CHRIST UNIVERSITY

BANGALORE, INDIA

Declared as Deemed to be University under Section 3 of UGC Act 1956

FACULTY OF ENGINEERING

Kengeri Campus, Kanminike, Kumbalagodu, Bangalore – 560060

DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING

Master of Technology in Power Systems

JANUARY 2013

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1. INTRODUCTION

Christ University was formerly Christ College (Autonomous) affiliated to Bangalore University. Established in July 1969, Christ College became the most preferred educational institution in the city of Bangalore within the first three decades. From 1990 onwards it scaled from heights to heights. By the introduction of innovative and modern curriculum, insistence on academic discipline, imparting of Holistic Education and with the help of the creative and dedicated staff, Christ College has been continually rated among the top 10 educational institutions of the country. It has the rare distinction to be the first institution in Karnataka to be accredited by National Assessment and Accreditation Council (NAAC) UGC for quality education. On 7 October 2004, UGC has conferred Autonomy to Christ College (No.F.13-1/2004).

On May 20, 2005, it became the first College in South India to be reaccredited with A+ by NAAC. UGC has identified it as an Institution with Potential for Excellence in June 2006. July 22, 2008 is the most glorious day in the history of the institution. Under Section 3 of the UGC Act, 1956, Ministry of Human Resources Development of the Union Government of India, vide Notification No. F. 9-34/2007-U.3 (A), has declared it a Deemed to be University, in the name and style of Christ University

VISION

"EXCELLENCE AND SERVICE"

- Christ University, a premier educational institution, is an academic fraternity of individuals dedicated to the motto of excellence and service. We strive to reach out to the star of perfection through an earnest academic pursuit for excellence and our efforts blossom into 'service' through our creative and empathetic involvement in the society to transform it.
- Education prepares one to face the challenges of life by bringing out the best in him/her. If this is well accepted, education should be relevant to the needs of the time and address the problems of the day. Being inspired by Blessed Kuriakose Elias Chavara, the founder of Carmelites of Mary Immaculate and the pioneer in innovative education, Christ University was proactive to define and redefine its mission and strategies reading the signs of the time.

MISSION STATEMENT

"Christ University is a nurturing ground for an individual's holistic development to make effective contribution to the society in a dynamic environment."

CORE VALUES

The values which guide us at Christ University are:

Faith in God

Moral Uprightness

Love of Fellow Beings

Social Responsibility

Pursuit of Excellence

2. COURSE OFFERED

- **Undergraduate Programmes (B. Tech) (4 Years Program)**
    - Electrical and Electronics Engineering (EEE)

- **Int. BTech with MBA (5 Years Program)**
    - Int. BTech(EEE) with MBA (Finance/HR/Marketing/Lean Operations & Systems)

- **Int. BTech with M. Tech (5 Years Program)**
    - Int. BTech(EEE) with MTech (Power Systems)

- **Postgraduate Programmes (M. Tech) (2 Years Program)**
    - Master of Technology in Power Systems

- **Doctoral Programmes (Ph.D.) (Doctor of Philosophy)**
    - Doctor of Philosophy (Ph.D.) in Electrical Engineering

3. ELIGIBLITY CRITERIA

❖ **For Undergraduate Programmes and Int. B Tech (EEE) with MBA & Int. B. Tech (EEE) with M. Tech:**

- A pass in PUC (10+2) or equivalent with 50% marks in aggregate with Mathematics, Physics and Chemistry is the minimum eligibility for admission

Lateral Entry:

Candidates who have successfully completed 3 year diploma in Engineering or Bachelor of Science (as applicable) are eligible to apply for lateral entry into:

BTech Electrical and Electronics Engineering

Candidates will be admitted to second year of the programme only after appearing the Christ University selection process for engineering programmes.

❖ **For Postgraduate Programmes:**

- For Master of Technology in Power Systems
  - A Pass Class in BE/BTech in Electrical & Electronics Engineering

❖ **For Doctoral Programmes (Ph.D.):**

- Doctor of Philosophy (Ph.D.) in Electrical Engineering
  - A pass with 55% marks in post graduation and/or equivalent in the relevant subject from any recognized university.
  - A research proposal (Maximum 1500 words) has to be submitted along with the application.

4. SELECTION PROCESS

1) Candidates can process the admission based on the Undergraduate Entrance Test and Ranking by COMEDK.

   OR

2) Christ University Selection Process as given below:

Process	Particulars	Date	Venue/Centre
Entrance Test	Christ University Entrance test for each candidate	As per the E-Admit Card	As per the E- Admit Card
Personal Interview	Personal interview for 15 minutes for each candidate by an expert panel	As per the E-Admit Card	As per the E- Admit Card
Academic Performance	Assessment of past performance in Class 10, Class 11/12 during the Personal Interview	As per the E-Admit Card	As per the E- Admit Card

5. ADMISSION PROCESS

Candidates will be intimated about the Selection status (Selected/Wait Listed/Not Selected) through the University Notice Board/on the “Application Status” link on University website. The Selection results will be declared within 24 hours of Personal Interview session.

The selected candidates must process admission at Office of Admissions, Central Block, Christ University within 3 working days of declaration of Selection Process results/as per the stipulated date and time mentioned by Office of Admissions.

Selected candidates should collect the Fee Challan from the Office of Admissions and remit the Annual fee at the South Indian Bank, Christ University Branch. The Offer of Admission will stand cancelled, if failing to remit the fee within the stipulated date and time.

Admission will not be processed without the presence of the candidate and the mandatory original documents mentioned below;

1. The Offer of Admission Card (E-Admission Card/Mail)
2. Class 10 Marks Statement
3. Class 11 Marks Statement, if Candidate is pursuing class 12 and appearing for final examination during March-April 2012
4. Class 12 Marks Statement, if candidate has appeared and passed the Class 12 examination

The University ID card is a smart card, which is both an ID card as well as a South Indian Bank ATM card with a chip containing the student personal details. All transactions within the University campus after commencement of classes, including fees payment will be processed only through this card. It is also an access card for Library and other restricted places. Candidates are advised to collect the South Indian Bank account opening form along with fees challan and process it at the Bank branch within the University premises.

Candidates who fall under International student category (ISC), If selected, should register with the Foreigner Regional Registration Officer (FRRO/FRO) of the Local Police in Bangalore, India within 14 working days from the date of admission or arriving in Bangalore.

All International student category (ISC) candidates if studied in India should obtain an NOC from the previous qualifying institution.

6. GENERAL RULES

- **There is a grading scheme for each paper and for all the courses.**
- All marks will indicate the marks, percentage obtained, grade and grade point average.
- The grade point average will be calculated as follows: for each subject, multiply the grade point with the number of credits; divide the sum of product by the total number of credits.
- The CGPA [Cumulative GPA] is calculated by adding the total number of earned points [GP x Cr] for all semesters and dividing by the total number of credit hours for all semesters.

$$\textbf{GPA}=\frac{\sum[\text{GPA x Cr}]}{\sum \text{Cr}}$$

7. Grading scheme for Each Paper: Postgraduate Courses

Percentage	Grade	Grade Point	Interpretation	Class
80 and above	A+	4.0	Excellent	First Class with Distinction
70-79	A	3.5	Very Good	
65-69	B+	3.0	Good	First Class
60-64	B	2.5	Above Average	
55-59	C+	2.0	Average	Second Class
50-54	C	1.5	Satisfactory	
40-49	C-	1.0	Exempted if aggregate is more than 50%	Pass Class
39 and below	F	0	Fails	Fail

8. COURSE OVERVIEW:

Electrical energy is probably the cleanest forms of energy that is suitable for easy, efficient and economical to transmission, distribution and control. As a result the captive electrical powers system, viz. generation transmission and consumption are ubiquitous all over the world. So much so that in today's world, the country's development index is represented in terms of per capita power consumption. Ensuring safe, reliable and quality power is hence a mandate for any company engaged in power industry. This of course, hugely depends on the competence and the expertise of the power system engineers in that company. The MTech Power system, a two year, four semester course, offered by Christ University faculty of Engineering is designed to develop the needed knowledge and expertise in this area with emphasis on power system operation and practice. Our desire is provide the students with facilities and curriculum for a comprehensive learning and help them develop expertise in this area. With needs of energy growing day-by-day, demand for professional in the area of power will continue to rise.

9. COURSE OBJECTIVE:

The MTech (Electrical Power Systems) course aims at to fulfill the following broad objectives:

1. To familiarize the students to the Power systems infrastructure, its operation and analysis, to ensure safe and reliable energy transmission and distribution at reasonable costs

2. To enable students to identify design and development problems in Power systems and allied topics and propose an optimal solution to the identified problem.

3. To deliver hands on skills in

- operation and trouble shooting of power system components,
- prediction and forecasting of energy
- Fault detection and Diagnosis of power system
- Reliability and stability of power system
- Power system Software tools

4. To make students sensitive to energy conservation, study alternative energy sources and explore the possibilities of integrating renewable energy sources to main line power networks.

10. TEACHING PEDAGOGY:

Our teaching methodology ensures that students are being exposed to a holistic education experience in an active and dynamic learning environment, giving them the opportunity to identify and realize their potential, and to achieve excellence. In order to realize the objectives, a methodology based on the combination of the following will be adopted:

- Team/Class room teaching.
- PowerPoint presentations and handouts.
- Simulated situations and role-plays.
- Video films on actual situations.
- Assignments.
- Case Studies.
- Exercises are solved hands on.
- Seminars
- Industry / Field visits.
- Information and Communication Technology.
- Project work.
- Learning Management System.

