concepts, fuzzy relations, membership functions, matrix representation, de-fuzzification methods

**UNIT-III**

**Artificial Neural Network:** Introduction, multi-layer feed forward networks, back propagation algorithms, radial basis function and recurrent networks

**UNIT-IV**

**Evolutionary Techniques**: Introduction and concepts of genetic algorithms and evolutionary programming

**UNIT-V**

**Hybrid Systems**: Introduction and Algorithms for Neuro-Fuzzy, Neuro-Genetic, Genetic-Fuzzy systems

**UNIT-VI**

**Application of AI Techniques:** Load forcasting, load flow studies, economic load dispatch, load frequency control, reactive power control, speed control of DC and AC motors

**TEXT BOOKS/REFERENCES:**


1. NP Padhy , Artificial Intelligence and Intelligent Systems, Oxford University Press
2. Rajasekaran S. and Pai G.A.V., "Neural Networks, Fuzzy Logic and Genetic Algorithm Synthesis and applications", PHI New Delhi.
3. Lin C. and Lee G., "Neural Fuzzy Systems", Prentice Hall International Inc.
4. Goldberg D.E. "Genetic Algorithms in Search Optimization & Machine Learning", Addition Wesley Co., New York.
5. Kosko B., "Neural Networks & Fuzzy Systems A dynamical systems approach to machine intelligence, Prentice Hall of India.
6. Taylor C.W., "Power System stability" Mc-Graw Hill, New York.

## EL-608 POWER SYSTEM OPERATION & CONTROL

| L | P | Cr | INTERNAL:40 |
|---|---|---|---|
| 4 | 0 | 4 | EXTERNAL:60 |
| | | | TOTAL:100 |

**UNIT-I**

Load Forecasting: Introduction, Estimation of Average and trend terms, Estimation of periodic components, Estimation of Stochastic components: Time series approach, Auto- Regressive Model, Auto-Regressive Moving, Average Models, Kalman Filtering Approach, On-line techniques for non stationary load prediction.

**UNIT-II**

Unit Commitment: Constraints in unit commitment, Spinning reserve, Thermal unit constraints, Other constraints – Solution using Priority List method, Dynamic programming method, Forward DP approach Lagrangian relaxation method , adjusting $\lambda$

**UNIT-III**

Generation Scheduling: The Economic dispatch problem, Thermal system dispatching with network losses considered, The Lambda, iteration method, Gradient method of economic dispatch, Economic dispatch with Piecewise Linear cost functions, Transmission system effects, A two generator system, coordination equations, Incremental losses and penalty factors, Hydro Thermal Scheduling using DP.

**UNIT-IV**

Control of Power Systems: Review of AGC and reactive power control -System operating states by security control functions , Monitoring, evaluation of system state by contingency analysis – Corrective controls (Preventive, emergency and restorative), Energy control center – SCADA system – Functions – monitoring , Data acquisition and controls – EMS system.

**UNIT-V**

State Estimation: Introduction to state estimation, Maximum likelihood Weighted Least Squares Estimation: - Concepts – Matrix formulation - Example for Weighted Least Squares state estimation ; State estimation of an AC network: development of method – Typical results of state estimation on an AC network – State Estimation by Orthogonal Decomposition algorithm, Introduction to Advanced topics : Detection and Identification of Bad Measurements , Estimation of Quantities Not Being Measured , Network Observability and Pseudo – measurements – Application of Power Systems State Estimation.

**REFERENCE BOOKS:**


1. Allen J. Wood, and Bruce F. Wollenberg, “Power Generation, Operation and Control”, John Wiley & Sons, Inc., New York.
2. Olle I. Elgerd, “Electric Energy Systems Theory – An Introduction”, Mc Graw-Hill Book Company, New York.
3. John J. Grainger and William D. Stevenson, Jr., “Power System Analysis”, Mc Graw Hill Book Company, Inc., New York.
4. PSR Murty, “Power System Operation and Control”, Tata McGraw-Hill Publishing Company Ltd., New Delhi.
5. IJ Nagrath & DP Kothari, “Power System Engineering, Tata McGraw Hill Publishing Co., Ltd. New Delhi.
6. AK Mahalinabis, DP Kothari and SI Ahson, Computer-Aided Power System Analysis and Control, Tata McGraw Hill Publishing Co. Ltd. New Delhi.
7. Kothari and Dhillon, ‘Power Systems Optimization’, PHI, 2004.
8. BR Gupta, “Generation of Electrical Energy”, S. Chand & Co. Ltd. N. Delhi.

