

M.Tech Programme
Electrical Engineering- Power Systems
Curriculum and Scheme of Examinations

SEMESTER I

| Code No. | Name of Subject | Credits | Hrs / week | End Sem Exam hours | Marks | | | Remarks |
|-----------------|--|---------|------------|--------------------|--------------------------------|-------------------|-------|--|
| | | | | | Internal Continuous Assessment | End Semester Exam | Total | |
| EMA 1001 | Advanced Mathematics and Optimization Techniques | 3 | 3 | 3 | 40 | 60 | 100 | Of the 40 marks of internal assessment, 25 marks for tests and 15 marks for assignments. End sem exam is conducted by the University |
| EPC 1001 | Computer Aided Power System Analysis | 3 | 3 | 3 | 40 | 60 | 100 | Do |
| EMC 1001 | Power Electronic Circuits | 3 | 3 | 3 | 40 | 60 | 100 | Do |
| EMC 1002 | Modeling of Electrical Machines | 3 | 3 | 3 | 40 | 60 | 100 | Do |
| EPC 1002 | Operation and Control of Power System | 3 | 3 | 3 | 40 | 60 | 100 | Do |
| EPC 1003 | Power Quality | 3 | 3 | 3 | 40 | 60 | 100 | Do |
| EPC 1101 | Power System Lab I | 1 | 2 | - | 100 | - | 100 | No End Sem Examinations |
| EPC 102 | Seminar | 2 | 2 | - | 100 | - | 100 | Do |
| | TOTAL | 21 | 22 | | 440 | 360 | 800 | 7 Hours of Departmental assistance work |

SEMESTER II

| Code No. | Name of Subject | Credits | Hrs / week | End Sem Exam (hours) | Marks | | | Remarks |
|-----------------|------------------------------------|---------|------------|----------------------|--------------------------------|-------------------|-------|--|
| | | | | | Internal Continuous Assessment | End Semester Exam | Total | |
| EPC 2001 | Digital Protection of Power System | 3 | 3 | 3 | 40 | 60 | 100 | Of the 40 marks of internal assessment, 25 marks for tests and 15 marks for assignments. End sem exam is conducted by the University |
| EPC 2002 | Power System Dynamics and Control | 3 | 3 | 3 | 40 | 60 | 100 | Do |
| ** | Stream Elective I | 3 | 3 | 3 | 40 | 60 | 100 | Do |
| ** | Stream Elective II | 3 | 3 | 3 | 40 | 60 | 100 | Do |
| ** | Department Elective | 3 | 3 | 3 | 40 | 60 | 100 | Do |
| ECC 2000 | Research Methodology | 2 | 2 | 3 | 40 | 60 | 100 | End Sem Exam is conducted by the Individual Institutions |
| EPC 2101 | Power System Lab II | 1 | 2 | - | 100 | | 100 | No End Sem Examinations |
| EPC 2102 | Seminar | 2 | 2 | - | 100 | | 100 | do |
| EPC 2103 | Thesis – Preliminary – Part I | 2 | 2 | - | 100 | | 100 | do |
| | TOTAL | 22 | 23 | --- | 540 | 360 | 900 | 6 Hours of Departmental assistance work |

Stream Elective I

| | |
|---------|------------------------------------|
| EPE2001 | Transient Analysis in Power System |
| EPE2003 | Distributed Generation |
| EPE2005 | Engineering Optimization |

Stream Elective II

| | |
|---------|--|
| EPE2002 | FACTS and Custom Power |
| EPE2004 | Soft Computing Application to Power System |
| EME2002 | PWM Converters and Application |

List of Department Electives

| | |
|---------|---|
| ECD2001 | Industrial Data Networks |
| ECD2002 | Process Control and Industrial Automation |
| ECD2003 | Soft Computing Techniques |
| ECD2004 | Embedded Systems and Real-time Applications |
| ECD2005 | Biomedical Instrumentation |
| EPD2001 | New and Renewable Source of Energy |
| EPD2002 | SCADA System and Application |
| EMD2001 | Electric and Hybrid Vehicles |
| EDD2001 | Power Electronics System Design using ICs |
| EDD2002 | Energy auditing conservation and Management |
| EDD2003 | Advanced Power System Analysis |
| EDD2004 | Industrial Automation Tools |
| EID2001 | Advanced Microprocessors and Microcontrollers |
| EID2002 | Modern Power Converter |
| EID2003 | Power Plant Instrumentation |
| EID2004 | Advanced Control System Design |
| EID2005 | Multivariable Control Theory |

SEMESTER III

| Code No. | Name of Subject | Credit | Hrs / week | End Sem Exam (hours) | Marks | | | Remarks |
|-----------------|---|--------|------------|----------------------|-----------------------|-------------------|-------|--|
| | | | | | Continuous Assessment | End Semester Exam | Total | |
| ** | Stream Elective III | 3 | 3 | 3 | 40 | 60 | 100 | End Sem Exam is conducted by the Individual Institutions |
| ** | Stream Elective IV | 3 | 3 | 3 | 40 | 60 | 100 | Do |
| ** | Non- Dept. (Interdisciplinary) Elective | 3 | 3 | 3 | 40 | 60 | 100 | Do |
| EPC 3101 | Thesis – Preliminary – Part II | 5 | 14 | - | 200 | | 200 | No End Sem Examinations |
| | TOTAL | 14 | 23 | | 320 | 180 | 500 | 6 Hours of Departmental assistance work |

Stream Elective III

| | |
|---------|---|
| EPE3001 | Distribution System Planning and Automation |
| EPE3002 | Power System Stability and Reliability |
| EPE3005 | Power System Instrumentation |

Stream Elective IV

| | |
|---------|---|
| EPE3003 | EHV AC & DC Transmission System |
| EPE3004 | Static VAR Controllers and Harmonic Filtering |
| EME3001 | Dynamics of Power Converters |
| EME3002 | Design of Power Electronic System |

SEMESTER IV

| Code No | Subject Name | Credits | Hrs/ week | Marks | | | | Total |
|-----------------|--------------|-----------|-----------|-----------------------|----------------------|-------------------|------------|---|
| | | | | Continuous Assessment | | University Exam | | |
| | | | | Guide | Evaluation Committee | Thesis Evaluation | Viva Voce | |
| EPC 4101 | Thesis | 12 | 21 | 150 | 150 | 200 | 100 | 600 |
| | TOTAL | 12 | 21 | 150 | 150 | 200 | 100 | 8 Hours of Departmental assistance work |

EMA1001 ADVANCED MATHEMATICS AND OPTIMIZATION TECHNIQUES 3-0-0-3

Structure of the course

| | | |
|--------------------------|--------------|------------|
| Lecture | : 3 hrs/week | Credits: 3 |
| Internal Assessment | : 40 Marks | |
| End semester Examination | : 60 Marks | |

Course objective

1. Develop a conceptual basis for Linear algebra.
2. Equip the Students with a thorough understanding of vector spaces and optimization techniques.

Learning outcomes

Upon successful completion of this course, students will have basic knowledge of vector spaces and optimization theory which are essential for higher studies and research in Engineering.

Module I (Linear Algebra) (Definitions, theorems without proofs and problems)

Vector Spaces and sub spaces ,Null spaces ,Column spaces and Linear transformations , Dimensions of a vector space , Rank and Nullity, Innerproduct spaces, Norm and orthogonality- Gram -schemidt process. Matrix factorization-QR factorization, Singular value decomposition and least square problems.

Module II

Dual simplex method, Integer programming: Cutting plane method, Branch and bound method, Zero – One Programming, Unconstrained non-linear programming: Powel’s method, Hooke-Jeeves method.

Module III

Constrained non-linear programming: Kuhn-Tucker conditions, Convex programming problem, Quadratic programming, gradient of a function, steepest descent method, conjugate gradient method, Dynamic Programming: Minimal path problems.

References

1. David C. Lay, ‘*Linear Algebra*’, Pearson Edn., 4th Edn., 2012
2. Richard Bronson, Gabriel B. Costa, ‘*Linear Algebra - An Introduction*’, Elsevier-Academic Press, 2nd Edn.
3. Otto Bretsher, ‘*Linear Algebra with Application*’ - Pearson Education., 4th edn.
4. R. Hariprakash and B. Durga Prasad, *Operations Research* , Scitech. 1st edn., 2010
5. Handy A. Taha, *Operations Research an Introduction*, PHI, 9th Edn., 2011
6. B. S. Goel and S. K. Mittal, *Operations Research*, Pragathi Prakashan, 25th Edn., 2009.
7. K. V. Mittal and C. Mohan, ‘*Optimization Methods in Operations Research and System Analysis*’, 3rd Edn., New Age International Publishers.
8. Singiresu S Rao, *Engineering Optimization Theory and Practice*, 3rd Edn, New Age International Publishers.

Structure of the question paper

For the end semester examination, the question paper contains three questions from each module out of which two questions are to be answered by the student.

Structure of the course

| | | |
|--------------------------|--------------|------------|
| Lecture | : 3 hrs/week | Credits: 3 |
| Internal Assessment | : 40 Marks | |
| End semester Examination | : 60 Marks | |

Course Objective

1. To introduce computer applications in analysis of power systems
2. To understand the solution methods and techniques involved in power system studies

Learning outcomes

Upon successful completion of this course, students will have a better understanding of the merits and demerits of critical analytical solution methods which are the basis for valid techniques in solving power system problems

Module I

Review of solution of Linear System of equations by Gauss Jordan method, Gauss elimination, LU factorization and LDU factorization.

Load Flow Studies: Overview of Gauss, Gauss- Seidel and Newton Raphson Methods, Decoupled Load Flow, Fast Decoupled Load Flow, DC load flow, Three-phase Load Flow and Harmonic Load flow. Sparsity techniques, Triangular factorization and Optimal ordering.

Incorporation of FACTS devices in Load Flow: Static Tap Changing, Phase Shifting (PS), Static VAR Compensator (SVC), Thyristor Controlled Series Compensator (TCSC) and Unified Power Flow Controller (UPFC)

Module II

Elementary linear graph theory –Incidence and network matrices. Development of network matrices from Graph theoretic approach, Building algorithm for Bus impedance matrix, Modification of Z_{BUS} matrix due to changes in primitive network.

Short Circuit studies – Types of Faults – Short circuit study of a large power system – Algorithm for calculating system conditions after fault – three phase short circuit, three phase to ground, double line to ground, line to line and single line to ground fault.

Module III

State estimation – least square and weighted least square estimation methods for linear and non-linear systems. Static state estimation of power systems- injections only and line only algorithms, Treatment of bad data – detection, identification and suppression of bad data.

Contingency Analysis- adding and removing multiple lines, Analysis of single and multiple contingencies, Contingency Analysis by DC model, System reduction for contingency and fault studies

References

1. John J. Grainger, William D. Stevenson, Jr., *Power System Analysis*, Tata McGraw-Hill Series in Electrical and Computer Engineering.
2. I. J. Nagrath and D. P. Kothari, *Modern Power system Analysis*, 3rd Edition, Tata McGraw-Hill Publishers, 1980.
3. J. Arriliga and N. R. Watson, *Computer Modelling of Electrical Power Systems*, Wiley Publications, 2001
4. G.W. Stagg and El-Abiad, *Computer Methods in Power System Analysis*, McGraw Hill, 1968.
5. Hadi Saadat, *Power System Analysis*, McGraw-Hill Publishers.
6. Jos Arrillaga, Bruce C. Smith, Neville R. Watson, Alan Wood, *Power System Harmonic Analysis*, John Wiley and Sons, 1997.
7. S. A. Soman, S. A. Khaparde, Shubha Pandit, *Computational Methods For Large Sparse Power Systems Analysis: An Object Oriented Approach*, Kluwer Academic Publishers
8. G. L. Kusic, *Computer Aided Power System Analysis*, Prentice Hall, 1986.
9. H. E. Brown, *Large Networks by Matrix Methods*, John Wiley & Sons.

Structure of the question paper

For the end semester examination, the question paper contains three questions from each module out of which two questions are to be answered by the student.

EMC1001

POWER ELECTRONIC CIRCUITS

3-0-0-3

Structure of the course

| | | |
|--------------------------|--------------|------------|
| Lecture | : 3 hrs/week | Credits: 3 |
| Internal Assessment | : 40 Marks | |
| End semester Examination | : 60 Marks | |

Course Objective

To familiarize Power Electronic circuits.

Learning Outcome

Upon successful completion of this course, students will be able to:

1. Choose a suitable power semiconductor device for a specific application
2. Design experiments to characterize power devices
3. Develop ideal and nonideal model of power devices for analysis and simulation
4. Analyse and evaluate various power electronic converter topologies including AC-AC converters, DC-DC converters and inverters.
5. Design and develop power converter topologies.
6. Design control schemes for Power converters including PWM schemes

Module I

Power Electronic Elements: The ideal switch, Characteristics of ideal switches, two-quadrant and four-quadrant switches- Switching constraints in power electronic circuits-Practical switches: Static and dynamic characteristics of Power Diodes, MOSFETs, IGBTs and GTOs-implementations of different configurations of switches using semiconductor devices.

Losses in practical switches: Models of diode, MOSFET and IGBTs for evaluating conduction and switching losses.

Module II

AC voltage controllers: Analysis of single-phase ac voltage controller with R and RL load, Performance parameters, Sequential control of single-phase ac voltage controllers.

DC-DC converters: Buck, boost, buck-boost and Ćuk Topologies-Representation with ideal switches, Steady state analysis in continuous conduction mode using inductor volt-sec balance - current and voltage ripples. Design relations for inductor and capacitors. Discontinuous Conduction Mode operation of basic buck and boost converter. Isolated DC-DC converters: Steady-state analysis of flyback, forward, push-pull and bridge topologies.

Module III

Switched Mode Inverters: Topologies of single-phase half-bridge, full-bridge and three-phase bridge Voltage Source Inverters-Representation using ideal switches- stepped wave and PWM operation- Sine-Triangle PWM-Selective Harmonic Elimination--Space Vector PWM-Evaluation of dwell times.

Principles of Current-Controlled VSI- Hysteresis control and PWM current control.

Current Source Inverters: Analysis of capacitor commutated single phase CSI feeding resistive and pure-inductor loads.

References

1. Ned Mohan, *et al.*, *Power Electronics: Converters, Design and Applications*, Wiley
2. V. Ramanarayanan, *Course Notes on Switched Mode Power Converters*, Dept. of Electrical Engineering, IISc, Bangalore
3. G. K. Dubey, *et al.*, *Thyristorised Power Controllers*, New Age International Publishers
4. John Vithayathil, *Power Electronics: Principles and Application*, Tata McGraw-Hill
5. Bin Wu, *High Power Converters and AC Drives*, IEEE Press, Wiley Interscience, 2006.
6. L. Umanand, *Power Electronics: Essentials and Applications*, Wiley, 2009

Structure of the question paper

For the end semester examination, the question paper contains three questions from each module out of which two questions are to be answered by the student.