11. DETAILS OF CIA (Continuous Internal Assessment):

Assessment is based on the performance of the student throughout the semester.

Assessment of each paper

- Continuous Internal Assessment (CIA) for Theory papers: 50% (50 marks out of 100 marks)
- End Semester Examination(ESE) : 50% (50 marks out of 100 marks)

Components of the CIA

CIA I	: Mid Semester Examination (Theory)	: 25 marks
CIA II	: Assignments	: 10 marks
CIA III	: Quizzes/Seminar/Case Studies/Project Work	: 10 marks
Attendance		: 05 marks
Total		**: 50 marks**

For subjects having practical as part of the subject

End semester practical examination	: 25 marks
Records	: 05 marks
Mid semester examination	: 10 marks
Class work	: 10 marks
Total	**: 50 marks**

Mid semester practical examination will be conducted during regular practical hour with prior intimation to all candidates. End semester practical examination will have two examiners an internal and external examiner.

12. QUESTION PAPER PATTERN:

End Semester Examination (ESE):

Theory Papers:

The ESE is conducted for 100 marks of 3 hours duration.

The syllabus for the theory papers is divided into FIVE units and each unit carries equal weightage in terms of marks distribution.

Question paper pattern is as follows.

Two full questions with either or choice will be drawn from each unit. Each question carries 20 marks. There could be a maximum of three sub divisions in a question. The emphasis on the questions is broadly based on the following criteria:

50 % - To test the objectiveness of the concept

30 % - To test the analytical skill of the concept

20 % - To test the application skill of the concept

Laboratory / Practical Papers:

The ESE is conducted for 50 marks of 3 hours duration. Writing, Execution and Viva – voce will carry weightage of 20, 20 and 10 respectively.

Mid Semester Examination (MSE):

Theory Papers:

The MSE is conducted for 50 marks of 2 hours duration.

Question paper pattern; Five out of Six questions have to be answered. Each question carries 10 marks.

Laboratory / Practical Papers:

The MSE is conducted for 50 marks of 2 hours duration. Writing, Execution and Viva – voce will carry weightage of 20, 20 and 10 respectively.

Holistic Education:

End Semester Examination	25 Marks
Participation	25 Marks
Total	**50 Marks**

- **Assessment of Project Work(Phase I)**
  - Continuous Internal Assessment:100 Marks
    - Presentation assessed by Panel Members
    - Guide
    - Assessment of Project Report

- **Assessment of Project Work(Phase II) and Dissertation**
  - Continuous Internal Assessment:100 Marks
    - Presentation assessed by Panel Members
    - Guide
    - Assessment of Project Report
  - End Semester Examination:100 Marks
    - Viva Voce
    - Demo
    - Project Report
  - Dissertation (Exclusive assessment of Project Report): 100 Marks
    - Internal Review : 50 Marks
    - External review : 50 Marks

- **Assessment of Seminar**
  - Continuous Internal Assessment:50 Marks
    - Presentation assessed by Panel Members

13. Course Structure

I Semester

Sl. No.	Course Code	Course Name	Marks	Credits
THEORY				
1	MTEE131	Optimization Techniques	100	3
2	MTEE132	Advanced Control Systems	100	3
3	MTEE133	Power System Operation and Control	100	3
4	MTEE134	Computer Aided Power System Analysis	100	3
5	MTEE135	High Voltage DC Transmission	100	3
6	HE171	Holistic Education		1
PRACTICAL				
7	MTEE151	Power System Simulation Lab	50	2
8	MTEE152	Advanced control systems lab	50	2
Total			600	20

II Semester

Sl. No.	Course Code	Course Name	Marks	Credits
THEORY				
1	MTEE231	Power electronics in Power System	100	3
2	MTEE232	Power system Dynamics and control	100	3
3	MTEE233	Flexible AC Transmission Systems	100	3
4	MTEE234	Energy management systems and SCADA	100	3
5	MTEE235	Elective 1	100	3
6		Holistic Education		1
PRACTICAL				
7	MTEE271	Professional Practice I	50	2
8	MTEE251	Survey of Generation, transmission and distribution	50	2
9	MTEE252	Power systems SCADA Lab	50	2
Total			650	22

III Semester

Sl. No	Course Code	Course Name	Marks	Credit
THEORY				
1	MTEE331	Elective II	100	3
2	MTEE332	Elective III	100	3
3	MTEE333	Elective IV	100	3
PRACTICAL				
4	MTEE371	Professional Practice II	50	2
5	MTEE372	Project work Phase I	200	6
Total			650	17

IV Semester

Sl. No	Course Code	Course Name	Marks	Credit
1	MTEE471	Project work Phase II and Dissertation	300	9
2	MTEE472	Seminar	50	2
Total			350	11

Electives – List

Sl. No	ELECTIVES	Marks	Credit
1	Microcontroller Applications in Power	100	3
2	Renewable Power Generation Sources	100	3
3	Advanced Power System Analysis	100	3
4	Power System Reliability and Planning	100	3
5	Wind Energy Conversion Systems	100	3
6	Modern Rectifiers And Resonant Converters	100	3
7	Electrical Distribution Systems	100	3
8	Fuzzy And Neural Networks	100	3
9	Extra High Voltage Engineering Systems	100	3
10	Power Quality	100	3
11	Advanced Power System Protection	100	3
12	Real time control of power system	100	3
13	Power system Optimization	100	3
14	Advanced power electronics	100	3
15	Energy Conservation and Audit	100	3
16	Advanced Digital Signal Processing	100	3
17	Power System Measurement and Instruments	100	3
18	Adaptive Control Systems	100	3

14. Detailed Syllabus - I Semester

MTEE133 Optimization Techniques

Objective*: *To learn and apply the different optimization techniques to both linear and non-linear with emphasis on engineering systems.

Unit 1 9+3

Introduction, Statement of an optimization problem, design vector, design constraints, constraint surface, objective function, classification of optimization problem.

Classical optimization Techniques, single variable optimization, multivariable optimization with equality constraints, Direct substitution method, constrained variation method, Lagrange Multiplier method, formulation of multivariable optimization, Kunh- Tucker conditions.

Unit 2 9+3

Linear programming: Statement and classification of optimization problems overview of optimization techniques standard form of linear programming problems-Definitions and theorems-Simplex method-Revised simplex method-Duality and Dual simplex method-Sensitivity analysis.

Unit 3 9+3

Unconstrained dimensional optimization techniques: Necessary and sufficient conditions-search methods(unrestricted Fibonacci and golden)-Interpolation methods(Quadratic, Cubic and direct root method).Direct search methods-Random search-pattern search and Rosen Brock's hill climbing method-Descent methods-Steepest descent, conjugate gradient,Quasi Newton and DFE method.

Unit 4 9+3

Constrained optimization techniques & dynamic programming:

Necessary and sufficient conditions-Equality and inequality constraints-Kuhn-Tacker conditions-Gradient projection method-cutting plane method-Penalty function method(Interior and exterior).Principle of optimality-recurrence relation-Computation procedure-continuous dynamic programming.

Unit 5 9+3

Recent developments in optimization techniques:

Rosen brocks Rotating Coordinate Method-Tabu search-Simulated Annealing-Genetic Algorithm-Particle Swarm Optimization –Ant colony Optimization-Bees Algorithm.

Text Books:

1. Optimisation Techniques-S.S.Rao, Wiely Eastern Ltd, New Delhi.

REFERENCES:

1. Pierre, D.A. ‘Optimisation Theory with Applications’ John Wiley & Sons, 1969

2. Fox, R.L., ‘Optimisation method for Engineering Design’, Addition Welsey,1971.

3. Hadely,G., ‘Linear Programming’, Addition Wesley, 1962.

4. Bazaara&Shetty, ‘Non-linear Programming’.

5. D.E. Goldberg, Genetic Algorithm in Search, Optimization, and Machine Learning. Reading, MA: Addison-Wesly, 1989.

6. MarcoDorigo, Vittorio Miniezza and Alberto Colorni “Ant System:Optimization by a colony of Cooperation Agents” IEEE transaction on system man and Cybernetics-Part B:cybernetics, Volume 26, No 1, pp. 29-41,1996.

7.Shi, Y. Eberhart, R.C., “A Modified Particle Swarm Optimizer”, Proceedings of the IEEE International conference on Evolutionary Computation, Anchorage, AK, pp. 69-73, May 1998

8. ROSS BALDICK, “APPLIED OPTIMIZATION Formulation and Algorithms for Engineering Systems, CAMBRIDGE UNIVERSITY PRESS 2006.

MTEE132 Advanced control Systems

Objective:

To impart knowledge about advances in control system in the areas of state-space modeling & stability of continuous & discrete system. It will also make students familiar with the non-linear system – their modeling and analysis. At the end of the course a student will be equipped to handle linear and non-linear control problems.

UNIT 1 9+3

State Space Analysis: Review of state space representation of continuous linear time invariant system, conversion of state variable models to transfer functions and vice versa, transformation of state variables, solution of state equations, state and output controllability and observability.

UNIT 2 9+3

Analysis of Non linear Systems :Common Physical Nonlinearities, singular points, phase plane analysis, limitcycles, describing function method and stability analysis, Jump resonance,Linearization of nonlinear systems. Lyapunov stability, methods for generatingLyapunov function, statement of Lure problem, circle criterion, Popov criterion.

UNIT 3 9+3

Analysis of Discrete System :Discrete time signals and systems, z-transformation, modeling of sample-hold circuit, pulse transfer function, solution of difference equation by z-transform method, stability in z-plane.

UNIT 4 9+3

Basic concepts of optimal control, adaptive control and robust control systems.

