

M.E. CONTROL SYSTEMS ENGINEERING**SCHEME OF INSTRUCTION AND EXAMINATION (2007 Admitted batch onwards)****SEMESTER – I***** (COMMON FOR *CONTROL SYSTEMS & POWER SYSTEMS AND AUTOMATION*)

Code	Name of the Subject	No. of Periods / Week		Duration of exam. (hours)	Maximum Sessional marks	Marks of Qualifying Exam.	Total Marks	Credits
		Theory	Lab.					
*ECP 1.1	**Analysis of Dynamic Systems	3	-	3	30	70	100	3
*ECP 1.2	** Optimization Techniques	3	-	3	30	70	100	3
*ECP 1.3	Random Variables & Stochastic Processes	3	-	-	100	---	100	3
*ECP 1.4	Artificial Intelligence	3	-	-	100	---	100	3
*ECP 1.5	Elective-I	3	-	-	100	-	100	3
*ECP 1.6	Systems Lab.	-	3	-	100	-	100	3

Total Credits : 18

** External University Examination is only for the subjects ECP 1.1 and ECP 1.2

LIST OF SUBJECTS UNDER ELECTIVES :# **ECP 1.5 ELECTIVE -I:** (a) Digital Signal Processing,

(b) Large Scale Systems

(c) Computer Graphics.

Subjects common to M.E. (P.S.A.) also***ECP 1.1, *ECP 1.2, *ECP 1.3, *ECP 1.4, *ECP 1.5, and *ECP 1.6 common for both C.S.E. & P.S.A.**

M.E. (CONTROL SYSTEMS)

SCHEME OF INSTRUCTION AND EXAMINATION (2007 Admitted batch onwards)

SEMESTER – II

Code	Name of the Subject	No. of Periods / Week		Duration of exam. (hours)	Maximum Sessional Marks	Marks of Qualifying Exam.	Total Marks	Credits
		Theory	Practical					
EC 2.1	**Advanced Control System Design	3	-	3	30	70	100	3
EC 2.2	**Non-Linear Systems	3	-	3	30	70	100	3
EC 2.3	Optimal Control	3	-	-	100	----	100	3
EC 2.4	Stochastic Estimation & Control	3	-	-	100	----	100	3
EC 2.5	ELECTIVE-II	3	-	-	100	-	100	3
EC 2.6	Simulation Lab	-	3	-	100	-	100	3

Total Credits : 18

** External University Examination is only for the subjects EC 2.1 and EC 2.2

LIST OF SUBJECTS UNDER ELECTIVES :

EC 2.5 ELECTIVE -II:

- (a) System Identification and Parameter Estimation
- (b) Control of Large Scale Systems
- (c) Robotics

M.E. (POWER SYSTEMS AND AUTOMATION)

SCHEME OF INSTRUCTION AND EXAMINATION (2007 Admitted batch onwards)

SEMESTER – II

Code	Name of the Subject	No. of Periods / Week		Duration of exam. (hours)	Maximum sessionals	Marks of Qualifying Exam.	Total	Credits
		Theory	Practical					
EP 2.1	** Power System Operation & Control	3	-	3	30	70	100	3
EP 2.2	** Power System Dynamics and Stability	3	-	3	30	70	100	3
EP 2.3	HVDC Transmission	3	-	-	100	-	100	3
EP 2.4	EHVAC Transmission	3	-	-	100	-	100	3
EP 2.5	ELECTIVE-II	3	-	-	100	-	100	3
EP 2.6	Simulation Lab	-	3	-	100	-	100	3

Total Credits : 18

** External University Examination is only for the subjects EP 2.1 and ECP 2.2

LIST OF SUBJECTS UNDER ELECTIVES:

EP 2.5 ELECTIVE -II:

- (a) Advanced Electrical Machines
- (b) Power System Relaying and Protection
- (c) Power System Planning

SEMESTER – I

ECP 1.1: ANALYSIS OF DYNAMIC SYSTEMS

(COMMON FOR CONTROL SYSTEM ENGINEERING & POWER SYSTEMS AND AUTOMATION)

****Credits : 3**

Lectures per week : 3

Theory , **Univ. Exam.marks** : 70

Sessional Marks : 30

Total Marks : 100

Discrete-time Systems: Introduction, Spectrum analysis of sampling process, Difference equations, Z-Transform, Properties of Z-Transform, Z-transfer function (pulse transfer function) for linear discrete systems, Analysis of sampled-data systems, Z and S-domain relationships, Jury's stability test, Bilinear transformation, Root locus technique.