Structure of the course

| | | |
|--------------------------|--------------|------------|
| Lecture | : 3 hrs/week | Credits: 3 |
| Internal Assessment | : 40 Marks. | |
| End semester Examination | : 60 Marks | |

Course Objective

To develop the basic elements of generalized theory and to derive the general equations for voltage and torque of all type of rotating machines and to deal with their steady state and transient analysis.

Learning Outcome

Upon successful completion of this course, students will be able to:

1. To analyse machine behaviour based on the voltage and torque equations of the machine.
2. To analyse the transient behaviour of machines.

Module I

Unified approach to the analysis of electrical machine performance - per unit system - basic two pole model of rotating machines- Primitive machine -special properties assigned to rotor windings - transformer and rotational voltages in the armature voltage and torque equations resistance, inductance and torque matrix. Transformations - passive linear transformation in machines- invariance of power - transformation from three phase to two phase and from rotating axes to stationary axes-Park's transformation

Module II

DC Machines: Application of generalized theory to separately excited, shunt, series and compound machines. Steady state and transient analysis, transfer functions. Sudden short circuit of separately excited generator, sudden application of inertia load to separately excited dc motor.

Synchronous Machines: synchronous machine reactance and time constants-Primitive machine model of synchronous machine with damper windings on both axes. Balanced steady state analysis-power angle curves. Transient analysis- sudden three phase short circuit at generator terminals - armature currents and torque. - Transient power angle curve

Module III

Induction Machines: Primitive machine representation- Steady state operation-Equivalent circuit-Double cage rotor representation - Equivalent circuit -Single phase induction motor- Voltage and Torque equations.

References

1. P. S. Bhimbra, '*Generalized Theory Of Electrical Machines*', Khanna Publishers, 2002
2. Charles V. Johnes, '*Unified Theory Of Electrical Machines*'.
3. Adkins, Harley, '*General theory of ac machines*'.
4. C. Concordia, '*Synchronous Machines*'.
5. M. G. Say, '*Introduction to Unified Theory of Electrical Machines*'
6. E. W. Kimbark, '*Power System Stability - Vol. II*'.

Structure of the question paper

For the end semester examination, the question paper contains three questions from each module out of which two questions are to be answered by the student.

Structure of the course

| | | |
|--------------------------|--------------|------------|
| Lecture | : 3 hrs/week | Credits: 3 |
| Internal Assessment | : 40 Marks | |
| End semester Examination | : 60 Marks | |

Course Objective

Objective of the course is to make the students aware the importance of Economic operation as well as control of power system.

Learning Outcomes

Upon successful completion of this course, students will be able to:

1. Dispatch a power system economically considering take or pay fuel contract unit commitment and security constraints.
2. Model an AGC including excitation system and voltage regulators.

Module I

Introduction-Review of Thermal units.-The Lambda iteration method-First order gradient method base point and participation factors.

Generation with limited supply-Take or pay fuel contract-composite generation production cost function- solution of gradient search techniques. Hard limits and slack variables

Module II

Hydro-thermal coordination-Long range and short range scheduling- Hydro-electric plant models- scheduling problems types of scheduling problems. Scheduling energy -short-term hydrothermal scheduling problem- Pumped storage hydro plants- pumped storage hydro scheduling λ - γ iteration.

Inter change evaluation and power pools-Economy interchange evaluation with unit commitments. Types of interchange. Energy banking-power pools. Power system security-system monitoring-contingency analysis- security constrained optimal power flow- Factors affecting power system security. State estimation in power system-Introduction

Module III

Control of generation-Automatic Generation control Review-AGC implementation - AGC features - Modelling exercise using SIMULINK. AGC with optimal dispatch of Generation-Voltage control-AGC including excitation system.

MVAR control - Application of voltage regulator – synchronous condenser – transformer taps – static VAR compensators

References

1. Allen J.Wood, Wollenberg B.F., *Power Generation Operation and Control*, John Wiley & Sons, Second Edition, 1996.
2. S S. Vadhera, *Power System Analysis and Stability*, Khanna Publishers
3. Kirchmayer L.K., *Economic Control of Interconnected Systems*, John Wiley & Sons, 1959.
4. Nagrath, I.J. and Kothari D.P., *Modern Power System Analysis*, TMH, New Delhi, 2006.
5. B. M. Weedy, '*Electric Power Systems*', John Wiley and Sons, New York, 1987
6. A Montieelli., *State Estimation in Electric Power System-A Generalised Approach*
7. Ali Abur & Antonio Gomez Exposito, Marcel Dekkerjnc, *Power System State Estimation-Theory and Implementation*.
8. Hadi Sadat, *Power System Analysis*, Tata McGraw-Hill
9. Recent literature.

Structure of the question paper

For the end semester examination, the question paper contains three questions from each module out of which two questions are to be answered by the student.

EPC1003

POWER QUALITY

3-0-0-3

Structure of the course

| | | |
|--------------------------|-------------|------------|
| Lecture | : 3hrs/week | Credits: 3 |
| Internal Assessment | : 40 Marks | |
| End semester Examination | : 60 Marks | |

Course Objective

Objective of the course is to discuss various power quality issues and different methods to control them

Learning Outcomes

Upon successful completion of this course, students will be able to identify the power quality problems, causes and suggest suitable mitigating techniques.

Module I

Understanding Power Quality - Power quality issues in distribution systems - Sources and Effects of power quality problems, Power quality monitoring: Need for power quality monitoring, types of power quality disturbances - Voltage sag (or dip), Transients, short duration voltage variation, Long duration voltage variation, voltage imbalance, waveform distortion, and voltage flicker- methods of characterization- Power Quality Costs Evaluation - Causes and effects of power quality disturbances.

Module II

Harmonics -mechanism of harmonic generation-harmonic indices (THD, TIF, DIN, C - message weights). standards and recommended practices - Harmonic sources - SMPS, Three phase power converters, arcing devices, saturable devices, fluorescent lamps- Harmonic Analysis - Fourier series and coefficients, the Fourier transforms, discrete Fourier transform, fast Fourier transform, Window function- Effects of Power System harmonics on Power System equipment and loads

Module III

Harmonic elimination - Design philosophy of filters to reduce harmonic distortion - Power conditioners ,passive filter, active filter - shunt , series, hybrid filters, Computation of harmonic flows- Voltage regulation- devices for voltage regulation-capacitors for voltage regulation. Dynamic Voltage Restorers for sag, swell and flicker problems

Electromagnetic Interference (EMI -introduction -Frequency Classification - Electrical fields - Magnetic Fields - EMI Terminology - Power frequency fields - High frequency Interference - EMI susceptibility - EMI mitigation -Cable shielding- Health concerns of EMI

References

1. R. C. Durgan, M. F. Me Granaghan, H. W. Beaty, '*Electrical Power System Quality*', McGraw-Hill
2. Jose Arillaga, Neville R. Watson, '*Power System Harmonics*', Wiley, 1997
3. C. Sankaran, '*Power Quality*', CRC Press, 2002
4. G. T. Heydt, '*Power Quality*', Stars in circle publication, Indiana, 1991
5. Math H. Bollen, '*Understanding Power Quality Problems*'
6. *Power Quality Handbook*
7. J. B. Dixit & Amit Yadav, '*Electrical Power Quality*'
8. Recent literature

Structure of the question paper

For the end semester examination, the question paper consists of at least 60% design problems and derivations. The question paper contains three questions from each module out of which two questions are to be answered by the student.

Structure of the course

| | | |
|--------------------------|-------------|------------|
| Practical | : 2hrs/week | Credits: 1 |
| Internal Assessment | : 100 Marks | |
| End semester Examination | : Nil | |

Course Objectives

1. Ability to write program for load flow analysis and conduct different types of stability analysis, harmonic analysis and tie line control of power systems.
2. To conduct high voltage testing of insulators, various studies on power line training systems and relays.

Learning Outcomes

1. To understand concepts and problems involved in the power system analysis.
2. The students are able to perform analytical studies for issues in power system.

Experiments

1. Load flow analysis (Programming)
2. Short Circuit and Transient stability Studies
3. Voltage Instability Analysis
4. Harmonic Analysis
5. Simulation of AVR and AGC with Tie line control
6. High Voltage Testing of Insulators
7. Determination of Transmission line parameters, SIL, Regulation, Efficiency and Voltage control of Transmission Line Training System
8. Experiments on Relays
9. Active and Reactive Power Control of Alternator
10. Simulation of Power Electronic Circuits using PSCAD
11. Simulation study on Power Line Series Compensator

In addition to the above, the Department can offer a few experiments in the **Electrical Machines Laboratory** and newly developed experiments in the **Power Systems Laboratory**

Minimum of 10 experiments are to be conducted

EPC1102

SEMINAR

Structure of the Course

Seminar : 2 hrs/week Credits: 2
Internal Continuous Assessment : 100 Marks

The student is expected to present a seminar in one of the current topics in Power Systems related area. The student will undertake a detailed study based on current journals, published papers, books, on the chosen subject and submit seminar report at the end of the semester.

Marks:

Report Evaluation : 50

Presentation : 50

Structure of the course

| | | |
|--------------------------|-------------|------------|
| Lecture | : 3hrs/week | Credits: 3 |
| Internal Assessment | : 40 Marks | |
| End semester Examination | : 60 Marks | |

Course Objective

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

Learning Outcomes

Upon successful completion of this course, students will be able to suggest suitable advanced protection scheme for power system equipments.

Module I

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

Module II

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

Module III

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

References:

1. A. T. John and A. K. Salman- *Digital Protection for Power Systems*, IEE Power Series-15, Peter Peregrines Ltd., UK, 1997
2. Russeil C., Mason, '*The Art and Science of Protective Relaying*', John Wiley & Sons, 2002
3. Donald Reimert, '*Protective Relaying for Power Generation Systems*', Taylor & Francis-CRC press 2006
4. Gerhard Ziegler- '*Numerical Distance Protection*', Siemens, 2nd ed., 2006
5. A. R. Warrington, *Protective Relays*, Vol. 1&2, Chapman and Hall, 1973
6. T. S.Madhav Rao, *Power System Protection Static Relays With Microprocessor Applications*, Tata McGraw Hill Publication, 1994
7. Power System Protection Vol. I, II , III&IV, The Institution Of Electrical Engineers, Electricity Association Services Ltd., 1995
8. Helmut Ungrad , Wilibald Winkler, Andrzej Wiszniewski, '*Protection Techniques In Electrical Energy Systems*', Marcel Dekker, Inc. 1995
9. Badri Ram, D.N. Vishwakarma, '*Power System Protection and Switch Gear*', Tata McGraw-Hill, 2001

Structure of the question paper

For the end semester examination, the question paper contains three questions from each module out of which two questions are to be answered by the student.

Structure of the course

| | | |
|--------------------------|-------------|------------|
| Lecture | : 3hrs/week | Credits: 3 |
| Internal Assessment | : 40 Marks | |
| End semester Examination | : 60 Marks | |

Course Objective

To introduce various types of small signal stability problems that will encounter in power systems and also to introduce means to overcome them

Learning Outcomes

Upon successful completion of this course, students will be able to identify the small signal and stability problems, analyse them and to design power system stabilizers which can improve small signal stability in a power system.

Module I

Concept of Power system stability-Types of stability-Classical model of single machine connected to infinite bus and a multi machine system-mathematical modelling of power system elements for stability studies-Synchronous machines. Excitation systems and Prime mover controllers-Transmission lines-Loads-HVDC and FACTS devices

Module II

Small Signal Analysis-Fundamental concepts of Stability of Dynamic Systems: State Space representation-Linearization-Eigen properties of state matrix-Small Signal Stability of Single Machine Infinite Bus(SMIB) System-Heffron-Phillips constants-Effects on Excitation system -Block diagram representation with exciter and AVR-Power System Stabiliser (PSS): State matrix including PSS-Small Signal Stability of Multi Machine Systems-Special Techniques for analysis of very large systems: Analysis of Essentially Spontaneous Oscillations in Power Systems(AESOPS) algorithms-Modified Arnoldi Method(MAM), Characteristics of Small Signal Stability Problems: local problems and global problems-Small Signal Stability Enhancement: Using Power System Stabilisers-Supplementary control of Static VAR Compensators-Supplementary Control of HVDC transmission links-Inter area oscillations

Module III

Sub-synchronous Resonance (SSR)-Turbine-Generator torsional Characteristics-Torsional interaction with Power System Controls-Sub synchronous resonance-Impact of network switching disturbances-Torsional interaction between closely coupled units-Hydro generator torsional characteristics

References:

3. Anderson and Foud, '*Power System Control and Stability*', Galgotia Publications, 1981
4. K. R. Padiyar, '*Power System Dynamics*', 2nd Edition, B. S. Publishers, 2003
5. P. Kundur, '*Power system Stability and Control*', McGraw-Hill Inc., 1994
6. P. W. Sauer & M. A. Pai, '*Power System Dynamics and Stability*', Pearson, 2003
7. Olle I. Elgerd, '*Electric Energy Systems Theory an Introduction*', 2nd Edition, McGraw-Hill, 1983
8. E. W. Kimbark, '*Power System Stability*', Wiley & IEEE Press, 1995
9. Yao-nan-Yu, '*Electric Power Systems Dynamics*', Academic Press, 1983

Structure of the question paper

For the end semester examination, the question paper contains three questions from each module out of which two questions are to be answered by the student.

Structure of the course

| | | |
|--------------------------|-------------|------------|
| Lecture | : 3hrs/week | Credits: 3 |
| Internal Assessment | : 40 Marks | |
| End semester Examination | : 60 Marks | |

Course Objective

To introduce various types of transient over-voltages in power system and the methods to overcome them

Learning Outcomes

Upon successful completion of this course, students will be able to

1. Identify different types of transient over-voltages.
2. Model different equipments for transient study.
3. Design protective devices against transient over-voltages.

Module I

Lightning and travelling waves : Transients in electric power systems - internal and external causes of over voltages - lightning strokes - mathematical model to represent lightning - stroke to tower and midspan - travelling waves in transmission lines selection of typical wave to represent over voltages.

Switching Transients : Switching transients - the circuit closing transient - the recovery transient initiated by the removal of the short circuit — double frequency transients

Module II

Abnormal switching transients - current suppression - capacitance switching - arcing ground - transformer inrush current – ferro resonance - neutral connections - transients in switching a three phase reactor- three phase capacitor.

Surges in transformers: Step voltage - voltage distribution in transformer winding -winding oscillations - Travelling wave solutions - Transformer core under surge conditions.

Module III

Voltage surges -Transformers - Generators and motors -Transient parameter values for transformers - Reactors - Generators - Transmission lines Protective Devices and Systems: Basic idea about protection - surge diverters - surge absorbers - ground fault neutralizers - protection of lines and stations by shielding -ground wires - counter poises - driven rods - modern lightning arrestors - insulation coordination - protection of alternators- industrial drive systems.