UNIT 5 9+3

Study of at least 05 papers as prescribed by the faculty incharge

Text Books:

1. K. Ogata, "Modern Control Engineering", Prentice Hall of India, 1999.
2. M. Gopal, "Digital Control and State Variable Methods", Tata Mcgraw Hill, 1997

References :

1. Noraman S. Nise, "Control System Engineering", John Wiley Sons, 2001
2. Kuo.,BC., "Digital Control Systems", Saunders College Publishing, 1992
3. K. Ogata, "Discrete Time control System," Prentice Hall International, 1987
4. I.J Nagrath & M. Gopal "Control System Engg" Fifth Edition New Age Publication, 2007

Related e-Journals and books for advanced work.

(i) IEEE Transaction on Control System Technology
(ii) IET Research Journal on Control Theory & Applications
(iii)NPTEL Courses on Electrical Engg.

MTEE133 Power system Operation and Control

UNIT I

REACTIVE POWER AND VOLTAGE CONTROL 9+3

Production and absorption of reactive power- Methods of Voltage Control – Shunt reactors – Shunt Capacitors – Series Capacitors – Synchronous condensers – Static Var systems – Principles of Transmission system compensation – Modeling of reactive compensating devices – Application of tap changing transformers to transmission systems – Distribution system voltage regulation – Modelling of transformer ULTC control systems.

UNIT II

UNIT COMMITMENT 9+3

Constraints in unit commitment – Spinning reserve – Thermal unit constraints – Other constraints – Solution using Priority List method, Dynamic programming method - Forward DP approach Lagrangian relaxation method – adjusting .

UNIT III

GENERATION SCHEDULING 9+3

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

UNIT IV

CONTROL OF POWER SYSTEMS 9+3

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

UNIT V

STATE ESTIMATION 9+3

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

Text Books:

1. Elgerd.O.I, "Electric Energy System Theory - an Introduction", - Tata McGraw Hill, New Delhi – 2002.
2. Kundur.P ; "Power System Stability and Control", EPRI Publications, California , 1994.

REFERENCES:

1. Allen J.Wood and Bruce.F.Wollenberg, "Power Generation Operation and Control" , John Wiley &Sons , New York, 1996.
2. Mahalanabis. A.K, Kothari. D.P. andAhson.S.I., "Computer Aided Power System Analysis and Control", Tata McGraw Hill publishing Ltd , 1984.
3. K Uma Rao, Power system operation and control, Wiley India, 2012

MTEE134 Computer Aided Power System Analysis

UNIT 1 9+3

Introduction: Graph of a power system, incidence matrices, primitive network, formation of network matrices by singular and non singular transformation, Representation of power system for computerized analysis, mathematical model of synchronous generator for steady state and transient analysis, transformer with tap changer, transmission line, phase shifter and loads.

UNIT 2 9+3

Algorithm for formation of bus impedance matrix, modification for changes in the network. Incidence and network matrices for three phase network, transformation matrices, algorithm for formation of bus impedance matrix for three phase networks.

UNIT 3 **9+3**

Short Circuit Studies: Symmetrical component, Thevenin's theorem and short circuit analysis of multi node power systems using bus impedance matrix. Short circuit calculations for balanced and unbalanced faults.

UNIT 4 **9+3**

Load Flow and Transient Analysis: Types of buses, load flow equations, power flow solution through GS and NR methods, decoupled and fast decoupled methods, sparsity. Transient stability Analysis including synchronous machines, system network and loads, solution of swing equation by Euler's, Euler's modified and RK methods.

UNIT 5 Economic Load Scheduling: **9+3**

Unit commitment, transmission loss, load scheduling considering transmission losses, unit commitment by dynamic programming method, start up consideration, reliability analysis, hydrothermal scheduling.

Text Books

1. Computer Methods in Power System Analysis, G.W. Stagg &A.H.El-Abiad McGraw Hill 2003
2. Computer Aided Analysis of Power System, Kusis, PHI-2006

References

1. K. Uma Rao, “Computer Techniques and models in power systems”, IK International Pub. House Pvt. Ltd., 2007

2. Modern Power System Analysis (3rd Edn.), Kothari & Nagrath TMH.-2004

2. Power System Analysis, Hadi Saadat TMH-2004

3. Advanced Power System Analysis and Dynamics, L. P. Singh WEL-2002.

MTEE135 HVDC TRANSMISSION

Objectives:

To familarise the Evolution of HVDC systems and the comparison of HVAC and HVDC transmission systems, Understand components of HVDC transmission system and analysis of HVDC converters, different application of HVDC system and advances in HVDC systems.

Unit 1

DC POWER TRANSMISSION TECHNOLOGY 9+3

Introduction - Comparison of AC and DC transmission - Application of DC transmission – Description of DC transmission system - Planning for HVDC transmission - Modern trends in DC transmission.

Unit 2

ANALYSIS OF HVDC CONVERTERS 9+3

Pulse number, choice of converter configuration - Simplified analysis of Graetz Circuit - Converter bridge characteristics – Characteristics of a twelve pulse converter - Detailed analysis of converters.

Unit 3

CONVERTER AND HVDC SYSTEM CONTROL 9+3

General principles of DC link control - Converter control characteristics - System control hierarchy - Firing angle control - Current and extinction angle control - Starting and stopping of DC link - Power control - Higher level controllers- Telecommunication requirements.

Unit 4

MULTITERMINAL DC SYSTEM 9+3

Multi terminal DC systems: Introduction – Potential application of MTDC systems – Types of MTDC systems –Control and protection of MTDC systems - Operation of HVDC breaker.

Unit 5

HARMONICS AND CONVERTER COMPONENT MODEL

Introduction - Generation of harmonics - Design of AC filters - DC filters - Carrier frequency and RI noise.

Converter model - Continuous time model - Discrete time converter model - Detailed model of the converter.

TEXT BOOKS:

1. Padiyar, K.R., "HVDC Power Transmission System", Wiley Eastern Limited, New Delhi 1990. First Edition.

2. Edward Wilson Kimbark, "Direct Current Transmission", Vol. I, Wiley Interscience, New York, London, Sydney, 1971.

REFERENCE BOOKS:

1.J Arrillaga, "*High Voltage Direct current Transmission*", Peter Peregrinus Ltd, UK.

2. SN Singh, "*Electric Power Generation, Transmission and Distribution*, PHI, New Delhi 2nd edition, 2008.

3.Rakosh Das Begamudre, "Extra high voltage AC transmission Engineering", New Age International (P) Ltd., New Delhi, 2006.

4.Arillaga, J., "High Voltage Direct Current Transmission", Peter Pregrinus, London, 1998.

5.VIijay K. Sood, "HVDC & FACTS Controllers – Application of static converters in power system".

6.Jos Arillaga, Y.H.Liu, N.R. Watson, "Flexible Power Transmission" – The HVDC option-John Wiley & sons ltd, 2007.

MTEE151 Power system simulation lab 1

Objective: *To develop programs to solve power system problems. Also to train the students in using commercially available application software packages in power system field.*

1. Develop a program for solving
   a.Unit commitment problem
   b.Thermal dispatch problem
   c.Hydro thermal co-ordination problem
2. Simulate single area and two area system using any application software.
3. Develop a program for Y_{BUS} formation by two dimensional matrix.
4. Develop a program for load flow by Newton-Raphson method (Q adjusted and Q unadjusted cases)
5. Develop a program for load flow by Fast Decoupled method.
6. Develop a program for Z_{BUS} formation.
7. Measurement of sequence reactance of 3-phase alternator and 3-phase transformer.
8. Measurement of synchronous machine parameters – Xd, Xq, Xd', Xq', Xd", Xq", Tdo', Tqo', Tdo" and Tqo".
9. Insulation testing of LT and HT insulators.
10. Study of characteristics of long transmission lines using Lab models.

MTEE152 Advanced control systems laboratory

1. Simulation of first order and second order system with and without dead time using discretization method and Range – Kutta method
2. Design of Discrete P+I+D controller and Deadbeat controller for a first order system
3. State feedback control of a process by pole placement.
4. State estimation of a process using full order and reduced order observers.
5. Logic gates operations, Timing Operations, counter operations and math operations using PLC.
6. Control of Bottle filling system and sequential operation of motors using PLC.
7. PC based data acquisition report generation.
8. Simulation of complex control systems using mat lab package.
9. Study of distributed control system.
10. Control of a given process using Real Time Embedded controller

Detailed Syllabus

1. Simulation of first order and second order system with and without dead time using discretization method and Runge – Kutta method

Aim

To simulate a first order system and second order system with and without dead time using discretization method and Runge-Kutta method.

Exercises

1. Write a program in C language for a first order system and second order system with and without dead time using discretization method.

2. Write a program in C language for a first order system and second order system with and without dead time using Runge – Kutta method.

3. To analyse the responses for various standard forcing functions.

Equipment.

Computer Pentium (3 or 4) - 1 No

2. Design of Discrete P+I+D controller and Deadbeat controller for a first order system

Design of Discrete P+I+D controller

Aim

To design a discrete P+I+D controller for a first order system

Exercise

1. Write a program in C for position form of control algorithm.
2. Write a program in C for velocity form of control algorithm.
3. Analysis of the responses by implementing the position and velocity form of control algorithms for the first order system.
4. How to select the sampling rate in a digital control loop.

Equipment

Pentium Computer (3 or 4) - 1 No

Deadbeat controller for a first order system

Aim

To design a deadbeat for a first order process.

Objective

To examine a different methodology for designing digital feedback controllers, which makes use of the computational flexibility, offered by a digital computer.