P.P.489-535.

Non linear Systems: Introduction, Behaviour of Non linear systems, Common Physical Non-linearities, Phase-plane method, Singular points, Isocline method, Delta method.

P.P.622-652.

Liapunov's stability criterion, Basic Liapunov stability theorems, Liapunov functions, Direct method of Liapunov, Application to linear systems, Application to Non-linear systems, Variable Gradient method.

P.P.670-693.

TEXT BOOK: Control Systems Engineering. (3rd Edition) by I.J.Nagrath and M.Gopal, New Age International publishers.

ECP 1.2 : OPTIMIZATION TECHNIQUES

(COMMON FOR CONTROL SYSTEM ENGINEERING & POWER SYSTEMS AND AUTOMATION)

****Credits : 3**

Lectures per week : 3

Theory, **Univ. Exam. marks** : 70

Sessional Marks : 30

Total Marks : 100

1. Introduction to Optimization, Engineering Applications of Optimization, Problem formulation.

2. Classical Optimization Techniques : Necessary and Sufficient conditions of the general problem, Single variable optimization, Multivariable optimization with no constraints; Multivariable optimization with Equality constraints – Solution by Direct Substitution method, Method of constrained variation, Method of Lagrangian multipliers; Multivariable optimization with inequality constraints: Kuhn-Tucker conditions.

3. Linear programming : Basic Terminology and Definitions, Exceptional cases, Simplex method, Big-M method, Two-phase method, Revised Simplex method, Duality.

4. Non-Linear programming : Unconstrained optimization-Powell's method, Steepest descent method, Newton's method; Constrained optimization : Direct method, methods of feasible directions.

5. CPM and PERT : Basic Terminology, Network representation of project, critical path-The PERT method, Optimum scheduling by CPM, LP formulation of CPM-PERT problems.

TEXT BOOK : 'Optimization : Theory and Applications' By S.S.Rao, Wiley Eastern Limited.

ECS 1.3 : RANDOM VARIABLES AND STOCHASTIC PROCESSES

(COMMON FOR CONTROL SYSTEM ENGINEERING & POWER SYSTEMS AND AUTOMATION)

****Credits : 3**

Lectures per week : 3

Theory, Univ. Exam. marks : Nil

Sessional Marks : 100

Total Marks : 100

Random Variables : The concept of Random variables, Functions and Sequences of Random Variables.

Stochastic Processes : General concepts, Correlations and power spectrum of Stationary processes, Linear Mean Square estimation, Non-stationary processes, Transients in Linear Systems with Stochastic Inputs.

TEXT BOOK : Probability, Random Variables and Stochastic Processes, A.Papoulis, International student edition, Kogakusha Ltd., New Delhi.

ECP 1.4 ARTIFICIAL INTELLIGENCE

(COMMON FOR CONTROL SYSTEM ENGINEERING & POWER SYSTEMS AND AUTOMATION)

****Credits : 3**

Lectures per week : 3

Theory, Univ. Exam. marks : Nil

Sessional Marks : 100

Total Marks : 100

1.AI and Internal representation :

Artificial Intelligence and the world, what is artificial intelligence, representation in AI, properties of internal representation, the predicate calculus, other kinds of inference, indexing, pointers and alternative notations.

2.Lisp :

Why Lisp? typing at Lisp, Defining Programs, Basic flow of control in Lisp style, Atoms and lists, basic debugging, building up Lisp structure, More on predicates, properties, pointers, cell notation and internals of Lisp, destructive modifications of Lisp, the FOR function, recursion scope of variables, Input/Output, Macros.

3.Vision :

Introduction, Defining the problem, overview of the solution, early processing, representing and

recognizing scenes.

4.Search :

Introduction, a search algorithm, Goal trees, game trees, Avoiding repeated states, transition-oriented state representations, GPS.

5.Logic and Deduction :

Introduction, using predicate calculus deduction as search, applications of theorem proving, advanced topics in representation.

6.Memory organization and deduction :

The importance of memory organization, Approaches to memory organization, Data dependencies, Recognizing involving time, Spatial reasoning, rule based programming.

7. Abduction, uncertainty and expert systems :

What is abduction? Statistics in abduction, the mycin programs for infectious diseases, search considerations in abduction, Multiple diseases, caduceus, Bayesian inference networks, still more complicated cases.