## EL-610 ARTIFICIAL INTELLIGENCE LAB

| L | P | Cr | |
|---|---|---|---|
| 0 | 2 | 1 | |

**INTERNAL:60**
**EXTERNAL:40**
**TOTAL:100**

Load Flow analysis using Neural Network, State Estimations using Neural Network, Contingency Analysis using Neural Network, Power system Security using Neural Network, Fuzzy Logic based AGC, Single area system, Two area system, Fuzzy Logic based small signal stability analysis, Simulation and verification of fuzzy Logic experiments using fuzzy logic trainer.

## EL-612 POWER SYSTEMS SIMULATION LAB

| L | P | Cr | |
|---|---|---|---|
| 0 | 2 | 1 | |

**INTERNAL:60**
**EXTERNAL:40**
**TOTAL:100**

1. Power flow analysis by Newton-Raphson method
2. Power flow analysis by Fast decoupled method
3. Load frequency control for multi-area system using SIMULINK
4. Contingency analysis: Generator shift factors and line outage distribution factors
5. Economic dispatch using lambda-iteration method
6. Unit commitment: Priority-list schemes and dynamic programming
7. Small-signal stability analysis of multi-machine configuration with classical machine model using Power System Toolbox
8. Transient stability study for multi-machine system using power system toolbox/SIMULINK
9. Learning power world simulator package and utilizing its capability for load flow studies, voltage stability studies, ATC etc.
10. Load flow analysis with FACTS devices
11. Transient stability analysis using Range-Kutta method
12. Available Transfer Capability calculation using an existing load flow program, power world simulator
13. PV/QV analysis using power world simulator
14. Optimal power flow study using MATPOWER/Power World Simulator/GAMS
15. Learning PSAT toolbox (available freely on waterloo site) and using for stability studies

## EL-701 FLEXIBLE A.C. TRANSMISSION SYSTEM

| L | P | Cr | INTERNAL:40 |
|---|---|---|---|
| 4 | 0 | 4 | EXTERNAL:60 |
| | | | TOTAL:100 |

FACTS concept and general power system consideration. Brief idea about the power semiconductor devices. Voltage source converter

Static shunt Compensator: SVC and STATCOM

Static series compensator: GCSC,TSSC,TCSC and SSSC

Static voltage and phase angle regulator: TCVR and TCPAR

Combined Compensator: unified power flow controller and interline power flow controller, coordination of FACTS controller

Special purpose Facts controllers NGH-SSR damping scheme and thyristor-controlled braking resistor

**REFERENCE BOOKS:**


1. Thyristor based FACTS controllers for electrical transmission systems by R.Mohan Mathur and R.K.Verma IEEE Press A John Wiley and sons Inc. Publication
2. Flexible AC Transmission System by N.G.Hingorani
3. Flexible Transmission systems by Y.H Song and Allan T Johns lEE press

## EL-703 RECENT TRENDS IN POWER SYSTEM

| L | P | Cr | INTERNAL:40 |
|---|---|---|---|
| 4 | 0 | 4 | EXTERNAL:60 |
| | | | TOTAL:100 |

**UNIT-I**

Introduction to Power System Deregulation Market Models Pool & Bilateral International Experiences, Role of ISO, Market Power, Bidding and Auction Mechanisms

**UNIT-II**

Transmission Open Access, Transmission Pricing, Impact of Congestion and Congestion Management, ATC and Factor affecting ATC Determination of ATC, Ancillary Services and their management, Electricity Bill 2003 and its impact on ESI in India

**UNIT-III**

Power System Computation and Computer Application

**UNIT-IV**

OPF and its Formulation, Solution Techniques NLP Methods, LPOPF Interior Point Method. AI Techniques and Genetic Algorithm

**UNIT-V**

SCADA & Distribution Automation, Energy management systems, Power system communication, PLCC Digital Communication, Microwave communication - Utility communication architecture, Java and Web based technologies. Software Agents

**REFERENCES:**


1. Lei Lee Lai, Power System restructuring and deregulation. John Wiley and Sons, UK. 2001.
2. K. Bhattacharya, MHT Bollen and J.C Doolder, Operation of Restructured Power Systems, Kluwer Academic Publishers, USA, 200 I.
3. AJ Wood and B.F Wollenberg. Power System Operation and Control, John Wiley and Sons.
4. S.A Soman, S.A Khafasok, Shubha Pandit, Computational Methods for large Sparse Power System Analysis: An Object Oriented Approach. Kluwer Academic Publishers.