References

1. Allen Greenwood, '*Electrical Transients in Power Systems*', Wiley Interscience, 1971
2. Bewely L. W., '*Travelling Waves and Transmission Systems*', Dover Publications, New York, 1963
3. Gallagher P. J. and Pearmain A. J., '*High Voltage Measurement, Testing and Design*', John Wiley and Sons, New York, 1982.
4. Klaus Ragallea, '*Surges and High Voltage Networks*', 1980.
5. Diesendorf W., '*Overvoltages on High Voltage Systems*', Rensselaer Book Store, Roy, New York, 1971.

Structure of the question paper

For the end semester examination, the question paper contains three questions from each module out of which two questions are to be answered by the student.

Structure of the course

| | | |
|--------------------------|-------------|------------|
| Lecture | : 3hrs/week | Credits: 3 |
| Internal Assessment | : 40 Marks | |
| End semester Examination | : 60 Marks | |

Course Description

This course focuses on the new renewable energy based electric energy generation technologies and their integration into the power grid. The principles of new energy based distributed generation technologies: solar, wind, and fuel cells. Interconnection of distributed generation sources to power distribution grid. Economic aspects of distributed generation.

Course Objectives

1. Have a working knowledge of the emerging power generation technologies such as photovoltaic arrays, wind turbines, and fuel cells.
2. Model renewable electrical energy systems for analysis and design.
3. Calculate the basic performance parameters of these systems, such as efficiency and cost.
4. Perform basic assessment and design of a renewable electrical energy system for a given application.
5. Determine the requirements for interconnecting a renewable electrical energy system to the utility electric power grid.

Learning Outcomes

Upon successful completion of this course, students will be able to

1. Choose the right renewable energy source and storage method
2. Design various interconnecting options of DG with the grid and its control
3. Address the problems of islanding, reactive power management and harmonics in a DG systems and its economic aspects

Module I

Distributed Generation Definition, Distributed generation advantages, challenges and needs. Non conventional and renewable energy sources-Wind Power- wind turbine and rotor types, wind speed – power curve, power coefficient, tip speed ratio, wind energy distribution, environmental impact. Photovoltaic and Thermo-solar power –Solar cell technology, Photovoltaic power characteristics and Thermo-solar power generation. Biomass Power, Fuel cells types, types of Tidal power generation schemes, mini and micro hydro power schemes, and Micro turbines for DG, bulb and tubular turbines. Energy Storage for use with Distributed Generation-Battery Storage, Capacitor Storage, ultra capacitors and Mechanical Storage: Flywheels, Pumped and Compressed Fluids.

Module II

Grid Interconnection Options, Pros and Cons of DG – Grid Interconnection, Standards of interconnection. Recent trends in power electronic DG interconnection. General power electronic DG interconnection topologies for various sources and control. Control of DG inverters, current control and DC voltage control for stand alone and grid parallel operations. Protection of the converter, Control of grid interactive power converters, phase locked loops ,synchronization and phase locking techniques, current control, DC bus control during grid faults, converter faults during grid parallel and stand alone operation.

Module III

Intentional and unintentional islanding of distribution systems. Passive and active detection of unintentional islands, non detection zones. Reactive power support using DG. Power quality improvement using DG, Power quality issues in DG environment.

Economic aspects of DG- Generation cost, investment, tariffs analysis. Hybrid energy systems.

References

1. Lee Willis & Walter G. Scott, '*Distributed Power Generation, Planning & Evaluation*', 2000 Edition, CRC Press Taylor & Francis Group.
2. Godfrey Boyle, '*Renewable Energy Power for A Sustainable Future*', 2004 Oxford University Press in association with the Open University.
3. D. Mukherjee, S.Chakrabarti, '*Fundamentals of Renewable Energy Systems*', New Age International Publishers.
4. W. Kramer, S. Chakraborty, B. Kroposki, and H. Thomas, '*Advanced Power Electronic Interfaces for Distributed Energy Systems Part 1: Systems and Topologies*', March 2008, *Technical Report NREL/TP-581-42672*

In addition to readings from the textbook, the course will use selected papers and articles from professional magazines and industry internet sources as reference materials.

Structure of the question paper

For the end semester examination, the question paper contains three questions from each module out of which two questions are to be answered by the student.

Structure of the course

| | | |
|--------------------------|-------------|------------|
| Lecture | : 3hrs/week | Credits: 3 |
| Internal Assessment | : 40 Marks | |
| End semester Examination | : 60 Marks | |

Learning Outcomes

Upon successful completion of this course, students will be able to solve optimisation problems in engineering very effectively.

Course Objectives

1. Provide the students with basic mathematical concepts of optimization
2. Provide the students with modelling skills necessary to describe and formulate optimization problems
3. Provide the students with the skills necessary to solve and interpret optimization problems in engineering.

Module I

Review of linear and non-linear programming

Sensitivity analysis to linear programming problem-changes in constants of constraints, changes in cost coefficients-changes in the coefficients of constraints, addition of new variables and addition of new constraints.

Piecewise linear approximation of a non-linear function, multi objective optimization-weighted and constrained methods, multilevel optimization

Module II

Genetic algorithm: Basic concept , encoding , fitness function, Reproduction ,Basic genetic programming concepts, differences between GA and Traditional optimization methods, Applications, Variants of GA-Simulated Annealing, Particle Swarm optimization

Module III

Theory of Games : Characteristics-Two Persons Zero sum Games- Maximin, Minimax principle - Saddle points- Games without Saddle Points

Reliability- Basic concepts-conditional failure rate function-failure time distributions-certain life models – reliability of a system in terms of the reliability of its components- series systems- parallel systems

References

1. G. V. Reklaitis, A. Ravindran & K. M. Ragsdell, '*Engineering Optimization, Methods and Applications*', John Wiley & Sons.
2. Singiresu S. Rao, John, '*Engineering Optimization Theory and Practice*', 3rd Edition, Wiley and Sons, 1998
3. A. Ravindran, Don T. Philips and Jamer J. Solberg, '*Operations Research - Principles and Practice*', John Wiley & Sons.
4. P. G. Gill, W Murray and M. H. Wright, '*Practical Optimization*', Academic Press, 1981.
5. Fredrick S. Hiller and G J Liberman, '*Introduction to Operations Research*', McGraw-Hill Inc., 1995.
6. Ashok D. Belegundu, Tirupathi R. Chandrapatla, '*Optimization Concepts and Applications in Engineering*', Pearson Education, Delhi, 2002.
7. G Owen, Game Theory
8. Hans Peters, *Game Theory: A Multilevel Approach*
9. Davis E. Goldberg , *Genetic Algorithms: Search, Optimization and Machine Learning*, Addison Wesley

Knowledge in matrix algebra and differential calculus.

Structure of the question paper

For the end semester examination, the question paper contains three questions from each module out of which two questions are to be answered by the student.

Structure of the course

| | | |
|--------------------------|-------------|------------|
| Lecture | : 3hrs/week | Credits: 3 |
| Internal Assessment | : 40 Marks | |
| End semester Examination | : 60 Marks | |

Course Objective

Advances in Power electronics Industry led to rapid development of Power Electronics controllers for fast real and reactive power control and to introduce these advancements.

Learning Outcomes

Upon successful completion of this course, students will be able to select suitable FACTS device for the enhancement of power transfer capability and to control the power flow in an efficient manner.

Module I

Power flow in Power Systems-Benefits of FACTS Transmission line compensation- Uncompensated line -shunt compensation - Series compensation -Phase angle control. Reactive power compensation – shunt and series compensation principles – reactive compensation at transmission and distribution level – Static vs. Passive VAR Compensators – Converters for Static Compensation

Module II

Static shunt Compensator - Objectives of shunt compensations, Methods of controllable VAR generation - Variable impedance type VAR Generators -TCR, TSR, TSC, FC-TCR Principle of operation, configuration and control, Switching converter type VAR generators- Principle of operation, configuration and control, SVC and STATCOM, Comparison between SVC and STATCOM - Applications

Module III

Static Series compensator - Objectives of series compensations, Variable impedance type series compensators - GCSC. TCSC, TSSC - Principle of operation, configuration and control. Application of TCSC for mitigation of SSR. Switching converter type Series Compensators (SSSC)- Principle of operation, configuration and control. Static Voltage and Phase Angle Regulators (TCVR &TCPAR): Objectives of Voltage and Phase angle regulators, Thyristor controlled Voltage And Phase angle Regulators

Unified Power Flow Controller: Circuit Arrangement, Operation and control of UPFC- Basic principle of P and Q control- independent real and reactive power flow control- Applications - Introduction to interline power flow controller. Modelling and simulation of FACTS controllers

References

1. T. J. E. Miller, '*Reactive Power Control in Power Systems*', John Wiley, 1982
2. J. Arriliga and N. R. Watson, '*Computer Modelling of Electrical Power Systems*', Wiley, 2001
3. N. G. Hingorani and L. Gyugyi, '*Understanding FACTS*', IEEE Press, 2000
4. K. R. Padiyar, '*FACTS Controllers in Power Transmission and Distribution*', New Age International Publishers, 2007
5. Y.H. Song and A.T. Johns, '*Flexible ac Transmission Systems (FACTS)*', IEE Press, 1999
6. Ned Mohan et al., '*Power Electronics*', John Wiley and Sons.
7. Dr. Ashok S. & K. S. Suresh Kumar, '*FACTS Controllers and Application*' Course Book for STTP 2003
8. Current Literature

Structure of the question paper

For the end semester examination, the question paper contains three questions from each module out of which two questions are to be answered by the student.

EPE2004

SOFT COMPUTING APPLICATION TO POWER SYSTEM

3-0-0-3

Structure of the course

| | | |
|--------------------------|--------------|------------|
| Lecture | : 3 hrs/week | Credits: 3 |
| Internal Assessment | : 40 Marks | |
| End semester Examination | : 60 Marks | |

Course Objective

The course provides exposure to soft computing techniques and its applications in Power Systems

Learning Outcomes

Upon successful completion of this course, students will be able to apply soft computing techniques in power system analysis such as load-flow analysis, power quality analysis, stability analysis etc.

Module I

Biological foundations - ANN models - Types of activation function - Introduction to Network architectures -Multi Layer Feed Forward Network (MLFFN) - Radial Basis Function Network (RBFN) - Recurring Neural Network (RNN). Supervised and unsupervised learning - Error-correction learning - Hebbian learning – Boltzmann learning - Single layer and multilayer perceptrons - Least mean square algorithm – Back propagation algorithm – application in power systems-load flow analysis-contingency analysis-power quality analysis

Module II

Fuzzy set operations - Properties - Membership functions - Fuzzy to crisp conversion - fuzzification and defuzzification methods -fuzzy control systems –fuzzy logic model s-applications in power systems-AGC single area system-small signal stability

Module III

Genetic Algorithm -Introduction - basic concepts - application
Adaptive fuzzy systems - hybrid systems - Adaptive Neuro-fuzzy Inference System (ANFIS) controllers

References

1. J.M. Zurada, '*Introduction to Artificial Neural Systems*', Jaico Publishers, 1992.
2. Simon Haykins, '*Neural Networks - A comprehensive foundation*', Macmillan College, Proc., Con., Inc., New York, 1994.
3. D. Driankov. H. Hellendorn, M. Reinfrank, '*Fuzzy Control - An Introduction*', Narosa Publishing House, New Delhi, 1993.
4. HJ. Zimmermann, '*Fuzzy Set Theory and its Applications*', 111 Edition, Kluwer Academic Publishers, London.
5. G.J. Klir, Boyuan, '*Fuzzy Sets and Fuzzy Logic*', Prentice Hall of India Pvt. Ltd, 1997.
6. Stamatios V Kartalopoulos, '*Understanding Neural Networks and Fuzzy Logic Basic Concepts and Applications*', Prentice Hall of India (P) Ltd., New Delhi, 2000.
7. Timothy J. Ross, '*Fuzzy Logic with Engineering Applications*', McGraw Hill, New York.
8. Suran Goonatilake, Sukhdev Khebbal (Eds.), '*Intelligent Hybrid Systems*', John Wiley & Sons, New York, 1995.
9. Vose Michael D., '*Simple Genetic Algorithm - Foundations and Theory*', Prentice Hall of India.
10. Rajasekaran & Pai, '*Neural Networks, Fuzzy Logic, and Genetic Algorithms: Synthesis and Applications*', Prentice-Hall of India, 2007.
11. J.S. Roger Jang, C.T. Sun and E. Mizutani, '*Neuro Fuzzy and Soft Computing*', Prentice Hall Inc., New Jersey, 1997.
12. Recent Literature

Structure of the question paper

For the end semester examination, the question paper contains three questions from each module out of which two questions are to be answered by the student.

Structure of the course

| | |
|--------------------------|--------------|
| Lecture | : 3 hrs/week |
| Internal Assessment | : 40 Marks |
| End semester Examination | : 60 Marks |

Credits: 3

Course Objective

To equip the students with knowledge of PWM technique that has emerged from recent research and various topologies of multi-level converters and application of PWM converters

Learning Outcomes

Upon successful completion of this course, students will be able to:

1. Represent complex power converters using simple switch elements and analyse their steady state behaviour.
2. Create simulation models of advanced PWM converters including multilevel converters.
3. Design and implement modulation/control strategies such as sine-triangle PWM, Space Vector PWM and hysteresis control.
4. Develop control strategies for PWM converters with applications to drives, active front-end rectifier and shunt active filters.
5. Analyse and develop selective harmonic elimination strategies for converters.
6. Implement space vector modulation for CSI.

Module-I

Use of Single-Pole-Double-Throw Single-Pole-Multi-Throw switches to describe Converter Topologies: Basic switch constraints-Implementation of various switch schemes using available power semiconductor devices.

Topologies of Inverters and Rectifiers--relation between Pole voltages, Line voltages and Line-to-load neutral voltages in multi-phase two-level inverters-Basic modulation methods--duty ratio--sine-triangle modulation--implementation of unipolar and bipolar modulation--three-phase inverters- Harmonic performance of Unipolar and Bipolar modulation schemes in single phase and three phase inverters-linear modulation and overmodulation

Module-II

Space vector PWM - conventional sequence- 30 degree and 60 degree bus clamped PWM--relation between sine-triangle and space vector PWM--dc bus utilisation of SPWM and SVPWM. Overmodulation in SVPWM-Overmodulation zones.

Synchronised and non-synchronised PWM-Multilevel Converters: Topologies. Neutral Point Clamped and Flying Capacitor Topologies. Cascaded Multilevel Inverters-Multilevel Converters Modulation - Carrier based approach-Conventional Space Vector Modulation for 3-level inverters.

Module-III

Applications of PWM converters--Active front end rectifier--vector control of front-end rectifier--Control of Shunt active filter - PWM converters in AC drives--Current Control in inverters: Current controlled PWM VSI -Hysteresis Control - fixed band and variable band hysteresis.

