ANNAMALAI UNIVERSITY

Faculty of Engineering and Technology

Department of Electrical Engineering

M.E. (Smart Energy Systems)

HANDBOOK

DEPARTMENT OF ELECTRICAL ENGINEERING
M.E. (Smart Energy Systems) DEGREE COURSE

Regulations and Syllabus

FULL TIME: 4 SEMESTERS

CHOICE BASED CREDIT SYSTEM (CBCS)

REGULATIONS

R1. CONDITION FOR ADMISSION

Candidates for admission to M.E. Degree Program in Smart Energy Systems, shall be required to have passed the B.E/B.Tech in Electrical and Electronics Engineering or Electronics and Instrumentation Engineering or graduates of any other authority accepted by the syndicate of this University as equivalent thereto. They shall satisfy the conditions regarding qualifying marks, and physical fitness as may be prescribed from time to time by the syndicate of the Annamalai University.

R2. CREDITS

ME full-time program will have a duration of four semesters and part time six semesters.

The number of credits for each semester for the full-time program shall be as follows:

First and second semesters	: 20 credits per semester
Third Semester	: 12 credits
Fourth Semester	: 13 credits

The number of credits for each semester for the part-time program shall be as follows:

First and second semesters	: 9 credits per semester
Third and Fourth Semester	: 11 credits
Fifth Semester	: 12 credits
Sixth Semester	: 13 credits

The total credits for both the program will be 65 each. For the award of the degree, a student has to earn a minimum of 65 credits.

R3. DURATION OF THE PROGRAMME

A student of the full-time program is normally expected to complete in four semesters but any case not more than four years from the time of admission.

A student of the part-time program is normally expected to complete in six semesters but any case not more than six years from the time of admission.

R4. REGISTRATION FOR COURSES

A student newly admitted will automatically be registered for all the courses prescribed for the first semester, without any option.

Every other student shall submit a completed registration form indicating the list of courses intended to be credited during the next semester. This registration will be done a week before the last working day of the current semester. Late registration with the approval of the Dean on the recommendation of the Head of the Department along with a late fee will be done up to the last working day.

Registration for the thesis phase-I and phase-II shall be done at the appropriate semesters.

R5. ASSESSMENT

The break-up of assessment and examination marks for theory courses is as follows.

First assessment (I Mid Term Test)	: 10
Second assessment (II Mid Term Test)	: 10
Third assessment	: 05
Examination	: 75

The break-up of assessment and examination marks for practical courses/Thesis is as follows.

First assessment	: 15
Second assessment	: 15
Third assessment	: 10
Examination	: 60

The thesis phase-I will be assessed for 40 marks by a committee consisting of the Head of the Department, the guide and a minimum of two members nominated by the Head of the Department. The Head of the Department will be the chairman. 60 marks are allotted for the thesis work and viva voce examination at the end of the pre-final semester. The same procedure will be adopted in the final semester also.

R6. COUNSELLOR

To help the students in planning their course of study and for general advice on the academic program, the Head of the Department will attach a certain number of students to a member of the faculty who shall function as counselor throughout their period of study. Such counselors shall advise the students, give preliminary approval for the courses to be taken by the students during each semester and obtain the final approval of the Head of the Department.

R7. CLASS COMMITTEE

For each semester, separate class committee will be constituted by the respective Heads of Departments.

The composition of the class committee for each semester except the final semester shall be as follows:

Teachers of the individual courses.

A project co-coordinator (in the prefinal and final semester committee only) who shall be appointed by the Head of the Department from among the project supervisors.

One professor or Reader, preferably not teaching the concerned class, appointed as chairman by the Head of the Department.

The Head of the Department may opt to be a member or the Chairman.

All student counselors of the class, the Head of the Department (if not already a member) and any staff member nominated by the Head of the Department may serve as special invitees.

The class committee shall meet four times during the semester.

The first meeting will be held within two weeks from the date of commencement of the class to decide the type of assessment like test, assignment etc. for the three assessments and the dates of completion of the assessments.

The second and third meetings will be held within a week after the completion of the first and second assessments respectively to review the performance and for follow-up action.

The fourth meeting will be held on completion of all the assessments except the end semester examination and at least one week before the commencement of the end semester examinations.

During this meeting the assessment on a maximum of 40 marks will be finalized for every student and tabulated and submitted to the Head of the Department for approval and transmission to the Controller of Examinations.

R8. WITHDRAWAL FROM A COURSE

A student can withdraw from a course at any time before a date fixed by the Head of the Department prior to the second assessment, with the approval of the Dean of the faculty on the recommendation of the Head of the Department.

R9. TEMPORARY BREAK OF STUDY

A student can take a one-time temporary break of study covering the current semester and/or the next semester with the approval of the Dean on the recommendation of the Head of the Department, not later than seven days after the completion of the second assessment test. However, the student must complete the entire program within the maximum period of four years for full-time.

R10. SUBSTITUTE ASSESSMENTS

A student who has missed one or more of the assessments of a course other than the end semester examination, for genuine reasons accepted by the Head of the Department, may take a substitute assessment for any one of the missed assessments. The substitute assessment must be completed before the date of the fourth meeting of the respective class committee.

A student who wishes to have a substitute assessment must apply to the Head of the Department within a week from the date of the missed assessment.

R11. ATTENDANCE REQUIREMENTS

To be eligible to appear for the examination in a particular course, a student must put in a minimum of 80% of attendance in that course. However, if the attendance is 75% or above but less than 80% in any course, the authorities can permit the student to appear for the examination in that course on payment of the prescribed condemnation fee.

A student who withdraws from or does not meet the minimum attendance requirement in a course must re-register for and repeat the course.

R12. PASSING AND DECLARATION OF EXAMINATION RESULTS

All assessments of all the courses on an absolute marks basis will be considered and passed by the respective results passing boards in accordance with the rules of the University. The marks for each course shall be converted to the corresponding letter grade as follows. Thereafter, computation of the Grade Point Average (GPA) and Overall Grade Point Average(OGPA) shall be done.

Grade

90 to 100 marks	: Grade S
80 to 89 marks	: Grade A
70 to 79 marks	: Grade B
60 to 69 marks	: Grade C
55 to 59 marks	: Grade D
50 to 54 marks	: Grade E
Less than 50 marks	: Grade F
Insufficient attendance	: Grade I
Withdrawn from the course	: Grade W

In order to pass a course the student has to score 30 marks out of 75(end semester examination) for theory courses and to score 24 marks out of 60 (end semester examination) for practical courses and 50 marks out of 100(total marks).

A student who earns a grade of S, A, B, C, D or E for a course is declared to have successfully completed that course and earned the credits for that course. Such a course cannot be repeated by the student.

A student who obtains letter grades I or W in a course must reregister for and repeat the course.

A student who obtains letter grade F in a course has to reappear for the examination in that course.

A student who obtains letter grade I or W or F in thesis phase-I must reregister in the next semester. Registration for thesis phase-II for such students can be done in the subsequent semesters.

The following grade points are associated with each letter grade for calculating the GPA and OGPA.

S - 10; A - 9; B - 8; C - 7; D - 6; E - 5; F - 0

Courses with grades I and W are not considered for calculation of grade point average or cumulative grade point average. F grade will be considered for computing GPA and OGPA

A student can apply for retotalling of one or more of his/her examination answer papers within a week from the date of issue of grade sheet to the student on payment of the prescribed fee per paper. The application must be made to the Controller of Examinations with the recommendation of the Head of the Department.

After results are declared, grade cards will be issued to the students. The grade card will contain the list of courses registered during the semester, the grades scored and the grade point average for the semester.

GPA is the sum of the products of the number of credits of a course with the grade point scored in that course, taken over all the courses for the semester, divided by the sum of the number of credits for all courses taken in that semester. OGPA is similarly calculated considering all the courses taken from the time of admission.

The results of the final semester will be withheld until the student obtains passing grades in all the courses of all the earlier semesters.

R13. AWARDING DEGREE

After successful completion of the program, the degree will be awarded with the following classifications based on OGPA.

For First class with Distinction the student must earn a minimum of 65 credits within four semesters for full-time from the time of admission, pass all the courses in the first attempt and obtain a OGPA of 8.25 or above.

For First class, the student must earn a minimum of 65 credits within two years and six months for full time and three years and six months for part time from the time of admission and obtain a OGPA of 6.75 or above.

For second class, the student must earn a minimum of 65 credits within four years for full-time from the time of admission.

R14. RANKING OF CANDIDATES

The candidates who are eligible to get the M.E. degree in First Class with distinction will be ranked on the basis of OGPA for all the courses of study from I to IV Semester for M.E. Full time.

The candidates passing with First class and without failing in any subjects from the time of admission will be ranked next to those with distinction on the basis of OGPA for all the courses of study from I to IV Semester for M.E. Full time.

R15. ELECTIVES

Apart from the various elective courses offered in the curriculum of the branch of specialization, a student can choose a maximum of two electives from any specialization under the faculty during the entire period of study, with the approval of the Head of the Department and the Head of the Department offering the course.

R16. TRANSITORY REGULATIONS

If a candidate studying under the old regulations could not attend any of the courses in his/her program, shall be permitted to attend equal number of courses, under the new regulation and will be examined in those courses. The choice of courses will be decided by the concerned Head of the Department. However he/she will be permitted to submit the thesis as per the old regulations. The results of such candidates will be passed as per old regulations.

The University shall have powers to revise or change or amend the regulations, the scheme of examinations, the courses of study and the syllabi from time to time.

M.E. FULL-TIME (TWO YEAR) DEGREE

PROGRAMME IN SMART ENERGY SYSTEMS

Subject of Study and Scheme of Examinations

FIRST SEMESTER

Code	Subjects	Periods / Week		Duration of exam. Hrs.	Marks			Credits
		L	P		CA	FE	Total	
SESC-101	Applied Mathematics	4		3	25	75	100	3
SESC-102	Non Conventional Energy Engineering	4		3	25	75	100	3
SESC-103	Digital Simulation of Power Systems	4		3	25	75	100	3
SESC-104	Elective - I	4		3	25	75	100	3
SESC-105	Elective - II	4		3	25	75	100	3
SESE-106	Elective - III	4		3	25	75	100	3
SESP-107	Energy System Laboratory-I		3	3	40	60	100	2
	Total	**24**	**3**		**190**	**510**	**700**	**20**

L:- Lecture P :- Practical S :- Seminar
Marks for each subject : 100 (25 for continuous assessment,75 for examination)
Marks for Practical: 100 (40 for continuous assessment,60 for examination)
Duration of examination : 3 hours for each subject

SECOND SEMESTER

Code	Subjects	Periods/ Week		Duration of exam. Hrs.	Marks			Credits
		L	P		CA	FE	Total	
SESC-201	Non-linear Control Systems	4		3	25	75	100	3
SESC-202	Power Quality Studies	4		3	25	75	100	3
SESC-203	Energy management and Audit	4		3	25	75	100	3
SESE-204	Elective – IV	4		3	25	75	100	3
SESE-205	Elective – V	4		3	25	75	100	3
SESE-206	Elective – VI	4		3	25	75	100	3
SESP-207	Energy System Laboratory-II		3	3	40	60	100	2
	Total	**24**	**3**		**190**	**510**	**700**	**20**

L:- Lecture P :- Practical S :- Seminar
Marks for each subject : 100 (25 for continuous assessment, 75 for examination)
Marks for Practical: 100 (40 for continuous assessment, 60 for examination)
Duration of examination : 3 hours for each subject

THIRD SEMESTER

Code	Subjects	Periods/ Week		Duration of exam. Hrs.	Marks			Credits
		L	P		CA	FE	Total	
SESE - 301	Elective-VII	4		3	25	75	100	3
SESE - 302	Elective-VIII	4		3	25	75	100	3
SEST - 303	Thesis Phase-I				40	60	100	6
	Total	**8**			**190**	**210**	**300**	**12**

L:- Lecture P :- Practical S :- Seminar
Marks for each subject : 100 (25 for continuous assessment, 75 for examination)
Marks for Thesis Work and Seminar: 100 (40 for continuous assessment, 60 for examination)
Duration of examination : 3 hours for each subject
Examination for subject 303in the form of viva voce and/or demonstration

FOURTH SEMESTER

Code	Subjects	Periods/ Week		Duration of exam. Hrs.	Marks			Credits
		L	P		CA	FE	Total	
SEST - 401	Thesis Phase-II				40	60	100	13
	Total						**100**	**13**

L:- Lecture P :- Practical S :- Seminar
Marks for Thesis Work and Seminar: 100 (40 for continuous assessment, 60 for examination)
Duration of examination : 3 hours for each subject
Examination for subject 401 in the form of viva voce and/or demonstration

L: Lecture **CA:** Continuous Assessment **FE:** Final Examination **P:** Practical

M.E. PART-TIME (THREE YEAR) DEGREE

PROGRAMME IN SMART ENERGY SYSTEMS

Subject of Study and Scheme of Examinations

FIRST SEMESTER

Code	Subjects	Periods / Week		Duration of exam. Hrs.	Marks			Credits
		L	P		CA	FE	Total	
SESPC-101	Applied Mathematics	4		3	25	75	100	3
SESPC-102	Non Conventional Energy Engineering	4		3	25	75	100	3
SESPE-103	Elective - I	4		3	25	75	100	3
	Total	**12**			**75**	**225**	**300**	**9**

L:- Lecture P :- Practical S :- Seminar
Marks for each subject : 100 (25 for continuous assessment,75 for examination)
Marks for Practical: 100 (40 for continuous assessment,60 for examination)
Duration of examination : 3 hours for each subject

SECOND SEMESTER

Code	Subjects	Periods/ Week		Duration of exam. Hrs.	Marks			Credits
		L	P		CA	FE	Total	
SESPC-201	Non-linear Control Systems	4		3	25	75	100	3
SESPC-202	Power Quality Studies	4		3	25	75	100	3
SESPE-203	Elective – II	4		3	25	75	100	3
	Total	**12**			**75**	**225**	**300**	**9**