Exercise

1. Design of Deadbeat controller for a first order process and analyse the closed loop response using C language.
2. Analysis of closed loop responses to step changes in set point using deadbeat.

Equipment

Computer Pentium (3 or 4) - 1 No

3. State feedback control of a process by pole placement.

Aim

To design state feedback gain matrix by pole placement technique for a multivariable process.

Exercise

1. Write a program using any software package to find state feedback gain matrix.
2. Analysis of the responses by implementing the state feedback technique by pole placement for a multivariable process.

Equipment

Computer Pentium (3 or 4) - 1 No

4. State estimation of a process using full order and reduced order observers

Aim

To estimate the states of a multivariable process using full order and reduced order observers

Exercise

1. Write a program using any simulation software package to estimate the states using full order and reduced order observers.
2. Analysis of responses by implementing the designed observers for a multivariable process.

Equipment

Computer Pentium (3 or 4) - 1 No

5. Logic gates operations, Timing Operations, counter operations and math operations using PLC

Aim

To study the operation of Programmable logic controller.

Exercise

1. Implementation of the AND / OR gate using PLC.
2. Implementation of proportional (P) control system.
3. A program which sounds an alarm when a preset count value is reached.
4. A program sounds an alarm after a time delay.
5. A program which illustrates the use of flags and the flag instructions.

Equipment

1. PLC Unit - 1 No
2. Computer Pentium (3 or 4) - 1 No

6. Control of Bottle filling system and sequential operation of motors using PLC.

Aim

To study the control of bottle filling system using PLC and sequential operation of motors using PLC.

Objectives

1. Instead of achieving the desired control or automation through physical wiring of control devices, in PLC how it is achieved through a program of software.
2. To develop the programming skills for the industrial needs.
3. How to develop an interface between PLC and the bottle filling system.
4. How to develop an interface between PLC and sequential motors using PLC.

Exercise

1. To develop the ladder diagram for the bottle filling system.
2. To develop the ladder diagram for the sequential operation of motors using PLC.

Equipment

1. Computer Pentium (3 or 4) - 1 No
2. PLC - 1 No
3. Bottle filling system - 1 No

7. PC based data acquisition report generation.

Aim

To acquire real world signals using Data Acquisition card.

Exercise

Develop a program in C – language to acquire the data and display

Equipment

1. Data Acquisition card - 1 No
2. Computer Pentium (3 or 4) - 1 No

8. Simulation of complex control systems using matlab package.

Aim

To study the simulation of complex control systems using MATLAB package.

Objective

To examine the advanced control strategies like cascade control, feed forward plus feedback control, ratio control.

Exercise

1. To simulate cascade control, feed forward – feedback control using MAT LAB.

2. Compare the results of cascade control with conventional control.
3. To simulate a ratio control for a process to maintain a desired ratio.
4. Compare the results of feed forward – feedback with feedback control.

Equipment

1. Computer Pentium (3 or 4) - 1 No
2. MATLAB original licensed version 6.0.

9. Study of distributed control system.

Aim

To study the distributed control system

Objectives

1. To get the knowledge of communication interface between the controller and the server, server and the clients and the controller to the I/O units.
2. To know how the I/O connection with the process control station to the DCS I/O units.
3. To know how several LCU's is used to implement control strategies.
4. To know how the transmission of process data is connected to the high level system elements (i.e. human interface and computing devices).
5. To know how the high – level element transmits information requests and control commands to the LCU's.
6. To know how the cost of plant wiring is reduced significantly by the few cables or buses used to implement the shared communication system.
7. To know how the transmission of process variables, controlled variables, alarm status information from the LCU's to the high – level interfaces and to low-level human interfaces in the system.

Exercise

1. Using graphic and text features design different types of operator interaction pages, to suit different process stations available in process control lab.
2. Implement the various control actions like ON-OFF, Proportional, Proportional + Integral, Proportional +Derivative, Proportional + Derivative + Integral on different process stations available in process control lab.
3. Analyze the responses for set point and disturbance changes.

Equipment

1. Computer Pentium (3 or 4) - 1 No
2. DCS - 1 No

II Semester

MTEE231 Power Electronics in Power Systems

UNIT I

POWER DEVICES

Basic concept of power electronics - different types of power electronic devices - diodes - transistors and SCR - MOSFET - IGBT and GTO's.

UNIT II

A.C. TO D.C. CONVERTERS

Single phase and three phase bridge rectifiers - half controlled and fully controlled converters with R, RL, and RLE loads - free wheeling diodes - dual converter - sequence control of converters - inverter operation - input harmonics and output ripple - smoothing inductance - power factor improvement effect of source impedance - overlap - inverter limit.

UNIT III

D.C. TO A.C. CONVERTERS

General topology of single phase and three phase voltage source and current source inverters – need for feedback diodes in anti parallel with switches - multi quadrant chopper viewed as a single phase inverter - configuration of single phase voltage source inverter - half and full bridge - selection of switching frequency and switching device - voltage control and PWM strategies.

UNIT IV

STATIC REACTIVE POWER COMPENSATION

Shunt reactive power compensation - fixed capacitor banks - switched capacitors - static reactor compensator - thyristor controlled shunt reactors (TCR) - thyristor controlled transformer - FACTS technology - applications of static thyristor controlled shunt compensators for load compensation - static var systems for voltage control - power factor control - harmonic control of converter fed systems.

UNIT V

POWER QUALITY

Power quality - terms and definitions - transients - impulsive and oscillatory transients -harmonic distortion - harmonic indices - total harmonic distortion - total demand distortion -locating harmonic sources harmonics from commercial and industrial loads - devices for controlling harmonics passive and active filters - harmonic filter design.

REFERENCES

1. N. Mohan, T.M. Undeland and W.P. Robbins, 'Power Electronics: Converter, Applications and Design', John Wiley and Sons, 1989.
2. M.H. Rashid, 'Power Electronics', Prentice Hall of India, 1994.
3. B.K. Bose, 'Power Electronics and A.C. Drives', Prentice Hall, 1986.
4. Roger C. Dugan, Mark F. Mc Granaghan, Surya Santaso and H. Wayne Beaty, 'Electrical Power Systems Quality', Second Edition, McGraw-Hill, 2002.
5. T.J.E. Miller, 'Static Reactive Power Compensation', John Wiley and Sons, New York,1982.

MTEE232 Power system Dynamics and control

Unit 1

Concept of Power System Dynamics and Stability:

Types of stability, stability of synchronous machine, factors affecting stability and recent trends in improving stability, tie line oscillations.

Unit 2

Large disturbance Stability: System of one machine connected against infinite bus, classical model, and equal area criteria technique and its applications, precalculated swing curve, Evaluation and simulation

Small disturbance Stability: Two-machine system with and without losses, techniques for S.S.S.limit, effect of inertia, saliency, saturation, governor action and SCR on SS power limit.

Unit 3

Excitation System: Effect of excitation system on generator power limit, transformation model of excitation system, dynamic stability, Routh's criteria for dynamic stability, self excite electro-mechanical oscillations in Power System, power system stabilizer

Unit 4

Multi machine Stability: Machine representation by classical model, voltage stability, angular stability, method of analysis of stability of power system.

Unit 5

Prime mover controllers: Control of Voltage, frequency, SCADA for stability, tie line power flow, and emergency control techniques for stability. Application of energy functions for direct stability evaluation

Text Books

1. Power System stability and Control, P. Kunder , McGraw Hill, New York 2006
2. Power System Stability, E.W. Kimbark, Vol 1 and 3, Dover Publications- 2004

References

1. Power System Dynamics, Stability and Control, K. R. Padiyar Interline Publishers, -2003

2. Power System Control and Stability, P.M Anderson and A. A. Fouad - McGraw Hill-2004

3. http://www.nptel.iitm.ac.in/

4. www.ocw.mit.edu

MTEE233 FACTS (Flexible AC Transmission System)

Unit 1

Introduction: Fundamentals of EHVAC power transmission, transmission need and Problems, emergence of FACTS, FACTS controllers.

Unit 2

Reactive Power Compensation: Compensation by STATCOM and SSSC, Synchronous condenser, saturated reactor, Thyristor-controlled reactor (TCR), Thyristor controlled transformer (TCT), Fixed capacitor-Thyristor controlled reactor (FC-TCR), Thyristor switched capacitor (TSC), Thyristor-switched capacitor-thyristor controlled reactor (TSC-TCR)

Unit 3

Shunt Compensator: Principle of operation, Analysis of a three phases six pulse STATCOM, Multi-pulse converters, Applications of STATCOM. Analysis of SVC, Configuration of SVC, SVC Controller, Modeling of SVC, Voltage Regulator Design, Voltage control by the SVC, Advantages of the slope in the SVC, Dynamic Characteristic, Influence of the SVC on System Voltage, Design of the SVC Voltage Regulator

Unit 4

Series Compensator: Thyristor Controlled Series Capacitor (TCSC), Principle of operation, Analysis and control, Applications, Static Synchronous Series Compensator (SSSC), Principle of operation, Analysis and control, Applications

Unit 5

Combined Compensators: Operation of UPFC, Applications of UPFC, Operation of IPFC, Applications of IPFC

Text books:

1. N.G Hingorani, J Gyugi, “Understanding FACTS”, JEEE Press
2. Y.H.Song, “Flexible AC Transmission Systems (FACTS)”, JEEE Series

Reference Books:

1. N.G Hingorani, J Gyugi, “Understanding FACTS”, JEEE Press
2. Y.H.Song, “Flexible AC Transmission Systems (FACTS)”, JEEE Series
3. R Mathur& P.K Verma, “Thyristor Based FACTS Controller for Electrical Transmission Systems”, IEEE Press (Wiley)
4. K.R.Padiyar, “FACTS controllers for transmission and Distribution systems‟ New Age international Publishers 1st edition -2007

MTEE234 Energy Management Systems and SCADA

Objective

The course provides an introduction to the role of Computers and Communication in Electrical Power Engineering. Energy Management Systems (EMS) and Supervisory Control and Data Acquisition (SCADA) are strongly linked and associated with each other.

