UNIVERSITY OF CALICUT
(Abstract)

Faculty of Engineering – Regulations, scheme & Syllabi of M.Tech Courses – implemented with effect from 2010 admn onwards - Orders Issued.

GENERAL AND ACADEMIC BRANCH - IV 'E' Section

GAIV/E1/AC / 03.07.2010 Dated, Calicut University.P.O., 27-08-2010.

Read:- 1) U.O. No. GAI/D4/4085/2003 dated, 21.11.2009.
2) Minutes of the meeting of the BOS in Engineering (PG) held on 10.12.2009 and 28.01.2010.
3) Minutes of the meeting of the faculty of Engineering held on 28.01.2010.
4) Minutes of the meeting of the Academic Council held on 03.07.2010.

ORDER

As per paper read 1st, Provisional affiliation was granted to start a new course in M.Tech Machine Design in Nehru College of Engineering & Research Centre, Pampady.

As per the paper read 2nd, the Board of Studies in Engineering (PG) framed, formulated and approved the syllabi of M.Tech in Machine design for 2010-2011. The Board of Studies also framed the revised M.Tech regulations, scheme and Syllabi of the following M.Tech Courses for the year 2010-2011.

1) Environmental Engineering
2) Production Engineering
3) Thermal Systems
4) Power Systems
5) Chemical Process Control
6) Embedded Systems

As per the paper read 3rd, the meeting of the faculty of Engineering approved the decision of the Board of Studies held on 10.12.2009 and 28.01.2010 and approved the revised M.Tech regulations and scheme and syllabi of the above M.Tech Courses.

The faculty also recommended the following in the revised regulations of M.Tech in the case of self financing colleges that there should be sufficient qualified faculty members and sufficient infrastructure in self financing colleges as recommended by All India Council for Technical Education.

As per paper read 4th, the meeting of the Academic Council held on 03.07.2010, approved the decisions of the Board of Studies held on 10.12.2009 and 28.01.2010 and the minutes of the faculty of Engineering held on 28.01.2010 for implementing the regulations and scheme and syllabi of the above M.Tech courses with effect from 2010 admission.

Contd…..2

Sanction has therefore been accorded for implementing the revised M.Tech regulations and Scheme & Syllabi of the following M.Tech Courses with effect from 2010 admission onwards.

1) Environmental Engineering
2) Production Engineering
3) Thermal Systems
4) Power Systems
5) Chemical Process Control
6) Embedded Systems
7) Machine design

Orders are issued accordingly, (regulations, scheme & Syllabi appended)

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UNIVERSITY OF CALICUT

SCHEME AND SYLABUS FOR M.Tech IN POWER SYSTEMS

(2010 ADMISSION ONWARDS)

Scheme of M.Tech programme in Power Systems

SEMESTER-1

Sl No	Course Code	Subject	Hours / Week			ICA	ESE	Total	Credits
			L	T	P				
1	EPS10 101	Applied Mathematics	3	1	0	100	100	200	4
2	EPS10 102	System Dynamics	3	1	0	100	100	200	4
3	EPS10 103	Power System Operation and Control	3	1	0	100	100	200	4
4	EPS10 104	Advanced Topics in Power System Analysis	3	1	0	100	100	200	4
5	EPS10 105	Elective	3	1	0	100	100	200	4
6	EPS10 106(P)	Power System Lab 1	0	0	2	100	-	100	2
7	EPS10 107(P)	Seminar	0	0	2	100	-	100	2
Total			15	5	4	700	500	1200	24

L-Lecture T-Tutorial P-Practical ICA- Internal Continuous Assessment
ESE- End Semester Examination

Electives

EPS10 105 (A)	Advanced Electric Drives
EPS10 105 (B)	Adaptive Signal Processing
EPS10 105 (C)	Optimization Techniques
EPS10 105 (D)	High Voltage A C & D C Transmission

Note: 6 hours per week is meant for departmental assistance by students.

SEMESTER-2

Sl No	Course Code	Subject	Hours / Week			ICA	ESE	Total	Credits
			L	T	P				
1	EPS10 201	Digital Protection of Power Systems	3	1	0	100	100	200	4
2	EPS10 202	Power System Dynamics	3	1	0	100	100	200	4
3	EPS10 203	Power System Security	3	1	0	100	100	200	4
4	EPS10 204	Elective 1	3	1	0	100	100	200	4
5	EPS10 205	Elective 2	3	1	0	100	100	200	4
6	EPS10 206(P)	Power System Lab II	0	0	2	100	-	100	2
7	EPS10 207(P)	Seminar	0	0	2	100	-	100	2
Total			15	5	4	700	500	1200	24

L-Lecture T-Tutorial P-Practical ICA- Internal Continuous Assessment
ESE- End Semester Examination

Elective I

EPS10 204 (A)	FACTS and Custom Power Devices
EPS10 204 (B)	Power Quality
EPS10 204 (C)	Switched Mode Power Controllers

Elective II

EPS10 205 (A)	Power System Planning and Reliability
EPS10 205 (B)	Power Distribution Systems
EPS10 205 (C)	Distributed Generation

Note: 6 hours per week is meant for departmental assistance by students

SEMESTER-3

Sl No	Course Code	Subject	Hours / Week			ICA		ESE	Total	Credits
			L	T	P					
1	EPS10 301	Elective I	3	1	0	100		100	200	4
2	EPS10 302	Elective II	3	1	0	100		100	200	4
3	EPS10 303 (P)	*Industrial Training						50	50	1
4	EPS10 304(P)	Master Research Project Phase I	0	0	22	Guide	EC		300	6
						150	150			
Total			6	2	22	500		250	750	15

* Industrial Training is for a minimum period of two weeks.