L:- Lecture P :- Practical S :- Seminar
Marks for each subject : 100 (25 for continuous assessment, 75 for examination)
Marks for Practical: 100 (40 for continuous assessment, 60 for examination)
Duration of examination : 3 hours for each subject

THIRD SEMESTER

Code	Subjects	Periods / Week		Duration of exam. Hrs.	Marks			Credits
		L	P		CA	FE	Total	
SESPC-301	Digital Simulation of Power Systems	4		3	25	75	100	3
SESPC-302	Elective - III	4		3	25	75	100	3
SESPC-303	Elective - IV	4		3	25	75	100	3
SESPP-304	Energy System Laboratory-I		3	3	40	60	100	2
	Total	**12**	**3**		**115**	**285**	**400**	**11**

L:- Lecture P :- Practical S :- Seminar
Marks for each subject : 100 (25 for continuous assessment,75 for examination)
Marks for Practical: 100 (40 for continuous assessment,60 for examination)
Duration of examination : 3 hours for each subject

FOURTH SEMESTER

Code	Subjects	Periods/ Week		Duration of exam. Hrs.	Marks			Credits
		L	P		CA	FE	Total	
SESPC-401	Energy management and Audit	4		3	25	75	100	3
SESPE-402	Elective – V	4		3	25	75	100	3
SESPE-403	Elective – VI	4		3	25	75	100	3
SESPP-404	Energy System Laboratory-II		3	3	40	60	100	2
	Total	**12**	**3**		**115**	**285**	**400**	**11**

L:- Lecture P :- Practical S :- Seminar
Marks for each subject : 100 (25 for continuous assessment, 75 for examination)
Marks for Practical: 100 (40 for continuous assessment, 60 for examination)
Duration of examination : 3 hours for each subject

FIFTH SEMESTER

<table>
<tr><th rowspan="2">Code</th><th rowspan="2">Subjects</th><th colspan="2">Periods/ Week</th><th rowspan="2">Duration of exam. Hrs.</th><th colspan="3">Marks</th><th rowspan="2">Credits</th></tr>
<tr><th>L</th><th>S</th><th>CA</th><th>FE</th><th>Total</th></tr>
<tr><td>SESPE - 501</td><td>Elective-VII</td><td>4</td><td></td><td>3</td><td>25</td><td>75</td><td>100</td><td>3</td></tr>
<tr><td>SESPE - 502</td><td>Elective-VIII</td><td>4</td><td></td><td>3</td><td>25</td><td>75</td><td>100</td><td>3</td></tr>
<tr><td>SESPT - 503</td><td>Thesis Phase-I</td><td></td><td>3</td><td></td><td>40</td><td>60</td><td>100</td><td>6</td></tr>
<tr><td></td><td>Total</td><td>8</td><td></td><td></td><td>190</td><td>210</td><td>300</td><td>12</td></tr>
<tr><td colspan="9"># L:- Lecture P :- Practical S :- Seminar
Marks for each subject : 100 (25 for continuous assessment, 75 for examination)
Marks for Thesis Work and Seminar: 100 (40 for continuous assessment, 60 for examination)
Duration of examination : 3 hours for each subject
Examination for subject 303 in the form of viva voce and/or demonstration</td></tr>
</table>

SIXTH SEMESTER

<table>
<tr><th rowspan="2">Code</th><th rowspan="2">Subjects</th><th colspan="2">Periods/ Week</th><th rowspan="2">Duration of exam. Hrs.</th><th colspan="3">Marks</th><th rowspan="2">Credits</th></tr>
<tr><th>L</th><th>S</th><th>CA</th><th>FE</th><th>Total</th></tr>
<tr><td>SESPT - 601</td><td>Thesis Phase-II</td><td></td><td>3</td><td></td><td>40</td><td>60</td><td>100</td><td>13</td></tr>
<tr><td></td><td>Total</td><td></td><td>3</td><td></td><td>40</td><td>60</td><td>100</td><td>13</td></tr>
<tr><td colspan="9"># L:- Lecture P :- Practical S :- Seminar
Marks for Thesis Work and Seminar: 100 (40 for continuous assessment, 60 for examination)
Duration of examination : 3 hours for each subject
Examination for subject 401 in the form of viva voce and/or demonstration</td></tr>
</table>

L: Lecture **CA:** Continuous Assessment **FE:** Final Examination **P:** Practical

List of Electives

Group A:

1. Smart Grid
2. State Estimation and Security Control of Power Systems
3. Power System Economics and Control
4. Power System Stability
5. Power System Restructuring And Deregulation
6. Emerging Techniques in Modern Power System Analysis
7. Wind Energy Conversion Systems
8. Energy Conversion Systems
9. Energy Systems Modelling And Analysis
10. Solid State Controlled Electric Drives
11. Flexible AC Transmission Systems (FACTS)
12. Distributed Energy Systems

Group B:

13. Smart Sensors
14. System Modelling and Identification
15. Adaptive Control Systems
16. Intelligent Instrumentation System
17. Industrial Automation and Control
18. Advanced embedded system
19. Real Time Systems
20. Industrial Data Communication
21. Network Engineering
22. Data Base Management
23. Optimization Techniques
24. Soft Computing Techniques
25. Linear multivariable system design
26. Advanced computer networks
27. Advanced wireless systems

SESC 101 - APPLIED MATHEMATICS

AIM

To strengthen the mathematical background of the students and expose him to the latest areas required in the field of study of power systems.

OBJECTIVES

The course is offered to enable the student to build up his mathematical ability and acquire the knowledge to understand the concepts with a sense of applicability.

A review of matrix methods to solving problems is expected. An emphasis is to be laid on the study of operations research with specified reference to quadratic programming. The importance of statistical analysis is to brought out. A course on time series analysis is envisaged. Techniques used to solve higher order equation with more than one variable are to be explained.

The student will be able to exploit the use of mathematical skill for design analysis and simulation of power systems.

MATRICES

Computation of the greatest and the lst eigen values of a matrix by power method - Modal matrix and spectral matrix - Hermitian form - Canonical form.

OPERATIONS RESEARCH

Linear programming - Graphical method - Simplex method - Nonlinear programming with special reference to quadratic programming - Kuhn Tucker conditions - Wolfe's method - Dynamic programming - Bellman's principle of optimality.

STATISTICS

Probability - Baye's theorem for conditional probability - Random variables - Distribution function - Density function - Variance and covariance - Stochastic process - Auto correlation and auto covariance - Cross correlation and cross covariance - Stationary process - Auto correlation and cross correlation functions - Power spectrum.

TIME SERIES ANALYSIS

Methods of forecasting - Significance of time series analysis - Components of time series - Secular trends - Linear trend - Graphical method - Semi average method - Method of least squares - Nonlinear trends - Moving average method - Method of least squares - Seasonal variations - Seasonal index - Method of simple averages - Ratio to trend method - Ratio to moving average method - Cyclical variations - Smoothing with moving averages - Irregular variations .

BOUNDARY VALUE PROBLEMS

a) Special functions and multiple Fourier series: Orthogonal functions, Bessel functions and Legendre polynomials – Generalized Fourier series expansions of an arbitrary function in terms of orthogonal functions, Bessel functions of order zero and Legendre polynomials - Fourier series expansions of functions of two and three variables.

b) Partial Differential Equations: Solution of wave equation, diffusion equation, Poisson equation and Laplace equation by the method of separation of variables - Transverse vibration of rectangular and circular membranes - Potentials due to charged circular rings, circular plates and spheres.

REFERENCE BOOKS

1. **Shanti Narayan** A Text Book of Matrices *S.Chand & Co.*
2. **Swarup.K, Gupta. P.K. and Man Mohan** Operations Research *Sultan Chand & Sons.*
3. **Papoulis .A** Probability, Random Variables and Stochastic Processes *McGraw Hill. 1965*
4. **Gupta S.P. and Gupta .M.P** Business Statistics *Sultan Chand & Sons.*
5. **Raymond Willis. E** A Guide to Forecasting for Planners and Managers *Prentice Hall. 1987*
6. **Venkataraman. M.K** Higher Mathematics for Engineering & Science *The National Publishing Co. 1992*
7. **Erwin Kreyszig** Advanced Engineering Mathematics: *Wiley Eastern.*
8. **Louis Pipes .A and Hartill** Applied Mathematics for Engineers and Physicists *McGraw Hill.*

SESC 102 - NON CONVENTIONAL ENERGY ENGINEERING

AIM

This subject enables the students to gain a vast knowledge about various Non conventional energy engineering .

OBJECTIVES

To impart wide knowledge of basics on Wind energy, Solar energy, energy from Bio mass , Geo-Thermal, Ocean Energy and other energy sources.

WIND ENERGY

Basic principles of wind energy conversion – site selection consideration – types of wind mills – basic components of wind energy conversion systems (WECS) – types of WECS – applications of wind energy – safety system – environmental aspects.

SOLAR ENERGY

Physical principles of conversion of solar radiation into heat – flat plate collector – collector efficiency – concentrating collector: focusing type – advantages of focusing collectors – cylindrical parabolic concentrating collector – selective absorber coatings – central receiver tower solar power plant – solar energy storage systems – solar pond – principle of solar photo voltaic cell – solar photo voltaic power generation – MPPT (Maximum Power Point Tracking) – solar pump – solar hydrogen energy – solar refrigerator.

ENERGY FROM BIO MASS

Bio gas generation principle – types of bio-gas plants – applications of bio-gas plants – bio-mass as a source of energy – energy plantation – thermal gasification of bio mass – energy from agricultural waste – agro thermal power plant – Bagasse-based cogeneration programme – integrated waste management.

GEO-THERMAL AND OCEAN ENERGY

Nature of geo-thermal energy – geo-thermal sources – prime movers for geo-thermal energy conversion – advantages and disadvantages of geo-thermal energy – application of geo-thermal energy – principle of ocean thermal energy conversion (OTEC) – open cycle OTEC system – applications – basic principle and components of tidal power plant – site requirements – storage – advantages and limitations of tidal power generation – ocean wave energy conversion devices.

OTHER ENERGY SOURCES

Basic principle and components of a fuel cell – types of fuel cell – advantages and disadvantages of fuel cell – conversion energy and application of fuel cell – basic battery theory – batteries applied for bulk energy storage – Magneto Hydro Dynamics (MHD) – MHD generators – working principle – types – characteristics – area of use – Hydrogen fuel – hydrogen production – storage – transportation and utilization – hydrogen as alternative fuel for motor vehicle – safety management.

REFERENCE BOOKS

1**..Rai G.D**, 'Non Conventional Energy Sources', *Khanna Publishers, New Delhi, 2000.*
2. **Gupta B.R.,** 'Generation of Electrical Energy', *S.Chand & Co. Ltd, NewDelhi,2001.*
3**..Agarwal M.P,** 'Future Sources of Electrical Power', *S.Chand & Co. Ltd, New Delhi, 1999.*

SESC 103 - DIGITAL SIMULATION OF POWER SYSTEMS

AIM

To explain to the student the basic concept related to analysis of power systems and enable him to understand the newer algorithms.

OBJECTIVES

A review of the basic studies in the area of power systems is expected. Improvements that enable the effective use of computers for large power networks is to be highlighted. An emphasis of how the power system models are built for different types of studies is to be laid.

The course will pave the way for a student to incorporate the use of intelligent techniques in the area of power system analysis.

INTRODUCTION

Importance of basic power system studies (power flow, short circuit and stability) in the planning and operation of power system - distinction between steady state, quasi steady state and transient modeling of power system.

SPARSITY ORIENTED NETWORK SOLUTION

Solution of network equation - Exploiting sparsity of bus admittance matrix - compact storage, optimal ordering, triangular factorization and solution using the factors - Solution using Gaussian elimination.

POWER FLOW STUDIES

Power flow model using bus admittance matrix - Fast decoupled power flow method (FDPF) - with voltage controlled buses using sparsity technique - Load flow based on sparsity oriented solution of I = YV - AC/DC power flow analysis using sequential FDPF method - Radial System power flow –Current injection based techniques - Multiarea power flow analysis with tie-line control - Special Purpose Power Flow Studies - Harmonic power flow - three phase load flow –distribution power flow - interactive load flows - contingency analysis - sensitivity analysis.

SHORT CIRCUIT STUDIES

Short circuit analysis of a multi-node power system using bus impedance matrix ZBUS - Building algorithm for ZBUS - Algorithm for symmetrical fault analysis using ZBUS - Development of voltage and current equations under unsymmetrical faults using symmetrical components and algorithm for unsymmetrical fault analysis using ZBUS - Use of sparse factors of YBUS for obtaining the columns of ZBUS.

STABILITY STUDIES

Mathematical model for stability analysis of a multimachines system with exciters and governors - solution of state equation by modified Euler method/4th order R.K. method .

REFERENCE BOOKS

1. **Stagg G.Wand El- Abiad .A.H** Computer Methods in Power System Analysis: *McGraw Hill Book Co,1987*
2. **Pai M.A.** Computer Techniques in Power System Analysis *Tata McGrawHill,2006.*
3. **Brown. H.E** Solution of Large Networks by Matrix Methods: *John Wiley and Sons. 1975*
4. **Arrillaga .J and Arnold. C.P** Computer Modelling of Electrical Power Systems: *John Wiley and Sons,2006*
5. **Kusic.G.L** Computer Aided Power System Analysis *PHI,1989.*
6. **Heydt. T** Computer Techniques in Power System Analysis *1996.*

SESC 201- NON LINEAR CONTROL SYSTEMS

AIM

This subject enables the students to gain a vast knowledge about various control system design methods ,Digital control system state space analysis ,optimal and nonlinear control systems.