EMS deals with the computer operation, optimization and control of power systems. Power System operation, optimization ad control, which are the studies carried in an EMS are presented in detail.

SCADA deals with the communication protocols and control of power systems using EMS. Open Systems, protocols for power system protection and relaying under IEC 6180 will also be covered in this course.

This course provides an introductory course material for power system automation and recent advances in technological aspects of computers and communications in networking.

Unit 1

Energy Management Centers and Their Functions, Architectures, recent Developments. Characteristics of Power Generating Units and Economic Dispatch. Unit Commitment (Spinning Reserve, Thermal, Hydro and Fuel Constraints); Solution techniques of Unit Commitment.

Unit 2

Generation Scheduling with Limited Energy. Energy Production Cost – Cost Models, Budgeting and Planning, Practical Considerations. Interchange Evaluation for Regional Operations, Types of Interchanges. Exchange Costing Techniques.

Unit 3

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.

Unit 4

Introduction to Supervisory Control and Data Acquisition.SCADA Functional requirements and Components. General features, Functions and Applications, Benefits. Configurations of SCADA, RTU (Remote Terminal Units) Connections.Power Systems SCADA and SCADA in Power System Automation.

Unit 5

SCADA Communication requirements. SCADA Communication protocols: Past Present and Future. Structure of a SCADA Communications Protocol.

SCADA Applications: Utility Applications- Transmission and distribution sector-Operations-Monitoring -Analysis and improvement- Substation automation structure- substation automation architecture.

REFERENCES

1. Handschin, E. “Energy Management Systems”, Springer Verlag, 1990.
2. Handschin, E. “Real Time Control of Electric Power Systems”, Elsevier, 1972.
3. John D Mc Donald, “Electric Power Substation Engineering”, CRC press, 2001.
4. Wood, A. J and Wollenberg, B. F, “Power Generation Operation and Control”, 2nd Edition John Wiley and Sons, 2003.
5. Green, J. N, Wilson, R, “Control and Automation of Electric Power Distribution Systems”, Taylor and Francis, 2007.
6. Turner, W. C, “ Energy Management Handbook”, 5th Edition, 2004.
7. Stuart.A. Boyer: SCADA – Supervisory Control and Data Acquisition, Instrument So-ciety of America Publication, USA, 1999.
8. Gordon Clarke, Deon Reynders: Practical Modern SCADA Protocol:DNP3, 60870.5 and Related Systems, Newnes Publications, Oxford UK,2004

III Semester
Electives

Transient over Voltages in Power Systems

Unit 1

Transients in electric power systems – Internal and external causes of over voltages – Lightning strokes – Mathematical model to represent lightning- Travelling waves in transmission lines – Circuits with distributed constants – Wave equations – Reflection and refraction of travelling waves – Travelling waves at different line terminations

Unit 2

Switching transients –double frequency transients – abnormal switching transients – Transients in switching a three phase reactor- three phase capacitor.

Unit 3

Voltage distribution in transformer winding – voltage surges-transformers –generators and motors. Transient parameter values for transformers, reactors, generators and transmission lines.

Unit 4

Basic ideas about protection –surge diverters-surge absorbers-protection of lines and stations Modern lighting arrestors. Insulation coordination- generation of high AC and DC –impulse voltages, currents- measurement .

Unit 5

Generation of high AC and DC –impulse voltages, currents-measurement using sphere gap speak voltmeters-potential dividers and CRO.

References

1. Allen Greenwood, 'Electrical transients in power systems', Wiley Interscience, 1971.

2. Bewley, L.W., 'Traveling waves and transmission systems', Dover publications, New York, 1963

3. Gallaghar, P.J. and Pearmain, A.J., 'High voltage measurement, Testing and Design', John Wiley and sons, New York, 1982.

Microcontroller Applications in Power Converter

Unit 1

Use of microcontrollers for pulse generation in power converters – Overview of Zero-Crossing Detectors – typical firing/gate-drive circuits – firing/gate pulses for typical single-phase and three phase power converters - PIC16F876 Micro-controller – device overview - pin diagrams.

Unit 2

PIC16F876 micro-controller memory organisation – Special Function Registers – I/O ports – Timers – Capture/Compare/PWM modules (CCP).

Unit 3

Analog to Digital Converter module - Instruction set – Instruction description - Introduction to PIC microcontroller programming – Oscillator selection – reset – interrupts - watch dog timer.

Unit 4

Introduction to MPLAB IDE and PICSTART plus - Device Programming using MPLAB and PICSTART plus- generation of firing/gating pulses for typical power converters.

Unit 5

8051 microcontroller - architecture – addressing modes – I/O ports – instruction sets – simple assembly language programming.

References

1. PIC16F87X Datasheet 28/40 - pin 8 bit CMOS flash microcontrollers, Microchip technology Inc., 2001 and MPLAB IDE Quick start guide, Microchip Technology Inc., 2007.

2. John B. Peatman, "Design with PIC Microcontrollers", Prentice Hall, 2003.

3. Myke Predko, "Programming and customizing the PIC microcontroller", Third Edition, Tata McGraw Hill, 2008.

4. M.A. Mazidi, J.G Mazidi and R.D McKinlay, "The 8051 microcontroller and embedded systems", Second Edition, PHI, New Delhi, 2007.

Renewable Power Generation Sources

Unit 1

Basic characteristics of sunlight – solar energy resource – photovoltaic cell-characteristics – equivalent circuit – photo voltaic for battery charging.

Unit 2

Wind source – wind statistics - energy in the wind – aerodynamics - rotor types – forces developed by blades – aerodynamic models – braking systems – tower - control and monitoring system – power performance

Unit 3

Wind driven induction generators-power circle diagram-steady state performance –modeling integration issues –impact on central generation- transmission and distribution systems – wind farm electrical design.

Unit 4

Wind-diesel systems-fuel savings-permanent magnet alternators – modeling – steady state equivalent circuit-self-excited induction generators – integrated wind-solar systems.

Unit 5

Micro-hydel electric systems – power potential – scheme layout – generation efficiency and turbine part flow-isolated and parallel operation of generators – geothermal-tidal and OTEC systems.

Reference Books

1. Biomass Renegerable Energy – D.O. hall and R.P. Overeed (John Wiley and Sons, New york, 1987)
2. Biomass for energy in the developing countries – D.O. Hall, G.W. barnard and P.A. Moss (Pergamon Press Ltd. 1982)

3. Thermo chemical processing of Biomass, Bridgurater A V.

4. Biomass as Fuel – L.P. White (Academic press1981)

5. Biomass Gasification Principles and Technology, Energy technology review No. 67, - T.B. Read (Noyes Data Corp. , 1981)

6. Wind energy Conversion Systems – Freris L.L. (Prentice Hall1990)

7. Wind Turbine Technology: Fundamental concepts of wind turbine technology Spera D.A. (ASME Press, NY, 1994)

8. Wind Energy Systems – G.L. Johnson (Prentice Hall, 1985)

9. Wind Energy Explained – J.F. Manwell, J.G. McGowan and A.L. Rogers (John Wiley & Sons Ltd.)

ADVANCED POWER SYSTEM ANALYSIS

Unit 1

Load Flow - Network modeling – Conditioning of Y Matrix – Load flow-Newton Raphson method- Decoupled – Fast decoupled Load flow -three-phase load flow

Unit 2

DC power flow –Single phase and three phase -AC-DC load flow - DC system model – Sequential Solution Techniques – Extension to Multiple and or Multi-terminal DC systems – DC convergence tolerance – Test System and results.

Unit 3

Fault Studies -Analysis of balanced and unbalanced three phase faults – fault calculations – Short Circuit faults – open circuit faults

Unit 4

System optimization - strategy for two generator system – generalized strategies – effect of transmission losses - Sensitivity of the objective function- Formulation of optimal power flow solution by Gradient method-Newton's method.

Unit 5

State Estimation – method of least squares – statistics – errors – estimates – test for bad data – structure and formation of Hessian matrix – power system state estimation.

References

1. Grainger, J.J. and Stevenson, W.D. „Power System Analysis, Tata McGraw hill, New Delhi, 2003.

2. Arrillaga, J and Arnold, C.P., „Computer analysis of power systems, John Wiley and Sons, New York, 1997.

3. Pai, M.A., „Computer Techniques in Power System Analysis, Tata McGraw hill, New Delhi, 2006.

Modeling and Analysis of Electrical Machines

Unit 1

Principles of Electromagnetic Energy Conversion, General expression of stored magnetic energy, co-energy and force/torque, example using single and doubly excited system.

Unit 2

Basic Concepts of Rotating Machines-Calculation of air gap mmf and per phase machine inductance using physical machine data; Voltage and torque equation of dc machine.

Unit 3

Three phase symmetrical induction machine and salient pole synchronous machines in phase variable form; Application of reference frame theory to three phase symmetrical induction and synchronous machines, dynamic direct and quadrature axis model in arbitrarily rotating reference frames.

Unit 4

Determination of Synchronous Machine Dynamic Equivalent Circuit Parameters, Analysis and dynamic modeling of two phase asymmetrical induction machine and single phase induction machine.