L-Lecture T-Tutorial P-Practical ICA- Internal Continuous Assessment
ESE- End Semester Examination EC- Evaluation Committee

Elective I

EPS10 301 (A)	Soft Computing Techniques
EPS10 301 (B)	Research Methodologies
EPS10 301 (C)	Energy Auditing and Management

Elective II

EPS10 302 (A)	Computer Networking
EPS10 302 (B)	Power System Economics
EPS10 302 (C)	Power system Monitoring and SCADA Systems.

Note: The student has to undertake the departmental work assigned by HOD.

SEMESTER-4

Sl No	Course Code	Subject	Hours / Week			ICA		ESE		Total
			L	T	P	Guide	Evaluation Committee	External Examiner	Viva Voce	
1	EPS10401	Master Research Project Phase II	0	0	30	150	150	150	150	600

Credits : 12

L-Lecture T-Tutorial P-Practical ICA- Internal Continuous Assessment
ESE- End Semester Examination

Note: The student has to undertake the departmental work assigned by HOD.

Total Credits for all Semesters : 75

SEMESTER 1

EPS10 101: APPLIED MATHEMATICS **Credits: 4**

Hours per week: Lecture-3 and Tutorial-1

Objective: *To enable the students apply probability and reliability theory in power system problems*

MODULE 1

Probability: Probability distributions,Binomial,Poisson,Normal,Uniform,Exponential,Weibull, Log normal,Beta,Gama,Joint distributions

Sampling distributions: Sampling distributions of mean and variance, Estimation, Point animation, Interval Estimation, Test of hypothesis

MODULE 2

Curve fitting: Method of least squares, Normal Equations, Fitting of straight line, Fitting of second degree curve, Correlations and regressions, Curvilinear regression, Multiple regression &Multiple correlation

Design of experiments: Analysis of variance-statistical principle of experimentation, Basic designs-Completely randomized design- Randomized block design.

MODULE 3

Stochastic Process: Examples, Specifications of Stochastic Process, stationary process

Markov chains: Definition and examples, Transition matrix, order of Markov chain, higher transition probabilities, Generalization of independent Bernoulli trails, Markov – Bernoulli chain, Correlated Random walk-Classification of states and chains. Determination of higher transition probabilities- Stability of Markov system.

MODULE 4

Reliability: series configuration- Parallel configuration-An r -out of n configuration-Failure time distributions-Exponential model in reliability-exponential model in life testing –Weibull model in life testing

REFERENCES:

1. Miller & Freud's- Probability and statistics in Engineering -6th edition, Pearson edition.
2. Schupta and V.K.Kapoor Fundamentals of statistics(Sultan Chand)
3. J. Medhi- Stochastic Process- 2nd edition New age international publication- Chapter 2.1,2.2,2.3,3.1,3.2.3.3,3.4,3.5,3.6
4. Martin Shoo man- Mc Graw Hill-Probabilistic reliability An engineering Approach

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern

Answer any 5 questions by choosing at least one question from each module.

Module I

Question 1 : 20 marks

Question 2 : 20 marks

Module II

Question 3 : 20 marks

Question 4: 20 marks

Module III

Question 5 : 20 marks

Question 6: 20 marks

Module IV

Question 7 : 20 marks

Question 8: 20 marks

EPS10 102: SYSTEM DYNAMICS **Credits: 4**

Hours per week: Lecture-3 and Tutorial-1

Objectives:

To study the analysis of systems using state space model
To understand the concept of stability
To familiarize the optimal control problem

MODULE 1:

State variable representation of system-concept of state-Equilibrium points-Stability-Solution of state equation-eigen values-eigen vectors-modes-modal decomposition-eigen value and stability-mode shape-sensitivity-participation factor-State space representation of discrete time systems-Discretization of continuous time state equation

MODULE 2 :

Lyapunov stability-definition of stability, asymptotic stability and instability-Lyapunov's second method-Lyapunov's stability analysis of LTIV continuous time and discrete time systems-stability analysis of non linear system-Krasovski's theorem-variable gradient method

MODULE 3:

Concepts of controllability and observability, controllability and observability tests for continuous time and discrete time systems-controllability and observability studies based on canonical forms of state model-effect of state feedback on controllability and observability-pole placement by state feedback for continuous and discrete time systems.Design of full order and reduced order observer for continuous time and discrete time systems

MODULE 4:

Optimal control-formulation of optimal control problem-Minimum time control problem-minimum energy problem-minimum fuel problem-state regulator problem-output regulator problem –tracking problem-choice of performance measure -optimal control based on quadratic performance measure –optimal control system design using second method Lyapunov-solution of reduced Riccatti equation.