OBJECTIVES

At the end of the course, students are familiar with

(i)The design of suitable compensator for a given plant and a set of specifications.

(ii)The analysis of sampled data control system, Multi-input Multi-output control system, Optimal Control system and Non-linear Control system.

MATHEMATICAL DESCRIPTIONS OF SYSTEMS

Transfer function matrix - state space representation using physical, phase and canonical variables - comparison of input-output description and state-variable description - mathematical description of composite systems - Solution of dynamical equation - state transition matrix - - impulse response matrix-controllability and observability- linear independence of time functions – Canonical – form of dynamical equations for single-variable.

Common Nonlinear behavior - Autonomy - Equilibrium points of nonlinear systems, Feedback Linearization, Series Approximation Methods.

STATE FEEDBACK

Effects of state feedback, pole placement and feedback gain matrix-State estimators: Full-dimensional state estimator - reduced dimensional state estimator connection of state feedback and state estimator -decoupling by state feedback.

DESCRIBING FUNCTION TECHNIQUES

Describing function. of non linearities - gain function and its determination for analytically and graphically defined nonlinearities - multiple nonlinearites – conditions for stability – stability of oscillation - accuracy of Describing function method - stabilityof systems with multiple non linearites – closed – loop ftequency response - dual input describing function and its applications.

PHASE PLANE ANALYSIS

Singular points - construction of phase portraits using lsocline, Lienard, Delta and Pells method - limit cycle analysis – Poin care index and Bendixson's theorems - Closed loop trajectory - systems with non linear damping - effect of non - linearities on the step response of position control system. Stability in the sense of Liapunov - Liapunov's second method and Liapunov's theorems on stability and instability of non linear systems - Krasovkii's theorem – variable gradient method of generating Liapunov functions - Lure's problem - Popov's stability criterion.

SLIDING MODE CONTROL

Variable structure systems - Basic concepts - Sliding modes in variable structure system conditions for existence of sliding regions – Case Study.

REFERENCE BOOKS

1. **Katsuhiko Ogata**, “Modem Control Engineering”*, Prentice Hall of India Pvt. Ltd., 1997.*

2.**John E Gibson**, “Non linear Automatic Control”, McGraw Hill Inc., 1963.

3.**M Gopal**,“Digital Control and State Variable Methods, Conventional and Intelligent Control Systems”,McGraw-Hill Inc., New Delhi,Third Edition, 2009.

4.**Hasen K Khalil**, "Nonlinear Systems", Prentice Hall Inc., New York, 1996.

5.**Jean Jacques Slotine and Weiping Li**,“Applied Nonlinear Control”, Prentice Hall Inc., 1991.

SESC 202- POWER QUALITY STUDIES

AIM

This subject enables the students to acquire knowledge in the area of Power Quality studies.

OBJECTIVES

To impart wide knowledge of basics on Introduction to power quality, Voltage sags and interruptions, Harmonics, Harmonic analysis, Power quality bench marking.

INTRODUCTION TO POWER QUALITY

Terms and definitions- Overloading- under voltage- sustained interruption- sags and swells- Waveform distortion- Total Harmonic Distortion (THD)- Computer Business Equipment Manufacturers Associations (CBEMA) curve.

VOLTAGE SAGS AND INTERRUPTIONS

Sources of sags and interruptions- Estimating voltage sag performance- Motor starting sags- Estimating the sag severity- Mitigation of voltage sags- Active series compensators- Static transfer switches and fast transfer switches.

HARMONICS

Harmonic distortion- Voltage and current distortion- Harmonic indices- Harmonic sources from commercial and industrial loads- Locating harmonic sources- Power system response characteristics- Resonance- harmonic distortion evaluation- devices for controlling harmonic distortion- Passive filters- Active filters - IEEE and IEC standards.

HARMONIC ANALYSIS

Harmonic distortion evaluation - Concept of point of common coupling – Principles for controlling harmonics – Reducing harmonic currents in loads – Development of a system model – modeling harmonic sources – Computer tools for harmonic analysis – Design of harmonic filter.

POWER QUALITY BENCH MARKING

Bench marking process – RMS voltage variation indices – Harmonic indices – Sampling techniques – Harmonic bench mark data – Power quality contracts – Power quality state estimation – Estimating RMS variation .

REFERENCE BOOKS

1. **Roger.C.Dugan- Mark.F.McGranagham- Surya Santoso- H.Wayne Beaty**- ‘Electrical Power Systems Quality’ McGraw Hill- 2003.
2. **Sastry Vedam R., Mulukutla S. Sarma,** “Power Quality VAR compensation in Power Systems”, *CRC Press, Taylor&Francis Group, New York.*
3. **Sankaran C.,** “Power Quality”, *CRC Press, New York.*
4. **Angelo Baggini,** “Handbook of Power Quality”, *John Wiley & Sons, 2008.*
5. **Bollen M.H, “**Under standing Power Quality Problems, Voltage sags and Interruptions, *wiley-1999.*
6. **Fucks E and Masoum M, “**Power Quality is Power Systems and Electrical Machines”, *Academic Press-2008*.

SESC 203 - ENERGY MANAGEMENT AND AUDIT

AIM

This subject enables the students to gain knowledge in the area of Energy management and audit.

OBJECTIVES

*To impart wide knowledge of basics on Distribution Automation, Demand side management, Energy Management In Electric Utilities, Energy Audit And Energy Audit Of Electrical Systems***.**

DISTRIBUTION AUTOMATION

Introduction – Need Based Energy Management (NBEM) – advantages – conversional distribution network – automated system – Distribution Automation System (DAS) – communication interface – PLCC – different data communication systems – distribution SCADA – distribution automation – load management in automated distribution system – RTU – substation automation – feeder automation – consumer side automation

DEMAND SIDE MANAGEMENT

Introduction – scope of demand side management (DSM) – evolution of DSM concepts – DSM planning and implementation – load management as DSM strategy – application of load control – end use of energy conversion – tariff options for DSM – customer acceptance – implementation issues – implementation strategies – DSM environment – international experience with DSM.

ENERGY MANAGEMENT IN ELECTRIC UTILITIES

Industrial heating – resistance heating, induction heating, arc heating, dielectric and micro wave heating – Radiant heating – cost of electrical energy – lighting – lamp life time – efficient lighting – motive power and power factor improvement – capacitor rating – siting of capacitors – effects of power factor improvement – temperature measurement – optimum start control – efficient use of electrical energy in air conditioning – Motors and Adjustable speed drives – high efficiency motors – rewinding electric motors – Motor drives and controls – other factors in motor system efficiency – Utility rebates for motor and drives.

ENERGY AUDIT

Basic principles of energy audit – definition of energy auditing – objectives – energy flow diagram – strategy of energy audit – comparison with standards – energy management team – considerations in implementing energy with conservation programmes – periodic progress review– energy audit concept – reduced line loss – power quality – differed capital expenses – energy cost reduction – optimal energy use – improved reliability.

ENERGY AUDIT OF ELECTRICAL SYSTEMS

Instruments for energy audit – energy audit of heating, ventilation and air conditioning systems – energy audit of compressed air systems – energy audit of buildings – energy audit of steam generation, distribution and utilization systems – energy audit of electric drive utilities – economic analysis.

REFERENCE BOOKS

1. **Gupta B.R.,** ‘Generation of Electrical Energy’, *S.Chand & Co. Ltd, New Delhi, 2001.*
2. **Rai G.D,** ‘Non Conventional Energy Sources’*, Khanna Publishers, New Delhi, 2000.*
3. **Murphy W.R, McKay G.,** “Energy Management”, *Butterworths Publications, London,1982.*
4. **Trivedi P.R., Jolka B.R.,** “Energy Management”, *Common Wealth Publishers, New Delhi, 1997.*

LABORATORY COURSES

The syllabus for the laboratory courses SESP-107 and 207 in Fulltime and SESPP-304 and 404 will generally follow the theory subjects concerned taking into account the needs of the course, the needs of the time and the technological advances.

The list of experiments will be prepared by the Head of the Department of Electrical Engineering from time to time.

1. (Elective) SMART GRID

AIM

This subject enables the students to acquire knowledge to the students in the area of Smart power grids.

OBJECTIVES

To impart wide knowledge of basics on Introduction, Operation and control of micro grids, Micro grid load frequency control, Voltage Regulation on Micro grid, Advanced metering infrastructure (AMI).

INTRODUCTION

Solar Energy - Wind energy - Micro grid of Renewable and Green (MRG) Power Grids - Control Operation of Interconnected Network Bulk Power Grids - Smart Power Grid -Cyber Controlled Smart Power Grids - Research Issues.

OPERATION AND CONTROL OF MICROGRIDS

Introduction - Overview of MG Operation - MicroGrids Dynamic Modeling - Fuel Cells - Solid Oxide Fuel Cell Modeling - Micro-Wind Turbines - Photovoltaic Panels - MicroGrids Emergency Control Strategies - Frequency Control - Explolting Low Voltage MicroGrids for Service Restoration - MicroGrid Black Start - General Requirement & Sequence of Actions for MicroGrid Black Start.

MICRO GRID LOAD FREQUENCY CONTROL

Introduction - Angle Droop Control for VSC Interfaced DGs - Angle Droop Control and Power Sharing - Angle Droop and Frequency Droop Controller - Systems with Lower Droop Gains - System Stability with High Droop Gain - Power Quality Enhanced Operation of a Microgrid - Load Sharing of the DGs with Utility - Change in Power Supply From Utility - Power Supply from Microgrid to Utility.

VOLTAGE REGULATION ON MICROGRID

Introduction - Voltage regulation in Conventional Distribution Network - Voltage regulation on Microgrid - Worst Case Voltage regulation - Mitigation on Voltage Variation Based on Worst Case Scenario - Mitigation methods of Voltage regulation : Regulating Primary DS Voltage (VS), Reducing Line Resistance , using Reactive Power Control - Voltage Level and Connection Cost.

ADVANCED METERING INFRASTRUTURE (AMI)

Smart metres - benifits and applications of smart metering - AMI architecture - Components Overview - Smart meter requirement and technology : Neighborhood Area Network (NAN) - Home Area Network topology (HAN) - Power line carriers - HAN gateways - Field Area Networks (FAN) - requirments , IP based networks - overview of smart metering.

REFERENCE BOOKS

1. ***Ali Keyhani and Muhammad Marwali,*** "smart power Grids 2011",Springer Publications, 2011.
2. ***Feredoon.P.Sioshnsi,*** "smart grid - integrating renewable, distibuted and efficient energy", academic press, 2011.
3. ***Janaka Ekanayake , Nick Jenekins,***"smart grid : technology and applications", John Wiley and Sons Canada, 2011.
4. ***Christine Hertzog,***"smart Grid Dictionary", Spinger publications, 2009.
5. ***Tony Flick,Justin morehouse,*** "Securing the smart grid : Next generation power grid security", Elsevier ,2010.

2 - (Elective) STATE ESTIMATION AND SECURITY CONTROL OF POWER SYSTEMS

AIM

To impart to the students the need for power system monitoring and highlight the significance of estimation and enhancement with the use of SCADA systems.

OBJECTIVES

A review of SCADA, measurement techniques, concept of data transmission and telemetry is expected.
Algorithms for state estimation and methods of computing the states of the system is to instilled in the needs of the students.
The requirement of the system to be secure even during contingent conditions is to be explained. Measures that the operator will have to initiate are to be highlighted. The student will be able to incorporate security procedures not only in the design of power systems but also when he attempts to build newer techniques.

INTRODUCTION

Concept of power system security - factors affecting security - functions of security control - system monitoring, state estimation, security assessment and security enhancement.

SYSTEM MONITORING

Power system control centres: equipment and interfaces - dual computer configuration, organisation and functions - SCADA system.

DATA ACQUISITION TRANSMISSION AND TELEMETRY

Block diagram of a typical microprocessor based data acquisition system for power systems - analog and digital signal acquisition modules - interface - microprocessor system - software - display devices.

Amplitude modulation - frequency modulation -frequency shift keying - modems - PLCC equipment.

POWER SYSTEM STATE ESTIMATION

Static state estimation : Maximum likelihood weighted least squares estimation algorithm - active and reactive power bus measurements - active and reactive power line flow measurements - line current measurements - bus voltage measurements -measurement redundancy - accuracy and variance of measurements - variance of measurement residuals - detection, identification and suppression of bad measurements. Computational aspects - approximations to reduce computations - external system equivalencing -fast decoupled state estimation - state estimation using d.c. model of power system. Weighted least absolute value state estimation - comparison with WLSE. Network observability - psuedo measurements - virtual measurements. Stability and robustness of estimation algorithms. tracking state estimation : algorithm - computational aspects.

SECURITY ASSESSMENT

Classification of security states : Normal, alert, contingency, emergency and restorative modes. Network equivalent for external system. Contingency analysis : a.c., linearised a.c. and linearised d.c. models of power systems for security assessment - line outage distribution factors and generation shift factors for d.c. and linearised a.c. models - single contingency analysis using these factors - double line outage analysis techniques using bus impedance matrix and factors of bus admittance matrix. Fast contingency algorithms for nonlinear a.c. models. Contingency ranking, security indices.

SECURITY ENHANCEMENT

Correcting the generator dispatch for security enhancement using linearised d.c. models - methods using sensitivity factors - compensated factors - optimisation methods. Emergency and restorative control procedures.

REFERENCE BOOKS

1. ***Wood and Wollenberg*** ,"Power generation, operation and control ", *John Wiley and Sons,1996.*
2. ***Mahalanabis, Kothari and Ahson,"*** Computer aided power system analysis and control ", *Tata McGraw Hill,1991*
3. ***Kusic .G.L***," Computer aided power system analysis", *Prentice Hall of India,1989.*
4. ***Murty P.S.R*** "Power system operation and control *Tata McGraw Hill. 1984*

3 –(Elective) POWER SYSTEM ECONOMICS AND CONTROL

AIM

To bring out the need for operating the power system in a viable and affordable manner.