# EL-705 POWER QUALITY

**L P Cr** **INTERNAL:40**
**4 0 4** **EXTERNAL:60**
**TOTAL:100**

**UNIT-I**

**Introduction To Electrical Power Quality**: definition power quality. power quality issue, power quality equipment immunity, electric power quality standards

**UNIT-II**

**Power Frequency Disturbance**: common power frequency disturbances, voltage sag, isolation transformer, voltage regulator. Static's UPS systems

**UNIT-III**

**Electrical Transients**: types and causes of transients, atmospheric causes, switching on or off, interruption of fault circuits, capacitor bank switching, motor start transients, power factor correction, capacitor switching transients

**UNIT-IV**

**Harmonics**: definition of harmonics, causes of voltage and current harmonics, individual and total harmonics distortion, effects of harmonics on power system devices, guidelines for harmonic voltage and current limitation, harmonic current mitigation

**UNIT-V**

**Measuring And Power Quality Problems**: power quality measurement devices, harmonic analyzer, transient disturbances analyzer, oscilloscopes, data logger and chart recorder, true RMS meters, power quality measurement

**REFERENCE BOOKS**


1. G.T.HEYDT,ELECTRIC POWER QUALITY,2nd west Lafayette,IN stars in a circle, 1994
2. A.Ghosh ,G.Ledwich ,power quality enhancement using custom power devices, Kluwer Academic,2002
3. R.C.Dugan M.F.McGranaghan and H.W.Beaty ,Electric power System quality,Mc-Graw Hill, 1996
4. C.Sankaran , power quality. CRC

## EL-707 ADVANCED MICROPROCESSSOR AND MICROCONTROLLERS

**L P Cr** **INTERNAL:40**
**4 0 4** **EXTERNAL:60**
**TOTAL:100**

**UNIT-I**

Overview of microprocessor/Microcomputers: Types of computers, time sharing and multi tasking systems, batch processing, distributed processing, block diagram of simple microcomputer, hardware, software, firmware, introduction to 8086, 8088, 80186 / 80188, 80286, 80386 and 80486 MMU.

**UNIT-II**

8086 microprocessor: architecture, pin diagram, segment registers, maximum and minimum mode system, memory banking, memory (RAM or ROM) interface to microprocessor using memory mapped I/O and I/O mapped I/O techniques, address decoding, addressing modes i.e. data addressing, branch addressing and stack addressing modes.

**UNIT-III**

Instruction set of microprocessor and programming: data transfer instructions, arithmetic instructions, process control instructions, program development steps, instruction templates, write programs for use with an assembler, instruction timing and delay loops, assembly language program development tools, programming using if-then, if-then-else, nested if-then-else control statements.

**UNIT-IV**

Programmable supporting chips and their applications: 8255(PPI) , 8253/54(PTI) , 8259(PIC) , usart/uart .

**UNIT-V**

Microcontrollers / RISC processor: 8031/51 micro controller architecture, pin diagram, registers, external memory, counter and timer, addressing mode and instruction set, overview of RISC, based architecture of Motorola 68000, scalable architecture of SPARC chips

**UNIT-VI**

Microprocessor application: interfacing of microprocessor to A/D and D/A converter and their applications, interfacing of microprocessor to stepper motor, microprocessor based firing scheme for 3 phase fully controlled bridge converter, microprocessor control AC and DC drives.

**UNIT-VII**

Microprocessor application in power system: protective relaying, over current, impedance, MHO, reactance, bi-directional relays, measurement frequency, power angle and power factor, voltage and current, resistance and temperature control.

**REFERENCE BOOKS**


1. D.V.Hall, microprocessor and interfacing programming and hardware, TMH, 1990.
2. Y.Liu and G.A.Gibson, microcomputer system: the 8086/8088 family architecture programming and design.
3. B.B.Bery the Intel micro chip-8086/8088, 80186/80188, 80286, 80386,80486, Pentium and Pentium processor architecture programming and interfacing. PHI 1998.
4. Kenneth.J.Ayaia. 8051 micro controller architecture programming and applications, PRI 1998.

## EL-709 POWER SYSTEMS TRANSIENTS

| L | P | Cr | |
|---|---|---|---|
| 4 | 0 | 4 | |

**INTERNAL:40**
**EXTERNAL:60**
**TOTAL:100**

Origin and nature of power system transients. Traveling waves on transmission lines. General wave equation. Attenuation and distortion of waves. Reflection and refraction of traveling waves at different line terminations. Traveling waves in multi-conductor systems. Transition points on multi-conductor circuits.