Robust control systems-introduction-sensitivity analysis of robustness-system with uncertain parameters-design of robust PID controlled systems.

REFERENCES

1. Thomas Kailath, Linear systems, Prentice Hall Inc;1980
2. K.Ogata; Modern control Engg(second Edison) ;prentice Hall Inc,1990
3. K.Ogata, Discrete time control systems.P.H.I
4. M.Gopal, Digital Control and State Variable methods, Tata Mc.Graw Hill Publishing company, 1997
5. M.Gopal, Modern control system Theory
6. P.Kundur, Power System Stability and Control, McGraw-Hill Publishing Company,1994
6. C.T.Chen, Linear system theory and design, New York,Holt Rinechart and Winston ,1984
7. Richard.C.Dorf and R.T Bishop Modern Control System P.H.I

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern

Answer any 5 questions by choosing at least one question from each module.

Module I

Question 1 : 20 marks

Question 2 : 20 marks

Module II

Question 3 : 20 marks

Question 4: 20 marks

Module III

Question 5 : 20 marks

Question 6: 20 marks

Module IV

Question 7 : 20 marks

Question 8: 20 marks

EPS10 103: POWER SYSYTEM OPERATION AND CONTROL

Credits: 4

Hours per week: Lecture-3 and Tutorial-1

Objective: *To acquaint the students with various optimization techniques that can be applied to power system operations and to introduce load frequency control and voltage control in powers systems*

MODULE 1

Economic operation and OPF: The economic dispatch problem-Thermal system dispatching with network losses considered-Loss Formula calculations.

Optimal Load Flow: Problem statement and formulation. Solution of OPF, Gradient method-Newton's method and LP methods.

MODULE 2

Hydro thermal coordination and Unit commitment: Hydro electric Plant Models-Scheduling Problems-short term hydro thermal scheduling problem-gradient approach-Pumped storage hydro plants- Hydro scheduling using linear programming.

Unit Commitment: Constraints in unit commitment-Unit commitment solution methods-Priority list methods-DP approach.

Note : Programming exercises are to be given as assignment questions in module 1 and 2.

MODULE 3

Automatic Generation Control: Basic generator control loops -Models for generator, Load, Prime movers ,Governor-Block diagram models for single area and Two area system-Tie line bias control .AGC with optimal dispatch-Introductory modern control application -Pole placement design and optimal control design.

MODULE 4

Reactive Power and Voltage Control: Impedance and reactive power-System voltage and reactive power-Reactive power generation by synchronous machines-Effect of excitation control-Voltage regulation and power transfer-Exciter and voltage regulator-Block schematics of excitation control AVR for alternator -Static and dynamic response stability compensators-Stability compensation power system stabiliser(PSS)-Methods of system voltage control-Tap changing transformer-Shunt reactors-Shunt capacitors-Series capacitors-Synchronous condensers-Static VAR Systems-FACTS devices(introduction only)

Note: MATLAB SIMULINK based exercises are to be given as assignment questions.

REFERENCES

1. Allen J. Wood and Bruce Wollenberg , Power Generation Operation and Control, 2nd edition, John Wiley& Sons,Inc.,
2. P Kundur, Power system Stability and Control, McGraw-Hill, Inc.,1994.
3. PSR Murthy, Operation and Control of Electric Power systems, BS publications, Hyderabad, 2005.
4. Hadi Saadat, Power System Analysis , Tata McGra-Hill, Edition, 2002.

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

End semester Examination:100 marks

Question pattern

Answer any 5 questions by choosing at least one question from each module.

Module I

Question 1 : 20 marks

Question 2 : 20 marks

Module II

Question 3 : 20 marks

Question 4: 20 marks

Module III

Question 5 : 20 marks

Question 6: 20 marks

Module IV

Question 7 : 20 marks

Question 8: 20 marks

EPS10 104: ADVANCED TOPICS IN POWER SYSTEMS

Credits:4

Hours per week: Lecture-3 and Tutorial-1

Objective: *To study about various power system analysis techniques and its necessity.*

MODULE 1

Network modelling, Impedance and Admittance representation. Power flow analysis – Gauss Siedel method – Newton Raphson method – DLF and FDLF method, DC Load flow, sparsity oriented programming.

MODULE 2

3-Φ AC Load flow analysis: Introduction to 3-Φ AC Load flow, problem formulation, fast decoupled 3-Φ AC Load flow algorithm.

Introduction to AC-DC load flow, problem formulation and analysis. 3-Φ AC-DC Load flow concept, problem formulation, assumptions made.

MODULE 3

Short circuit analysis of a multi node system using bus impedance matrix, Z-bus building algorithm, asymmetrical fault analysis using Z-bus, development of voltage and current equations under asymmetrical fault using symmetrical components.

MODULE 4

Computer control of power system:- Need of real time and computer control of power system, Operating states of power system, Supervisory control and data acquisition system, Energy Management Centers.