OBJECTIVES

A review of the dispatch studies in power system networks is expected. An emphasis on the development of algorithms suitable for efficient operation is to be laid. Techniques used to solve mathematical formulations is to be explained. The basic idea of unit commitment schedule and its significance is to be pointed out. The problems associated with interconnected networks, the need for maintaining co-coordinated actions and the use of controllers in augmenting these actions is to addressed.

The student will derive the benefit of having understood the credentials of smooth and satisfactory operation of power systems.

OPTIMUM DISPATCH

Economic Dispatch problem with and without losses - Analysis of two bus and 'N' bus systems - Incremental transmission loss – Lambda iteration method – base point and participation factors - Optimal dispatch for cost and loss minimization – Security constrained economic dispatch – Solution algorithms – Kuhn Tucker conditions – Inequality constraint on control and dependant variables –Penalty function approach for constraint violations - Gradient search and Dynamic programming methods.

OPTIMAL DISPATCH WITH CONSTRAINTS

Environmental constraints – Clean Air Act – Emission function – Emission Dispatch – Combined Economic Emission Dispatch – Economic dispatch with multiple fuels – Ramp rate limits – Dynamic economic dispatch – Valve Point Effects.

UNIT COMMITMENT

Unit commitment problem – spinning reserve – thermal unit constraints –other constraints – solution methods – priority List method – dynamic programming method – Lagrangian Relaxation method.

HYDRO THERMAL SCHEDULING

Hydrothermal systems – Hydroelectric plant models – Glimn – Kirchmayer's model – Hildebrand's model – Arivanitidis Rosing model – Short range fixed and variable head scheduling – lambda – gamma iteration algorithm – gradient approach – hydro units in series – pumped storage hydro scheduling – hydro plant modeling for long term operation – long range generation scheduling of hydrothermal systems.

LOAD FREQUENCY CONTROL

Control area – Automatic generation Control – Area control error – Transfer function model for single area and two area power systems – PID controllers – steady state error in two area system – Implementation of Load Frequency control (LFC) – Power/Frequency characteristic in an interconnected power system – Flat frequency control – Parallel Frequency control – Tie-line biased control – Selective frequency control – State variable models: Single and Two-Area Systems - Optimal Load – Frequency control – Digital Load Frequency Control – Decentralized Control – Biased Control – State variable models: Single and Two-Area Systems – Optimal Load-Frequency control – Digital Load Frequency Control – Decentralized Control – Biased Control.

REFERENCE BOOKS

1. **Elgerd.O.I,** "Electric Energy Systems: Theory – An Introduction", *Tata Mc Graw Hill, New Delhi, 1999.*
2. **Murthy P.S.R**, "Power System Operation and Control", *Tat McGraw Hill, 1984.*
3. **Kothari D.P and Dhillon J.S**, "Power System Optimization", *Prentice Hall of India, New Delhi, 2004.*
4. **Ji Zhong Zhu**, "Optimization of Power System Operation", *Wiley IEEE Press, New Jersey, 2009.*
5. **Nagrath and Kothari,** "Modern Power System Analysis", *Tata Mc Graw Hill, New Delhi 2005.*
6. **Wood and Wollenberg,** "Power Generation, Operation and Control", *John Wiley and Sons, 1996.*
7. **Kirchmeyar**, " Economic Operation of Power Systems", *1985*
8. **Mahalanabis,** Kothari and Ahson, "Computer Aided Power System Analysis and Control", *Tata Mc Graw Hill, 1991.*
9. **Das. D**, "Electrical Power Systems", New Age International Publishers, *New Delhi, 2008.*
10. **Wang. X.,.Mc Donald. J.R**, "Modern Power System Planning", *Mc Graw Hill, New Delhi, 1994.*

4 –(Elective) POWER SYSTEM STABILITY

AIM

To create an awareness of the need for stability of the system when it is subjected to disturbances and study its performance under such exigencies.

OBJECTIVES

A review of the mathematical background that enables the operator to build the system model during various operating states is expected. State space algorithms that extract the system behavior are to be discussed. An emphasis on the need of mechanisms for connecting the system state through the use of closed loop operation is to be laid.

The influence of the use of regulators and excitors and methods to study the overall system performance are to be probed.

Approach that facilitates extension of the existing techniques to multi machine systems are to be explained.

The students will realize the significance of stability analysis and be capable of including its effects in the design of newer systems, besides being to able to suggest preventive measures in the event of occurrence of a disturbance.

INTRODUCTION

Distinction between transient and dynamic stability - complexity of stability problem in large system - need for reduced models - stability of interconnected systems.

EXCITER AND VOLTAGE REGULATOR

Function of excitation systems - typical excitation system configuration - block diagram and state space representation of IEEE type 1, type 2, type 3 excitation systems - saturation function - stabilising circuit. - Block diagram and state space representation of IEEE mechanical hydraulic governor for hydro turbines and electrical hydraulic governors for steam turbines – Function of voltage regulator - block diagram – transfer function model.

VOLTAGE STABILITY ANALYSIS

Definitions – active and reactive power transmiison using elementary models – Difficulties with rective power tansmission – System response to power impacts – steady state stability analysis of two bus system using PV and QV curves - Maximum deliverable power – voltage stability assessment using indices – determination of weakest bus and weak bus ordering vector – latge disturbance stability analysis - Load compensator as a voltage regulator - phase balancing and power factor correction of unsymmetrical loads. Effect of compensation - series, shunt and , SVC devices.

DYNAMIC STABILITY

System response to small disturbances - linear model of the unregulated synchronous machine and its modes of oscillation – Park's Transformation – State space model –Simplified models - regulated synchronous machine - distribution of power impact - linearization of the load equation for the single machine problem - simplified linear model - effect of excitation on dynamic stability - approximate system representation - supplementary stabilizing signals - linear analysis of stabilized generator - linearized model for the network - dynamic stability analysis of multi machine system using linearized model of generator regulators and network.

DYNAMIC PERFORMANCE OF SYSTEMS

Introduction - dynamic performance of systems with different types of compensation - Passive shunt compensation - static compensators - synchronous condensers - series capacitor compensation - The thyristor controlled reactor - thyristor controlled high impedance transformer - thyristor switched capacitor - saturated reactor.

Turbine - generator torsional characteristics - torsional interaction with power system controls - sub synchronous resonance (SSR) - impact of network-switching disturbances - torsional counter measures to SSR problems - Methods of improving stability - Small signal and transient stability enhancement methods.

REFERENCE BOOKS

1. **Anderson P.N** and **Fouad. A.A** "Power System Control and Stability" *Galgotia Publication, New Delhi,1984.*
2. **Kundur P**., " Power system stability and control ", McGraw Hill, 1994.
3. **Miller .T.J.E.** "Reactive power control in electric systems" , *John Wiley & Sons New York*.
4. **Peter. W. Sauer and M.A. Pai** Power System Dynamics and Stability *Prentice Hall New Jersey. 1998*
5. **Pai M.A, Sen Gupta .D.P, Padiyar. K. R** Small Signal Analysis of Power Systems, *Narosa Publishing House, New Delhi 2004*
6. **Kimbark .E.W** Power System Stability, Vol.I and III *John Wiley,1976*.
7. **Taylor C.W.**, " Power systems voltage stability ", *McGraw Hill, New Delhi, 1994.*
8. **Gyngyi. L, Otto. R.A and T.H.Putman** Principles and application of static thyristor controlled shunt compensators Trans. IEEE . Power Apparatus and Systems, *pp. 1935 - 1945, September/October, 1978.*

5 - (Elective) POWER SYSTEM RESTRUCTURING AND DEREGULATION

AIM

This subject enables the students to gain indepth knowledge about the power system restructuring and deregulation.

OBJECTIVES

The students are expected to gather knowledge about Power System Restructuring And Electrical Utility, Evaluation Of Transmission Systems, Optimum Power Flow (Opf) Analysis In Market Environment And Agc In Restructured Power System.

POWER SYSTEM RESTRUCTURING

Introduction –Deregulation - Need for deregulation – Power system restructure models - Electricity Market Participants – GENCOS- DISCOS- TO- ISO- PX- SC - trading arrangements - Operational Planning Activities (OPA) of Electricity Market Participants - Causes of restructuring- types and effects of restructuring – restructured models.

ELECTRICAL UTILITY

Electrical utility restructuring Power System Operation in competitive environment –Electricity Market Models (PoolCo- bilateral- hybrid)- Components of restructured system - Power Sector restructuring and influence on environment - Functions and responsibilities of PX- ISO- RTO and ITP - Electric Utility Market – Market Models - wholesale electricity market characteristic – Electricity Market types (energy- ancillary services- transmission- forward- real time) – Market power evaluation and mitigation

EVALUATION OF TRANSMISSION SYSTEMS

Electricity pricing and Transmission pricing in a restructured market - Congestion management in a deregulated market – Available Transfer Capabilities (ATC) of transmission system – Application of Monte Carlo Simulation in ATC calculation – ATC calculation with sensitivity analysis method - Tagging Electricity Transaction – Tagging process – Implementation- Curtailment and cancellation of transaction - Availability Based Tariff

OPTIMUM POWER FLOW (OPF) ANALYSIS IN MARKET ENVIRONMENT

Introduction – Approaches to OPF – Application of OPF analysis in Electricity and Power Markets with Electricity Market Participants – Power Flow Tracing – current decomposition axioms- Mathematical model of loss allocation- usage sharing problem on transmission facilities - Methodology of graph theory - Economic issues- Mechanism and transmission issues in the new market environment.

AGC IN RESTRUCTURED POWER SYSTEM

Introduction – Traditional Vs Restructured Scenario –AGC in New market environment - Block diagram and State Space representation of a two-area interconnected power system in deregulated environment – Load-Frequency Control (LFC) dynamics and Bilateral Contacts – Modelling- DISCO Participation Matrix (DPM)- Generation Participation Matrix (GPM).

REFERENCE BOOKS

1. **Loi Lei Lai-** "Power System Restructuring and deregulation"- *John Wiley & Sons-2001*
2. **Md.Shahidehpour- Muwaffag Almoush**- "Restructured Electric Power System – Operation- Trading and Volatility"- *Marcel Dekker Inc- New York- 2001.*
3. **Arthur.R.Bergen- Vijay Vittal-** "Power System Analysis"- *Prentice Hall- New Jersey- 2000*
4. **Xi Fan-Wang- Yonghua Song- Malcolm Irving-** "Modern Power System Analysis"- *Springer- 2008.*
5. **Das D-** "Electrical Power Systems"- *New Age International (P) Ltd- New Delhi- 2008.*
6. **Hassan Bevrani**- "Robust Power System Frequency Control"- *Springer- 2009*
7. **Iiic M, Galiana F, Fink L** - "Power Systems Restructuring"- *Norwell- MA- Kluwer 1998*
8. **Philipson. L- Willis H.Le-** "Understanding Electric Utilities and de-regulation"- *Marcel Dekker Inc Publishers- New York, 2006.*

6 – (Elective) EMERGING TECHNIQUES IN MODERN POWER SYSTEM ANALYSIS

AIM

This subject enables the students to gain indepth knowledge about the power flow solutions, balanced and unbalanced fault analysis of an interconnected power system.

OBJECTIVES

The students are expected to gather knowledge about emerging techniques in power system analysis.

FUNDAMENTALS OF EMERGING TECHNIQUES

Principles of Deregulation - Overview of Deregulation Worldwide - Typical Electricity Markets -Uncertainties in a Power System - Load Modeling Issues - Distributed Generation - Control Performance - Local Protection and Control - Power System Cascading Failure and Analysis Techniques - Phasor Measurement Units - Topological Methods - Power System Vulnerability Assessment

DATA MINING TECHNIQUES IN POWER INDUSTRY

Introduction - Fundamentals of Data Mining - Correlation, Classification and Regression -Available Data Mining Tools - Data Mining based Market Data Analysis - Introduction to Electricity Price Forecasting - The Price Spikes in an Electricity Market - Framework for Price Spike Forecasting - The Interval Forecasting Approach - Data Mining based Power System Security Assessment - Network Pattern Mining and Instability Prediction - Price Spike Forecasting - Interval Price Forecasting.

GRID COMPUTING

Introduction - Fundamentals of Grid Computing – Architecture - Features and Functionalities - Grid Computing vs Parallel and Distributed Computing - Commonly used Grid Computing Packages - Grid Computing based Security Assessment - Grid Computing based Reliability Assessment - Grid Computing based Power Market Analysis - Probabilistic Load Flow - Power System Contingency Analysis

POWER SYSTEM RELIABILITY ASSESSMENT

Introduction - Identify the Needs for The Probabilistic Approach - Power System Reliability Analysis - Probabilistic Small Signal Stability Assessment - Probabilistic System Planning - Feasible Options Selection - Reliability and Cost Evaluation

FUTURE TRENDS

Introduction - Event Identification and Fault Location - Model Validation - Identified Emerging Techniques - Trends in Emerging Techniques - Economic Impact of Emission Trading Schemes and Carbon Production Reduction Schemes - Power Generation based on Renewable Resources - Smart Grid

REFERENCE BOOKS

1. **Zhaoyang Dong, Pei Zhang,** "Emerging Techniques in Power System Analysis", Higher Education Press, *Beijing and Springer-Verlag Berlin Heidelberg 2010.*
2. **Xi-Fan Wang, Yonghua Song, Malcolm Irving**, "Modern Power Systems Analysis", *Springer, 2008.*
3. **Jack Casazza, Frank Delea,** "Understanding Electric Power Systems", *IEEE Press, John Wiley & Sons, New Jersey 2010.*
4. **Marko Cepin,** "Assessment of Power System Reliability Methods and Applications", *Springer-Verlag London Limited 2011.*
5. **Wood and Wollenberg,** "Power Generation, Operation and Control", *John Wiley and Sons, 1996.*
6. **Nagrath and Kothari,** "Modern Power System Analysis", *Tata Mc Graw Hill, New Delhi 2005.*
7. **Das.D.**, "Electrical Power Systems", *New Age International Publishers, New Delhi, 2008.*
8. **Kundur. P.**, "Power System Stability and Control", *McGraw Hill, 1993.*
9. **Saadat. H.**, "Power System Analysis", *McGraw-Hill, 1999.*

7 – (Elective) WIND ENERGY CONVERSION SYSTEMS

AIM

This subject enables the students to gain indepth knowledge about the Wind Energy Conversion System.