TEXT BOOK: 'Introduction to Artificial Intelligence' by E.Charniak and D.McDerwott, Addison - Western, 1985.

ECP 1.5 (a) :DIGITAL SIGNAL PROCESSING (ELECTIVE-I)

(COMMON FOR CONTROL SYSTEM ENGINEERING & POWER SYSTEMS AND AUTOMATION)

****Credits : 3**

Lectures per week : 3

Theory, Univ. Exam. marks : Nil

Sessional Marks : 100

Total Marks : 100

Introduction, Discrete-time description of signals and systems, Fourier transform of discrete-time signals. The Discrete Fourier transform. The Z-transform. Digital filter structures from analysis to synthesis. IIR filter design techniques. FIR filter design techniques.

TEXT BOOK : 'Introduction to digital signal processing', Roman Kuc, McGraw Hill book company, 1988.

ECP 1.5 (b) : LARGE SCALE SYSTEMS (ELECTIVE-I)

(COMMON FOR CONTROL SYSTEM ENGINEERING & POWER SYSTEMS AND AUTOMATION)

****Credits : 3**

Lectures per week : 3

Theory, Univ. Exam. marks : Nil

Sessional Marks : 100

Total Marks : 100

1.L.S.S. Modelling : Time Domain

Introduction, Aggregation methods, exact and model aggregation by continued fraction, chained aggregation descriptive variables approach, descriptive variable systems, solvability and conditionality, time invariance, shuffle algorithm.

2.L.S.S. Modelling - Frequency Domain :

Introduction, Moment matching, Pade approximation, Routh approximation, continued fraction method, error minimization methods, mixed methods and unstable systems, Pade model method, Pade-Routh method, multi input and multi output systems, reduction, matrix continued fraction method, Model continued fraction method, Pade model method, frequency comparison method.

3.Time Scales and Singular Perturbations :

Introduction, problem statement and preliminaries, numerical algorithm, basic properties, relation to model aggregation, feedback control design, singularly perturbed linear systems, fast and slow sub systems, eigenvalue distribution, approximation to time scale approach, system properties, design of optimal controllers, fast and slow controllers, lower order controls.

TEXT BOOKS :

1. 'Large Scale Systems Modelling and Control', Mohammad Jamshidi, 1989, North Holland (Series in systems science and engineering, vol.9).
2. 'Large Scale Systems Modelling', Magdi S. Mohamoud and Madan G. Singh, Pergamon Press (International series on Systems and Control), 1981.

ECP 1.5 (c) COMPUTER GRAPHICS (Elective I)

(COMMON FOR CONTROL SYSTEM ENGINEERING & POWER SYSTEMS AND AUTOMATION)

****Credits : 3**

Lectures per week : 3

Theory, Univ. Exam. marks : Nil

Sessional Marks : 100

Total Marks : 100

Geometry and line generation - Graphics primitives. polygons - Transformations, Segments, Windowing and clipping. Interaction Three Dimensions and Hidden surfaces and lines (P. 1 to 348).

TEXT BOOK: 'Computer Graphics', A programming Approach by Steven Harrington Second Edition, Mcgraw Hill International Edition.

M.E.(CS) SEMESTER – II

E.C. 2.1 : ADVANCED CONTROL SYSTEM DESIGN

****Credits : 3**

Lectures per week : 3

Theory , **Univ. Exam.marks** : 70

Sessional marks : 30

Total marks : 100

Classical compensation of continuous - time Control systems: Root Locus, Bode Diagram, and s-plane Synthesis approaches.

Classical Compensation of Discrete-time control systems: Forward path continuous, Forward-path Digital, Z-plane Synthesis approaches, Deadbeat performance.

State variable feedback compensation: State variable Feedback compensation of continuous - time and discrete-time systems.

Integral-square error compensation: parameter optimization using Integral-square error criterion with and without constraints.

TEXT BOOK:

1. Gupta and Hasdorf, 'Fundamentals of Automatic control Willey Eastern, 1970.
2. B.C.Kuo, 'Automatic control systems' (5th Edition), Prentice Hall of India, 1988.

E.C 2.2 : NON-LINEAR SYSTEMS

****Credits : 3**

Lectures per week : 3

Theory , **Univ. Exam.marks** : 70

Sessional marks : 30

Total marks : 100

Induction: Autonomy and Equilibrium states (singular points).