Transient over voltages due to lightning. Theory of ground wires. Direct stroke to a tower. Effect of reflection up and down the tower. Tower grounding and counterpoises. Switching transients. Single and double frequency transients. Abnormal switching transients. Capacitance switching. Kilometric fault. Line dropping and load ejection. Closing and reclosing of lines. High charging currents. Over voltages induced by faults. Ferro-resonance. Switching transients in integrated systems. Peaking switching over voltages in EHV lines and cables.

Transients in transformers. High frequency transients and voltage distribution in transformer windings.

Protection of Power Systems against transients, and insulation coordination.

**REFERENCES**


1. I V Begley, 'Traveling waves in Transmission Systems', John Wiley (1933,51), Dover.
2. R. Rudenberg. 'Electric Stroke waves in Power Systems', Harvard University Press, Cambridge, Massachusetts.
3. Allan Greenwood, 'Electric Transients in Power Systems', Wiley Interscience.
4. CS Indulkar and DP Kothari, 'Power System Transients, A Statistical Approach', Prentice-Hall of India Pvt Ltd., New Delhi. 110 001.
5. VA Venikov, 'Transient phenomena in Electrical Power Systems', Pergamon Press, London.

## EL-711 POWER PLANT INSTRUMENTATION

| L | P | Cr | INTERNAL:60 |
|---|---|---|---|
| 4 | 0 | 4 | EXTERNAL:40 |
| | | | TOTAL:100 |

**Unit -I- An overview of Power Generation**

Brief survey of methods of power generation – Hydro, Thermal, Nuclear, Solar, Biomass, Geo-thermal, Wind - An outline of boilers – Feed water systems – Steam circuits – combustion process – Products of combustion process – Fuel systems – Treatment of flue gases – steam turbine – condensate systems – Alternators – feed water conditioning – Turbine bypass valves.

**Unit-II- Parameters and their mesurement**

Current Testing Equipment – Arnold Current Transformer test Bridge, Petch Elliott Current Transformer Test Bridge, Voltage Testing Equipment – Arnold Bridge Modification, Petch Elliot Bridge Modification, Power factor Measurement and Compensation, Capasitive Compensation for Power Factor Control, Generator Frequency Measurement. None electrical parameters – flow of feed water, fuel, air and steam with correction factors for temperature – pressure – temperature – smoke density measurements – dust monitors

**Unit-III- Control loops and Interlocks in Boiler**

Combustion control – Control of main header pressure, air-fuel ratio control – furnace draft and excessive air control, drum level (three element) control, main and reheat steam temperature control - burner tilting up, bypass damper, super heater, spray and gas re-circulation control – B.F.P re-circulation control – hot well and De-aerator level control – Pulverizer control – computers in power plant.

**Unit-IV- Turbine Monitoring and Control**

Turbine supervising system; pedestal vibration, shaft-vibration, eccentricity vibration. Installation of non-contact transducers for speed measurement, rotor and casing movement, Expansion measurement.

**Unit-V- Analyzers in Power Plant-I**

Thermal conductivity type – Paramagnetic type Oxygen analyzer – Infrared type and trim analyzer – Spectrum analyzer – Hydrogen purity meter- Chromatography – pH meter – conductive cell – fuel analyzer – brief survey of pollution monitoring and control equipment.

**Text Books:**


1. Modern Power Station Practice, Vol.6, British Electricity International Pergamon Press, London ,1992
2. Boiler Control Systems, David Lindlsey, McGraw Hill Book Company,1997
3. Power Station Instrumentation , Jervice M.J., Butterwortth Heinemann,1933
4. Standard Boiler Operations (Q & A), by Elonka S.M and Kohal A.L., Tata McGraw Hill.
5. Power Plant Technology – by Wakil M.M, McGraw Hill

# EL-713 DIGITAL SIGNAL PROCESSING

| L | P | Cr | INTERNAL:40 |
|---|---|---|---|
| 4 | 0 | 4 | EXTERNAL:60 |
| | | | TOTAL:100 |

**UNIT-I**

Classification of signals, concept of frequency in continuous-time and discrete-Time signals A/D and D/A conversion i.e. sampling and quantization, Classification of discrete time systems, introduction HR and FIR systems.