Unit 5

Special Machines - Permanent magnet synchronous machine: Surface permanent magnet (square and sinusoidal back emf type) and interior permanent magnet machines. Construction and operating principle, dynamic modeling and self controlled operation; Analysis of Switch Reluctance Motors.

Text Books:

1. *Charles Kingsley,Jr., A.E. Fitzgerald, Stephen D.Umans, „Electric Machinery‟, Tata Mcgraw Hill,6ht Edition, 2003.*

2. *R. Krishnan, „Electric Motor & Drives: Modeling, Analysis and Control‟, Prentice Hall of India, 2001.*

3. *Miller, T.J.E,. „Brushless permanent magnet and reluctance motor drives‟, Clarendon Press, Oxford, 1989.*

Power System Reliability

Unit 1

Basics of Probability theory & Distribution: Basic probability theory – rules for combining probabilities of events – Bernoulli's trials – probabilities density and distribution functions – binomial distribution – expected value and standard deviation of binomial distribution.

Network Modeling and Reliability Analysis: Analysis of Series, Parallel, Series-Parallel networks – complex networks – decomposition method.

Unit 2

Reliability functions: Reliability functions f(t), F(t), R(t), h(t) and their relationships – exponential distribution – Expected value and standard deviation of exponential distribution –

Bath tub curve – reliability analysis of series parallel networks using exponential distribution – reliability measures MTTF, MTTR, MTBF.

Unit 3

Markov Modeling: Markov chains – concept of stochastic transitional probability Matrix, Evaluation of limiting state Probabilities. – Markov processes one component repairable system – time dependent probability evaluation using Laplace transform approach – evaluation of limiting state probabilities using STPM – two component repairable models.

Unit 4

Frequency & Duration Techniques : Frequency and duration concept – Evaluation of frequency of encountering state, mean cycletime, for one , two component repairable models – evaluation of cumulative probability and cumulative frequency of encountering of merged states.

Unit 5

Generation System Reliability Analysis : Reliability model of a generation system– recursive relation for unit addition and removal – load modeling - Merging of generation load model – evaluation of transition rates for Power quality merged state model – cumulative Probability, cumulative frequency of failure evaluation – LOLP, LOLE.

Reference Books:

1. Reliability Evaluation of Engg.System – R. Billinton, R.N.Allan, Plenum Press, New York.
2. Reliability Evaluation of Power systems – R. Billinton, R.N.Allan, Pitman Advance Publishing Program, New York.
3. An Introduction to Reliability and Maintainability Engineering. Charles E. Ebeling, TATA McGraw - Hill – Edition.

Electromagnetic Field Computation and Modeling

Unit 1 INTRODUCTION

Review of basic field theory – electric and magnetic fields – Maxwell's equations – Laplace, Poisson and Helmoltz equations – principle of energy conversion – force/torque calculation – Electro thermal formulation.

Unit 2 SOLUTION OF FIELD EQUATIONS I

Limitations of the conventional design procedure, need for the field analysis based design, problem definition , solution by analytical methods-direct integration method – variable separable method – method of images, solution by numerical methods- Finite Difference Method.

Unit 3 SOLUTION OF FIELD EQUATIONS II

Finite element method (FEM) – Differential/ integral functions – Variational method – Energy minimization – Discretisation – Shape functions –Stiffness matrix –1D and 2D planar and axial symmetry problem.

Unit 4 FIELD COMPUTATION FOR BASIC CONFIGURATIONS

Computation of electric and magnetic field intensities– Capacitance and Inductance – Force, Torque, Energy for basic configurations.

Unit 5 DESIGN APPLICATIONS

Insulators- Bushings – Cylindrical magnetic actuators – Transformers – Rotating machines.

REFERENCES

1. K.J.Binns, P.J.Lawrenson, C.W Trowbridge, "The analytical and numerical solution of Electric and magnetic fields", John Wiley & Sons, 1993.
2. Nathan Ida, Joao P.A.Bastos , "Electromagnetics and calculation of fields", Springer- Verlage, 1992.
3. Nicola Biyanchi , "Electrical Machine analysis using Finite Elements", Taylor and Francis Group, CRC Publishers, 2005.
4. S.J Salon, "Finite Element Analysis of Electrical Machines." Kluwer Academic Publishers, London, 1995, distributed by TBH Publishers & Distributors, Chennai, India
5. User manuals of MAGNET, MAXWELL & ANSYS software.
6. Silvester and Ferrari, "Finite Elements for Electrical Engineers" Cambridge University press, 1983.

Wind Energy Conversion Systems

Unit 1 BASICS OF WIND ENERGY CONVERSION

History of wind energy, Current status and future prospects, Wind resource assessment, Wind Speed Prediction, Wind Power estimation techniques, Site Selection.

WECS-System Components, Turbine Rating; Speed and Power Relations, Power Extracted from the Wind, Rotor swept area, Air Density, Global Wind Patterns; Maximum Energy Capture, Maximum Power Operation-Constant-TSR Scheme and Peak-Power-Tracking Scheme, System.

Unit 2 WIND TURBINES

Simple momentum theory-Power coefficient-Sabinin‟ s theory-Aerodynamics of Wind turbine; Design Trade-offs-Turbine Towers and Spacing, Number of Blades; Power Output from an Ideal and practical Turbines.

Types of Wind turbine- Vertical Axis Type, Horizontal Axis-Power developed -Thrust-Efficiency-Rotor selection-Rotor design considerations-Tip speed ratio-Regulation-yaw control-Pitch angle control-stall control, Upwind, Downwind.

Unit 3 FIXED SPEED SYSTEMS

Generating Systems- Constant speed constant frequency systems -Choice of Generators-Deciding factors-Synchronous Generator-Squirrel Cage Induction Generator- Model of Wind Speed- Model wind turbine rotor - Drive Train model-Generator model for Steady state and Transient stability analysis.

Unit 4 GRID INTEGRATION

Stand alone and Grid Connected WECS system- Basics of Grid Connection; Characteristics of Wind Generator; State-of-the-art of power electronics in Wind Energy - Soft-starter, Capacitor bank, Rectifiers and inverters, Frequency converters.

Unit V POWER QUALITY

Power Converters for WECS; Power Quality Standards in Wind Farms- Reactive power, flicker coefficient, Maximum number of wind turbine switching operations, flicker step factor, Voltage change factor, Harmonic currents.

REFERENCES:

1. L.L.Freris "Wind Energy conversion Systems", Prentice Hall, 1990.

2. IonBoldea, "Variable speed generators", Taylor and Francis group, 2006.

3. Sathyajith Mathew, "Wind Energy-Fundamentals, Resource Analysis and Economics", Springer, 2006.

4. FredeBlaabjerg and Zhe Chen, "Power Electronics for Modern Wind Turbines" Morgan and Claypool Publishers, 2006.

5. Muyeen.S.M, Junji Tamura and Toshiaki Murata, Stability Augmentation of a Grid- connected Wind Farm" Springer-Verlag London Limited, 2009.

6. ErichHau, "Wind Turbines-Fundamentals, Technologies, Application, Economics" Springer, 2006

Modern Rectifiers and resonant Converters

Unit 1 POWER SYSTEM HARMONICS & LINE COMMUTATED RECTIFIERS

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

Unit 2 PULSE WIDTH MODULATED RECTIFIERS

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

Unit 3 RESONANT CONVERTERS

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

Unit 4 DYNAMIC ANLYSIS OF SWITCHING CONVERTERS

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

Unit 5 CONTROL OF RESONANT CONVERTERS

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

REFERENCES

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

Electrical Distribution Systems

Unit 1

Industrial and commercial distribution systems – Energy losses in distribution system – system ground for safety and protection – comparison of O/H lines and under ground cable system.

Unit 2

Network model – power flow, short circuit and loss calculations.Distribution system reliability analysis – reliability concepts – Markov model – distribution network reliability – reliability performance.

Unit 3

Distribution system expansion planning – load characteristics – load forecasting – design concepts – optimal location of sub station – design of radial lines – solution technique.

Unit 4

Voltage control – Application of shunt capacitance for loss reduction – Harmonics in the system – static VAR systems –loss reduction and voltage improvement.

Unit 5

System protection – requirement – fuses and section analyzers-over current. Under voltage and under frequency protection – coordination of protective device.

Books

1. Pabla, A.S., 'Electrical Power Distribution System', Tata McGraw hill, 1981.

2. Tuvar Goner, 'Electrical Power Distribution System Engineering', McGraw hill, 1986.

3. Sterling, M.I.H., '`Power System Control', Peter Peergisus, 1978.

Fuzzy and Neural Networks

UNIT I

INTRODUCTION TO NEURAL NETWORKS

Basics of ANN - perceptron - delta learning rule - back propagation algorithm - multilayer feed forward network - memory models - bi-directional associative memory - Hopfield network

UNIT II

APPLICATIONS TO POWER SYSTEM PROBLEMS

Application of neural networks to load forecasting - contingency analysis - VAR control - economic load dispatch.

UNIT III

INTRODUCTION TO FUZZY LOGIC

Crispness - vagueness - fuzziness - uncertainty - fuzzy set theory fuzzy sets - fuzzy set operations -fuzzy measures - fuzzy relations - fuzzy function - structure of fuzzy logic controller – fuzzification models - data base - rule base - inference engine defuzzification module.

UNIT IV

APPLICATIONS TO POWER SYSTEMS

Decision making in power system control through fuzzy set theory - use of fuzzy set models of LP in power systems scheduling problems - fuzzy logic based power system stabilizer.

UNIT V

GENETIC ALGORITHM AND ITS APPLICATIONS TO POWER SYSTEMS

Introduction - simple genetic algorithm - reproduction - crossover - mutation – advanced operators in genetic search - applications to voltage control and stability studies.