Selective Harmonic Elimination-Derivation of simultaneous transcendental equations for elimination of harmonics- PWM Current Source Inverters--Current Space Vectors- Space Vector Modulation of CSI-Application of CSI in high-power drives-Fundamental principles of Hybrid schemes with CSI and VSI.

References

1. Joseph Vithayathil, '*Power Electronics*', McGraw-Hill
2. Bin Wu, '*High Power Converters and AC Drives*'
3. Ned Mohan, *et. al.*, '*Power Electronics: Converters, Design and Applications*', Wiley
4. L. Umanand, '*Power Electronics: Essentials and Applications*', Wiley, 2009.
5. Werner Leonhard, '*Control of Electrical Drives*', 3rd Ed., Springer
6. Bimal K. Bose, '*Modern Power Electronics and AC Drives*', Prentice Hall

Technical Papers

1. J. Holtz, "Pulse-width Modulation - A Survey", *IEEE Trans. IE*, Vol. IE-39(5), 1992,
2. J. Holtz, "Pulse-width Modulation for Electronic Power Conversion", *Proc. IEEE*, Vol. 82(8), 1994, pp. 1194-1214.
3. V. T. Ranganathan, *Space Vector Modulation: A Status Review*, *Sadhana*, Vol. 22(6), 1997, pp. 675-688.
4. L. M. Tolbert, F.Z.Peng and T. G. Habelter, "Multilevel inverters for large electric drives, *IEEE Transactions on Industry Applications*, vol. 35, No.1, pp. 36-44, Jan./Feb. 1999.
5. Sangshin Kwak, Hamid A. Toliyat, "A Hybrid Solution for Load-Commutated-Inverter- Fed Induction Motor Drives," *IEEE Trans. on Industry Applications*, vol. 41, no. 1, January/February 2005.
6. Sangshin Kwak, Hamid A. Toliyat, "A Hybrid Converter System for High-Performance Large Induction Motor Drives," *IEEE Trans. on Energy Conversion*, vol. 20, no. 3, September 2005.
7. Sangshin Kwak, Hamid A. Toliyat, "A Current Source Inverter With Advanced External Circuit and Control Method," *IEEE Trans. on Industry Applications*, vol. 42, no. 6, November/December 2006.
8. A.R. Beig, and V.T. Ranganathan, "A novel CSI-fed Induction Motor Drive," *IEEE Trans. on Power Electronics*, vol. 21, no. 4, July 2006.
9. H.Stemmler, "High-power industrial drives," *Proc. IEEE*, Vol. 82(8), 1994, pp. 1266- 1286.

Thesis/Reports

1. A.R.Beig, “Application of three level voltage source inverters to voltage fed and current fed high power induction motor drives” -*Ph.D. Thesis of Electrical Engineering*, IISc, Bangalore, April 2004.
2. G. Narayanan, “Synchronised Pulse-width Modulation Strategies based on Space Vector Approach for Induction Motor Drives”-*Ph.D. Thesis of Electrical Engineering*, IISc, Bangalore, August 1999.
3. Debmalya Banerjee, “Load Commutated Current Source Inverter fed Induction Motor drive with sinusoidal voltage and current,” - *PhD. Thesis of Electrical Engineering*, IISc, Bangalore, June 2008.

Structure of the question paper

For the end semester examination, the question paper contains three questions from each module out of which two questions are to be answered by the student.

ECD2001

INDUSTRIAL DATA NETWORKS

3-0-0-3

Structure of the course

| | |
|--------------------------|--------------|
| Lecture | : 3 hrs/week |
| Internal Assessment | : 40 Marks |
| End semester Examination | : 60 Marks |

Credits: 3

Course objectives

1. To understand the basics of data networks and internetworking
2. To have adequate knowledge in various communication protocols
3. To study the industrial data networks

Learning Outcomes

Upon successful completion of this course, students will be able to:

1. Explain and analyse the principles and functionalities of various industrial Communication Protocols
2. Implement and analyse industrial Ethernet and wireless communication modules

Module I

Data Network Fundamentals: Network hierarchy and switching – Open System Interconnection model of ISO– Data link control protocol: - HDLC – Media access protocol – Command/response – Token passing – CSMA/CD, TCP/IP, Bridges – Routers – Gateways –Standard ETHERNET and ARCNET configuration special requirement for networks used for control.

Module II

Hart, Fieldbus, Modbus and Profibus PA/DP/FMS and FF: Introduction- Evolution of signal standard – HART communication protocol – Communication modes - HART networks - HART commands - HART applications. Fieldbus: Introduction - General Fieldbus architecture - Basic requirements of Field bus standard - Fieldbus topology - Interoperability - Interchangeability - Introduction to OLE for process control (OPC). MODBUS protocol structure - function codes - troubleshooting Profibus: Introduction - profibus protocol stack – profibus communication model - communication objects - system operation - troubleshooting - review of foundation field bus.

Module III

Industrial Ethernet and Wireless Communication: Industrial Ethernet: Introduction - 10Mbps Ethernet, 100Mbps Ethernet. Radio and wireless communication: Introduction - components of radio link - the radio spectrum and frequency allocation - radio modems.

References

1. Steve Mackay, Edwin Wrijut, Deon Reynders, John Park, '*Practical Industrial Data Networks Design, Installation and Troubleshooting*', Newnes publication, Elsevier, First edition, 2004.
2. William Buchanan '*Computer Busses*', CRC Press, 2000.
3. Andrew S. Tanenbaum, '*Modern Operating Systems*', Prentice Hall India, 2003
4. Theodore S. Rappaport, '*Wireless Communication: Principles & Practice*, 2nd Edition, 2001, Prentice Hall of India
5. Willam Stallings, '*Wireless Communication & Networks*' 2nd Edition, 2005, Prentice Hall of India

Structure of the Question Paper

For the end semester examination, the question paper consists of three questions from each module, out of which two are to be answered by the students.

Industrial Relevance of the Course

There is a serious shortage of industrial data communications and industrial IT engineers, technologists and technicians in the world. Only recently these new technologies have become a key component of modern plants, factories and offices. Businesses throughout the world comment on the difficulty in finding experienced industrial data communications and industrial IT experts, despite paying outstanding salaries. The interface from the traditional SCADA system to the web and SQL databases has also created a new need for expertise in these areas. Specialists in these areas are few and far between. The aim of this course is to provide students with core skills in working with industrial data Communications and industrial IT systems and to take advantage of the growing need by industry.

Structure of the course

| | |
|--------------------------|--------------|
| Lecture | : 3 hrs/week |
| Internal Assessment | : 40 Marks |
| End semester Examination | : 60 Marks |

Credits: 3

Course objectives

1. To provide an insight into process control.
2. To provide knowledge on the role of PID controllers in an industrial background.
3. To give an overview of the different control structures used in process control.
4. To give an in depth knowledge on industrial automation-SCADA and PLC.

Learning Outcomes

Upon successful completion of this course, students will be able to

1. Model a process control system and analyse its performance.
2. Design and tune PID controllers for a system.
3. Recognise the need of each type of control structure used in industry.
4. Write simple ladder programs for simple industrial automation –case study.

Module I

Introduction to process dynamics: Physical examples of first order process-first order systems in series-dynamic behaviour of first and second order systems - Control valves and transmission lines, the dynamics and control of heat exchangers. Level control, flow control, dynamics, Stability and control of chemical reactors, Control modes: on-off, P, PL PD, PID, Controller tuning-Zeigler Nichols self tuning methods.

Module II

Advanced control techniques: Feed forward control, Cascade control. Ratio control. Adaptive control, Override control, Control of nonlinear process. Control of process with delay. Hierarchical control, Internal mode control, Model predictive control. Statistical process control. Digital controllers Effects of sampling-implementation of PID controller-stability and tuning-digital feed forward control.

Module III

Industrial Automation: SCADA Systems, SCADA Architecture: Monolithic, Distributed and Networked. Programmable logic controllers, combinational and sequential logic controllers - System integration with PLCs and computers - PLC application in Industry - distributed control system - PC based control - Programming On /Off Inputs to produce On/Off outputs, Relation of Digital Gate Logic to contact /Coil Logic, PLC programming using Ladder Diagrams from Process control Descriptions, Introduction to IEC 61511/61508 and the safety lifecycle.

References

1. George Stephanopoulos, "*Chemical Process Control*", Prentice-Hall of India
2. Donald R. Coughnour, '*Process System Analysis and Control*', McGraw-Hill, 1991
3. D. E. Seborg, T. F. Edgar, '*Process Dynamics and Control*', John Wiley, 1998
4. Enrique Mandado, Jorge Marcos, Serafin A Perrez, '*Programmable Logic Devices and Logic Controllers*', Prentice-Hall, 1996
5. Dobrivoje Popovic, Vijay P. Bhatkar, Marcel Dekker, '*Distributed Computer Control for Industrial Automation*', INC, 1990
6. G. Liptak, '*Handbook of Process Control*, 1996
7. Ronald A. Reis, '*Programmable logic Controllers Principles and Applications*', Prentice-Hall of India
8. *Pocket Guide on Industrial Automation for Engineers and Technicians*, Srinivas Medida, IDC Technologies

Structure of the Question Paper

For the end semester examination, the question paper consists of three questions from each module, out of which two are to be answered by the students.

ECD2003

SOFT COMPUTING TECHNIQUES

3-0-0-3

Structure of the course

| | | |
|--------------------------|--------------|------------|
| Lecture | : 3 hrs/week | Credits: 3 |
| Internal Assessment | : 40 Marks | |
| End semester Examination | : 60 Marks | |

Course objectives

1. To provide concepts of soft computing and design controllers based on ANN and Fuzzy systems.
2. To identify systems using soft computing techniques.
3. To give an exposure to optimization using genetic algorithm.
4. To provide a knowledge on hybrid systems.

Learning Outcomes

Upon successful completion of the course, students will be able to:

1. Design a complete feedback system based on ANN or Fuzzy control.
2. Identify systems using soft computing techniques.
3. Use genetic algorithm to find optimal solution to a given problem.
4. Design systems by judiciously choosing hybrid techniques.

Module I

Neural network: Biological foundations - ANN models - Types of activation function - Introduction to Network architectures - Multi Layer Feed Forward Network (MLFFN) - Radial Basis Function Network (RBFN) - Recurring Neural Network (RNN).

Learning process : Supervised and unsupervised learning - Error-correction learning - Hebbian learning – Boltzmann learning - Single layer and multilayer perceptrons - Least mean square algorithm – Back propagation algorithm - Applications in pattern recognition and other engineering problems Case studies - Identification and control of linear and nonlinear systems.

Module II

Fuzzy sets: Fuzzy set operations - Properties - Membership functions , Fuzzy to crisp conversion, fuzzification and defuzzification methods , applications in engineering problems.

Fuzzy control systems: Introduction - simple fuzzy logic controllers with examples - Special forms of fuzzy logic models, classical fuzzy control problems , inverted pendulum, image processing , home heating system, Adaptive fuzzy systems.

Module III

Genetic Algorithm: Introduction - basic concepts, application.

Hybrid Systems: Adaptive Neuro-fuzzy Inference System (ANFIS), Neuro-Genetic, Fuzzy-Genetic systems. Ant colony optimization, Particle swarm optimization (PSO). Case Studies.

References

1. J. M. Zurada, '*Introduction to Artificial Neural Systems*', Jaico Publishers, 1992.
2. Simon Haykins, '*Neural Networks - A Comprehensive Foundation, Mcmillan College*', Proc., Con., Inc., New York. 1994.
3. D. Driankov. H. Hellendorn, M. Reinfrank, '*Fuzzy Control - An Introduction, Narora Publishing House*', New Delhi, 1993.
4. H. J. Zimmermann, '*Fuzzy Set Theory and its Applications*', 111 Edition, Kluwer Academic Publishers, London.
5. G. J. Klir, Boyuan, '*Fuzzy Sets and Fuzzy Logic*', Prentice Hall of India (P) Ltd, 1997.
6. Stamatios V Kartalopoulos, '*Understanding Neural Networks And Fuzzy Logic Basic Concepts And Applications*', Prentice Hall of India (P) Ltd, New Delhi, 2000.
7. Timothy J. Ross, '*Fuzzy Logic With Engineering Applications*', McGraw Hill, New York.
8. Suran Goonatilake, Sukhdev Khebbal (Eds.), '*Intelligent Hybrid Systems*', John Wiley & Sons, New York, 1995.
9. Vose Michael D., '*Simple Genetic Algorithm - Foundations and Theory*', Prentice Hall of India.
10. Rajasekaran & Pai, '*Neural Networks, Fuzzy Logic, and Genetic Algorithms: Synthesis and Applications*', Prentice-Hall of India, 2007.
11. J. S. Roger Jang, C. T. Sun and E. Mizutani, '*Neuro Fuzzy and Soft Computing*', Prentice Hall Inc., New Jersey, 1997.

Structure of the Question Paper

For the end semester examination, the question paper consists three questions from each module, out of which two are to be answered by the students.

ECD2004 EMBEDDED SYSTEMS AND REAL TIME APPLICATIONS

3-0-0-3

Structure of the course

| | | |
|--------------------------|--------------|------------|
| Lecture | : 3 hrs/week | Credits: 3 |
| Internal Assessment | : 40 Marks | |
| End semester Examination | : 60 Marks | |

Course objectives

1. To equip students for the development of an Embedded System for Control/ Guidance/ Power/Electrical Machines applications.
2. To make students capable of developing their own embedded controller for their applications

Learning outcomes

Upon successful completion of this course, students will be able to design and develop suitable embedded controller for any physical system and implement it in real-time.

Module I

Introduction to Embedded Systems: Embedded system definition, features. Current trends and Challenges, Real-time Systems. Hard and Soft, Predictable and Deterministic kernel, Scheduler. 8051-8 bit Microcontroller: Architecture, CPU Block Diagram, Memory management, Interrupts peripheral and addressing modes. ALP & Embedded C programming for 8051 based system-timer, watch dog timer, Analog & digital interfacing, serial communication. Introduction to TI MSP430 microcontrollers. Architecture, Programming and Case study/Project with popular 8/16/32 bit microcontrollers such as 8051, MSP 430, PIC or AVR.

Module II

High Performance RISC Architecture : ARM Processor Fundamentals, ARM Cortex M3 Architecture, ARM Instruction Set, Thumb Instructions, memory mapping, Registers, and programming model. Optimizing ARM assembly code. Exceptions & Interrupt handling. Introduction to open source development boards with ARM Cortex processors, such as Beagle Board, Panda board & leopard boards. Programming & porting of different OS to open source development boards.

Module III

Real time Operating System: Basic Concepts, Round robin, Round robin with interrupts, Function queue scheduling architecture, semaphores, Mutex, Mail box, memory management, Priority inversion, thread Synchronisation. Review of C-Programming, RTOS Linux & RTLinux Internals, Programming in Linux & RTLinux Configuring & Compiling RTLinux.