OBJECTIVES

To impart wide knowledge of basics on Introduction, Wind turbine and Wind Electric Generator, Power convertor and Wind Power Management.

INTRODUCTION

Wind resources – Nature and occurrence of wind –Power in the wind – Wind characteristics – Principles of wind energy conversions – Components of wind energy conversions system (WECS) - Classification of WECS – Advantages and disadvantages of WECS.

WIND TURBINES

Selection of site – Factors affecting the choice of site – Average wind speed – Effect of wind direction - Measurement of wind velocity – Wind data and energy estimation – Types of wind turbines – Horizontal axis machine – Vertical axis machine – Performance characteristics – Lift and drag – Effective flow direction – Control of Speed and output.

WIND ELECTRIC GENERATORS

Characteristics of Induction generators – Permanent magnet generators – Single phase operation of induction generators – Doubly fed generators – dq axis modeling – Grid connected and stand alone systems – Off shore power station –Controllers for wind driven self excited systems and capacitor excited isolated systems – Synchronized operation with grid supply - Real and reactive power control.

POWER CONVERTERS

DC Power conditioning converters – AC power conditioners – Voltage source inverters - PWM inverters – Voltage and frequency control - Harmonic problems – Remedial Solutions.

WIND POWER MANAGEMENT

Wind energy storage - Storage systems – Wind farms and grid connections – Grid related problems on absorption of wind - Grid interfacing arrangement -Simulation of wind energy conversion system - Operation, control and technical issues of wind generated electrical energy - Inter connected operation – Hybrid systems – Economic considerations – Optimization strategies – Futuristic options.

REFERENCE BOOKS

1. **Gary L. Johnson**, "Wind Energy Systems*", Prentice Hall Inc., 1985.*
2. **Rai G D.,** "Non – Conventional Energy Resources" *Khanna Publishers, 1993*
3. **Daniel, Hunt V**, "Wind Power – A hand book of WECS"' *Van Nostrend Co., New York, 1981.*
4. **Freris L.L.,** " Wind Energy Conversion", *Prentice Hall (UK)Ltd., 1990*.

8- (Elective) ENERGY CONVERSION SYSTEMS

AIM

This subject enables the students to gain indepth knowledge about the Energy Conversion Systems.

OBJECTIVES

To impart wide knowledge of basics on Introduction, Wind turbine and Wind Electric Generator, Power convertor and Wind Power Management.

PHOTO VOLTAIC POWER GENERATION

Spectral distribution of energy in solar radiation, solar ceil configurations, voltage developed by **solar** cell, photo current and load current, practical soJar cell performance, commetetal photo voltaic systems, test specifications for pv systems, appiications of super conducting materials in electrical equipment systems.

MHD POWER GENERATION

Principles of MHD power generation, ideal MHD generator performance, practical MHD generator,MHD technology.

WIND ENERGY CONVERSION

Power from wind, properties of air and wind, types of wind Turbines, operating characteristics - Tides and tidal power stations, modes of operation, tidal project examples, turbines and generators for tidal power generation. Wave energy conversion; properties of waves and power conteiit, vertex motion of Waves, device applications. Types of ocean thennal energy conversion systems Application of OTEC systems examples,

OTHER ENERGY CONVERSION SYSTEMS

Coal gasification and liquefaction, biomass conversion, geothennal energy, thenno electric energy conversion, principles of EMF generation, description of fuel cells.

CO-GENERATION AND ENERGY STORAGE

Combined cycle co-generation, energy storage. Global energy position and environmental effects: energy units, global energy position.

Types of fuel cells, HZ-02 Fuel cells, Application of fuel cells - Batteries, Description of batteries, Battery application for large power.

REFERENCE BOOKS

1. ***Rakosh das Begamudre,*** "Energy conversion systems" New age international publishers, New Delhi 2000.
2. ***John Twidell and Tony Weir,*** "Renewable Energy Resources" 2nd edition, Fspon AND Co.

9- (Elective) ENERGY SYSTEMS MODELING AND ANALYSIS

AIM

This subject enables the students to gain indepth knowledge about the Energy Systems Modeling and analysis.

OBJECTIVES

To impart wide knowledge of basics on Introduction, Modeling and systems simulation, Optimisation Techniques, Energy- Economy Models , Applications And Case Studies

INTRODUCTION

Primary energy analysis – dead states and energy components – energy balance for closed and control volume systems - applications of energy analysis for selected energy system design – modeling overview – levels and steps in model development – examples of models – curve fitting and regression analysis.

MODELLING AND SYSTEMS SIMULATION

Modeling of energy systems – heat exchanger - solar collectors – distillation - rectification turbo machinery components - refrigeration systems - information flow diagram – solution of set of non- linear algebraic equations – successive substitution – Newton Raphson method- examples of energy systems simulation.

OPTIMISATION TECHNIQUES

Objectives – constraints, problem formulation – unconstrained problems – necessary and sufficiency conditions.Constrained optimization - lagrange multipliers, constrained variations, Linear Programming - Simplex tableau, pivoting, sensitivity analysis.

ENERGY- ECONOMY MODELS

Multiplier Analysis - Energy and Environmental Input / Output Analysis - Energy Aggregation –Econometric Energy Demand Modeling – Overview of Econometric Methods – Dynamic programming – Search Techniques – Univariate / Multivariate.

APPLICATIONS AND CASE STUDIES

Case studies of optimization in Energy systems problems- Dealing with uncertainty- probabilistic techniques – Trade-offs between capital and energy using Pinch analysis.

REFERENCE BOOKS

1. ***Stoecker, W.F.,*** Design of Thermal Systems, McGraw Hill, 1989.
2. ***Bejan, A, Tsatsaronis, G and Moran, M.,*** Thermal Design and Optimization, John Wiley & Sons 1996.
3. ***Rao, S.S.***, Engineering Optimization - Theory and Applications, Wiley Eastern, 2000.
4. ***Meier, P.,*** Energy Systems Analysis for Developing Countries, Springer Verlag, 1984.
5. ***Beveridge and Schechter,*** Optimization Theory and Practice, McGraw Hill, 1970.
6. ***Jaluria, S.,*** Design and Optimization of Thermal Systems, McGrawHill, 1997.

10 - (Elective) SOLID STATE CONTROLLED ELECTRIC DRIVES

AIM

To enlighten the students on the emerging techniques in the control of DC and AC electric motors and enable him to develop never application.

OBJECTIVES

The detailed analysis of DC separately excited and series motors when fed from different types of AC-DC converters, and DC-DC converters is to be covered

The inherent characteristics of the two motors and how they can be reshaped through the use of such circuits and controllers is to be brought out.

Basic equations and conventional means of control of Ac motors are to be revived. A detailed analysis of the characteristics of both induction and synchronous motors when fed from different types of AC-AC, DC-AC converter circuits is to be covered. Different control measures and as to how they will shape the industrial needs is to be brought out.

The course will enable a student to acquire a detailed knowledge of the different aspects of modeling, design and performance of AC motors and be able to come up with newer applications for them.

DC DRIVES

Introduction : - fundamentals of electric drives - comparison between conventional and solid state drives - open loop and closed loop speed control - motor transfer function - speed and current loops - load torque disturbance

Phase controlled drives - Motor and input supply performance parameters – separately excited d.c. motor and continuous series motor drive, waveforms, equations, performance characteristics, Operation of semi and full converters - series connected converters - dual converters - non circulating and circulating modes - reversible drives - armature and field current reversal - dynamical regenerative braking of phase controlled drives.

CHOPPER CONTROLLED DRIVES (USING DEVICES OTER THAN THYRISTORS)

Principles of chopper operation - chopper configuration - chopper fed d.c. motors, analysis and performance characteristics - Dynamic and regenerative braking of chopper controlled drives - regenerative reversals - transit systems.

INDUCTION MOTOR DRIVES

Stator voltage control of induction motor - adjustable voltage. Constant voltage / frequency operation, torque characteristics - stator current control - controlled slip operation - Rotor resistance control - types of rotor choppers - typical rotor chopper circuits - Slip power recovery scheme – static Kramer and Scherbius drives systems.

SYNCHRONOUS MOTOR DRIVES

Adjustable frequency operation - controlled current operation - voltage source and current source inverter fed synchronous motor drive - PWM inverter fed synchronous motor drive - cyclo converter fed synchronous motor drive - torque angle control of the self controlled synchronous motor drive.

SPECIAL MACHINES DRIVES

Switched reluctance motor drives - Principle of operation - Torque speed characteristics - Current regulation -Brushless DC Motors - Evolution of brushless DC motors from the classical AC and DC motors - Square wave permanent magnet brushless DC motors - Torque speed characteristics - Permanent Magnet Synchronous Motors - Steady state phasor diagram - Current control techniques - UPF operation - Power input and Torque expressions - Torque speed characteristics - Self control and vector control schemes.

REFERENCE BOOKS

1. ***Sen P.C.***Thyristor D.C. Drives: *John Wiley and Sons 1987.*
2. ***Murphy J.M.D and Turnbull F.G.*** Power Electronic Control of A.C. Motors : *Pergamon Press 1983.*
3. ***Dewan, S.B. Slemon G.R., Straughen. A.*** Power Semiconductor Drives :: *John Wiley and Sons 1984.*
4. ***Ramamoorthy.M*** An Introduction to Thyristors and their Applications : *Eastwest Press 1989.*
5. ***Subrahmanyan.V*** Thyristor Control of Electric Drives : *TMH*.
6. ***Bose. B.K*** Power Electronics and A.C. Drives : : PHI 2002.
7. ***Miller, T.J.E*** 'Brushless permanant magnet and reluctance motor drives' *Clarendon Press, Oxford, 1989.*

11- (Elective) FLEXIBLE AC TRANSMISSION SYSTEMS (FACTS)

AIM

To explain to the student the need for voltage control due to inadequate reactive power support and introduce the latest technologies in that direction.

OBJECTIVES

The need for controllers and basic varieties of compensators are to be discussed. Characteristics, modeling and operating schemes of different types of shunt and series switched reactive power generating devices are to be studied. Emergence of FACTS controller and its superior performance is to be brought out. Techniques for co-ordination of the different FACTS controllers and algorithm for their effective operation, design and stability are to be covered.

The course will help to build an enhanced knowledge of how to realise control strategies to ensure a smooth transfer of power with improved performance indices.

INTRODUCTION

Reactive Power Control in AC Transmission lines – Uncompensated transmission line – Need for Controllers – Basic types of Controllers - shunt compensated controller – series compensated controller – Thyristor controlled voltage regulator – comparison of HVDC and FACTS technologies.

STATIC VAR COMPENSATORS (SVC)

Objectives of shunt compensation - Methods of controllable Var Generation - Merits of Hybrid compensators - General control scheme of static Var compensator – VI and VQ Characteristics of SVC – Voltage control by SVC – Influence of SVC on system voltage – Design of SVC voltage regulator.

STATIC SERIES COMPENSATORS (SSC)

Objectives of Series Compensation – Variable impedance type Series Compensators – Modeling and operating control schemes of GCSC, TSSC,TCSC – Sub Synchronous characteristics – Variable reactance model – Modeling for Stability studies – Switching Converter type Series Compensators – Model and Operating Control scheme of SSSC – Capability to provide real power Compensation.

EMERGING FACTS CONTROLLLERS

Static Synchronous Compensator (STATCOM) – Transfer function model – Dynamic performance – Capability to exchange real power – Operation in unbalanced ac systems – Comparison between STATCOM and SVC – Special purpose FACTS Controller – NGH-SSR Damping Scheme – Thyristor Controlled Braking resistor – Generalized and multifunctional FACTS Controllers.

CO-ORDINATION OF FACTS CONROLLERS

Controller interactions –SVC – SVC interaction - Co-ordination of multiple Controllers using linear Control techniques - Unified Power Flow Controller(UPFC) – Independent real and reactor Power flow Control – Control Schemes for P and Q Control – Interline Power flow Controller(IPFC) – Control Structure - Design of FACTS Controllers – Variable Structure FACTS Controllers for Power System transient Stability – Non linear Variable Structure model.

REFERENCE BOOKS

1. ***Narain G.Hingorani, Laszio. Gyugy***, " Understanding FACTS Concepts and Technology of Flexible AC Transmission Systems", Standard Publishers Distributors , NewDelhi ,2001.
2. ***Narain G.Hingorani*** , " High power Electronics and Flexible AC Transmission Systems", IEEE High Power Engineering Review,1998.
3. ***Mohan Mathur.R,Rajiv.K.Varma,*** "Thyristor Based FACTS Controller for Electrical transmission Systems", IEEE press ,John Wiley and Sons, 2002.
4. ***John .A.T,*** " Flexible AC Transmission System" , IEEE 1999.
5. ***Singh.S.N ,*** " Electric Power Generation Transmission and Distribution", PHI, New Delhi 2003.

12- (Elective) DISTRIBUTED ENERGY SYSTEMS

AIM

To derive the tools for distribution analysis and lay out steps for the planning and design of a distribution infrastructure.

OBJECTIVES

The planning of distribution systems, sub-transmission networks and substation design are to be discussed. The current status and future trends technical and economical impacts of DG technologies are to be overviewed. The scope entitles the complete design perspective of distributed generation applications.