REFERENCES

1. James A. Freeman and B.M. Skapura 'Neural Networks - Algorithms Applications and Programming Techniques', Addison Wesley, 1990.

2. George Klir and A. Tina Folger, ‘Fuzzy sets, Uncertainty and Information’, Prentice Hall of India, 1993.

3. H.J. Zimmerman, ‘Fuzzy Set Theory and its Applications’, Kluwer Academic Publishers, 1994.

4. IEEE tutorial on ‘Application of Neural Network to Power Systems’, 1996

5. Loi Lei Lai, ‘Intelligent System Applications in Power Engineering’, John Wiley & Sons Ltd., 1998.

Extra High Voltage Engineering Systems

UNIT I

INTRODUCTION 9

Standard transmission voltages – different configurations of EHV and UHV lines – average values of line parameters – power handling capacity and line loss – costs of transmission lines and equipment – mechanical considerations in line performance.

UNIT II

CALCULATION OF LINE PARAMETERS 9

Calculation of resistance, inductance and capacitance for multi-conductor lines – calculation of sequence inductances and capacitances – line parameters for different modes of propagation – resistance and inductance of ground return, numerical example involving a typical 400/220kV line using line constant program.

UNIT III

VOLTAGE GRADIENTS OF CONDUCTORS 9

Charge-potential relations for multi-conductor lines – surface voltage gradient on conductors – gradient factors and their use – distribution of voltage gradient on sub conductors of bundle - voltage gradients on conductors in the presence of ground wires on towers.

UNIT IV

CORONA EFFECTS 9

Power losses and audible losses: I2R loss and corona loss - audible noise generation and characteristics - limits for audible noise - Day-Night equivalent noise level- radio interference**:** corona pulse generation and properties - limits for radio interference fields.

UNIT V

ELECTROSTATIC FIELD OF EHV LINES 9

Effect of EHV line on heavy vehicles - calculation of electrostatic field of AC lines effect of high field on humans, animals, and plants - measurement of electrostatic fields –electrostatic

Induction in unenergised circuit of a D/C line - induced voltages in insulated ground wires - electromagnetic interference.

REFERENCES

1. Rakosh Das Begamudre, "Extra High Voltage AC Transmission Engineering", Second Edition, New Age International Pvt. Ltd., 1990.
2. Power Engineer's Handbook, Revised and Enlarged 6th Edition, TNEB Engineers' Association, October 2002.
3. Microtran Power System Analysis Corporation, Microtran Reference Manual, Vancouver Canada. (Website: www.microtran.com).

Power Quality

AIM:

To study the various issues affecting power quality, their production, monitoring and suppression.

OBJECTIVES:

- To study the production of voltages sags, overvoltages and harmonics and methods of control.

- To study various methods of power quality monitoring.

UNIT I INTRODUCTION TO POWER QUALITY

Terms and definitions: Overloading - under voltage - over voltage. Concepts of transients - short duration variations such as interruption - long duration variation such as sustained interruption. Sags and swells - voltage sag - voltage swell – voltage imbalance - voltage fluctuation - power frequency variations. International standards of power quality. Computer Business Equipment Manufacturers Associations (CBEMA) curve.

UNIT II VOLTAGE SAGS AND INTERRUPTIONS

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

UNIT III OVERVOLTAGES

Sources of over voltages - Capacitor switching – lightning - ferro resonance. Mitigation of voltage swells - surge arresters - low pass filters - power conditioners. Lightning protection –

shielding - line arresters - protection of transformers and cables. An introduction to computer analysis tools for transients, PSCAD and EMTP.

UNIT IV HARMONICS

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

UNIT V POWER QUALITY MONITORING

Monitoring considerations - monitoring and diagnostic techniques for various power quality problems - modeling of power quality (harmonics and voltage sag) problems by mathematical simulation tools - power line disturbance analyzer – Quality measurement equipment - harmonic / spectrum analyzer - flicker meters - disturbance analyzer.

Applications of expert systems for power quality monitoring.

TEXT BOOKS

1. Roger. C. Dugan, Mark. F. McGranagham, Surya Santoso, H.Wayne Beaty, ‘Electrical Power Systems Quality’ McGraw Hill,2003.(For Chapters1,2,3, 4 and 5)

REFERENCES

1. G.T. Heydt, 'Electric Power Quality', 2nd Edition. (West Lafayette, IN, Stars in a Circle Publications, 1994). (For Chapter 1, 2, 3 and 5)

2. M.H.J Bollen, ‘Understanding Power Quality Problems: Voltage Sags and Interruptions’, (New York: IEEE Press, 1999). (For Chapters 1, 2, 3 and 5)

3. J. Arrillaga, N.R. Watson, S. Chen, 'Power System Quality Assessment', (New York: Wiley, 1999). (For Chapters 1, 2, 3, 4 and 5)

4. PSCAD User Manual.

Advanced Power System Protection

Unit 1

General philosophy of protection-Characteristic function of protective relays-basic relay elements and relay terminology-basic construction of static relays-non-critical switching circuits.

Unit 2

Protective relays –protection of generators – Transformer protection – magnetizing inrush current – Application and connection of transformer differential relays – transformer over current protection.

Unit 3

Bus protection, Techniques applicable for line protection –long EHV line protection Backup remote local and Breaker failure

Unit 4

Placement of reactors in power system- Transformer tap changing –Protection of boosters-capacitors in an interconnected power system.

Unit 5

Digital signal processing –digital filtering in protection relays- numeric protection –testing Digital filtering in protection relays – digital data transmission– relay hardware – relay algorithms.Concepts of modern coordinated control system.

1. *Lewis Blackburn, J., „Protective Relaying – Principles and Applications", Marcel Dekkar, INC, New York, 2006.*

2. *The Electricity Training Association, „Power System Protection Vol1-4", The IEE, U.K., 1995.*

3. *Stanley, H.Horowitz (ED), „Protective relaying for power systems II", IEEE Press, 1992.*

Power System Optimization

Unit 1

Introduction To Optimization And Classical Optimization Techniques: Single variable optimization, multivariable optimization without constraints, multivariable optimization with equality constraints, multivariable optimization with inequality constraints.

Unit 2

Linear Programming Problem: Standard form, simplex method, two phase simplex method, duality, dual simplex method, sensitivity analysis, decomposition principle, transportation problem.

Non-Linear Programming Problem: Unimodal function, elimination methods – unrestricted search, Fibonacci method, golden section method, direct search method – random and grid search methods, indirect search methods – steepest descent and conjugate gradient method.

Unit3

Dynamic Programming: Multistage decision process, concept of suboptimization and principle of optimality, conversion of final value problem into an initial value problem, LP as a case of dynamic programming.

Unit 4

Genetic Algorithm :introduction to genetic algorithm, working principle, coding of variables, fitness function, GA operators, similarities and differences between GA and traditional methods, unconstrained and constrained optimization using GA.

Unit 5

Applications To Power System: economic load dispatch in thermal and hydro thermal system using GA, unit commitment problem, reactive power optimization, LPP and NLP techniques to optimal flow problems.

Text Books:

1. Optimization – Theory and Applications , S. S. Rao Wiley Eastern Ltd.-2007
2. Operations Research , Hiller and Liberman McGraw Hill Publishing.-2005
3. Power System Optimization, Kothari and Dhillon PHI -2004

References

1. Optimization for Engineering Design – Algorithms and Examples ,Kalyanmoy Deb Prentice-Hall of India Private Limited.-2004
2. Genetic Algorithms in Search, Optimization and Machine Learning , D. E. Goldberg Addison-Wesley Reading, Mass.-2004
3. http://www.nptel.iitm.ac.in/
4. www.ocw.mit.edu

Advanced Power Electronics

Unit 1 AC Voltage Controllers:

Principle of On-Off Control, Principle of Phase control, Single Phase Bi-directional Controllers with Resistive Loads, Single Phase Controllers with Inductive Loads, Three Phase full wave AC controllers, AC Voltage Controller with PWM Control.

Unit 2: Inverters

Principle of Operation, Single-phase bridge inverters, Three phase bridge Inverters: 180 and 120 degree of conduction. Voltage control of Single Phase and Three Phase Inverters, Current Source Inverters, Harmonics and its reduction techniques.

Unit 3 Cycloconverters

Basic principle of operation, single phase to single phase, threephase to three-phase and three phase to single phase cycloconverters. Output equation, Control circuit.

Unit 4 DC Power Supplies

Switched Mode DC Power Supplies, flyback converter, forward converter, half and full bridge converter, resonant DC power supplies, bidirectional power supplies.

Unit 5 AC Power Supplies

Switched mode power supplies, Resonant AC power supplies, bidirectional AC power supplies. Multistage conversions, Control Circuits: Voltage Mode Control, Current Mode Control

Reference

1. R. S. Ramshaw, "Power Electronics Semiconductor Switches", Champman & Hall, 1993.
2. N. Mohan, T. M. Undeland and W. P. Robbins, "Power Electronics, Converter, Application and Design", Third Edition, John Willey & Sons, 2004.
3. M. H. Rashid, "Power Electronics, circuits, Devices and Applications", Pearson, 2002, India.