Second-order systems: Linear systems and Linearization of non- linear systems, phase-plane trajectories, periodic solutions and limit cycles-K.B. and power series methods.

Approximate Methods: Quasilinearization, Equivalent linearization, Harmonic Balance and Describing functions-Existence of periodic solutions/limit cycles-singular perturbations.

Liapunov stability analysis: Definition, sign-definite functions, Liapunov's Direct (or second) method, stability of linear Auto-namous systems, Liapunov's indirect (or first) method.

TEXT BOOK: M.Vidyasagar, 'Nonlinear systems Analysis', 2nd Edition, 1991, prentice-Hall Inc.

E.C. 2.3 : OPTIMAL CONTROL

****Credits : 3**

Lectures per week : 3

Theory, Univ. Exam. marks : Nil

Sessional Marks : 100

Total Marks : 100

Introduction: State variable representation of systems - Optimal control problems - selection of performance measure.

The Calculus of variations and Pontryagin's minimum principles: Fundamental concepts-maximum and minimum of functionals - the fundamental theorem of the calculus of variations - the simplest variational problem - functions involving several independent functions. (pp 108 - pp 171).

Dynamic programming: The optimal control law - principle of optimality and its application - optimal control system - interpolation - recurrent regulator problem - Hamilton-Jacobi-Bellman equation. (pp 53 - 95).

The variational approach to optimal control problems: Necessary conditions for optimal control - Linear regulator problem - Pontryagin's minimum principle and state inequality constraints - minimum time problem - minimum control - effort problem. (pp 184-290).

TEXT BOOK: Optimal control theory-An Introduction by Donald E.Kirk - Prentice Hall Networks series.

E.C. 2.4 : STOCHASTIC ESTIMATION AND CONTROL

****Credits : 3**

Lectures per week : 3

Theory, Univ. Exam. marks : Nil

Sessional Marks : 100

Total Marks : 100

Elements of the theory of stochastic processes and development of system models - optimal prediction and filtering for discrete linear systems - Optimal smoothing for discrete linear systems-Optimal estimation for continuous linear systems-Stochastic optimal control for discrete linear systems-Stochastic optimal control for continuous linear systems.

TEXT BOOK: Stochastic Optimal Linear Estimation and Control, J.S.Meditch, McGraw Hill Book Company, 1969.

E.C 2.5(a):SYSTEM IDENTIFICATION AND PARAMETER ESTIMATION
(ELECTIVE II)

****Credits : 3**

Lectures per week : 3

Theory, Univ. Exam. marks : Nil

Sessional Marks : 100

Total Marks : 100

Introduction: system models and model classification, identification problem, some fields of applications.

Classical models: Time response and frequency response methods of transfer function evolution, Impulse response identification using cross correlation test and orthogonal series expansion, methods of convolution, model learning technique.

Least square Method: Least square estimates and its properties, non recursive least square identification of dynamic system, extensions such as generalised least square repeated least square and instrumental variable method.

Recurse Methods: Recursive least square, minimum variance algorithms, stochastic approximation method, maximum likelihood method.

Identification of state variable models: State Estimator using Kalman and extended kalman filter, simultaneous state and parameter estimation of linear systems.

Non-Linear systems identification: Identification of a volterra series models, identification of non-linear state models using extended kalman filter, quasilinearization method, invariant imbedding, gradient method, Numerical identification through model following approach.

TEXT BOOKS:

1. J.M.Mendel, 'Discrete Techniques of parameter estimation' Marcel Dekker, 1973.
2. F. Eykhoff, 'system identification, parameter and state estimation, John Willey, 1974.
3. A.P.Sage and J.L.Melsa 'identification', Academic press, 1971.

E.C. 2.5 (b) : CONTROL OF LARGE SCALE SYSTEMS
(ELECTIVE II)

****Credits : 3**

Lectures per week : 3

Theory, Univ. Exam. marks : Nil

Sessional Marks : 100

Total Marks : 100

I. Hierarchical Control of Large Scale Systems :

Introduction- Coordination of Hierarchical Structures - open Loop and closed loop Hierarchical control of control of continuous - time systems-Hierarchical control of Discrete time approach - Costal prediction approach.

II. Decentralized control of Large Scale Systems : Introduction - problem formulation of decentralized stabilization - fixed polynomials and fixed modes - stabilization via dynamic compensation -stabilization Via local state feedback - stabilization Via Multilevel control.