**UNIT-II**

Analysis of discrete-time linear time invariant systems, techniques for the analysis of linear systems, convolution sum, properties of convolution and the Interconnection of LTI systems, stability of LTI systems, difference equation to Describe the LTI system, impulse response of LTI system.

**UNIT-III**

Z-transform, ROC, properties of Z-transformation, rational Z-transformation, one sided Z-transformation, solution of difference equation, basic network structure for HR system: direct form, cascade form, parallel form, basic network structure for FIR systems, DFT and its properties, fast Fourier transforms (FFT), decimation- In-time algorithm, decimation-in-frequency algorithm, design of HR filter by the bilinear transformation, design of FIR filter using window, property of the FIR filters.

**UNIT-IV**

Linear prediction and optimum linear filters-forward and backward linear Prediction, levinson Durbin algorithm, schur algorithm, AR & ARMA model, Wiener filter –FIR, HR, non causal (speech recognition applications).

**UNIT-V**

Harmonics analysis models-pisasenko, music, ESPRIT and applications to power Systems

**UNIT-VI**

Effects of finite register length in digital signal processing, effect of truncation or rounding, finite register length effects in realization of HR digital signal filters: statistical analysis of quantization in fixed point realization of HR digital signals, statistical analysis of quantization in floating point realization of HR digital filter, finite register length effects in realization of FIR digital filter, statistical analysis of quantization in fixed point realization of FIR digital filters, statistical Analysis of quantization in floating point point realization of FIR digital filter.

**REFERENCE BOOKS:**


1. Alan V.Oppenhelm/Ronald W.Schafer, Digital Signal Processing, Pearson Education.
2. John G. Prokis & Dimities G.Manolakis, Digital Signal Processing, PHI, 1998.
3. Dimities G. Manolakis, Vinay K. Ingle & Stephen M Kogon, Statistical and Adaptive Signal Processing, McGraw Hill International Editions.

## EL-715 COMPUTER COMMUNICATION NETWORK

**L P Cr** **INTERNAL:40**
**4 0 4** **EXTERNAL:60**
**TOTAL:100**

**UNIT-I**

Introduction: communication links required in telemetry, tele control and tele protection. Analog and digital communication: speed and banding requirement, noise in power systems. Communication links: PLCC, microwaves, telephone lines, satellite, fibre optics. Requirements of various communication equipments used in power systems. Computer networking in power system

**UNIT-II**

Review of data communication techniques. OSI/TCP/IP models, transmission media, BW limited signals. Max. Bit rate, wireless transmission, satellite communication, PSTN, mobile telephone communication, Data transmission, line coding, error control coding, Data switching, circuit switching, massage and packet switching, Network model ISO-OSI model, primitives and services.

**UNIT-III**

Data link control, MAC layer protocols, Simplex, pipelined and sliding window protocols, Simplex performance analysis. X-25 data link layer. Random access techniques, Pure Signed and finite population. ALOHAs. Stability in ALOHAs. Local area networks LAN topologies and protocols, implementation and performance issues.

**UNIT-IV**

Routing and congestion control static, adaptive, centralized and distributed routing procedures, congestion control, synchronization. session and presentation layer synchronization issues, formatting, data compression, data security. Routing Algorithm-DV routing, link state hierarchical, broadcast routing. Routing for mobile agent. Ad-hoc networks, peer to peer networks and congestion control.

**UNIT-V**

High speed LANs, WAN, BW optimization. FDDL 100 VG-Any LAN. 100 Base-T. Gigabit Ethernet, Fiber channels Layering, ISO Ethernet,ISDN. Switched Multi megabit Data services, Frame relay working, ATM, ATM migration issues.DSL . ADSL. HDSL. VDSL. SDSL. RADSL.DEVICE MANAGEMENT BY SNMP.

**UNIT-VI**

Transport layer. Quality of service transport classes. Design issues, buffer management. TCP/IP-IP scheme (Class A, B and C), IPV6.0 (Architecture, implementation details, advantages, disadvantages), virtual Lans, Fire-walls.

**UNIT-VII**

Network security-Cryptography, compression, VOIP, video conference, Video on demand, oipher modes. Digital signatures, wireless security, virtual private networks, IPSEC E-mail security.

**UNIT-VIII**

Noise in power systems. Communication links PLCC, satellite, fibre optics. Requirement of various communication equipments used in power system, computer networking in power system.