Distribution system planning

Short term planning, Long term planning, Dynamic planning, Sub-transmission and substation design - Sub-transmission networks configurations, Substation bus schemes, Distribution substations ratings, Service areas calculations, Substation application curves

Distributed Generation Standards,

DG potential, Definitions and terminologies; current status and future trends, Technical and economical impacts, Definitions and terminologies; current status and future trends, Technical and economical impacts DG Technologies, DG from renewable energy sources, DG from non-renewable energy sources

Distributed generation applications

Operating Modes, Base load; peaking; peak shaving and emergency power, Isolated, momentary parallel and grid connection

Primary and secondary system

Design considerations Primary circuit configurations, Primary feeder loading, secondary networks design Economic design of secondary's, Unbalance loads and voltage considerations.

Distribution system performance

Distribution automation and control, Voltage drop calculation for distribution networks, Power loss Calculation, Application of capacitors to distribution systems, Application of voltage regulators to distribution systems.

REFERENCE BOOKS

1. ***Anthony J. Pansini*** "Electrical Distribution Engineering", CRC Press.

2. ***H Lee Willis,*** "Distributed Power Generation Planning and Evaluation", CRC Press.

3. ***James A Momoh,*** "Electric Power Distribution Automation Protection And Control" CRC press

4. ***James J. Burke*** "Power distribution engineering: fundamentals and applications", CRC Press.

5. ***James A Momoh***, "Electric Power Distribution Automation Protection And Control" CRC press

6. ***James J. Burke*** "Power distribution engineering: fundamentals and applications", CRC Press.

13- (Elective) SMART SENSORS

AIM

This subject enables the students to acquire a thorough knowledge about the Smart sensors.

OBJECTIVES

To impart wide knowledge of basics on Introduction, Smart sensors fundamentals and sensor networks architectures, communication protocols and security.

INTRODUCTION

Basic sensor technolog- Sensor systems-definitions- Characteristics-architectures.

SMART SENSORS FUNDAMENTALS

Smart sensors buses and interfaces-software- Data acquisition methods -Virtual sensor systems -Smart sensors for electrical and non-electrical variables

SENSOR NETWORKS ARCHITECTURES

Single node architecture, Multi node architectures. Design principles- Energy efficient topologies- Wired sensor networks and wireless sensor networks-Applications.

COMMUNICATION PROTOCOLS

Physical layer- MAC protocols - Link layer protocols- Localization and positioning- Routing protocols- Transport layer- Data gathering and processing: Protocols for gathering information- Data processing techniques- Energy management- Energy consumption of sensor nodes. Techniques for reducing consumption and communication energy- Energy aware routing

SECURITY

Security, reliability and fault-tolerant issues - Security and privacy protection-Reliability support- Fault-tolerance- Sensor networks standards- platforms and tools: IEEE 802.15.4 and IEEE 802.11; Berkeley motes- Operating systems.

REFERENCE BOOKS

1. **N. V. Kirianaki, S. Y. Yurish, N. O. Shpak V. P. Deynega**: “Data Acquisition and Signal Processing for Smart Sensors”, John Wiley, 2004
2. **H. Karl, A. Willig**: “Protocols and Architectures for Wireless Sensor Networks”, John Wiley, 2005
3. **M. Ilyas, I. Mahgoub (ed.)**: Handbook of Sensor Networks: Compact Wireless and Wired Sensing Systems, CRC, 2004

14- (Elective) SYSTEM MODELLING AND IDENTIFICATION

AIM

This subject enables the students to gain indepth knowledge about the system modelling and identification.

OBJECTIVES

To impart wide knowledge of basics on Introduction, Process Identification and Discrete Time System Models For Control, Recursive Plant Model Identification In Open-Loop and Closed-Loop, Robust Parameter Identification .

PROCESS IDENTIFICATION (NON-PARAMETRIC METHODS)

Transient response analysis - frequency response analysis - correlation analysis - spectrum analysis.

DISCRETE TIME SYSTEM MODELS FOR CONTROL

ARX models - ARMAX models - NARMAX models - Hammerstein models - linear and non-linear model structure selection. Selection of pseudo random binary sequence.

RECURSIVE PLANT MODEL IDENTIFICATION IN OPEN-LOOP

Identification methods - least squares - recursive least squares - extended least squares - maximum likelihood method - model validation identified in open-loop.

RECURSIVE PLANT MODEL IDENTIFICATION IN CLOSED-LOOP

Identification methods - closed-loop output error algorithms - filtered closed-loop error algorithms - filtered open-loop identification algorithms - model validation identified in closed-loop - comparative evaluation of various algorithms.

ROBUST PARAMETER IDENTIFICATION

Real time identification - stability considerations. Introduction to non-linear process identification and identification of multivariable models.

State estimation using Kalman Filter and extended Kalman filter for parameter Identification. Practical aspects of system identification and control.

REFERENCE BOOKS

1. **I.D. Landou, R. Lozano and M.M. Saad**, Adaptive Control, Springer-Verlag, 1998.
2. **T.Soderstorm and P.Stoica**, System Identification, Prentice Hall International, 1989.
3. **Wellstead P.E. and Zarrop M.B,** Self Tuning Systems, John Wiley and Sons, 1991.
4. **Mendal. J.M.,** Discrete Techniques of parameter estimation, Marcel Dekkar, New York, 1973.
5. **M.Chidambaram**, Computer control of processes, Narosa publishing house, 2002.

15- (Elective) ADAPTIVE CONTROL SYSTEMS

AIM

To explain to the student the need for a corrective approach to meet desired performances through the use of control strategies.

OBJECTIVES

The course is offered to enable the student to build up his ability to develop transfer function based mathematical models, acquire the approach to illustrate the performance of a circuit through state space equations, analyze its stability and robustness, and develop an art to simulate them through the use of MATLAB.

Design of controllers suitable for drive applications, need for compensators and their applicability, besides a focus on the optimality with special reference to discrete systems is to be covered.

Adaptive approaches and use of sliding mode control is to be explained.

The student will be able to incorporate the control techniques in Drives driven by Power Electronic Circuits. He will be able to tune the performance of the industrial drives.

INTRODUCTION

Definitions - essential aspects - classifications of adaptive control systems Introduction to System Identification: – Comparison of Adaptive and Conventional feedback control - adaptive control schemes

DIRECT ADAPTIVE CONTROL

Introduction – Adaptive tracking and regulation with independent objectives – Basic design – Extensions of the design – Adaptive tracking and regulation with weighted input – Adaptive minimum variance tracking and regulation – The Basic Algorithms – Asymptotic convergence analysis – Martingale convergence analysis – Adaptive generalized minimum variance control – Robust direct adaptive control – The problem – Direct adaptive control with bounded disturbances – Direct adaptive control with unmodelled dynamics

INDIRECT ADAPTIVE CONTROL

Introduction – Adaptive pole placement – The basic algorithm – Analysis of the indirect adaptive pole placement – The “Singularity” problem – Adding external excitation – Robust indirect adaptive control - Standard robust adaptive pole placement – Modified robust adaptive pole placement – Adaptive generalized predictive control – Adaptive linear quadratic control – Iterative identification in closed loop and controller redesign

MODEL REFERENCE ADAPTIVE SYSTEMS

Introduction – The MIT rule – Determination of the adaptation gain Lyapunov theory – Design of MRAS using Lyapunov theory – Bounded input bounded output stability – output feedback – Relation between MRAS and STR – Non-Linear systems. Gain Scheduling: Introduction – the principle – Design of gain scheduling controllers – Non-linear transformation – Application of gain scheduling – Introduction to self oscillating adaptive system.

RECENT TRENDS OF ADAPTIVE CONTROL

Different Approaches to self - recursive parameter estimation - implicit and, Explicit STR-LQG self tuning - convergence Analysis. Minimum variance and pole Assignment approaches to multivariable self tuning regulators. Recent trends in self-tuning -Robustness studies - Multivariable systems - Model updating - General purpose Adaptive Regulator - Applications to power systems – Electric drives - Process control.

REFERENCE BOOKS

1.**I.D.Landau, R.Lozano and M.M'Saad,** Adaptive Control, Springer – Verlog London limited, 1998.

2.**Karl J.Astron Bjorn Wittenmark**, Adaptive Control, second edition, Pearson Education pte. Llimited. 1995**.**

3. **Wellsted P.E. and Zarop. M.B**., Self tuning systems, John wiley & sons, 1991.

4. **Chalam V.V., Marcel Dekker, Inc. NY and Basel** Adaptive Control Systems,Technique & Applications, *1987.*

5. **Sastry S. and Bodson M.,** Adaptive Control, *Prentice Hall,1989*.

16-(Elective) INTELLIGENT INSTRUMENTATION SYSTEM

AIM

To explain to the student the need for a corrective approach to meet desired performances through the use of intelligent instrumentation system.

OBJECTIVES

The subject is offered to enable the student to build up his ability to develop Introduction to intelligent instrumentation, acquire the approach to illustrate the performance of a virtual instrumentation programming techniques, fiber optic and laser instrumentation, smart instrumentation and data acquisition methods .

INTRODUCTION

Introduction to intelligent instrumentation - Historical Perspective-Current status- software based instruments.

Virtual Instrumentation: Review of Virtual Instrumentation - Historical perspective, advantages etc - block diagram and architecture of a Virtual Instrument. Data-flow techniques: Graphical programming in data flow - comparison with conventional programming.

VIRTUAL INSTRUMENTATION PROGRAMMING TECHNIQUES

VIs and sub VIs, loops and charts, arrays, structures, clusters and graphs case and sequence structures, formula nodes, local and global Variables, string and file I/O– PC for DAQ and Instrument Control- Instrument drives-VXI Bus.

FIBER OPTIC AND LASER INSTRUMENTATION

Fiber optic sensors, Intrinstic & extrinsic type(Temperature, flow, pressure, level) Characteristics and laser generation, Types of lasers, Industrial applications of lasers: laser for measurement of distance and length, velocity, acceleration – Calculation of power requirements of laser for material processing

SMART INSTRUMENTATION

Introduction to Intelligent sensors – smart sensors for temperature and pressure – Smart transmitters for measurement of differential pressure, flow and temperature- self diagnosis and remote calibration features.

DATA ACQUISITION METHODS

Analog and Digital IO, Counters, Timers, Basic ADC designs, interfacing methods of DAQ hardware, software structure, use of simple and intermediate Vis. Use of Data Sockets for Networked communication and controls.

Communication: Basic networking methods and their applications in instrumentation, use of Data sockets for distributed control.

REFERENCE BOOKS

1. **Allen. H.C**. An Introduction to optical fibers, McGraw Hill International Book Co., 1993.

2. **D.C. oshes and W. Russel callen**, Introduction to Laser and applications, Addison Wesley, 1978.

3. **Whereelt B.S**. Laser Advances and applications John Willey, 1979.

4. **Skoog, Holler & Nieman**, Principles of Instrumental Analysis, Fifth Edition- Standers College Publisher, Harcourt Brace College publishing, 1998.

5. **Leonard Sokolof**, Basic concepts of LabVIEW4, Prentice Hall, 1998.

17- (Elective) INDUSTRIAL AUTOMATION AND CONTROL

AIM

The subject enables the students to gain indepth knowledge about the industrial automation and control.

OBJECTIVES

To impart wide knowledge in Process modeling and Controllers, Digital control strategies, Programmable Logic Controllers and Distributed Control Systems.

PROCESS MODELLING

Mathematical modelling of a process - Process Identification - Open loop identification - First order and second order model - without and with pure delay - Closed loop identification method - Identification of unstable systems - Self regulation characteristics - Inverse response - Tuning theory - Antireset windup technique.

CONTROLLERS

Transfer function of control equipments - ON OFF control - Time proportional control - Proportional plus integral control - Derivative control - PID controller - Electronic controller - Ratio control systems - Split range control - Cascade control - Selective control - Inverse derivative control - Feedback control - feed forward control - bumpless automatic control - Typical process - PID algorithms - design for load changes.

DIGITAL CONTROL STRATEGIES

Introduction – Basics of a digital control system -Sampling - Sample and hold circuits - Discrete time signal - Linear discrete time systems - Pulse transfer functions - Analysis of digital control system using Z transform - Stability analysis - Jury's stability criterion.

PROGRAMMABLE LOGIC CONTROLLERS

Evolution of modern day PLC - relay based PLC - microprocessor based PLC - input and output modules - other functional elements - personal computer as PLC - Programming the PLC - ladder logic diagram - Boolean language - on line and off line programming aids - communication in PLC - typical applications of PLC - PID control capability in programmable controllers.

DISTRIBUTED CONTROL SYSTEMS

Evolution of DCS - Factors to be considered in selecting a DCS – Typical architecture - local control unit (LCU) and architecture - LCU languages - LCU - process inte7rfacing issues - communication system requirements - architectural issues - protocol issues - communication media - message security - communication system standards - field bus, HART. Operation interface - requirements - display -alarms and alarm management - engineering interface – requirements - Comparison of DCS with direct digital control and supervisory control

REFERENCE BOOKS

1.**George Stephanopoulos,** “Chemical Process Control, An introduction to the theory and Practice”, *Prentice Hall International Inc.,2001*

2. **Gopal.M**, "Digital control and state variable methods" *TMH -2002*

3. **Michal P Lucas**., "Distributed Control Systems" *Van Noster and Reinhold Co.,.1986*

4**. Donald R Coughanowr, ” Process System and Conttrol, Second Edition”** , *McGraw Hill 2006.*

5.. **F.D Petruzella.,** "Programmable Logic Controllers" *McGraw Hill 2006.*

6. **Thomas Hughes**, "Programmable Controller" *Instrument Society of America, 1992.*

18 – (Elective) ADVANCED EMBEDDED SYSTEM

AIM

To expose the architecture of embedded systems and enumerate the scope of its utility in real time applications..