III. Near -optimum control Design of large systems:

Near optimum control of LTI systems - Aggregation methods perturbation methods - Multi time - scale approach - Hierarchical and decentralized methods - Bounds on Near - optimal cost functional - Near optimality due to aggregation - Near optimality due to perturbation Near optimality in Hierarchical control with structural perturbation.

TEXT BOOK:

1. Large scale systems Modelling and control, Mobamma Jamshidi, 1983, North-Hochand (Chapters 4, 5 and 6).

EC 2.5 (c) ROBOTICS
(ELECTIVE-II)

****Credits : 3**

Lectures per week : 3

Theory, Univ. Exam. marks : Nil

Sessional Marks : 100

Total Marks : 100

Introduction, classification, major components etc., applications. Systems Over view, basic components, The Robot system in an application, functions and specifications. Mechanical components and systems, review of basic mechanical concepts, practical components, modelling of mechanical systems and End deflectors etc.

Control of Robotic Systems, Closed-loop control, effect of friction and gravity, frequency domain considerations, control of the robotic joint, introduction to actuators.

TEXT BOOK :

R.D. Klafter, T.A. Chmielewski and M.Negin, 'Robotic Engineering : An Integrated Approach', Prentice Hall Interational, 1989.

SEMESTER III and IV : THESIS WORK

Work load 6 periods/week/student

****Credits per semester : 15**

****Total Credits : 30**

***The valuation of the thesis credits should be allotted but for the calculation of CGPA these credits will not be taken into consideration.**

Candidates can do their work in the department or in any industry/research organization for two semesters (ie 3rd and 4th semesters)

In case of thesis to be done in an industry/research organization, the advisor/advisors should be from the industry/research organization.

At the end of 4th semester, five spiral bound copies of the thesis are to be submitted to the department, out of which 3 to be retained by the department for evaluation purpose.

The thesis is to be evaluated by an examiner external to the University with minimum M.E./M.Tech qualification with relevant specialization and must have minimum 5 years of experience in service.

A Viva-voce examination is to be conducted by a Committee consisting of Head of the department, Chairman, Board of Studies, the External Examiner who evaluate the thesis and the Advisor of the thesis, after receiving the evaluation report from the External Examiner.

In case the advisor happens to be HOD or Chairman, Board of Studies or from industry/research organization one more member from the department with relevant specialization is to be recommended as examiner by Chairman, Board of Studies for Viva-voce examination.

The Board will submit a report stating whether the thesis is approved or not approved.

M.E.(PSA) SEMESTER – II

EP 2.1 : POWER SYSTEM OPERATION AND CONTROL

****Credits : 3**

Lectures per week : 3

Theory, **Univ. Exam. marks** : 70

Sessional Marks : 30

Total Marks : 100

I. System Modelling and Power Flow Analysis operation states, p-f and Q-V interactions, the power flow problem, Gauss-Siedel and Newton Raphson's methods, Computational Aspects of Large-Sector systems and sparsity oriented methods, Control of power flow.

II. Optimum Operating Strategies: Optimum Economic dispatch the loss-less and lossy cases- Inequality constraints, Incremental Transmission Losses, Computational procedure.

III. The control problem: Basic control loops of the Generators, Exciter-Generator Modelling, AVR-loop and its static and dynamic performance, stability compensation; Automatic load frequency control of single area systems: Speed governing system, turbine generator response, ALFC loop and its Performance: ALFC of multi-area systems: The two-area system, Tie-line Bias control; steady state Instabilities: Torsional Oscillatory Modes-Damper windings and negative damping, effect of AVR loop: AGC Design using kalman method-state variable form of the dynamic model, Optimum control Index, state Trajectories, the RICCATI equations.

Emergency Control and Automation: Concepts of reliability security and transient stability, preventive and emergency control, protective relaying, long-Term frequency dynamic, computer control.

TEXT BOOK:

'Electric Energy systems Theory - An Introduction' Olle I Elgard, TMH Second Edition.