TEXT BOOKS

1. Power System Stability and Control: –P.Kundur – McGraw Hill publications

2. Computer Modelling of Electric Power Systems: - J Arrillaga and N R Watson, John Wiley and sons,2001

3. John J Grainger and William D Stevenson Jr: -Power System Analysis, McGraw Hill

REFERENCES

1. E. Handschin: Real time control of electrical power systems, Elsevier Pub. Co. 1988

2. Allen J Wood and Bruce Woolenberg: Power system Generation, Operation and Control, John Wiley and sons, 1996

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern

Answer any 5 questions by choosing at least one question from each module.

Module I

Question 1 : 20 marks

Question 2 : 20 marks

Module II

Question 3 : 20 marks

Question 4: 20 marks

Module III

Question 5 : 20 marks

Question 6: 20 marks

Module IV

Question 7 : 20 marks

Question 8: 20 marks

EPS10 105: ELECTIVE

EPS10 105(A) ADVANCED ELECRICAL DRIVES **Credits: 4**

Hours per week: Lecture-3 and Tutorial-1

Objective: *To study the dynamics and control of conventional and modern electrical drives with analysis and design*

MODULE 1

Motor drive – Selection of drives – Power converters – DC motor speed control – Filed and armature control – Four-quadrant operation – Phase-controlled converters – 1- phase and 3-phase – Steady-state analysis of 3-phase converter – Controlled DC motor drive – Transfer functions of the subsystems – Design of controllers – Two-quadrant DC motor drive with field weakening – Four-quadrant DC motor drive – Chopper-controlled DC motor drive – Steady-state analysis – Closed-loop operation – PWM current controller – Hysteresis current controller.

MODULE 2

3-phase induction motor – Equivalent circuit – Steady-state performance equations – Dynamic modeling of induction machines – 3-phase to 2-phase transformation – Power-equivalence – Generalized model in arbitrary reference frame – stator reference frame model –Rotor reference frame model – Synchronously rotating reference frames model – Equations in flux linkages.

MODULE 3

Phase controlled induction motor drives – Stator voltage control – Closed loop operation – Slip-energy recovery scheme – Closed loop control – Static scherbius drive – Stator frequency control – Constant volts/Hz control – Constant slip-speed control – Constant air gap flux control – control of harmonics – Phase shifting control – Pulse-width modulation – Flux weakening operation – current source induction motor (CSIM) drives – closed loop CSIM drive system.

MODULE 4

Vector controlled induction motor drives – Direct vector control – Vector control with space vector modulation – Indirect vector control scheme – flux weakening operation – Direct torque control (DTC) – Permanent magnet synchronous motor (PMSM) drives – Vector control – Sensor less PMSM drive – permanent magnet brushless DC motor drive.

TEXT BOOK

1. Electric Motor Drives – Modeling, Analysis and Control by R.Krishnan, Pearson Education

REFERENCES

1. Modern Power Electronics and AC drives by Bimal K. Bose, Pearson Education
2. Fundamentals of Electrical Drives by Gopal K. Dubey, Narosa Publishing House

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

End semester Examination:100 marks

Question pattern

Answer any 5 questions by choosing at least one question from each module.

Module I

Question 1 : 20 marks

Question 2 : 20 marks

Module II

Question 3 : 20 marks

Question 4: 20 marks

Module III

Question 5 : 20 marks

Question 6: 20 marks

Module IV

Question 7 : 20 marks

Question 8: 20 marks

EPS10 105(B): ADAPTIVE SIGNAL PROCESSING

Credits:4

Hours per week: Lecture-3 and Tutorial-1

Objective: *To impart knowledge about advanced signal processing techniques like stochastic methods and adaptive filtering to power engineering students, so that they can apply them in applications like state estimation, control, protection etc.*

MODULE 1

Discrete random processes: Random variables, random processes, filtered random processes, Ensemble averages, correlation, covariance, power spectrum, cross power spectrum, Ergodicity, time averages, biased & unbiased estimators, consistent estimators.
[Papoulis; O&S-DTSP (§2.10, App. A); Haykin (Chps. 2-3)]

Linear prediction: Direct form linear prediction filtering, Normal equations for linear prediction filtering, Levinson algorithm, Linear prediction lattice filtering.
[Haykin (Chp. 6)]

MODULE 2

Digital Wiener filtering : Wiener smoothing and prediction filters, Application of Wiener smoothing to noise cancelling, Application of Wiener prediction filters, Constrained, linear MMSE filtering, Minimum variance beamforming,
[Haykin (Chp. 5)]

Least mean squares adaptive filter: LMS adaptive algorithm, Properties of LMS adaptive filter,
[Haykin (Chps. 8,9,16 and 17)]

MODULE 3

Gradient adaptive lattice filter: Noisy gradient forms, Direct forms,
[Haykin (App. G)]

Least squares adaptive filters : Godard algorithm, Lattice.
[Haykin (Chps. 11,13,15)]

MODULE 4

Other adaptive filtering techniques: Neural networks and multi-layer perceptrons, Adaptive IIR filtering, The constant modulus algorithm.
[Haykin (Chps. 18,19)]

Blind adaptive filtering : Cost functions, Higher-order statistics, Examples.
[Haykin (Chp. 18)]

TEXT BOOK:

1. Adaptive Filter Theory, S. Haykin, Prentice-Hall, 4-th edition, 2001.

REFERENCES

1. Statistical and Adaptive Signal Processing: Spectral Estimation, Signal Modeling, Adaptive Filtering and Array Processing, D. Manolakis, V. Ingle, S. Kogan, McGraw Hill, 1999.
2. Adaptive Signal Processing, B. Widrow, S. Stearns, Prentice-Hall, 1985.
3. Theory and Design of Adaptive Filters, J. Triechler, C. Johnson, M. Larimore Prentice-Hall, 1995.
4. Adaptive Filtering: Algorithms and Practical Implementation, P. Diniz, Kluwer, 1997.
5. Adaptive Filters: Structures, Algorithms and Applications, M. Honig, D. Messerschmitt, Kluwer,1984.
6. Adaptive Signal Processing, L. Sibul, Ed., IEEE Press, 1987.