OBJECTIVES

The architecture, various interfacing techniques and the structure of embedded C programs are to be described. The RTOS services and the theory of embedded Linux are to be detailed. The discussion leaves way to develop methodologies for implementing useful real world applications.

Embedded system Introduction:

Introduction to Embedded System, History, Design challenges, optimizing design metrics, time to market, applications of embedded systems and recent trends in embedded systems, embedded design concepts and definitions, memory management, hardware and software design and testing, communication protocols like SPI, SCI, I2C, CAN etc

System Architecture:

Introduction to ARM core architecture, ARM extension family, instruction set, thumb Instruction set, Pipeline, memory management, Bus architecture, study of on-chip peripherals like I/O ports, timers, counters, interrupts, on-chip ADC, DAC, RTC modules, WDT, PLL, PWM, USB etc.

Interfacing and Programming:

Basic embedded C programs for on-chip peripherals studied in system architecture. Need of interfacing, interfacing techniques, interfacing of different displays including Graphic LCD (320X240), interfacing of input devices including touch screen etc, interfacing of output devices like thermal printer etc., embedded communication using CAN and Ethernet, RF modules, GSM modem for AT command study etc.

Real time Operating System Concept:

Architecture of kernel, task scheduler, ISR, Semaphores, mailbox, message queues, pipes, events, timers, memory management, RTOS services in contrast with traditional OS. Introduction to uCOSII RTOS, study of kernel structure of uCOSII, synchronization in uCOSII, Inter-task communication in uCOSII, memory management in uCOSII, porting of RTOS.

Embedded Linux:

Introduction to the Linux kernel, Configuring and booting the kernel, The root file system, Root file directories, /bin, /lib etc., Linux file systems, Types of file system: Disk, RAM, Flash, Network. Some debug techniques- Syslog and strace, GDB, TCP/IP Networking- Network configuration, Device control from user space- Accessing hardware directly, Multi processing on Linux and Inter Process Communication- Linux process model and IPCs, Multithreading using pThreads - Threads vs. Processes and pThreads, Linux and Real-Time- Standard kernel problems and patches, Device Driver Basics, Writing Device Driver, Boot loaders, configuring, Kernel configuration, Linux Porting and Flashing, File System.

REFERENCE BOOKS

1***. Frank Vahid,*** " Embedded sytem design" , PHI.

2. ***Rajkamal,*** " Embedded Sytems", TMH.

3. ***David Simon,*** " Embedded systems software primer", Pearson.

4. ***Steve Furber,*** "ARM System-on-Chip Architecture", Pearson.

5. ***Jean J Labrose,*** " MicroC/OS-II", Indian Low Price Edition.

19- (Elective) REAL TIME SYSTEMS

AIM

This subject enables the students to impart a sound knowledge regarding the modeling and analysis of real time systems.

OBJECTIVES

To impart the knowledge as basics of real time systems, modeling and analyzing RTS, some study of Real time operating systems and real-time programming.

INTRODUCTION TO REAL TIME SYSTEMS (RTS)

Typical examples of real-time systems - characteristics features of real-time -structural, functional and performance requirements of reactive real-time system - distinctive features from non-real-time and off-line systems.

MODELLING RTS

Representation of time - concurrency and distributed ness in discrete event systems - examples of modelling practical systems.

ANALYSIS OF RTS

Analysing logical properties of discrete event systems - analysing timing related properties . Examples of checking safety and timing properties of industrial systems.

REAL-TIME OPERATING SYSTEM

Multitasking - task management - task dispatch and scheduling - static and dynamic scheduling. Memory management - code sharing - input/output sub-system - task co-operation and communication. Concurrent programming - mutual exclusion - rendezvous

REAL - TIME PROGRAMMING

User requirement - language requirement - declaration - constants - control structure - modularity - exception handling - low-level and multi-tasking facilities. Introduction to Ada.

REFERENCE BOOKS

1. **Krishna C.M**, "Real-time Systems" *McGraw-Hill,1998.*
2. **Stuart Bennett**., "Real-time Computer Control" *Prentice - Hall, 1988.*
3. **Laplante P.A.**., "Real-time System Design and Analysis" *IEEE Press, 1992.*
4. **Lawerance.,** "Real-time Microcomputer systems design - An Introduction", *McGraw Hill, 1992.*
5. **Levi S and Agrawala A.K.**, "Real-time System Design" *McGraw Hill, 1990.*
6. **Burns and Wellings,**"Real-Time Programming Language",*Addison-Wesley, 1990.*
7. **Son S.H**.., "Advances in Real-time Systems" *Prentice-Hall of India, 1990.*

20-(Elective) INDUSTRIAL DATA COMMUNICATION AND CONTROL

AIM

This subject enables the students to impart the concepts of Industrial data communication and control.

OBJECTIVES

The students will gain knowledge on fundamental concepts of industrial data communication and control, data acquisition systems and modems, distributed Control Systems, network model and hart communication.

DATA ACQUISITION SYSTEMS(DAS)

Review of A/D and D/A Converters - Sampling and digitizing - Review of Analog Communication Systems and techniques - multiplexing –TDM & FDM- Data Communication - transmission lines and digital signals - practical line interface circuits - serial asynchronous communication protocol - Intel 8251A - current loop, RS 232 C-RS 485 - GPIB - USB.

MODEM

Transmission Characteristics of a wire telephone network - Data coding methods - error detection, correction and encryption. Fiber Optic transmission - Optical fiber Cables - connectors and couplers - light sources and detectors - Introduction to SCADA.

Methods of Computer Control of Processes, their configuration and comparison: Direct Digital Control, Supervisory Digital Control, Distributed Control System (DCS).

DISTRIBUTED CONTROL SYSTEMS

Local Control Unit(LCU) and architecture - LCU languages - LCU - Process interfacing issues. Operator interface - requirements Engineering interface - requirements - displays - alarms and alarm management. Factors to be considered in selecting a DCS.

NETWORK MODEL

Network topology and media - switching systems – OSI model - Data link Control protocol. Media access protocol: Command/response - Token passing - CSMA/CD, TCP/IP. Bridges - Routers - Gateways. Standard ETHERNET and Industrial ETHERNET Configuration - Special requirement for networks used for Control.

HART

Introduction - Evolution of Signal standard - HART Communication protocol - Communication modes - HART Commands – HART and the OSI model.- Field Bus- Introduction - General Field bus architecture - basic requirements of field bus standard - field bus topology - Interoperability – Interchangeability - Introduction to MODBUS, CANBUS, LON WORKS, FIP

REFERENCE BOOKS

1. **William L. Schweber**, Data Communications, McGraw-Hill, 1988.
2. **Michale P. Lucas,** Distributed Control Systems,Van Nostrand Reinhold Co., 1986.
3. **Romilly Bowden**, HART Application Guide, HART Communication Foundation,1999.
4. **M.Chidambaram**, Computer control of processes, Narosa publishing house, 2002.
5. **Lawerence M.Thompson**, Industrial data Communications, ISA Press 1997.
6. **Behrouz A. Forouzan,** Data communications and Networking, Tata Mcgraw Hill , 2000.

21-(Elective) NETWORK ENGINEERING

AIM

To enable the student to acquire a thorough knowledge about the Network Engineering, which are now being, treated as the emerging technology.

OBJECTIVES

To impart the knowledge as basics of Network Engineering, Computer network architecture, some study of Data link layer and Network layer, Transport layer and TCP/IP Architecture .

COMPUTER NETWORK ARCHITECTURE

Layers, Services and Protocols, Design issues for the layers; Interfaces and Services, Connection-oriented and connectionless services.-Applications and Layered Architecture: ISO-OSI Reference Model; Overview of TCP/IP Architecture; The Berkeley API; Application Protocols and TCP/IP utilities - Physical Layer: The Theoretical Basis for data communication – guided transmission media.

DATA LINK LAYER

Design issues - Error Detection and Correction - Elementary data link protocol - Sliding window protocol - Medium Access Control: Channel Allocation Problem - Multiple Access protocol - Ethernet-Wireless LANs - Broadband wireless - Blue tooth - Data Link Layer Switching.

NETWORK LAYER

Design Issues - Routing Algorithms: Optimality principle, shortest path routing, flooding, distance vector routing, link state routing, hierarchical routing, broadcast routing, multicast routing - routing for mobile hosts - routing in adhoc networks- Congestion Control Algorithms - QOS - Internetworking - Network Layer in Internet.

TRANSPORT LAYER

Transport Service - Elements of Transport Protocol - Simple transport Protocol - Internet transport Protocols: TCP and UDP - Performance Issues - Application Layer: DNS - Electronic Mail - WWW - Multimedia. Security: Digital Signature - Mail Security - Web Security.

TCP/IP ARCHITECTURE

The Internet Protocols – IPv4 & IPv6, UDP & TCP, DHCP and Mobile IP; Internet Routing Protocols, Multicast Routing, Broadband Technology and Services.- ATM Networks – Layers – QoS - ATM Adaptation Layers - Signalling and PNNI Routing. Internetworking - Virtual Circuit and Datagram Subnets - Internet Control Protocols - Internetworking Protocols – Tunneling – Fragmentation - Firewalls - Security Protocols - Security and Cryptographic Algorithm.

REFERENCE BOOOKS

1. **Andrew S Tanenbaum**, "Computer Networks", Pearson Education, 4th edition, 2003.
2. **Behrouz A Forouzan,** "Data Communication and Networking", Tata McGraw Hill, 4th edition, 2006.
3. **William Stallings**, "Data and Computer Communications", Prentice Hall of India, 7th edition, 2004.

22-(Elective)DATABASE MANAGEMENT SYSTEMS

AIM

To enable the student to acquire a thorough knowledge about the Database Management Systems*, which are now being, treated as the emerging technology.*

OBJECTIVES

The students are expected to gather complete knowledge about Query processing, distributed database design and distributed database issues.

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INTRODUCTION

Definition, Need for a DBMS, Uses of DBMS, Advantages. Comparison of database, file system.- DBMS concepts and architecture: Introduction to Data models, Schemes, Architecture. Languages and Environment - Conceptual modelling: Entity-Relationship concepts, Attributes, Domains, Keys, Foreign keys, ER Diagram, Naming.

Relational models and Relational Languages: Relational algebra operations - SQL - Data definition, Queries in SQL, update statements, views and indexing. Relation calculus - Tuple calculus, Well-formed formula, specification directory. aggregate operators, basic DDL and DML Features, set functions, nested subqueries, view constructors, update statements, embedded SQL.

QUERY PROCESSING

Introductory Concepts: Query Resource Utilization, Gathering Statistics,Retrieving the Query Plan - Methods for Joining Tables: Nested Loop Join, Merge Join,Hybrid Join, Multiple Table Joins - Disk Sorts: N Way Merge Disk Sort Algorithm – Query Performance Measurements - Cost Performance Assessment.

UPDATE TRANSACTIONS

Transactional Histories - Serializability and Precedence Graphs -Locking to ensure Serializability - Transactional Recovery - Parallel and Distributed Databases: Multi CPU Architectures - Client-Server- Architectures - CPU Cost Vs Power - Shared-Nothing Database Architecture -Two Phase Commit - Query Parallelism.

DISTRIBUTED DATABASE DESIGN

Overview: Features Levels of Distribution Transparency - Distributed Database Design: framework, Design of Database Fragmentation, Allocation of Fragments - Translation of Global Queries to Fragment Queries - Optimization of Access Strategies

DISTRIBUTED DATABASE ISSUES

Management of distributed transactions: framework - supporting atomicity - Concurrency control - architectural aspects Concurrency Control: Foundations of Distributed Concurrency Control - Distributed Deadlocks – Concurrency Control based on Timestamps - Optimistic Methods for Distributed Concurrency Control - Reliability - Distributed Database Administration.

REFERENCE BOOKS

1**. R. Elmasri and S.B. Navathe** ,” Fundamental of Database Systems “, Cumming Pub. Co.,1989.

2. **Henry F. Korth and Abraham Silberschatz** ,”Database System Concepts”, McGraw Hill,1991.

3. **Patrick O’Neil and Elizabeth O’Neil**, “Database Principles Programming and Performance”, Morgan Kaufmann, 2nd edition, 2001.

4. **Stefano Ceri and Giuseppe Pelagatti**, “Distributed Databases Principles and Systems”,McGraw Hill, 1985.

5. **Raghu Ramakrishnan, Johannes Gehrke**, “Database management Systems”, McGraw Hill, Third Edition.

23-(Elective) OPTIMIZATION TECHNIQUES

AIM

The subject enables the students to gain indepth knowledge of the various optimization techniques applied in the engineering fields.

OBJECTIVES

The students must acquire a sound knowledge of obtaining optimal solution to the power system problems with the help of different mathematical techniques. This will be make the students well versed in the mathematical modeling of the problem and solving the power system problems efficiently. Several methods like linear, non-linear, geometric, quadratic, integer and stochastic and dynamic programming are introduced in the subject to train the student to use these techniques in power system optimization.

INTRODUCTION TO OPTIMIZATION

Engineering Applications - Classification of optimization problems - Classical optimization techniques - Single & multivariable optimization - multivariable optimization with & without constraints - Saddle point - Solution by the method of lagrange multipliers - Kuhn - tucker conditions.

LINEAR PROGRAMMING

Applications - Standard form of LPP - definitions & Theorem - Solution of a system of Linear simultaneous equations - Pivoted reduction - Simplex algorithm - Identifying an optimal point - Revised simplex methods - Gauss Jordan Elimination process - Duality in linear programming - Decomposition principle - Transportation problem - Northwest corner rule - Least cost method

NON LINEAR PROGRAMMING

Nonlinear programming - one dimensional minimization methods - unrestricted search - Exhaustive search - Interpolation methods - Quadratic interpolation method - Cubic method - unconstrained optimization techniques - Direct search methods - simplex method - Descent methods - Gradient of a function - Steepest Descent method - Constrained optimization techniques - Transformation techniques - penalty function methods or sequential unconstrained minimization techniques (SUMT) - Interior and exterior penalty function method - Extrapolation technique.