EP 2.2 : POWER SYSTEM DYNAMICS AND STABILITY

****Credits : 3**

Lectures per week : 3

Theory, Univ. Exam. marks : 70

Sessional Marks : 30

Total Marks : 100

1.Power System Stability: Basic definitions, statement of the problem, elementary model, swing equation, power angle equations, Natural frequency of oscillations, single machine infinite bus system, equal area criterion, classical model of multi machines system. (pp 1-52 Text Book-I)

2.Response to small disturbances : The unregulated synchronous machine, modes of oscillations of an unregulated multi machine system. Regenerated synchronous machine, Distribution of power impacts. (pp 53-80 Text Book-I)

3.Synchronous Machine : Reactance and time constants of a Synchronous machine, basic notations and relation to short circuit oscillogram. Circuit equations of synchronous machine and Parks transformations, vector diagrams in steady state and transient state, power angle curves of a salient pole machine, calculation of change of field flux linkages and computing the swing curves, a procedure for multi-machine systems, effect of saturation, effect of damper windings as stability action explained by theory of induction motor. Calculation of positive sequence and negative sequence changes, the D.C. braking, power angle curve with damping included. (pp 24-129 and pp 214-245, Text Book-II)

4.Excitation Systems : Typical Excitations configurations and excitation control, (Automatic) Voltage regulators. Exciter buildup and Excitation system response. Computer representation of excitation systems-Types 1,2,3 and 4. (pp 233-304 Text Book-I)

5.Effect of Excitation on Stability : Effect on (a) Power limits, (b) Transient stability, (c) Dynamic stability. Approximate excitation system representation, supplementary stabilizing signals, block diagram of a simplified model of a complete system. (pp 309-340 Text Book-I)

TEXT BOOKS

1. Power system control and stability : P.M. Anderson and A.A.Foud, The IOWA State University Press, AMES, IOWA, USA - Galgotia Publications (Indian English Language edition, 1981)
2. Power System stability : Synchronous Machines, Edward Wilson Kimbark, Dover publications Inc., New York.

EP 2.3 H.V.D.C. TRANSMISSION

****Credits : 3**

Lectures per week : 3

Theory, Univ. Exam. marks : Nil

Sessional Marks : 100

Total Marks : 100

Direct Current Transmission Links :

Basic aspects of direct current transmission control of the direct current transmission link, current control, higher level control system, stabilization of alternating current networks.

Multi-terminal transmission links, connection/arrangements, breakers in direct current networks, models.

Elements of the direct current transmission link :

Direct current side overhead lines, transmission line systems. Dimensioning of overhead transmission lines, corona effects, transmission line insulation, ground faults on direct current transmission lines, Harmonics on direct current lines, line end protection.

Direct current cables : Dimensioning of direct current cables, leakage currents, over voltages on cables.

Ground return : Current distribution in the ground-ground electrodes, sea electrodes, advantages and disadvantages of ground return electrode connection to the converter station.

Apparatus on direct current side : Capacitors, arresters, direct current circuit-breakers.

Converter Stations : Valves - mercury arc valves and thyristor valves. Converter transformers and direct current reactors : Converter transformers, direct current reactors, auxiliary equipment and circuits, insulation co-ordination, layout of the converter station.

Elements of the alternating current networks :

Electrical machines, harmonic load, speed control, rectifier connection to power stations.

Alternating current filters : Harmonic impedance of the alternating current network, filter dimensions, protection of filter elements.

Switching in alternating current networks :

TEXT BOOK:

Power Transmission by Direct Current, Rich Uhlmann, Springer-Verlag Berlin Heidelberg, New York, 1975.

EP 2.4 : EHV ALTERNATING CURRENT TRANSMISSION

****Credits : 3**

Lectures per week : 3

Theory, Univ. Exam. marks : Nil

Sessional Marks : 100

Total Marks : 100

Transmission line trends and preliminaries :

Standard transmission voltages, average values of line parameters, Power handling capacity and line loss, examples of giant power pools and number of lines, costs of transmission lines and equipment, mechanical considerations in line performance.

Calculation of line and ground parameters :

Temperature rise of conductors and current carrying capacity, properties of bundled conductors, inductances of EHV line configurations, line capacitance calculations, sequence inductances and capacitances, line parameters for mode of propagation, resistance and inductance of ground return.

Voltage gradients of conductors :

Charge potential relationships for multi conductor lines, surface voltage gradient of conductors, examples of conductors and maximum gradients on actual lines, gradient factors and their use, distribution of voltage gradient on sub-conductors of bundle design of cylindrical cages for corona experiments.

Corona effects -i :

Power loss and audible noise, I^2R loss and corona loss, corona loss formula, charge-voltage (q-v) diagram and corona loss, attenuation of traveling waves due to corona loss, audible noise - Generation and characteristics, limits for audible noise, AN measurement meters, formulae for audible noise and use in design. Relation between single phase and three phase AN levels, day-night equivalent noise level, some examples of AN levels from EHV lines.