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern

Answer any 5 questions by choosing at least one question from each module.

Module I

Question 1 : 20 marks

Question 2 : 20 marks

Module II

Question 3 : 20 marks

Question 4: 20 marks

Module III

Question 5 : 20 marks

Question 6: 20 marks

Module IV

Question 7 : 20 marks

Question 8: 20 marks

EPS10 105(C): OPTIMIZATION TECHNIQUES **Credits: 4**

Hours per week: Lecture-3 and Tutorial-1

Objective: *To apply the different optimization techniques to both linear and non-linear systems.*

MODULE 1

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

MODULE 2

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

MODULE 3

Constrained optimization techniques & dynamic programming:

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

MODULE 4

Recent developments in optimization techniques:

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

REFERENCES:

1. Pierre, D.A. ‘Optimisation Theory with Applications’ John Wiley & Sons, 1969
2. Fox, R.L., ‘Optimisation method for Engineering Design’, Addition Welsey,1971.
3. Hadely,G., ‘Linear Programming’, Addition Wesley, 1962.
4. Bazaara &Shetty, ‘Non-linear Programming’.
5. D.E. Goldberg, Genetic Algorithm in Search, Optimization, and Machine Learning. Reading, MA: Addison-Wesly, 1989.
6. Marco Dorigo, Vittorio Miniezza and Alberto Colorni “Ant System:Optimization by a colony of Cooperation Agents” IEEE transaction on system man and Cybernetics-Part B:cybernetics, Volume 26, No 1, pp. 29-41,1996.
7. Shi, Y. Eberhart, R.C., “A Modified Particle Swarm Optimizer”, Proceedings of the IEEE International conference on Evolutionary Computation, Anchorage, AK, pp. 69-73, May 1998

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced to students’ right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern

Answer any 5 questions by choosing at least one question from each module.

Module I

Question 1 : 20 marks

Question 2 : 20 marks

Module II

Question 3 : 20 marks

Question 4: 20 marks

Module III

Question 5 : 20 marks

Question 6: 20 marks

Module IV

Question 7 : 20 marks

Question 8: 20 marks

EPS10 105(D): High Voltage DC and AC Transmission

Credits: 4

Hours per week: Lecture-3 and Tutorial-1

Objective**:** *To give the students an in depth knowledge of the configuration and working of HVDC & AC systems.*

MODULE 1

General Aspects, Converter circuits and analysis: HVDC links - comparison –Economic, Technical performance – Reliability – Limitations - Properties of thyristor converter circuits-assumptions-Choice of best circuit for HVDC converters-Transformer connections - Analysis with gate control but no overlap less than 60 degrees- operation of inverters

MODULE 2

Bridge converters-Analysis, Control, Protection and Harmonics Filters: Converter Inverter circuits for HVDC Transmission-basic means of control –Power reversal-desired features of control – actual control characteristics. Converter disturbance –bypass action in bridges- commutation failure-basics of protection-DC Reactors-Voltage and current oscillations-Circuit breakers - Over voltage protection-Characteristics and uncharacteristic harmonics-troubles due to harmonics-harmonic filters-Converter charts of direct current and voltage- active and reactive power.

MODULE 3

Lightning, Travelling waves and switching Transients: Mathematical model to represent lightning- Travelling wave in transmission lines-Circuits with distributed constants- Wave equations- Reflection and Refraction of travelling waves-Travelling wave s at different line terminations-effect of short length of cables- Shape and attenuation and distortion of travelling waves- Selection of typical wave to represent over voltages-Switching transients-the circuit closing transient-the recovery transient initiated by the removal of the short circuit – Double frequency transients- Abnormal switching transients- Current suppression-capacitance switching- Arcing ground-Transformer inrush current –Ferro resonance- neutral connections- Transients in switching a three phase reactor –Three phase capacitor

MODULE 4

Protective device in HVAC transmission, Interaction between AC & dc System: Basic ideas about protection – surge diverters- surge absorbers- ground fault neutralizers-Protection of lines and stations by shielding- Ground wires – counter poises-Driven rods-Modern lightning arrestors- Insulation co ordination- Protection of alternators- Industrial drive system. Interaction between AC & DC systems- Voltage interaction-Harmonic instabilities- Smoothing Reactors – Overhead lines – Cable Transmission-Earth Electrodes-Design of back to back thyristor convertor system.