4. K. Billings, "Switch Mode Power Supply Handbook", McGraw-Hill, 1999, Boston.
5. A. I. Pressman, "Switch Mode Power Supply Design", McGraw-Hill, 1999, New York.
6. N. G. Hingorani and L. Gyugyi, "Understanding FACTS", IEEE Press, Delhi, 2001.
7. B. K. Bose, "Power Electronics and Variable Frequency Drive", Standard Publishers Distributors, 2000.
8. Bin Wu, "High-Power Converters and AC Drives", *IEEE Press, A John Wiley & Sons, Inc Publication*, New York, 2006.
9. G. T. Heydt, "Electric Power Quality", Stars in a Circle Publications, second edition, 1994, Avarua, Rarotonga, Cook Islands.
10. R. C. Duagan, M. F. Mcgranaghan and H. W. Beaty, "Electric Power System Quality", McGraw-Hill, 2001, 1221 Avenue of the Americas, New York.
11. Vijay K. Sood, "HVDC and FACTS Controllers - Applications of Static Converters in Power Systems", Kluwer Academic Publishers, Masachusetts, 2004.
12. J. Arrillaga, Y. H. Liu and N. R. Waston, "*Flexible Power Transmission-The HVDC Options*", *John Wiley & Sons, Ltd*, Chichester, UK, 2007.

Energy Conservation & Audit

Unit 1

Energy Scenario: Primary energy resources, Commercial and Non-commercial energy, commercial energy production, final energy consumption, energy needs of growing economy, long term energy scenario, energy pricing, energy sector reforms, energy and environment.

Unit 2

Energy management : Definition, significance and objectives of energy management, principle of energy management , sectors of supply side management , Energy and economy, electricity tariff, load management and maximum demand control, power factor improvement, selection and location of capacitors ,optimizing the input energy requirements, fuel and energy substitution

Energy strategies and energy planning: Energy Action Planning: Key elements, force field analysis, Energy policy purpose, Energy planning flow for supply side, essential data for supply side energy planning, roles and responsibilities of energy manager

Unit 3

Energy Audit: Definition, need of energy audit, types of energy audit, intermediate and comprehensive energy audit, end use of energy consumption profile, procedure of energy auditing, site testing and measurement. Energy security, bench marking, energy performance, matching energy use to requirement, maximizing system efficiencies, energy audit instruments, Energy Conservation Act-2001

Unit 4

Energy Conservation and Recycling: Energy conservation and its importance, Listing of energy conservation opportunities (ECOs),Electrical ECOs, ECOs in process industry, small industries building and shopping complexes , waste management , Recycling of discarded materials and energy recycling

Unit 5

Energy Monitoring and Targeting: Defining monitoring and targeting, elements of monitoring and targeting, data and information-analysis, On line energy monitoring: Various aspects and techniques of on line energy monitoring, Material and Energy balance: Facility as an energy system, methods for preparing process flow, material and energy balance diagrams. Financial analysis techniques-simple pay back period, return on investment, net present value, internal rate of return, cash flows, risk and sensitivity analysis, financing options, energy performance contracts .

Text Books:

1. Energy –Economy and prospective –Andre Gardel ,Pergmann Press-2005
2. Introduction to energy technologies – V.A.Venikov ,E.V.Putiatin , Mir, Moskow -2006
3. Electrical Energy utilization and energy conversion –S.C.Tripathy, Tata Mc-GrawHill -2003
4. Conventional energy technology – S.B.Pandya, Tata Mc-GrawHill -2003

References

1. Energy and Atmosphere- I.M.Campbell, Wiley, New York -2000

2. Power station engineering and economy-Skortzki and Vopat , Tata Mc-GrawHill -2003

Advanced Digital Signal processing

[Review of discrete-time signals and systems- DFT and FFT, Z-Transform, Digital Filters is recommended]

UNIT I 9

DISCRETE RANDOM SIGNAL PROCESSING

Discrete Random Processes- Ensemble averages, stationary processes, Autocorrelation and Auto covariance matrices. Parseval's Theorem, Wiener-Khintchine Relation- Power Spectral Density-Periodogram Spectral Factorization , Filtering random processes. Low Pass Filtering of White Noise. Parameter estimation: Bias and consistency.

UNIT II 9

SPECTRUM ESTIMATION

Estimation of spectra from finite duration signals, Non-Parametric Methods-Correlation Method , Periodogram Estimator, Performance Analysis of Estimators -Unbiased, Consistent Estimators- Modified periodogram, Bartlett and Welch methods, Blackman –Tukey method. Parametric Methods - AR, MA, ARMA model based spectral estimation. Parameter Estimation -Yule-Walker equations, solutions using Durbin’s algorithm

UNIT III 9

LINEAR ESTIMATION AND PREDICTION

Linear prediction- Forward and backward predictions, Solutions of the Normal equations- Levinson-Durbin algorithms. Least mean squared error criterion -Wiener filter for filtering and prediction , FIR Wiener filter and Wiener IIR filters ,Discrete Kalman filter

UNIT IV **9**

ADAPTIVE FILTERS

FIR adaptive filters -adaptive filter based on steepest descent method-Widrow-Hoff LMS adaptive algorithm, Normalized LMS. Adaptive channel equalization-Adaptive echo cancellation-Adaptive noise cancellation- Adaptive recursive filters (IIR). RLS adaptive filters-Exponentially weighted RLS-sliding window RLS.

UNIT V **9**

MULTIRATE DIGITAL SIGNAL PROCESSING

Mathematical description of change of sampling rate - Interpolation and Decimation , Decimation by an integer factor - Interpolation by an integer factor, Sampling rate conversion by a rational factor, Filter implementation for sampling rate conversion- direct form FIR structures, Polyphase filter structures, time-variant structures. Multistage implementation of multirate system. Application to sub band coding - Wavelet transform and filter bank implementation of wavelet expansion of signals.

REFERENCES:

[1] Monson H.Hayes, Statistical Digital Signal Processing and Modeling, John Wiley and Sons, Inc.,Singapore, 2002.

[2] John G. Proakis, DimitrisG.Manolakis, Digital Signal Processing Pearson Education, 2002.

[3] John G. Proakiset.al.,'Algorithms for Statistical Signal Processing', Pearson Education, 2002.

[4] DimitrisG.Manolakiset.al.,'Statistical and adaptive signal Processing', McGraw Hill, Newyork,2000.

[5] Rafael C. Gonzalez, Richard E.Woods, 'Digital Image Processing', Pearson Education, Inc., Second Edition, 2004.(For Wavelet Transform Topic)

Reactive power compensation &management

UNIT I: Load Compensation

Objectives and specifications – reactive power characteristics – inductive and capacitive approximate biasing – Load compensator as a voltage regulator – phase balancing and power factor correction of unsymmetrical loads- examples.

UNIT II: Steady – state and transient state reactive power compensation in transmission system:

Uncompensated line – types of compensation – Passive shunt and series and dynamic shunt compensation – examples

Characteristic time periods – passive shunt compensation – static compensations- series capacitor compensation –compensation using synchronous condensers – examples

UNIT-III: Reactive power coordination:

Objective – Mathematical modeling – Operation planning – transmission benefits – Basic concepts of quality of power supply – disturbances- steady –state variations – effects of under voltages – frequency – Harmonics, radio frequency and electromagnetic interferences

UNIT-IV: Distribution and user side Reactive power Management:

System losses –loss reduction methods – examples – Reactive power planning – objectives – Economics Planning capacitor placement – retrofitting of capacitor banks

KVAR requirements for domestic appliances – Purpose of using capacitors – selection of capacitors – deciding factors – types of available capacitor, characteristics and Limitations

UNIT-V: Reactive power management in electric traction systems and are furnaces:

Typical layout of traction systems – reactive power control requirements – distribution transformers- Electric arc furnaces – basic operations- furnaces transformer –filter requirements – remedial measures –power factor of an arc furnace

Reference Books:

1. Reactive power control in Electric power systems by T.J.E.Miller, John Wiley and sons, 1982 (Units I to IV)

2. Reactive power Management by D.M.Tagare,Tata McGraw Hill,2004.(Units V toVIII)

Adaptive Control Systems

AIM

To gain knowledge on adaptive control of systems through parameter identification and controller retuning.

OBJECTIVES

i. To study the definition of adaptive control and methods of adaptation.
ii. To study the parameter identification of systems.
iii. To study the self-tuning of PID controllers based on parameter identification.
iv. To study the model reference adaptive control.
v. To study the practical application through case studies.

UNIT I INTRODUCTION

Introduction to adaptive control - Effects of process variations – Adaptive control schemes – Adaptive control problem – Non-parametric identification – Step, Impulse and Frequency response methods.

UNIT II PARAMETRIC IDENTIFICATION

Linear in parameter models - ARX – ARMAX – ARIMAX – Least square estimation – Recursive least square estimation – Extended least square estimation – Maximum likelihood estimation – Introduction to non-linear systems identification - Pseudo random binary sequence.

UNIT III SELF-TUNING REGULATOR

Deterministic indirect self-tuning regulators – Deterministic direct self-tuning regulators – Introduction to stochastic self-tuning regulators – Stochastic indirect self-tuning regulator.

UNIT IV MODEL REFERENCE ADAPTIVE CONTROLLER

The MIT rule – Lyapunov theory – Design of model reference adaptive controller using MIT rule and Lyapunov theory – Relation between model reference adaptive controller and self-tuning regulator.

UNIT V TUNING OF CONTROLLERS AND CASE STUDIES

Design of gain scheduling controller - Auto-tuning of PID regulator – Stability analysis of adaptive controllers – Application of adaptive control in chemical reactor, distillation column and variable area tank system.

TEXT BOOK

1. Karl J Astrom and Bjorn Wittenmark, 2003, Adaptive Control, Pearson Education Singapore, 2nd Edition.

REFERENCES

1. Hsia, T. C.H.A., 1974, System Identification, Lexington books.
2. Stephanopoulis, G., 1990, Chemical Process Control, Prentice Hall of India, New Delhi.