References

1. Raj Kamal, "*Embedded Systems*", Tata McGraw-Hill, 2003
2. Shultz T. W., "C and the 8051: Programming for Multitasking", Prentice-Hall, 1993
3. Mazidi, "*The 8051 Microcontrollers & Embedded Systems*", Pearson Education Asia.
4. B. Kanta Rao, "*Embedded Systems*", PHI, 2011
5. Barnett, R. H., "*The 8051 family of Microcontroller*", Prentice Hall, 1995.
6. Ayala K. J., *The 8051 Microcontroller: Architecture, Programming and Applications*, West Publishing, 1991,
7. Stewart J. W., Regents, *The 8051 Microcontroller: Hardware, Software and Interfacing*, , Prentice Hall, 1993
8. Yeralan S., Ahluwalia A. '*Programming and Interfacing the 8051 Microcontroller*', Addison - Wesley, 1995
9. Andrew Dominic, Chris, *ARM System Developers Guide*, MK Publishers

Structure of the Question Paper

For the end semester examination, the question paper consists of three questions from each module, out of which two are to be answered by the students.

ECD2005

BIOMEDICAL INSTRUMENTATION

3-0-0-3

Structure of the course

Lecture : 3 hrs/week
Internal Assessment : 40 Marks
End semester Examination : 60 Marks

Credits: 3

Course objectives

To provide an introduction to the modern Biomedical instruments and systems, features and applications.

Learning outcome

Upon successful completion of this course, students will have insight into operation and maintenance of modern biomedical equipments used in clinical practice.

Module 1

Introduction to the physiology of cardiac, nervous, muscular and respiratory systems. Transducers and Electrodes. Different types of transducers and their selection for biomedical applications, Electrode theory. Different types of electrodes, reference electrodes, hydrogen, calomel, Ag-AgCl, pH electrode, selection criteria of electrodes.

Module II

Measurement of electrical activities in muscles and brain. Electromyography, Electroencephalograph and their interpretation. Cardiovascular measurement. The cardio vascular system, Measurement of blood pressure, sphygmomanometer, blood flow, cardiac output and cardiac rate. Electrocardiography, echo- cardiography, ballisto-cardiography, plethysmography, magnetic and ultrasonic measurement of blood flow.

Module III

Therapeutic Equipment Cardiac pace-makers, defibrillators, machine, diathermy.
Respiratory System Measurement: Respiratory mechanism, measurement of gas volume, flow rate, carbon dioxide and oxygen concentration in inhaled air, respiration controller.
Instrumentation for clinical laboratory - Measurement of pH value of blood, ESR measurements, oxygen and carbon concentration in blood, GSR measurement X-ray and Radio isotopic instrumentation, diagnostic X-ray, CAT, medical use of isotopes. Ultrasonography, MRI.

References

1. R. S. Khandpur, *Handbook of Biomedical Instrumentation*, TMH Publishing Company Ltd., New Delhi.
2. Joseph J. Carr, John M Brown, *Introduction to Biomedical Equipment Technology*, Pearson Education (Singapore) Pvt. Ltd.
3. Leslie Cromwell, "*Biomedical Instrumentation and Measurements*", Prentice Hall India, New Delhi

Prerequisite: Basic knowledge in electronic instrumentation

Structure of the Question Paper

For the end semester examination, the question paper consists of three questions from each module, out of which two are to be answered by the students.

EPD 2001

NEW AND RENEWABLE SOURCES OF ENERGY

3-0-0-3

Structure of the course

| | | |
|--------------------------|--------------|------------|
| Lecture | : 3 hrs/week | Credits: 3 |
| Internal Assessment | : 40 Marks | |
| End semester Examination | : 60 Marks | |

Learning Outcomes

Upon successful completion of this course, students will be able to design and analyse the performance of small isolated renewable energy sources.

Course Objective

This subject provides sufficient knowledge about the promising new and renewable sources of energy so as to equip students capable of working with projects related to its aim to take up research work in connected areas

Module I

Direct solar energy-The sun as a perennial source of energy; flow of energy in the universe and the cycle of matter in the human ecosystem; direct solar energy utilization; solar thermal applications - water heating systems, space heating and cooling of buildings, solar cooking, solar ponds, solar green houses, solar thermal electric systems; solar photovoltaic power generation; solar production of hydrogen.

Module II

Energy from oceans-Wave energy generation - potential and kinetic energy from waves; wave energy conversion devices; advantages and disadvantages of wave energy- Tidal energy - basic principles; tidal power generation systems; estimation of energy and power; advantages and limitations of tidal power generation- Ocean thermal energy conversion (OTEC); methods of ocean thermal electric power generation Wind energy - basic principles of wind energy conversion; design of windmills; wind data and energy estimation; site selection considerations.

Module III

Classification of small hydro power (SHP) stations; description of basic civil works design considerations; turbines and generators for SHP; advantages and limitations. Biomass and bio-fuels; energy plantation; biogas generation; types of biogas plants; applications of biogas; energy from wastes Geothermal energy- Origin and nature of geothermal energy; classification of geothermal resources; schematic of geothermal power plants; operational and environmental problems
New energy sources (only brief treatment expected)-Fuel cell: hydrogen energy; alcohol energy; nuclear fusion: cold fusion; power from satellite stations

References

1. John W. Twidell , Anthony D Weir, '*Renewable Energy Resources*' , English Language Book Society (ELBS), 1996
2. Godfrey Boyle , '*Renewable Energy -Power for Sustainable Future* ,Oxford University Press, 1996
3. S. A. Abbasi, Naseema Abbasi, '*Renewable energy sources and their environmental impact*" Prentice-Hall of India, 2001
4. G. D. Rai, '*Non-conventional sources of energy*', Khanna Publishers, 2000
5. G. D. Rai, '*Solar energy utilization*', Khanna Publishers, 2000
6. S. L. Sah, '*Renewable and novel energy sources*', M.I. Publications, 1995
7. S. Rao and B. B. Parulekar, '*Energy Technology*' , Khanna Publishers, 1999

Structure of the question paper

For the end semester examination, the question paper contains three questions from each module out of which two questions are to be answered by the student.

EPD 2002 SCADA SYSTEMS AND APPLICATIONS

Structure of the course

| | | |
|--------------------------|--------------|------------|
| Lecture | : 3 hrs/week | Credits: 3 |
| Internal Assessment | : 40 Marks | |
| End semester Examination | : 60 Marks | |

Course Objective

To introduce SCADA systems, its components, architecture, communication and applications.

Learning Outcomes

Upon successful completion of this course, students will be able to use SCADA systems in different engineering applications such as utility, communication, automation, control, monitoring etc.

Module I

Introduction to SCADA Data acquisition systems - Evolution of SCADA, Communication technologies-. Monitoring and supervisory functions- SCADA applications in Utility Automation, Industries- SCADA System Components: Schemes- Remote Terminal Unit (RTU), Intelligent Electronic Devices (IED), Programmable Logic Controller (PLC), Communication Network, SCADA Server, SCADA/HMI Systems

Module II

SCADA Architecture: Various SCADA architectures, advantages and disadvantages of each system - single unified standard architecture -IEC 61850-SCADA Communication: Various industrial communication technologies -wired and wireless methods and fibre optics-Open standard communication protocols

Module3

SCADA Applications: Utility applications- Transmission and Distribution sector -operations, monitoring, analysis and improvement. Industries - oil, gas and water. Case studies, Implementation. Simulation Exercises

References

1. Stuart A Boyer. *SCADA-Supervisory Control and Data Acquisition*', Instrument Society of America Publications. USA. 1999.
2. Gordan Clarke, Deon RzynAzvs, *Practical Modern SCADA Protocols: DNP3, 60870J and Related Systems*', Newnes Publications, Oxford, UK,2004

Structure of the question paper

For the end semester examination, the question paper contains three questions from each module out of which two questions are to be answered by the student.

EMD2001

ELECTRIC AND HYBRID VEHICLES

3-0-0-3

Structure of the course

Credits: 3

| | |
|--------------------------|--------------|
| Lecture | : 3 hrs/week |
| Internal Assessment | : 40 Marks |
| End semester Examination | : 60 Marks |

Course Objective

To present a comprehensive overview of Electric and Hybrid Electric Vehicle.

Learning Outcomes

Upon successful completion of this course, students will be able to:

1. Choose a suitable drive scheme for developing an electric or hybrid vehicle depending on resources.
2. Design and develop basic schemes of electric vehicles and hybrid electric vehicles.
3. Choose proper energy storage systems for vehicle applications.
4. Identify various communication protocols and technologies used in vehicle networks.

Module I

Introduction to Hybrid Electric Vehicles: History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies.

Conventional Vehicles: Basics of vehicle performance, vehicle power source characterization, transmission characteristics, mathematical models to describe vehicle performance.

Hybrid Electric Drive-trains: Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis.

Electric Drive-trains: Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis.

Module II

Electric Propulsion unit: Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, drive system efficiency.

Energy Storage: Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Super Capacitor based energy storage and its analysis, Flywheel based energy storage and its analysis, Hybridization of different energy storage devices.

Sizing the drive system: Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology,

Module III

Communications, supporting subsystems: In vehicle networks- CAN, Energy Management Strategies: Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy management strategies.

Case Studies: Design of a Hybrid Electric Vehicle (HEV), Design of a Battery Electric Vehicle (BEV).

References

1. Iqbal Hussein, *Electric and Hybrid Vehicles: Design Fundamentals*, CRC Press, 2003.
2. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, *Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design*, CRC Press, 2004.
3. James Larminie, John Lowry, *Electric Vehicle Technology Explained*, Wiley, 2003.

(The course syllabus is as presented in NPTEL, IIT-M. The online resources in the NPTEL library may be utilised for this course).

Structure of the question paper

For the end semester examination, the question paper contains three questions from each module out of which two questions are to be answered by the student.

EDD2001

POWER ELECTRONICS SYSTEM DESIGN USING ICs

3-0-0-3

Structure of the Course

| | | |
|--------------------------------|--------------|------------|
| Lecture | : 3 hrs/week | Credits: 3 |
| Internal Continuous Assessment | : 40 Marks | |
| End Semester Examination | : 60 Marks | |

Course Objectives

1. To learn about specialized IC's and its applications
2. To understand PLL design and its applications
3. To study basics of PLCs

Learning Outcomes

Upon successful completion of this course, students will be able to:

1. Understand analog and digital system design concepts
2. Learn the specifications and applications of PWM control ICs.
3. Learn about self-biased techniques used in power supplies
4. Obtain information about different special purpose ICs and their applications

Module I

Introduction: Measurement Techniques for Voltages, Current, Power, power factor in Power Electronic circuits, other recording and analysis of waveforms, sensing of speed.
Phase – Locked Loops (PLL) & Applications: PLL Design using ICs, 555 Timer & its applications, Analog to Digital converter using ICs, Digital to Analog converters using ICs, implementation of different gating circuits.

Module II

Switching Regulator Control Circuits: Introduction, Isolation Techniques of switching regulator systems, PWM Systems, Some commercially available PWM control ICs and their applications: TL 494 PWM Control IC, UC 1840 Programmable off line PWM controller, UC 1524 PWM control IC, UC 1846 current mode control IC, UC 1852 Resonant mode power supply controller.
Switching Power Supply Ancillary, Supervisory & Peripheral circuits and components: Introduction, Optocouplers, self-Biased techniques used in primary side of reference power supplies, Soft/Start in switching power supplies, Current limit circuits, Over voltage protection, AC line loss detection.

Module III

Programmable Logic Controllers (PLC): Basic configuration of a PLC, Programming and PLC, Program Modification, Power Converter control using PLCs.

References

1. G. K. Dubey, S. R. Doradla, A. Johsi, and R. M. K. Sinha, *Thyristorised Power Controllers*, New Age International, 1st Edition, 2004.
2. George Chryssis, *High Frequency Switching Power Supplies*, McGraw-Hill, 2nd Edition,
3. Unitrode application notes: <http://www.smeps.us/Unitrode.html>

Structure of the Question Paper

For the end semester examination, the question paper consists of three questions from each module, out of which two are to be answered by the students

EDD2002 ENERGY AUDITING CONSERVATION AND MANAGEMENT 3-0-0-3

Structure of the Course

| | | |
|--------------------------------|--------------|------------|
| Lecture | : 3 hrs/week | Credits: 3 |
| Internal Continuous Assessment | : 40 Marks | |
| End Semester Examination | : 60 Marks | |

Course Objective

Understanding, analysis and application of electrical energy management measurement and accounting techniques, consumption patterns, conservation methods.

Learning Outcomes

Upon successful completion of this course, students will be able to:

1. To understand the concept of analysis and application of electrical energy management measurement techniques.
2. To understand the various energy conservation methods in industries.

Module I

Energy Auditing and Economics: System approach and End use approach to efficient use of Electricity; Electricity tariff types; Energy auditing-Types and objectives-audit instruments –ECO assessment and Economic methods-cash flow model, time value of money, evaluation of proposals, pay-back method, average rate of return method, internal rate of return method, present value method, profitability index, life cycle costing approach, investment decision and uncertainty, consideration of income taxes, depreciation and inflation in investment analysis- specific energy analysis-Minimum energy paths- consumption models- Case study.

Module II

Reactive Power Management and Lighting: Reactive Power management –Capacitor Sizing-Degree of Compensation-Capacitor losses-Location-Placement-Maintenance-Case study. Economics of power factor improvement. Peak Demand controls- Methodologies –Types of Industrial Loads-Optimal Load scheduling-Case study. Lightning-Energy efficient light sources-Energy Conservation in Lighting schemes. Electronic Ballast-Power quality issues-Luminaries-Case study.

Module III

Cogeneration and conservation in industries: Cogeneration-Types and Schemes-Optimal operation of cogeneration plants- Case study. Electric loads of Air conditioning and Refrigeration –Energy conservation measures-Cool storage- Types- Optimal operation-Case study .Electric water heating-Geysers-Solar Water Heaters-Power Consumption in Compressors, Energy conservation measures-Electrolytic Process-Computer Control-Software –EMS.

References

1. Giovanni Petrecca, *Industrial Energy Management: Principles and Application*, The Kluwer International Series-207, 1999
2. Anthony J. Pansini, Kenneth D. Smalling, *Guide to Electric Load Management*, Pennwell Pub.,1998
3. Howard E. Jordan, *Energy-Efficient Electric Motors and their Applications*, Plenum Pub Corp. 2nd edition, 1994
4. Turner, Wayne C., *Energy Management Handbook*, Lilburn, The Fairmont Press, 2001.
5. Albert Thumann, *Handbook of Energy Audits*, Fairmont Press 5th Edition, 1998
6. IEEE Bronze Book, *Recommended Practice for Energy Conservation and Cost effective Planning in Industrial Facilities* ,IEEE Inc ,USA
7. Albert Thumann P.W, *Plant Engineers and Managers Guide to Energy Conservation*, 7th Edition, TWI Press Inc. Terre Haute.
8. Donald R. W., *Energy Efficiency Manual*, Energy Institute Press
9. Partab H., *Art and Science of Utilization of Electrical Energy*, Dhanpat Rai & Sons , New Delhi
10. Tripathy S. C., *Electrical Energy Utilization and Conservation*, Tata McGraw-Hill
11. NESCAP- *Guide Book on Promotion of Sustainable Energy Consumption*

Structure of the Question Paper

For the end semester examination, the question paper consists of three questions from each module, out of which two are to be answered by the students

Prerequisites: Basic Course in Power System Engineering

Structure of the Course

| | | |
|--------------------------------|--------------|------------|
| Lecture | : 3 hrs/week | Credits: 3 |
| Internal Continuous Assessment | : 40 Marks | |
| End Semester Examination | : 60 Marks | |

Course Objectives

6. At the end of the course students will be able to perform analysis power network systems.
7. Should be able to analyze faults and load flows
8. Can develop programming skills for coding load flows and its applications like OPF.
9. Ability to understand concepts for solving multi phase systems.