REFERENCES:

1. Kimbark,E.W., `Direct current transmission-Vol.1',Wiley Interscience, New York, 1971
2. Arrilaga,J., `High Voltage Direct current transmission',Peter Pereginver Ltd., London,UK.,1983
3. Allen Greenwood,` Electrical Transients in power system', Wiley Interscience,1971
4. Diesendorf,W., `Overvoltage on High voltage system'Rensselaer Book store ,Troy, New York,1971
5. Klaus Ragallea, `Surges and high voltage networks', Plenum Press,1980.
6. Padiyar,K.R., `HVDC Transmission system', Wiley Eastern Limited .,NewDelhi,1992.

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern

Answer any 5 questions by choosing at least one question from each module.

Module I

Question 1 : 20 marks

Question 2 : 20 marks

Module II

Question 3 : 20 marks

Question 4: 20 marks

Module III

Question 5 : 20 marks

Question 6: 20 marks

Module IV

Question 7 : 20 marks

Question 8: 20 marks

EPS10 106(P): POWER SYSTEM LAB - I

Credits: 2

Hours per week: 2

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

1. Develop a program for solving
    a. Unit commitment problem
    b. Thermal dispatch problem
    c. Hydro thermal co-ordination problem
2. Simulate single area and two area system using any application software.
3. Develop a program for Y_{BUS} formation by two dimensional matrix.
4. Develop a program for load flow by Newton-Raphson method (Q adjusted and Q unadjusted cases)
5. Develop a program for load flow by Fast Decoupled method.

6. Develop a program for Z_{BUS} formation.
7. Measurement of sequence reactance of 3-phase alternator and 3-phase transformer.
8. Study of characteristics of long transmission lines using Lab models.
9. Measurement of synchronous machine parameters – Xd, Xq, Xd', Xq', Xd", Xq", Tdo', Tqo', Tdo" and Tqo".
10. Insulation testing of LT and HT insulators.

Out of the above, a minimum of seven experiments are to be conducted.

In addition to the above, the department can offer a few newly developed experiments.

Internal continuous assessment: 100 marks

- **Regularity – 30%**
- **Record – 20%**
- **Test and Viva – 50%**

EPS10 107(P): SEMINAR

Credits: 2

Hours per week 2

Objective: To assess the debating capability of the student to present a technical topic. Also to impart training to a student to face audience and present his ideas and thus creating in him self esteem and courage that are essential for an engineer.

Individual students are required to choose a topic of their interest from power system/ power system related topics preferably from outside the M.Tech syllabus and give a seminar on that topic about 30 minutes. A committee consisting of at least three faculty members (preferably specialized in power systems) shall assess the presentation of the seminar and award marks to the students. Each student shall submit two copies of a write up of his seminar topic. One copy shall be returned to the student after duly certifying it by the chairman of the assessing committee and the other will be kept in the departmental library. Internal continuous assessment marks are awarded based on the relevance of the topic, presentation skill, quality of the report and participation.

Internal continuous assessment: 100 marks

SEMESTER 2

EPS10 201: DIGITAL PROTECTION OF POWER SYSTEMS

Credits 4

Hours per week: Lecture-3 and Tutorial-1

Objective: *To study principles and algorithms of digital relaying for protection of power systems***.**

MODULE 1

Introduction to computer relaying: Development and historical background, expected relay architecture, A-D converters, Anti –aliasing Filters, substation computer hierarchy.

Review of relaying practices: functions of a protective system, Protection of transmission lines, Transformers, Reactors and generator Protection ,Bus Protection, Performance of current and voltage protection,

Review of mathematical basis for protective relaying algorithms: Fourier series, Orthogonal expansions, Fourier transforms, Discrete Fourier transforms, Introduction to probability and random processes, Kalman Filtering.

MODULE 2

Transmission line relaying algorithms: Introduction, sources of error, relaying as parameter estimation, Symmetrical component distance relay, Protection of series compensated lines

Protection of transformers, Machines and buses: Power transformer algorithms, digital protection of generators and motors.

MODULE 3

Hardware organization: Computers for relaying, substation environment, Industry environmental standards, counter measures against EMI, Redundancy and Back up

System relaying and control: Measurement of frequency and phase, sampling clock synchronization, Application of phase measurements to static and dynamic state estimation, system monitoring

MODULE 4

Development in new relaying principles: Travelling waves in single phase and three phase lines travelling waves due to faults, directional wave relay, Travelling wave distance relay, Differential Relaying with phasors, travelling wave differential relays, adaptive relaying fault location algorithms, recent developments in relaying

TEXT BOOK:

1. Computer relaying for Power systems, Arun G Phadke and James S Thorp, John Wiley & Sons Inc, New York.

REFERENCES

1. “Power system Protection and Switchgear”, Badri Ram and D.N. Vishwakarma.
2. “Protective Relays”. Vol I & II, Warrington and Collins.
3. “Protective relaying for Power systems”, Edited by Stanley .H. Horowitz, IEEE Press.

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced to students’ right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern

Answer any 5 questions by choosing at least one question from each module.