Corona effects -ii :

Radio interference, corona pulses, their generation and properties of pulse trains and filter response, limits for radio interference fields, frequency spectrum of the RI field of line, lateral profile of RI and modes of propagation, the CIGRE formula, the RI excitation function, measurement of RI, RIV and excitation function.

Theory of travelling waves and standing waves :

Travelling waves and standing waves at power frequency, differential equations and solutions for general case, standing waves and natural frequencies, open ended line, double exponential response, open ended line. Response to sinusoidal excitation, line energization with trapped charge voltage, corona loss and effective shunt conductance. The method of Fourier Transforms, reflection and refraction of travelling waves, transient response of systems with series and shunt lumped parameters and distributed lines.

Lightning and lightning protection :

Lightning strokes to lines, lightning stroke mechanism, general principles of the lightning, protection problems, tower footing resistance, insulation flashover and withstand voltages. Probability of occurrence of lightning currents, lightning arresters and protective characteristics, dynamic voltage rise and arrester rating, operating characteristics of lightning arresters, insulation coordination based on lightning.

Over voltages in EHV systems caused by switching operation : Origin of over voltages and their types, short circuit current and the circuit breaker recovery voltage and the circuit breaker over voltages caused by interruption of low inductive current, interruption of capacitive currents, Ferro resonance over voltages, calculation of switching surges, single phase equivalent distributed parameter line energized by source, Generalized equations for single phase representation, generalized equations for three phase system, inverse Fourier transform for the general case. Reduction of switching surges on EHV systems, Experimental and calculated results of switching surge studies.

EHV testing and laboratory equipment : Standard specifications, standard wave shapes for testing, properties of double-exponential wave shapes, procedures for calculating a,b,e wave shaping circuits, Principles and theory of impulse generators, with inductance, generation of switching surges for transformer testing, impulse voltage generators, practical circuits, energy of impulse currents, generation of high alternating test voltage, Generation of direct voltage , measurement of high voltage, general layout of EHV laboratories.

Design of EHV lines based upon steady state limits and transients over voltages :

Introduction, design factors under steady state, design examples, steady state limits, line insulation design based upon transient over voltages.

TEXT BOOK :

Extra High Voltage AC transmission Engineering by Rakosh das Begamudre, A weily Eastern Ltd., publication.

EP 2.5 (a): ADVANCED ELECTRICAL MACHINES
(ELECTIVE – II)

****Credits : 3**

Lectures per week : 3

Theory, Univ. Exam. marks : Nil

Sessional Marks : 100

Total Marks : 100

D.C. Machine Dynamics and Control :

D.C. motor speed control, dynamic equations, transfer functions and block diagrams, effects of saturation, introduction to rectifier circuits, solid-state d.c. motor drive systems, motor speed regulator, Metadynes and Amplidynes.

Synchronous Machines : Steady state and transient performance :

Introduction, inductances, equivalent circuits, open and short circuit characteristics, steady state power-angle characteristics, steady state operating characteristics, effect of salient poles, introduction to d-axis and q-axis theory, power angle characteristics of salient pole machines, interconnected synchronous generators. Synchronous machine transients, transformation to d and q axes variables, basic machine relations in dqo variables, analysis of a 3-phase sudden short circuit, transient power angle characteristics, effects of additional rotor circuits, models of synchronous machines for transient analysis, synchronous machine dynamics.

Polyphase induction machines :

Introduction, equivalent circuit, analysis of equivalent circuit, torque-power by use of Thevenin's theorem, performance by no-load and blocked rotor tests. Effects of rotor resistances, double cage rotors, induction machine dynamics, speed control, electrical transients, application of adjustable speed, solid state A.C. motor drives.

Fractional horse power A.C. motors :

Single phase induction motors, starting and running performance of single phase induction and synchronous motors, revolving field theory of single phase induction motors, unbalanced operation of symmetrical two phase machines, the symmetrical component concept, two phase control motors, series universal motors, stepper motors, A.C. tachometers, synchros and control transformers.