Learning Outcomes

Upon successful completion of this course, students will be able to use various algorithms for solving a real time power system network.

Module I

Basics of graph theory-incidence matrices-Primitive network- Building algorithm for formation of bus impedance matrix (Z_{BUS})--Modification of Z_{BUS} due to changes in the primitive network with and without mutual coupling. Review of Y_{BUS} formation-Modification of Z_{BUS} and Y_{BUS} for change of reference.

Network fault Calculations: Review of sequence transformations and impedance diagrams- Fault calculations using Z_{BUS} , Analysis of balanced and unbalanced three phase faults –Short circuit faults – open circuit faults.

Module II

Network modelling – Conditioning of Y Matrix – Load Flow basics- Newton Raphson method– Fast decoupled Load flow –Three phase load flow.

Review of HVDC systems- DC power flow – Single phase and three phase

Need for AC-DC systems- AC-DC load flow – DC system model – Unified and Sequential Solution Techniques.

Module III

Review of economic dispatch: strategy for two generator system – generalized strategies – effect of transmission losses. Combined economic and emission dispatch- Reactive power dispatch-Formulation of optimal power flow (OPF) – various equality and inequality constraints -solution by Gradient method – Newton's method – Security constrained OPF- Sensitivity factors - Continuation Power flow method.

References

1. G. W. Stagg and El-Abiad, *Computer Methods in Power System Analysis*, McGraw-Hill, 1968.
2. Arrillaga J., and Arnold C.P., '*Computer Analysis of Power Systems*', John Wiley and Sons, New York, 1997
3. Allen J. Wood and Bruce F. Woollenberg, '*Power Generation Operation and Control*', John Wiley & Sons, 2nd Edition 1996.
4. D.P. Kothari, J.S. Dhillon, '*Power System Optimization*', Prentice-Hall India Pvt. Ltd., New Delhi, 2006
5. Grainger J. J., Stevenson W. D., '*Power System Analysis*', Tata McGraw-Hill, New Delhi, 2003
6. Nagrath, D. P. Kothari, "*Modern Power System Analysis*", Tata McGraw-Hill, 1980
7. Pai M.A., '*Computer Techniques in Power System Analysis*', 2nd edition, Tata McGraw-Hill, New Delhi, 2006.
8. Ajarapu V., Christy C., "*The Continuation Power Flow: A Tool for Voltage Stability Analysis*", [IEEE Transactions on Power Systems](#), Vol. 7(1), pp 416-423.

Structure of the Question Paper

For the end semester examination, the question paper consists of three questions from each module, out of which two are to be answered by the students

EDD2004

INDUSTRIAL AUTOMATION TOOLS

3-0-0-3

Prerequisite: Basic knowledge in electrical engineering, Control Systems.

Structure of the Course

| | | |
|--------------------------------|--------------|------------|
| Lecture | : 3 hrs/week | Credits: 3 |
| Internal Continuous Assessment | : 40 Marks | |
| End Semester Examination | : 60 Marks | |

Course Objectives

1. To introduce students to the use of PLCs in industry and to provide skills with modern PLC programming tools.
2. To acquire basic knowledge about multi-input multi-output (MIMO) systems.
3. To acquire extensive basic and advanced knowledge about various aspects of PLC, SCADA, DCS and Real Time Systems.

Learning Outcomes

Upon successful completion of this course, students will be able to:

1. Understand the operation of a PLC (Programmable Logic Controller) and its use in industry.
2. Hardwire a PLC and apply ladder logic programming to perform simple automation tasks.
3. Understand and apply common industrial analogue and digital input/output modules.
4. Demonstrate an understanding of field bus systems and SCADA at an introductory level.

Module I

Multivariable control- Basic expressions for MIMO systems- Singular values- Stability norms- Calculation of system norms- Robustness- Robust stability.

H_2/H_∞ Theory- Solution for design using H_2/H_∞ - Case studies. Interaction and decoupling- Relative gain analysis- Effects of interaction- Response to disturbances- Decoupling- Introduction to batch process control.

PLC Basics: PLC system, I/O modules and interfacing, CPU processor, programming equipment, programming formats, construction of PLC ladder diagrams, devices connected to I/O modules. PLC Programming: Input instructions, outputs, operational procedures, programming examples using contacts and coils, Drill press operation.

Module II

Digital logic gates, programming in the Boolean algebra system, conversion examples. Ladder diagrams for process control: Ladder diagrams and sequence listings, ladder diagram construction and flow chart for spray process system.

Large Scale Control Systems - SCADA: Introduction, SCADA Architecture, Different Communication Protocols, Common System Components, Supervision and Control, HMI, RTU and Supervisory Stations, Trends in SCADA, Security Issues

Module III

Distributed Control Systems (DCS): Introduction, DCS Architecture, Local Control (LCU) architecture, LCU languages, LCU - Process interfacing issues, communication facilities, configuration of DCS, displays, and redundancy concept - case studies in DCS.

Real time systems- Real time specifications and design techniques- Real time kernels- Inter task communication and synchronization- Real time memory management- Supervisory control- direct digital control- Distributed control- PC based automation.

References

1. Shinskey F.G., *Process Control Systems: Application, Design and Tuning*, McGraw Hill International Edition, Singapore, 1988.
2. Belanger P.R., *Control Engineering: A Modern Approach*, Saunders College Publishing, USA, 1995.
3. Dorf R. C. and Bishop R. T., *Modern Control Systems*, Addison Wesley Longman Inc., 1999
4. Laplante P.A., *Real Time Systems: An Engineer's Handbook*, Prentice Hall of India Pvt. Ltd., New Delhi, 2002.
5. Stuart A. Boyer: *SCADA-Supervisory Control and Data Acquisition*, Instrument Society of America Publications, USA, 1999
6. Efim Rosenwasser, Bernhard P. Lampe, *Multivariable Computer-Controlled Systems: A Transfer Function Approach*, Springer, 2006
7. John W. Webb, Ronald A. Reiss, *Programmable Logic Controllers: Principle and Applications*, Fifth Edition, PHI
8. R. Hackworth and F.D Hackworth Jr., *Programmable Logic Controllers: Programming Method and Applications*, Pearson, 2004.

Structure of the Question Paper

For the end semester examination, the question paper consists of three questions from each module, out of which two are to be answered by the students.

EID2001 ADVANCED MICROPROCESSORS AND MICROCONTROLLERS

Structure of the course

| | | |
|--------------------------------|-------------|------------|
| Lecture | : 3hrs/week | Credits: 3 |
| Internal Continuous Assessment | : 40 Marks | |
| End Semester Examination | : 60 Marks | |

Course Objective

To provide experience to design digital and analog hardware interface for microcontroller based systems. To provide in depth knowledge of higher bit processors

Learning Outcomes

Upon successful completion of this course, students will be able to use microprocessors and microcontrollers for different applications.

Module I

Internal architecture of 8086 CPU, instruction set and programming, assembly language programming on IBM PC, ROM bios and DOS utilities. 8086 basic system concepts, signals, instruction queue, MIN mode and MAX mode, bus cycle, memory interface, read and write bus cycles, timing parameters.

Module II

Input/output interface of 8086, I/O data transfer, I/O bus cycle. Interrupt interface of 8086, types of interrupts, interrupt processing. DMA transfer, interfacing and refreshing DRAM, 8086 based multiprocessing system, 8087 math coprocessor. Typical 8086 based system configuration, keyboard interface, CRT controller, floppy disk controller

Module III

Introduction to higher bit processors, 80286, 80386, 80486, Pentium. A typical 16 bit Microcontroller with RISC architecture and Integrated A-D converter e.g. PIC 18Cxxx family: Advantages of Harvard Architecture, instruction pipeline, analog input, PWM output, serial I/O, timers, in-circuit and self programmability. Instruction set. Typical application. Development tools.

References

1. Ray A. K., Bhurchandi K. M., *Advanced Microprocessor and Peripherals, Architecture, Programming and Interfacing*, TMH, 2006
2. Hall D.V., *Microprocessor & Interfacing – Programming & Hardware – 8086, 80286, 80386, 80486*, TMH, 1992
3. Rajasree Y., *Advanced Microprocessor*, New Age International Publishers, 2008
4. Brey B. B. 'The Intel Microprocessor 8086/8088, Pentium , Pentium Processor, PHI, 2008
5. Ayala K. J., *The 8086 Microprocessor*, Thomson Delmar Learning, 2004.
6. Cady F. M., *Microcontrollers & Microcomputers Principles of Software &Hardware Engineering*, Oxford University Press, 1997
7. Tabak D., *Advanced Microprocessors*,TMH, 1996
8. Deshmukh, *Microcontrollers : Theory and Application*, TMH, 2005

Structure of the Question paper

For the end semester examination, the question paper will consist of three questions from each module out of which two questions are to be answered by the students

EID2002

MODERN POWER CONVERTER

Structure of the course

| | | |
|--------------------------------|-------------|------------|
| Lecture | : 3hrs/week | Credits: 3 |
| Internal Continuous Assessment | : 40 Marks | |
| End Semester Examination | : 60 Marks | |

Course Objective

To equip students with various advanced topics in power electronics

Learning Outcomes

Upon successful completion of this course, students will be able to understand working of power converters and design converters for industrial applications

Module I

Introduction to switched mode power converters, Generalized comparison between switched mode and linear DC regulators, operation and steady state performance of Buck, Boost, Buck-Boost and Cuk Converters: Continuous conduction mode, discontinuous conduction mode and boundary between continuous and discontinuous mode of operation, output voltage ripple calculation, effect of parasitic elements.

Module II

DC-DC converter with isolation: Fly back converters- other fly back converter topologies, forward converter, The forward converter switching transistor- Variation of the basic forward converter, Push pull converter-Push pull converter transistor-Limitation of the Push Pull circuit-circuit variation of the push pull converter-the half bridge and full bridge DC-DC converters. High frequency inductor design and transformer design considerations, magnetic core, current transformers.

Module III

Control of switched mode DC power supplies: Voltage feed forward PWM control, current mode control, digital pulse width modulation control, isolation techniques of switching regulator systems: soft start in switching power supply designs, current limit circuits, over voltage protection circuit. A typical monolithic PWM control circuit and their application: TL 494. Power factor control in DC-DC converters. Electromagnetic and radio frequency interference, conducted and radiated noise, EMI suppression, EMI reduction at source, EMI filters, EMI screening, EMI measurements and specifications. Power conditioners and Uninterruptible Power Supplies, Types of UPS-Redundant and Non Redundant UPS.

References

1. Mohan, Undeland, Robbins, *Power Electronics: Converters, Application and Design*, John Wiley & Sons, 1989
2. A.I. Pressman, *Switching Mode Power Supply Design*, Tata McGraw-Hill, 1992
3. M. H. Rashid, *Power Electronics*, PHI, 2004
4. Michel, D., *DC-DC Switching Regulator Analysis*, Newness, 2000
5. Lee, Y., *Computer Aided Analysis and Design of Switch Mode Power Supply*, 1993
6. Staff, VPEC, *Power Device & their Application*, 2000

Structure of the Question paper

For the end semester examination, the question paper will consist of three questions from each module out of which two questions are to be answered by the students

EID2003

POWER PLANT INSTRUMENTATION

Structure of the course

| | |
|---------------------------------|------------|
| Lecture: 3hrs/week | Credits: 3 |
| Internal Continuous Assessment: | 40 Marks |
| End Semester Examination: | 60 Marks |

Course Objective

To equip students with various advanced topics in Power System Instrumentation

Learning Outcomes

Upon successful completion of this course, students will be acquainted to advanced instrumentation techniques employed in power plants.

Module I

General scope of instrumentation in power systems. Electrical instruments and meters. Telemetry. Data transmission channels-pilots, PLCC, Microwave links. Interference effect. Automatic meter reading and billing.

Module II

Simulators. SCADA and operating systems. Data loggers and data display system. Remote control instrumentation. Disturbance recorders. Area and Central Control station instrumentation.

Module III

Frontiers of future power system instrumentation including microprocessor based systems. Application of digital computers for data processing and on-line system control.

References

1. Central Power Research Institute (India), *Power System Instrumentation: National Workshop: Papers*, 1991
2. B.G Liptak, '*Instrumentation in Process Industries*', CRC, 2010
3. B. Singh, *Microprocessor control and instrumentation of electrical power systems*, University of Bradford, 1987
4. Bonneville Power Administration, *SCADA: Remote Control For a Power System*, 1995

Structure of the Question paper

For the end semester examination, the question paper will consist of three questions from each module out of which two questions are to be answered by the students

EID2004

ADVANCED CONTROL SYSTEM DESIGN

Structure of the course

| | | |
|--------------------------------|-------------|------------|
| Lecture | : 3hrs/week | Credits: 3 |
| Internal Continuous Assessment | : 40 Marks | |
| End Semester Examination | : 60 Marks | |

Course Objective

To understand about the basics of optimal control. To introduce about the current research in optimization for robust control.

Learning Outcomes

Upon successful completion of this course, students will be able to implement control techniques optimally.

Module I

Describing system and evaluating its performance: problem formulation - state variable representation of the system-performance measure-the carrier landing of a jet aircraft-dynamic programming

Module II

Linear quadratic optimal control: formulation of the optimal control problem- quadratic integrals and matrix differential equations-optimum gain matrix –steady state solution-disturbances and reference input: exogenous variables general performance integral –weighting of performance at terminal time, concepts of MIMO system.

Module III

Linear quadratic Gaussian problem : Kalman identity-selection of the optimal LQ performance index-LQR with loop shaping techniques-linear quadratic Gaussian problem-kalman state estimator -property of the LQG based controller-reduced order LQG control law design- advances in control system design-concept of robust control- H infinity design techniques

References

1. Bernad Friedland, *Control System Design*, McGraw-Hill, 2012.
2. Ching-Fang-Lin , *Advanced Control System Design*, Prentice Hall, 1994.
3. Krick D. E., *Optimal Control Theory*, Dover Publications, 2004.

Structure of the Question paper

For the end semester examination, the question paper will consist of three questions from each module out of which two questions are to be answered by the students.