Module I

Question 1 : 20 marks

Question 2 : 20 marks

Module II

Question 3 : 20 marks

Question 4: 20 marks

Module III

Question 5 : 20 marks

Question 6: 20 marks

Module IV

Question 7 : 20 marks

Question 8: 20 marks

EPS10 202: POWER SYSTEM DYNAMICS **Credits: 4**

Hours per week: Lecture-3 and Tutorial-1

Objectives: *To study the modelling of synchronous machine and stability analysis*

MODULE 1

Stability of Dynamic systems, Synchronous machine theory and modelling:- armature and field structure, parks transformation, machine with multiple pole pairs-mathematical description, d-q transformation, per unit representation, equivalent circuit for d-q axes, steady state analysis- voltage-current and flux linkage, phasor representation, rotor angle – steady state equivalent circuit.

MODULE 2

State space representation concept, Eigen properties of the state vectors, analysis of stability- small signal stability of a single machine connected to infinite bus system, classical representation of generator, small signal stability of a multi machine connected to infinite bus system. Characteristics of small - signal stability problems.

MODULE 3

Transient stability:- Concept of transient stability, response to a step change in mechanical power input, Swing equation- multimachine analysis, factors influencing transient stability, numerical integration method – Euler method – R-K method (4rth order), critical clearing time and angle- methods for improving transient stability.

MODULE 4

Voltage stability:- Basic concept, transmission system characteristics, generator characteristics, load characteristics, PV curve, QV curve and PQ curve, characteristics of reactive power compensating devices. Voltage collapse and prevention of voltage collapse.

TEXBOOKS

1. Power System Stability and Control: –P. Kundur – McGraw Hill publications

REFERENCES

1. Power System Dynamics: Stability and Control: – K.R.PADIYAR, II Edition, B.S.Publications.
2. Power system control and stability P.M. Anderson and A.A. Fouad, John Wiley & sons
3. Computer modelling of Electric Power Systems, J. Arrillaga and N. R. Watson, John Wiley & sons, 2001.

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

End semester Examination:100 marks

Question pattern

Answer any 5 questions by choosing at least one question from each module.

Module I

Question 1 : 20 marks

Question 2 : 20 marks

Module II

Question 3 : 20 marks

Question 4: 20 marks

Module III

Question 5 : 20 marks

Question 6: 20 marks

Module IV

Question 7 : 20 marks

Question 8: 20 marks

EPS10 203: POWER SYSTEM SECURITY Credits: 4

Hours per week: Lecture-3 and Tutorial-1

Objectives:

To understand the need for power system security, security measurement and assessment.

To study the techniques for security enhancement.

MODULE1

Basic concepts: Power system stability-security-observability and reliability, deregulation, factors affecting power system security, decomposition and multilevel approach, state estimation, system monitoring, security assessment, static and dynamic – online and offline, security enhancement.

MODULE 2

Power system state estimation: DC and AC network, orthogonal decomposition algorithm, detection identification of bad measurements, network observability and pseudo measurements, application of power system state estimation, introduction to supervisory control and data acquisition.

MODULE 3

Power system security assessment: contingency analysis, network sensitivity factors, contingency selection, performance indices, security constrained optimisation, SCOPF, basis of evolutionary optimization techniques, preventive, emergency and restorative controls though non- linear programming (NLP) and linear programming(LP)methods.

MODULE 4

Security in Deregulated Environment: Need and conditions for deregulation, electricity sector structure model, power wheeling transactions, congestion management methods, available transfer capability (ATC), system security in deregulation.

REFERENCES

5. Wood and Wollenberg, “Power generation, operation and control, John Wiley & Sons, 2000.
6. K.Bhattacharya, M.H.J Bollen and J.E. Daaider, “Operation of restructured power system” Kluwer Power Electronics and Power System series (2001)
7. N.S.Rau,”Optimization Principles: Practical Applications to the operation and Markets of the Electric Power Industry”.
8. Sally Hunt, “Making competition work in Electricity”, John Wiley, 2002

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students’ right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern

Answer any 5 questions by choosing at least one question from each module.

Module I

Question 1 : 20 marks

Question 2 : 20 marks

Module II

Question 3 : 20 marks

Question 4: 20 marks

Module III

Question 5 : 20 marks

Question 6: 20 marks

Module IV

Question 7 : 20 marks

Question 8: 20 marks

EPS10 204: ELECTIVE 1

EPS10 204(A): FACTS AND CUSTOM POWER DEVICES

Credits: 4

Hours per week: Lecture-3 and Tutorial-1

Objectives: Operation, control and application of different FACTS devices and custom power devices.

MODULE 1

FACTS and preliminaries: FACTS concept and general system considerations - power flow in AC system - definitions on FACTS - basic types of FACTS controllers.
Converters for Static Compensation - Three phase converters and standard modulation strategies (Programmed Harmonic Elimination and SPWM) - GTO Inverters - Multi-Pulse Converters and Interface Magnetics - Transformer Connections for 12, 24 and 48 pulse operation - Multi-Level Inverters of Diode Clamped Type and Flying Capacitor Type and suitable modulation strategies (includes SVM) - Multi-level inverters of Cascade Type and their modulation - Current Control of Inverters.