**REFERENCE BOOKS**


1. Principle of network and system administration by Mark Burgess. Wiley Publisher.
2. Computer networks by Tenenbaum.
3. STICP/IP Network administration by Giaig Hunt
4. Data communication & networking- by Frozen
5. Communication networks- by Leon Garcia & Widjaja (Tata McGraw hills)
6. TCP/IP Networking-by Comer (3 volume)
7. High speed networks by Parneii

## EL-717 SOLID STATE CONTROL OF DRIVES

| L | P | Cr | INTERNAL:40 |
|---|---|---|---|
| 4 | 0 | 4 | EXTERNAL:60 |
| | | | TOTAL:100 |

ROM based control of converters such as rectifiers, choppers, invertors, and cycloconvertors. Use of PLL for speed control. Basic microprocessor system for speed control of drives. Field oriented control and programmable controllers. VSl and CSI converter with PWM techniques for implementation of the filed oriented control. Energy saving drive system. Transfer function of converter controlled drive and analysis. Synchronous reluctance motor drives. Sensorless control. Direct torque control. Direct and indirect vector control. CLM drives. Power quality improvement in drives.

**REFERENCES**


1. First course on Electrical drives by S.K. Pillay, New Age Rs 130
2. Thyristorized power controllers by G.K. Dubey, S.R. Doradla; New Age; Rs 200
3. Electric drives by De&Sen; PHI
4. M.HJ. Bolan, "Understanding Power Quality Problems" , Standard Publishers and Distributors, Delhi.
5. TJ.E. Miller; " Brushless Permanent Quality magnet and reluctance motor drives" , Oxford Science New York
6. T. Kenjo and S. Nagamori, "Permanent-Magnet; design and Application", McGraw-Hill
7. TJ.E. Miller; "Switched Reluctance Motors and their Control" Magna Physics Publishing Co. and Claridon Press
8. B.c. Kuo, "Theory and Applications of Stepper Motors", West Publishing Co.
9. V.Ashani, "Sepper Motors, Fundamental, Applications and Design", New Edge International Ltd., New Delhi
10. H.E. Jordan, "Energy Efficient Motors and Their Applications", Pienum Press New York

# E-601-C MODERN CONTROL SYSTEM

| L | P | Cr | INTERNAL:40 |
|---|---|---|---|
| 4 | 0 | 4 | EXTERNAL:60 |
| | | | TOTAL:100 |

**UNIT-I**

**State Variable Analysis –** Introduction, vectors and matrices, state variable representation, conversion of transfer function model to state variable model, conversion of state variable model to transfer function model, decomposition of transfer function into canonical state variable models, Eigen values and Eigen vectors, solution of state equations. Concept of controllability and observability, equivalence between transfer function and state variable representation.

**UNIT-II**

**Discrete time system and Z transform methods –** Introduction to discrete time system**,** the Z transform, solution of difference equations, inverse Z transform, pulse transfer function, Stability analysis in Z plane.

**UNIT-III**

**State variable analysis of discrete time system –** state space analysis of linear discrete time system, controllability and observability, multivariable system.

**UNIT-IV**

**Pole placement and state observers –** introduction, stability improvement by state feedback, necessary and sufficient condition for arbitrary pole placement, state regulator design, design of state observers, state feedback with integral control, digital control system with state feedback.

**TEXT BOOKS –**


1. Control System by B. C. Kuo.
2. Digital and non linear control by M. Gopal
3. Control System by Nagrath and Gopal.

# E-607-C OPTIMIZATION TECHNIQUES

| L | P | Cr | INTERNAL:40 |
|---|---|---|---|
| 4 | 0 | 4 | EXTERNAL:60 |
| | | | TOTAL:100 |

**UNIT-I**

**Introduction –** Optimization concepts, Euclidean space, convex functions, gradient vector, Hessian matrix, formulation of engineering problems amenable to optimization, direct approach and indirect methods.

**UNIT-II**

**Classical Optimization Techniques –**maxima minima for functions of several variables, necessary and sufficient conditions, formulation of non linear optimization problems with equality and inequality constraints, solution techniques using Lagrange's multiplier and khun-tuckker conditions.

**UNIT-III**

**Uni-dimensional Optimization –** Elimination methods, interpolation methods

**UNIT-IV**

**Multivariable Optimization –** Concepts of Hill climbing, methods of steepest descent, Newton Raphson methods, Fletcher power method, constrained optimization.

**UNIT-V**

**Other Techniques –**Principle of optimality, solution for simple multistage problems, Dynamic Programming, Geometric Programming

**BOOKS**

S. S. Rao, "Optimization Techniques" -