EID2005

MULTIVARIABLE CONTROL THEORY

Structure of the course

| | | |
|--------------------------|--------------|------------|
| Lecture | : 3hrs /week | Credits: 3 |
| Internal Assessment | : 40 Marks. | |
| End semester Examination | : 60 Marks. | |

Course objectives

1. To introduce the concepts of linear and nonlinear multivariable systems.
2. To impart an in-depth knowledge on the different representations of MIMO systems.
3. To provide the difference between linear single and multivariable systems using time and frequency domain techniques and their design.
4. To provide an insight into nonlinear MIMO systems.

Learning Outcomes

Upon successful completion of this course, students will be able to:

1. Use different representations for MIMO systems.
2. Analyse given linear and non linear multivariable systems and assess its performance using frequency and time domain techniques.
3. Design linear MIMO systems.

Module I

Linear Multivariable Control Systems: Canonical representations and stability analysis of linear MIMO systems, General linear square MIMO systems, Transfer matrices of general MIMO systems, MIMO system zeros and poles, Spectral representation of transfer matrices: characteristic transfer functions and canonical basis, Representation of the open-loop and closed MIMO system via the similarity transformation and dyads, Stability analysis of general MIMO systems, Singular value decomposition of transfer matrices, Uniform MIMO systems, Characteristic transfer functions and canonical representations of uniform MIMO systems, Stability analysis of uniform MIMO systems, Normal MIMO systems, Canonical representations of normal MIMO systems.

Circulant MIMO systems, Anticirculant MIMO systems, Characteristic transfer functions of complex circulant and anticirculant systems, Multivariable root loci, Root loci of general MIMO systems, Root loci of uniform systems, Root loci of circulant and anticirculant systems.

Module II

Performance and design of linear MIMO systems: Generalized frequency response characteristics and accuracy of linear, MIMO systems under sinusoidal inputs, Frequency characteristics of general MIMO systems, Frequency characteristics and oscillation index of normal MIMO systems, Frequency characteristics and oscillation index of uniform MIMO systems, Dynamical accuracy of MIMO systems under slowly changing deterministic signals, Matrices of error coefficients of general MIMO systems.

Dynamical accuracy of circulant, anticirculant and uniform MIMO systems, Accuracy of MIMO systems with rigid cross-connections , Statistical accuracy of linear MIMO systems, Accuracy of general MIMO systems under stationary stochastic signals, Statistical accuracy of normal MIMO systems ,Statistical accuracy of uniform MIMO systems, Formulae for mean square outputs of characteristic systems , Design of linear MIMO systems

Module III

Nonlinear Multivariable Control System: Study of one-frequency self-oscillation in nonlinear harmonically linearized MIMO systems, Mathematical foundations of the harmonic linearization method for one-frequency periodical processes in nonlinear MIMO systems, One-frequency limit cycles in general MIMO systems, Necessary conditions for the existence and investigation of the limit cycle in harmonically linearized MIMO systems, Stability of the limit cycle in MIMO systems, Limit cycles in uniform MIMO systems, Necessary conditions for the existence and investigation of limit cycles in uniform MIMO systems, Analysis of the stability of limit cycles in uniform systems.

Limit cycles in circulant and anticirculant MIMO systems, Necessary conditions for the existence and investigation of limit cycles in circulant and anticirculant systems, Limit cycles in uniform circulant and anticirculant systems.

References

1. Oleg N. Gasparyan, *Linear and Nonlinear Multivariable Feedback Control: A Classical Approach*, John Wiley & Sons Ltd.,2008.
2. Sigurd Skogestad, Ian Postlethwaite, *Multivariable Feedback Control - Analysis and Design*, John Wiley & Sons Ltd., 2nd Edition, 2005.

Structure of the Question Paper

For the end semester examination, there will be three questions from each module out of which two questions are to be answered by the students.

ECC2000

RESEARCH METHODOLOGY

2-0-0-2

Structure of the course

Lecture : 2 hrs/week
Internal Assessment : 40 Marks
End semester Examination : 60 Marks

Credits: 2

Course Objective

1. To formulate a viable research question
2. To distinguish probabilistic from deterministic explanations
3. To analyze the benefits and drawbacks of different methodologies
4. To understand how to prepare and execute a feasible research project

Learning Outcomes

Upon successful completion of this course, students will be able to understand research concepts in terms of identifying the research problem, collecting relevant data pertaining to the problem, to carry out the research and writing research papers/thesis/dissertation.

Module I

Introduction to Research Methodology - Objectives and types of research: Motivation towards research - Research methods vs. Methodology. Type of research: Descriptive vs. Analytical, Applied vs. Fundamental, Quantitative vs. Qualitative, and Conceptual vs. Empirical.

Research Formulation - Defining and formulating the research problem -Selecting the problem - Necessity of defining the problem - Importance of literature review in defining a problem. Literature review: Primary and secondary sources - reviews, treatise, monographs, patents. Web as a source: searching the web. Critical literature review - Identifying gap areas from literature review - Development of working hypothesis. (15 Hours)

Module II

Research design and methods: Research design - Basic Principles- Need for research design — Features of a good design. Important concepts relating to research design: Observation and Facts, Laws and Theories, Prediction and explanation, Induction, Deduction. Development of Models and research plans: Exploration, Description, Diagnosis, Experimentation and sample designs. Data Collection and analysis: Execution of the research - Observation and Collection of data - Methods of data collection - Sampling Methods- Data Processing and Analysis strategies - Data Analysis with Statistical Packages - Hypothesis-Testing -Generalization and Interpretation. (15 Hours)

Module III

Reporting and thesis writing - Structure and components of scientific reports -Types of report - Technical reports and thesis - Significance - Different steps in the preparation, Layout, structure and Language of typical reports, Illustrations and tables, Bibliography, referencing and footnotes. Presentation; Oral presentation - Planning - Preparation -Practice - Making presentation - Use of audio-visual aids - Importance of effective communication.

Application of results of research outcome: Environmental impacts –Professional ethics - Ethical issues -ethical committees. Commercialization of the work - Copy right - royalty - Intellectual property rights and patent law - Trade Related aspects of Intellectual Property Rights - Reproduction of published material - Plagiarism - Citation and acknowledgement - Reproducibility and accountability.

References

1. C. R. Kothari, *Research Methodology*, Sultan Chand & Sons, New Delhi, 1990
2. Panneerselvam, *Research Methodology*, Prentice Hall of India, New Delhi, 2012.
3. J. W. Bames, *Statistical Analysis for Engineers and Scientists*, Tata McGraw-Hill, New York.
4. Donald Cooper, *Business Research Methods*, Tata McGraw-Hill, New Delhi.
5. Leedy P. D., *Practical Research: Planning and Design*, McMillan Publishing Co.
6. Day R. A., *How to Write and Publish a Scientific Paper*, Cambridge University Press, 1989.
7. Manna, Chakraborti, *Values and Ethics in Business Profession*, Prentice Hall of India, New Delhi, 2012.
8. Sople, *Managing Intellectual Property: The Strategic Imperative*, Prentice Hall of India, New Delhi, 2012.

EPC2101

POWER SYSTEMS LAB II

0-0-2-1

Structure of the course

| | | |
|--------------------------|-------------|------------|
| Lecture | : 2hrs/week | Credits; 1 |
| Internal Assessment | : 100 Marks | |
| End semester Examination | : Nil | |

Course Objectives

Ability to conduct advanced experiments in power systems.

Learning Outcomes

The students are able to perform advanced experimental works for industrial projects

Experiments

1. Three phase unbalanced Load flow analysis Short Circuit and Transient stability Studies
2. Economic Dispatch (Programming)
3. Optimal Load Flow
4. Relay Coordination
5. Simulation of SVC, STATCOM etc using PSCAD/MATLAB
6. Simulation of HVDC systems using PSCAD
7. Behaviour of Power System Components for different harmonic over voltages
8. Lab practice on LABVIEW software for power monitoring and control
9. String efficiency of insulators
10. Partial discharge measurement of dielectrics

*In addition to the above, the Department can offer a few experiments in the **Electrical Machines Laboratory** and a few newly developed experiments in the **Power Systems Laboratory***

Minimum of 10 experiments are to be conducted

EPC2102**SEMINAR****Structure of the Course**

Duration : 2 hrs/week Credits : 2

Continuous Assessment : 100 Marks

The student is expected to present a seminar in one of the current topics in the stream of specialisation. The student will undertake a detailed study based on current published papers, journals, books on the chosen subject, present the seminar and submit seminar report at the end of the semester.

Distribution of marks

Seminar Report Evaluation - 40 marks

Seminar Presentation - 60 marks

EPC2103**THESIS PRELIMINARY: PART-I****Structure of the Course**

Thesis : 2 hrs/week Credits : 2

Internal Continuous Assessment : 100 Marks

For the Thesis-Preliminary part I the student is expected to start the preliminary background studies towards the Thesis by conducting a literature survey in the relevant field. He/she should broadly identify the area of the Thesis work, familiarize with the design and analysis tools required for the Thesis work and plan the experimental platform, if any, required for Thesis work. The student will submit a detailed report of these activities at the end of the semester.

Distribution of marks

Internal assessment of work by the Guide : 50 marks

Internal evaluation by the Committee : 50 Marks

EPE 3001 DISTRIBUTION SYSTEM PLANNING AND AUTOMATION 3-0-0-3

Structure of the course

| | | |
|--------------------------|-------------|------------|
| Lecture | : 3hrs/week | Credits: 3 |
| Internal Assessment | : 40 Marks | |
| End semester Examination | : 60 Marks | |

Course Objective

Objective of the course is to introduce various advancements in the distribution systems

Learning Outcomes

Upon successful completion of this course, students will be able to do:

1. Distribution system expansion planning
2. Distribution automation

Module I

Power System: General Concepts - Distribution of power - Management - systems study - Loads and Energy Forecasting: Power loads - Area Preliminary survey load forecasting - Regression analysis - Correlation analysis - Analysis of time series - Factors in power system loading -Technological forecasting— Sources of error

Planning, Design and Operation methodology: System calculations, Network elements - Distribution load flow: Radial systems, distribution systems with loops - fault studies - effect of abnormal loads, Voltage control - line circuits - harmonics- urban distribution - load variations Distribution system expansion planning – load characteristics – load forecasting – design concepts – optimal location of substation – design of radial lines – solution technique.

Module II

Optimization of distribution systems: Introduction, Costing of Schemes, Typical network configurations - Long and Short term planning, network cost modelling, voltage levels - Synthesis of optimum line networks -Application of linear programming to network synthesis -Optimum Phase sequence – Economic loading of distribution transformers- Worst case loading of distribution transformers

Distribution automation: Distribution automation - Definitions - Project Planning - Communication, Sensors, Supervisory Control and Data Acquisition (SCADA), Consumer Information systems (CIS), Geographical Information Systems (GIS)

Power System reliability: Basic Reliability Concepts and Series, Parallel, Series-Parallel Systems- Development of State Transition Model to Determine the Steady State Probabilities

Module III

Consumer Services: Supply industry - Natural monopoly - Regulations - Standards - Consumer load requirements — Cost of Supply - load management - theft of power ~ Energy metering - Tariffs: Costing and Pricing, Classification of Tariffs – Deregulated Systems: Reconfiguring Power systems- Unbundling of Electric Utilities- Competition and Direct access Voltage control – Application of shunt capacitance for loss reduction – Harmonics in the system – static VAR systems – loss reduction and voltage improvement.

References

1. A. S. Pabla, '*Electrical Power Distribution Systems*', 4th edn., TMH, 1997
2. Turan Gonen, '*Electrical Power Distribution Engineering*', McGraw-Hill, 1986
3. Colin Bayliss, '*Transmission and Distribution Electrical Engineering*', Butterworth Heinemann, 1996
4. Pansini, '*Electrical Distribution Engineering*'
5. E. Lakervi & E. J. Holmes, '*Electricity Distribution Network Design*', 2nd Edition, Peter Peregrinus Ltd.
6. Dhillan B. S., '*Power System Reliability, Safety and Management*', An Arbor Sam 1981

Structure of the question paper

For the end semester examination, the question paper contains three questions from each module out of which two questions are to be answered by the student.

Structure of the course

| | | |
|--------------------------|-------------|------------|
| Lecture | : 3hrs/week | Credits: 3 |
| Internal Assessment | : 40 Marks | |
| End semester Examination | : 60 Marks | |

Course Objective

To equip the engineers for operating power systems more effectively and reliably utilizing the resources in an optimal manner

Learning Outcomes

Upon successful completion of this course, students will be able to

1. Analyse transient stability and voltage stability
2. Operate power systems more effectively and reliably.

Module I

Concept of Power system stability-Types of stability-Transient stability analysis: An Elementary View of Transient Stability-Structure of a complete power system model for transient stability analysis-Transient Stability Enhancement

Voltage Stability Analysis-Definition and Criteria-Mechanism of Voltage Collapse-Static Analysis: V-Q sensitivity analysis, Q-V modal analysis-Determination of Shortest distance to instability-The continuation load flow analysis-Important voltage stability indices-Prevention of Voltage Collapse

Module II

Concept of reliability, non-repairable components, hazard models, components with preventive maintenance, ideal repair and preventive maintenance, repairable components, normal repair and preventive maintenance.

System reliability, monotonic structures, reliability of series-parallel structures, the V out of 'r'f configuration, the decomposition methods, minimal tie and cut method, state space method of system representation, system of two independent components, two components with dependent failures, combining states, non-exponential repair times failure effects analysis, State enumeration method, application to non-repairable systems.

Other methods of system reliability, fault free analysis. Monte Carlo simulation, planning for reliability, outage definitions, construction of reliability models.

Module III

Generating capacity reserve evaluation, the generation model, the probability of capacity deficiency, the frequency and duration method, comparison of the reliability indices, generation expansion planning, uncertainties in generating unit failure rates and in load forecasts. Operating reserve evaluation, state space representation of generating units, rapid start and hot-reserve units, the security function approach.

Interconnected systems, two connected systems with independent loads, two connected system with correlated loads, more than two systems interconnected.

References

1. K. R. Padiyar, '*Power System Dynamics*', 2nd Edition, B.S. Publishers, 2003
2. P. Kundur, '*Power System Stability and Control*', McGraw-Hill Inc., 1994
3. T. Van Cutsem, C. Vournas, '*Voltage Stability of Electric Power System*', Kluwer Academic Publishers, 1998
4. J. J. Endrenyi, '*Reliability Modelling in Electric Power Systems*', John Wiley & Sons
5. Singh C., Billinton R. '*System Reliability Modelling and Evaluation*', Hutchinson,

Structure of the question paper

For the end semester examination, the question paper contains three questions from each module out of which two questions are to be answered by the student.

Structure of the course

| | | |
|--------------------------|--------------|------------|
| Lecture | : 3 hrs/week | Credits: 3 |
| Internal Assessment | : 40 Marks | |
| End semester Examination | : 60 Marks | |

Course Objective

To impart principles of different measurement systems and methods of various electrical parameters.