TEXT BOOK :

Electrical Machinery by Fitzgerald, Kingsley and Umans, McGraw Hill Int. Book Co., 4th ed. (chapters 6 to 11, pp 247-523)

EP 2.5 (b): POWER SYSTEM RELAYING AND PROTECTION
(ELECTIVE –II)

****Credits : 3**

Lectures per week : 3

Theory, Univ. Exam. marks : Nil

Sessional Marks : 100

Total Marks : 100

Introduction, basic principles of protective relays, development of static relays, a review of static relay tools.

Comparators: Amplitude and phase comparators, direct and integrated comparators, phase splitting methods, vector product devices, effect of off-set waves upon comparators.

Output devices : D.C. Supply and transient over voltages, tripping circuits and devices, d.c. supplies for transistors, causes and effects of transient over voltages and methods of diverting and suppressing them.

Power system faults : Types, causes and frequency of faults on the lines, cables, generators, motors, transformers and buses, determination of relay currents and voltages during faults, fault resistance.

Over current directional relays : A review of current and potential transformers, operating principles of static time current relays, timing and resetting currents, adjustments of characteristics, static operation indicators.

Differential relays : Basic principles, differential comparator circuits, application to protection of generators, transformers, buses and lines, effect of C.T. errors and primary current transients, summation C.T. versus sequence filter.

Distance relays : Inputs to phase and amplitude comparators, types and characteristics of distance relays. Special type conic section characteristics, quadrilateral characteristics, distance relays with linear couplers.

Steady state sources of distance relay errors : Effect of fault resistance with double ended feed, effect of power transfer and power swings, parallel lines, transients in fault current.

Multi-Input comparator circuits : conic sections characteristics, hybrid comparators. Multilateral characteristics, poly-phase comparators, phase sequence comparators.

Digital computer application to protective relaying : Digital simulation of distance relays during transient condition, on-line applications of computer-relay coordination, on-line application to relay protection.

TEXT BOOK :

Protective Relays : Their Theory and Practice, AR Van C. Warrington, Chapman and Hall, London, 1969. (Chapters 1,2,4-6,8-11)

EP 2.5 (c): POWER SYSTEM PLANNING
(ELECTIVE – II)

****Credits : 3**

Lectures per week : 3

Theory, Univ. Exam. marks : Nil

Sessional Marks : 100

Total Marks : 100

Introduction : The electric utility industry, generation systems and transmission systems.

Load forecasting: Classification and characteristics of loads, approaches to load forecasting, load forecasting methodology, energy forecasting, peak demand forecasting, non-weather sensitive forecast(NWSF), weather sensitive forecast, total forecast.

Generation system reliability analysis : Probabilistic generating unit models, probabilistic load models, effective load, reliability analysis of an isolated system and interconnected systems.

Generation system cost analysis : Cost analysis, corporate models, production analysis, production costing, fuel inventories, energy transactions and off-peak loading, environmental cost.

Transmission system reliability analysis : Deterministic contingency analysis, probabilistic transmission system, reliability analysis, capacity state classification by subsets, subset decomposition for system LOLP and (DNS) calculations, single area and multi area reliability analysis.

Automated transmission system expansion planning : Basic concepts, automated network design, automated transmission planning, a DC method, automated transmission planning by interactive graphics.

TEXT BOOK :

Power system planning, R. Sullivan, McGraw International book Co., New york and New Delhi (chapters 1-4,6,7 of the text book)

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SEMESTER III and IV : THESIS WORK

Work load 6 periods/week/student

****Credits per semester : 15**

****Total Credits : 30**

***The valuation of the thesis credits should be allotted but for the calculation of CGPA these credits will not be taken into consideration.**

Candidates can do their work in the department or in any industry/research organization for two semesters (ie 3rd and 4th semesters)

In case of thesis to be done in an industry/research organization, the advisor/advisors should be from the industry/research organization.

At the end of 4th semester, five spiral bound copies of the thesis are to be submitted to the department, out of which 3 to be retained by the department for evaluation purpose.

The thesis is to be evaluated by an examiner external to the University with minimum M.E./M.Tech qualification with relevant specialization and must have minimum 5 years of experience in service.

A Viva-voce examination is to be conducted by a Committee consisting of Head of the department, Chairman, Board of Studies, the External Examiner who evaluate the thesis and the Advisor of the thesis, after receiving the evaluation report from the External Examiner.

In case the advisor happens to be HOD or Chairman, Board of Studies or from industry/research organization one more member from the department with relevant specialization is to be recommended as examiner by Chairman, Board of Studies for Viva-voce examination.

The Board will submit a report stating whether the thesis is approved or not approved.