GEOMETRIC PROGRAMMING AND INTEGER PROGRAMMING

Geometric programming - Polynomial - Unconstrained minimization problem - Constrained minimization problem - Primal and Dual programmes – Geometric programming with mixed in equality constraints – Complementary geometric programming .

Integer linear programming – Mixed integer programming – Integer non linear programming – Sequential linear discrete programming.

DYNAMIC PROGRAMMING

Dynamic programming: Multistage decision processes – Concept of sub optimization – Principle of optimality – Conversion of a final value problem into an initial value problem – Linear programming as a case of dynamic programming – Continuous dynamic programming – Applications.

REFERENCE BOOKS

1. **Rao S.S , Optimization Theory and applications** : Wiley Eastern Ltd : Second Edition 1992.
2. **Bevridge G.S.G and Schechter R.S**: Optimization Theory and practice: McGraw Hill – 1969.
3. **Hadley G,** Nonlinear and dynamic programming: Addison-Wesley, - 1987.
4. **Dorfman R, Samuelson P. and Solow R**, Linear programming and economic analysis: McGraw Hill, -1958
5. **Fax R.L,** Optimization methods for engineering design: : Addison- Wesley, - 1971.
6. **Rao S.S,** Engineering Optimization Theory & Practice - Third Edition New Age international, - 1998.
7. **Srinath L.S**.Linear programming principles & Application, Affiliated East West Press 1984.

24 – (Elective) SOFT COMPUTING TECHNIQUES

AIM

To enable the student to acquire a thorough knowledge about the fuzzy logic and artificial neural networks, which are now being, treated as the emerging technology.

OBJECTIVES

The students are expected to gather complete knowledge about Fuzzy Logic, Neural Networks and Evolutionary Programming.

ARTIFICIAL NEURAL NETWORKS

Motivation for the development of neural networks - biological neural networks- artificial neural networks – Fundamental Concepts - weights - biases and thresholds – common activation functions. McCulloch-pitts neuron: Architecture – Algorithm - Applications - Hebb Net- Architecture - Algorithm - Application - Perceptron – Architecture- Algorithm - Applications- Linear separability - Perceptron learning rule convergence theorem - Delta rule.

NEURAL NETWORK ARCHITECTURE AND ALGORITHMS

Backpropogation Neural Net: Standard and counter backpropogation - architecture - algorithm - number of hidden layers - applications- Hopfield neural net- Discrete and Continuous- architecture - algorithm – applications- Associative Memory Neural Networks- Boltzman Machine.

COMPETITIVE NEURAL NETWORKS

Fixed-weight competitive nets – Maxnet- Mexican Hat Net- Kohonen self-organizing Maps – applications - Adaptive Resonance Theory- Basic architecture and operation- Neuro controllers - Functional diagram - Inverse dynamics - coping control action- Case studies.

FUZZY LOGIC

Fuzzy sets - Properties of Classical and Fuzzy sets- Operations on Fuzzy sets- Fuzzy relations- Linguistic variables - Linguistic Hedges- Fuzzy statements- Assignment statements- Conditional statements- unconditional statements- Fuzzy rule base- Canonical rule formation- Decomposition of compound rules.- Fuzzy logic controller: Functional diagram - Fuzzification - Membership value assignments using intuition - Membership functions- Defuzzification: Max-Membership principle - centroid method - weighted average method - Inference Engine – Knowledge Base -Rule base -Case studies

EVOLUTIONARY PROGRAMMING

Optimization – Traditional optimization methods – Concept of Evolutionary Algorithm – Simulated Annealing - Genetic Algorithm – encoding and decoding of variables – GA operators – reproductions – Cross over – mutation – fitness function – fitness scaling - Real coded GA – Advanced operators – Particle swarm optimization.

REFERENCE BOOKS

1. **Lawrence Faussett**, "Fundamental of neural networks", *Prentice Hall, 2004.*
2. **Ross T.J,"**Fuzzy Logic with Engineering Applications", *McGraw-Hill, Newyork, 2005.*
3. **David .E. Gold berg,"** Genetic algorithms in search optimization and machine learning," Addison Wesley, Pearson Education, Asia, 2001.
4. **Driankov.Hellendoornarow D.H Reinfrank M.**, "An introduction to Fuzzy Control", *Narosa Publishing co., New Delhi, 1996.*
5. **Zurada J.M.,** "Introduction to Artificial Neural Systems", *Jaico Publishing House, Delhi, 2001*.
6. **Klir G.J. and Folger T.A.,** "Fuzzy sets, uncertainty and information", *Prentice Hall, 2004.*
7. **Simon Haykin**, "Neural Networks", *Macmillan College Publishing co., New York , 1994*.
8. **Sivanandham. SN, and Deepa, SN,** "Neural networks with Matlab", *TMH 2007*.

25 – (Elective) LINEAR MULTIVARIABLE SYSTEM DESIGN

AIM

To introduce the state space approach and develop the mathematical background required for linear system analysis and design.

OBJECTIVES

The dynamics of a linear system are to be solved using system model/equation or domain transformation. The structure of a discrete time system is to be realized and examined for its stability, controllability and observability. The study offers a cohesive knowledge of control theory for practical implementations in engineering and network analysis

Mathematical Preliminaries

Linear vector spaces and linear operators: Fields, vectors and vector spaces, Linear dependence, Dimension of linear space, The notion of bases, Linear transformation and matrices, Scalar product and norms, Quadratic function anddefinite matrices, vector and matrix norms, Gram determinant, Solution of linear algebraic equation: Range space, Rank, Null space and nullity of a matrix, Homogenous and nonhomogeneous equations, Eigenvalues and Eigenvectors and a canonical form representation of linear operators, Functions of square matrix Caley-Hamilton theorem.

State Space Description for multivariable Control Systems:

The concept of state and state models, State equations for dynamic systems, State equations using phase, physical and canonical variables, Plant models of some illustrative control systems, State space representation and realization of transfer matrices, Minimal realization, Solution of state equation.

Multivariable Control Systems Analysis

Concept of Controllability and Reachability,Observability and Constructibility, Controllable and Uncontrollable subspace,Observable and unobservable subspace, Controllability and Observability tests: Kalman's test matrix, Gilbert's test, Popov-Belevitch-Hautus test, Controllability and observability canonical forms, Stability and stabilizability theory.

Multivariable Control Systems Design

Linear state variable feedback: The effect of state feedback on controllability and observability, Necessary and Sufficient condition for arbitrary pole placement, Ackermann's formula for pole placement, State observers: Fullorder state observers and minimum order observers, Study of some physical plant like inverted pendulum for analysis and design.

State Space and Matrix-Fraction

Descriptions of Multivariable systems: State observability, controllability and matrix-fraction descriptions, Some properties ofpolynomial matrices, Some basic state space realization, The Smith-McMillan form of atransfer function matrix, Poles and Zeros of a transfer function matrix, Matrix-fraction description (MFD) of a transfer function, State space realization from a transfer function matrix, Internal stability, The generalized Nyquist and inverse Nyquist stability criterion.

REFERENCE BOOKS

1. ***C. T. Chen,*** Linear System Theory and Design, Holt, Rinehart and Winston, New York,1984.

2. ***T. Kailath,*** Linear Systems, Prentice-Hall, Englewood Cliff's, NJ, 1980.

3. ***M. Gopal,*** Modern Control System Theory, Second Edition, New Age International (P)Limited, New Delhi, 1996.

4. ***W. A. Wolovich***, Linear Multivariable Systems, Springer-Verlag, and Berlin, 1974.

5. ***P. J. Antsaklis and A. N. Michel***, Linear Systems, McGraw-Hill International Editions, 1998.

6. ***K. Ogata,*** Modern Control Engineering, Third Edition, Prentice-Hall of India, New Delhi,1997.

26 – (Elective) ADVANCED COMPUTER NETWORKS

AIM

To explore the role of advanced concepts in computer networks and evolve protocols for routing the data.

OBJECTIVES

The requirements of networks and suitability of advanced technologies are to be discussed and a mathematical background for evaluating their performance established. The configuration of routing architectures is to be arrived at for transferring the data. The study opens up avenues to address challenges in this domain.

Introduction

Requirements , Network architecture , Networking principles, Network services and Layered architecture , Network services and Layered architecture, Future networks (Internet, ATM, Cable TV, Wireless – Bluetooth, Wi-Fi, WiMax, Cell phone)

Advanced Technologies

Virtual circuits, Fixed size packets, Small size packets, Integrated service, History, Challenges, ATM Network protocols, IP over ATM, Wireless networks : Wireless communication basics, architecture, mobility management, wireless network protocols. Ad-hoc networks Basic concepts, routing; Bluetooth (802.15.1), Wi-Fi (802.11), WiMAX (802.16), Optical Network links, WDM system, Optical LANs, Optical paths and networks.

Performance of Networks

Control of networks: objectives and methods of control, Circuit switched networks, datagram and ATM networks. Mathematical background for control of networks like Circuit switched networks, Datagram and ATM networks

Advanced Routing - I

Routing architecture , Routing between peers (BGP) , IP switching and Multi-Protocol Label Switching (MPLS), MPLS Architecture and related protocols, Traffic Engineering (TE) and TE with MPLS , NAT and Virtual Private Networks (L2, L3, and Hybrid), CIDR –Introduction , CIDR addressing, CIDR address blocks and Bit masks.

Advanced Routing - II

Mobile IP- characteristics, Mobile IP operation, Security related issues. Mobility in networks. Voice and Video over IP (RTP, RSVP, QoS) IPv6: Why IPv6, basic protocol, extensions and options, support for QoS, security, etc., neighbor discovery, auto-configuration, routing. Changes to other protocols. Application Programming Interface for IPv6.

Ad Hoc Networking

An Introduction, A DoD Perspective on Mobile Ad Hoc Networks, DSDV: Routing over a ultihop Wireless Network of Mobile Computers, Cluster-Based Networks, DSR: The Dynamic Source Routing Protocol for Multihop Wireless Ad Hoc Networks 8.

REFERENCE BOOKS

1. ***Larry L. Peterson, Bruce S*** ,"Computer Networks: A Systems Approach", 4th edition, Davie Publisher: Elsevier/Morgan Kaufmann, ISBN: 13:978-0-12-370548-8; 10:0-12-370548-7.

2. ***Douglas E. Comer***,"Internetworking with TCP/IP Vol –I", Prentice Hall, 5th edition.

3.***Jean Walrand and Pravin Varniya,***"High Performance Communication Networks",,Morgan Kaufmann Publisher, Second Edition, Elsevier ISBN: 1-5580-5746 India ISBN: 81-8147-652-2

4. ***Charles E. Perkins,*** "Ad Hoc Networking", Pearson, ISBN:9788131720967.

27– (Elective) ADVANCED WIRELESS SYSTEMS

AIM

To elaborate the need for wireless systems and perpetuate the growth of different media of communication.

OBJECTIVES

The fundamental concepts of wireless telecommunication and various services of networks are to be emphasized. The other systems of communication in prevalence are to be be briefed. The purview poses an opportunity to ascribe newer services and expand the services to customers.

Fundamental Concepts:

Introduction, Brief History of Wireless Telecommunication, Elements of a Wireless Communication System, Wireless Networks, Signals and Noise, The Frequency Domain,The Radio-Frequency Spectrum **-** Overview of Modulation Schemes - Analog Modulation, Amplitude Modulation, Frequency and Phase Modulation, Bessel Functions, Pre-emphasis and De-emphasis Digital Modulation, Pulse-Code Modulation, Differential PCM, Delta Modulation, Adaptive Delta Modulation, FSK, PSK, QAM, M-ary PSK, MSK, GMSK, OFDM - Multiple Access Techniques **-** Random Access, Conflict free multiple access, FDMA, TDMA, CDMA.

Cellular Radio:

Introduction, Improved Mobile Telephone Service (IMTS), Introduction to the Advanced Mobile Phone System (AMPS), Cellular Carriers and Frequencies, Channel Allocation, Frequency Reuse, AMPS Control System, Security and Privacy, Cellular Telephone Specifications and Operation, Cell-Site Equipment, Fax and Data Communication Using Cellular Phones, Digital Cellular Systems

Personal Communication Systems:

Introduction, Differences Between Cellular Systems and PCS, IS-136 (TDMA) PCS, TDMA Digital Control Channel, GSM, IS-95 CDMA PCS, Comparison of Modulation Schemes, Data Communication with PCS, Cellular and PCS antennas

Satellite-Based Wireless Systems :

Introduction, Satellite Orbits, Use of Satellites for Communication, Satellites and Transponders, Signal and Noise Calculations, Systems Using Geostationary Satellites, Systems Using Medium-Earth-Orbit Satellites

Paging and Wireless Data Networking:

Introduction, Paging and Messaging Systems, Wireless Local-Area Networks, Ethernet Bridges, Wireless LANs, Wireless Packet-Data Services

The Future of Wireless:

Introduction, Wireless Local Loop, Third Generation(3G), 4G services and applications, Wireless ATM and Ad-hoc Routing, Personal Area Networks, Residential Microwave Communication Systems, Convergence, Divergence, Safety and Esthetic Concerns.

REFERENCE BOOKS

1. ***John W. Mark and Weihua Zhuang***, "Wireless communications & Networking", PHI.

2. ***Roy Blake, "***Wireless Communication Technology", Delmar Thomson Pub.

3. ***T. S. Rappaport,*** "Wireless Communication", PHI.

4. ***K. Pahlvan and P***. ***Krishnamurthy***, "Principles of Wireless Networks: A unified approach", Pearson Pub.