Learning Outcomes

Upon successful completion of this course, students will be able to analyse the performance of measuring instruments and use it for different applications.

Module I

Generalized performance characteristics of instruments – Static and dynamic characteristics, development of mathematical model of various measurement systems. Classification of instruments based on their order. Dynamic response and frequency response studies of zero order, first order and second order instruments. Theory of errors: systematic and random errors, limits of error, probable error and standard deviation. Gaussian error curves, combination of errors.

Module II

Transducers, classification & selection of transducers, strain gauges, inductive & capacitive transducers, piezoelectric and Hall-effect transducers, thyristors, thermocouples, photo-diodes & photo-transistors, encoder type digital transducers, signal conditioning and telemetry, basic concepts of smart sensors and application. Data Acquisition Systems.

Module III

Measurement of voltage, current, phase angle, frequency, active power and reactive power in power plants. Energy meters and multipart tariff meters. Capacitive voltage transformers and their transient behaviour, Current Transformers for measurement and protection, composite errors and transient response.

Introduction to SCADA: Data acquisition systems, Evolution of SCADA, Communication technologies, Monitoring and supervisory functions, SCADA applications in Utility Automation, Industries

References

1. B. D. Doebelin, '*Measurement systems - Application and Design*', McGraw-Hill, New York.
2. John P. Bentley, '*Principles of Measurement System*', Pearson Education.
3. J. W. Dally, W. F. Reley and K. G. McConnel, '*Instrumentation for Engineering Measurements*' Second Edition, John Wiley & Sons Inc. New York, 1993
4. K. B. Klaasen, '*Electronic Measurement. And Instrumentation*', Cambridge University Press.
5. Helfrick and Cooper, '*Modern Electronic Instrumentation and Measurement Techniques*', Prentice-Hall of India
6. Jones, B. E., '*Instrumentation Measurement and Feedback*', Tata McGraw-Hill, 1986.
7. Golding, E. W., '*Electrical Measurement and Measuring Instruments*', 3rd Edition
8. Stuart A. Boyer, '*SCADA-Supervisory Control and Data Acquisition*', Instrument Society of America Publications, USA, 2004

Structure of the question paper

For the end semester examination, the question paper contains three questions from each module out of which two questions are to be answered by the student.

Structure of the course

| | | |
|--------------------------|-------------|------------|
| Lecture | : 3hrs/week | Credits: 3 |
| Internal Assessment | : 40 Marks | |
| End semester Examination | : 60 Marks | |

Course Objective

To enable the students gain a fair knowledge on the concepts and technology of EHV-AC & DC transmission systems

Learning Outcomes

Upon successful completion of this course, students will be able to analyse the problems faced in EHV AC and DC transmission and for protection of EHV AC-DC substation and transmission equipments.

Module I

EHV AC transmission-configuration-features-intermediate substations-applications- interconnected AC networks-HVDC system-classification-configuration-equipment in HVDC substations-Power flow in AC and HVDC lines-EHV AC vs. HVDC-economic comparison-HVDC power flow- power conversion principle-power loss in DC system-steady state U_d/I_d characteristics

Converter circuits-single phase and three phase circuits-analysis of bridge converter-with and without overlap-grid control - control characteristics-constant minimum ignition angle control-constant current control-extinction angle control

Harmonics-characteristics of harmonics-means of reducing harmonics-telephone interference-filters-single frequency and double frequency-tuned filters-DC harmonic filter

Module II

Reactive power requirements in HVDC substations-effect of delay angle and extinction angle-short circuit ratio in planning of HVDC

DC line oscillations and line dampers-over voltage protection-DC lightning arresters-DC circuit breakers -basic concepts types & characteristics

Earth electrode-location and configuration-earth return-materials of anode-sea electrode –shore electrode-troubles by earth currents and remedial measures

Module III

EHV AC Transmission-Components of transmission system-voltage gradients of conductor-single and bundled conductor

Corona & corona losses in EHVAC and HVDC-critical surface gradient-Peeks law-critical disruptive voltage and critical electric stress for visual corona-Insulation requirements of EHV AC and DC transmission lines - Electrostatic field of EHV lines-biological effects-live wire maintenance-insulation coordination-insulation for power frequency-voltage-switching over voltage-lightning performance-calculation of line & ground parameters

References

1. E. W. Kimbark, '*Direct Current Transmission Volume*', John Wiley, New York
2. Rakosh Das Begamudre, '*EHV AC Transmission Engineering*', New Age International Pvt. Ltd., 2nd Edition, 1997
3. K. R. Padiyar, '*HVDC Power Transmission Systems*', Wiley Eastern Ltd.
4. S. Rao, '*EHV AC and HVDC Transmission Engineering & Practice*', Khanna Publishers

Structure of the question paper

For the end semester examination, the question paper contains three questions from each module out of which two questions are to be answered by the student.

Structure of the course

| | | |
|--------------------------|--------------|------------|
| Lecture | : 3 hrs/week | Credits: 3 |
| Internal Assessment | : 40 Marks | |
| End semester Examination | : 60 Marks | |

Course Objective

To familiarize the different control schemes for Static VAR Compensators to mitigate power quality problems in Power System

Learning Outcomes

Upon successful completion of this course, students will be able to design controllers for FACTS device for different application and to develop power system conditioner.

Module I

Fundamentals of Load Compensation, Steady-State Reactive Power Control in Electric Transmission Systems, Reactive Power Compensation and Dynamic Performance of Transmission Systems.

Converters for Static Compensation, Single Phase and Three Phase Converters and Standard Modulation Strategies (Programmed Harmonic Elimination and SPWM). GTO Inverters, Multi-Pulse Converters and Interface Magnetics Multi-Level Inverters of Diode Clamped Type and Flying Capacitor Type and suitable modulation strategies. Multi-level inverters of Cascade Type and their modulation . Current Control of Inverters.

Module II

Static Reactive Power Compensators and their control. Shunt Compensators, SVCs of Thyristor Switched and Thyristor Controlled types and their control, STATCOMs and their control, Series Compensators of Thyristor Switched and Controlled Type and their Control, SSSC and its Control, Sub-Synchronous Resonance and damping, Use of STATCOMs and SSSCs for Transient and Dynamic Stability Improvement in Power Systems

Module III

Passive Harmonic Filtering . Single Phase Shunt Current Injection Type Filter and its Control, Three Phase Three-wire Shunt Active Filtering and their control using p-q theory and d-q modelling . Three-phase four-wire shunt active filters . Hybrid Filtering using Shunt Active Filters . Series Active Filtering in Harmonic Cancellation Mode . Series Active Filtering in Harmonic Isolation Mode. Dynamic Voltage Restorer and its control. Power Quality Conditioner

References

1. T. J. E. Miller, '*Reactive Power Control in Electric Systems*', John Wiley & Sons, 1982.
2. N. G. Hingorani & L. Gyugyi, '*Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems*', IEEE Press, 2000.
3. Ned Mohan et.al, '*Power Electronics*' John Wiley and Sons, 2006

Structure of the question paper

For the end semester examination, the question paper contains three questions from each module out of which two questions are to be answered by the student.

EME3001

DYNAMICS OF POWER CONVERTERS

3-0-0-3

Structure of the course

| | |
|--------------------------|--------------|
| Lecture | : 3 hrs/week |
| Internal Assessment | : 40 Marks |
| End semester Examination | : 60 Marks |

Credits: 3

Course Objective

To equip the students with the dynamic aspect of different converters and their analysis

Learning Outcomes

Upon successful completion of this course, students will be able to:

1. Develop dynamic models of switched power converters using state space averaging and circuit averaging techniques.
2. Develop converter transfer functions.
3. Design closed loop controllers for DC-DC power converters.
4. Design and implement current mode control for DC-DC converters.

Module I

Fundamentals of Steady state converter modelling and analysis, Steady-state equivalent circuits, losses and efficiency. Inclusion of semiconductor conduction losses in converter model.

Small-signal AC modelling- Averaging of inductor/capacitor waveforms- perturbation and linearisation.

State-Space Averaging-Circuit Averaging and averaged switch modelling- Canonical Circuit Model- Manipulation of dc-dc converters' circuit model into Canonical Form-Modelling the pulse width modulator

Module II

Converter Transfer Functions:-Review of frequency response analysis techniques- Bode plots – Converter transfer functions-graphical construction. Measurement of ac transfer functions and impedances.

Controller Design: Effect of negative feedback on the network transfer functions-loop transfer function-Controller design specifications- PD, PI and PID compensators - applications to the basic dc-dc topologies - Practical methods to measure loop gains: Voltage and current injection

Module III

Converters in Discontinuous Conduction Mode: AC and DC equivalent circuit modelling of the discontinuous conduction mode-Generalised Switch Averaging-small-signal ac modelling of the dcm switch network-

Current-Mode Control: Average Current-mode Control, Peak Current-mode control-first order models-accurate models for current-mode control-application to basic dc-dc converter topologies-Subharmonic oscillation for $d > 0.5$; Slope compensation- Discontinuous conduction mode in current-mode control.

References

1. Robert Erickson and Dragan Maksimovic, *Fundamentals of Power Electronics*, Springer India
2. John G. Kassakian, *et al.*, *Principles of Power Electronics*, Pearson Education

Structure of the question paper

For the end semester examination, the question paper contains three questions from each module out of which two questions are to be answered by the student.

Structure of the course

| | |
|--------------------------|--------------|
| Lecture | : 3 hrs/week |
| Internal Assessment | : 40 Marks |
| End semester Examination | : 60 Marks |

Credits: 3

Course Objective

To familiarize the standard design practices followed in the industry for power electronic systems.

Learning Outcomes

Upon successful completion of this course, students will be able to design entire power electronics systems including power circuit, protection and sensing, auxiliary devices (inductors, filters) etc.

Module I

Designing with Power Semiconductors: Gate Drive requirements of SCRs, BJTs, MOSFETs and IGBTs. Precautions- Typical gate drive circuits using discrete components and Integrated Circuits- High-side switch driving using isolated gate drives : Pulse transformers and Opto-isolator based circuits and limitations-Typical circuits. Boot-strap power supply technique for high-side Gate drives: IR 2110 family of Gate drive ICs.

Power circuit design: Selection of power devices, losses, thermal design, paralleling of MOSFETs. Considerations in Gate drive design for paralleled MOSFETs.

Module II

Passive elements in Power electronics: Inductors : types of inductor and transformer assembly, cores : amorphous, ferrite and iron cores : magnetic characteristics and selection based on loss performance and size, relative merits/demerits.

Capacitors: types of capacitors used in PE, selection of capacitors, dc link capacitors in inverters and rectifiers, filter capacitors in dc-dc and inverter circuits,- Equivalent Series Resistance and Equivalent Series Inductance of capacitors and their effects in converter operation-Resistors: Power resistors, use in snubbers. Resistors for special purpose: HV resistors and current shunts.

Magnetics design: Design based on area-product approach, inductors, transformers.

Sensors: Design of current transformers for Power Electronics Applications, Resistive shunts, Hall-effect based current sensors, typical design based on hall-effect sensors, auxiliary scaling and signal conditioning circuits.

Module III

Design of protection elements, thermal protection, thermal sensor based protection, short-circuit and over-current protection in IGBTs (de-saturation protection in gate drives). Snubbers and Snubber design for typical applications (in flyback/forward converters) (RCD snubbers)

Design of filters - input and output filters - selection of components - typical filter design for single phase and three phase inverters - LC filter - corner frequency selection - harmonic filtering performance - Constraints in the design. System integration issues: Parasitics and noise in Power Electronics: parasitics and their effects and tackling parasitics, leakage inductance and bus-bar inductance, Power circuit assembly, techniques in bus-bar design for medium and high power converters to minimise dc-bus loop inductance - idea of ground loops and their effects in converter operation. Creepage-requirements in power converter hardware.

References

1. V. Ramanarayanan, '*Switch Mode Power Conversion*,' e-book, Department of Electrical Engineering, IISc, Bangalore. Available at: <http://www.ee.iisc.ernet.in/new/people/faculty/vram> (For Thermal Design, Magnetics design, Reactive elements, Drive circuits, etc).
2. L. Umanand, "*Power Electronics: Essentials & Applications*," New Delhi, Wiley India Pvt. Ltd.
3. Ned Mohan et al., '*Power Electronics: Converters, Design and Applications*', John Wiley and sons, (Power circuit design, assembly, parasitics, current sensors, etc
4. Robert Erickson and Dragan Maksimovic, '*Fundamentals of Power Electronics*,' Springer India
5. Daniel W. Hart, "*Power Electronics*", Tata McGraw-Hill
6. International Rectifiers Application Notes. AN 936, AN 937, AN 941, AN 944, AN 978, AN 1084, AN1092
7. Data sheets EPCOS, ALCON etc., for capacitors, ferrite cores etc. (Available on <http://www.epcos.com>, and <http://www.alconelectronics.com>)

Structure of the question paper

For the end semester examination, the question paper contains three questions from each module out of which two questions are to be answered by the student.

EPC3101

THESIS PRELIMINARY: PART II

Structure of the Course

| | | |
|--------------------------------|---------------|------------|
| Thesis | : 14 hrs/week | Credits: 5 |
| Internal Continuous Assessment | : 200 Marks | |

The Thesis Preliminary Part - II is an extension of Thesis Preliminary Part - I. Thesis Preliminary Part II comprises preliminary thesis work, two seminars and submission of Thesis - Preliminary report. The first seminar would highlight the topic, objectives and methodology and the second seminar will be a presentation of the work they have completed till the third semester and the scope of the work which is to be accomplished in the fourth semester, mentioning the expected results.

Distribution of marks

Internal assessment of work by the Guide : 100 Marks

Internal evaluation by the Committee : 100 marks

EPC4101

THESIS

Structure of the Course

| | | |
|--------------------------------|---------------|-------------|
| Thesis | : 21 hrs/week | Credits: 12 |
| Internal Continuous Assessment | : 300 Marks | |
| End Semester Examination | : 300 Marks | |

The student has to continue the thesis work done in second and third semesters. There would be an interim presentation at the first half of the semester to evaluate the progress of the work and at the end of the semester there would be a pre-Submission seminar before the Evaluation committee for assessing the quality and quantum of work. This would be the qualifying exercise for the students for getting approval from the Department Committee for the submission of Thesis. At least once technical paper is to be prepared for possible publication in Journals/Conferences. The final evaluation of the Thesis would be conducted by the board of examiners constituted by the University including the guide and the external examiner.

Distribution of marks

Internal evaluation of the Thesis work by the Guide : 150 Marks

Internal evaluation of the Thesis by the Evaluation Committee : 150 Marks

Final evaluation of the Thesis Work by the Internal and External Examiners:

[Evaluation of Thesis: 200 marks *+ Viva Voce: 100 marks (**5% of the marks is ear marked for publication in Journal/Conference*)] TOTAL – 300 Marks