MODULE 2

Static Shunt and Series Compensators: Static Shunt Compensators - SVC and STATCOM - operation and control of TSC, TCR, STATCOM - Compensator Control - Comparison between SVC and STATCOM - STATCOM for transient and dynamic stability enhancement.
Static Series Compensation - GCSC, TSSC, TCSC and SSSC - operation and control - external system control for series compensators - SSR and its damping - static voltage and phase angle regulators - TCVR and TCPAR - operation and control.

MODULE 3

UPFC and IPFC: The Unified Power Flow Controller - operation, comparison with other FACTS devices - control of P and Q - dynamic performance - Special Purpose FACTS Controllers - Interline Power Flow Controller - operation and control.

MODULE 4

Power Quality and introduction to custom power devices: Power Quality issues related to distribution systems – custom power devices – Distribution STATCOM – Dynamic Voltage restorer – Unified Power Quality Conditioner – Application of D-STATCOM, DVR and UPQC for improving power quality in distribution systems.

REFERENCES:

1. N.G. Hingorani & L. Gyugyi, Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems IEEE Press, 2000.
2. T.J.E Miller, Reactive Power Control in Electric Systems, John Wiley & Sons.
3. Ned Mohan et.al, Power Electronics, John Wiley and Sons.
4. Dr Ashok S & K S Suresh Kumar "FACTS Controllers and applications" course book for STTP, 2003.
5. K. R. Padiyar, FACTS Controllers in Power Transmission and Distribution, New Age International, First Edition.

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern

Answer any 5 questions by choosing at least one question from each module.

Module I

Question 1 : 20 marks

Question 2 : 20 marks

Module II

Question 3 : 20 marks

Question 4: 20 marks

Module III

Question 5 : 20 marks

Question 6: 20 marks

Module IV

Question 7 : 20 marks

Question 8: 20 marks

EPS 10 204(B) POWER QUALITY **Credits:4**

Hours per week: Lecture-3 and Tutorial-1

Objectives:

To familiarize with power quality problems and measurements.

To study the impact of and on the device and different mitigation techniques.

MODULE 1

Overview of power quality phenomena-classification of power quality issues-power quality measures and standards-flicker-transient phenomena-Harmonics-sources of harmonics-occurrence of power quality problems-power acceptability curves-IEEE guides, standards and recommended practices.

MODULE 2

Modelling of networks and components under non-sinusoidal conditions-transmission and distribution systems-shunt capacitors-transformers-electric machines-ground systems-loads that cause power quality problems-power quality problems created by drives and its impact on drives.

MODULE 3

Power quality application of state estimation-flicker-impulses-high frequency issues-common mode and transverse mode noise-geometric interference-susceptibility of loads-loss of life of power system components

MODULE 4

Power quality improvement: harmonic filters-active filters-phase multiplication-power conditioners-uninterruptible power sources-constant voltage transformers-static compensators and static watt compensators.

TEXT BOOK

1. Heydt, G.T., “Electric Power Quality‟, Stars in a Circle Publications, Indiana,2 edition 1994.

REFERENCES

1. Bollen, M.H.J., “Understanding Power Quality Problems: Voltage sags and interruptions, IEEE Press, New York, 2000.
2. Arrillaga. J, Watson, N.R., Chen, S., “Power System Quality Assessment, Wiley, New York, 2000.

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students’ right at the beginning of the semester by the teacher.

End semester Examination:100 marks

Question pattern

Answer any 5 questions by choosing at least one question from each module.

Module I

Question 1 : 20 marks

Question 2 : 20 marks

Module II

Question 3 : 20 marks

Question 4: 20 marks

Module III

Question 5 : 20 marks

Question 6: 20 marks

Module IV

Question 7 : 20 marks

Question 8: 20 marks

EPS 10 204(C) SWITCHED MODE POWER CONVERTERS Credits:4

Hours per week: Lecture-3 and Tutorial-1

Objective:
To acquaint the students with working, analysis and modelling of different types of converters.

MODULE 1

Review of - Buck, Boost, Buck-Boost topologies, Basic Operation-Waveforms-modes of operation-voltage mode control principles.
Push-pull and Forward converter- Basic Operation-Waveforms-modes of operation-Transformer design-voltage mode control principles.
Half and Full Bridge Converters- Basic Operation-Waveforms-modes of operation-voltage mode control principles.
Fly back Converter - Basic Operation-Waveforms-modes of operation-voltage mode control principles.

MODULE 2

Voltage Mode Control of SMPS - Loop gain and Stability Considerations - Shaping the Error Amplifier gain versus frequency characteristics - Error amplifier Transfer function – Tran conductance Error amplifiers.
Current Mode Control of SMPS – Current Mode Control Advantages- Current Mode versus Voltage Mode Control of SMPS – Current Mode Deficiencies - Slope Compensation.

MODULE 3

Modelling of SMPS - Basic AC modelling Approach -– Modelling of non ideal fly back converter - State Space Averaging – basic state space averaged model – State space averaging of non ideal buck boost converter - Circuit averaging and averaged switch modelling – Modelling of pulse width modulator

MODULE 4

Introduction to Resonant Converters – Classification of Resonant Converters – Basic Resonant circuit concepts – load resonant converters – resonant switch converters – Zero voltage switching, clamped voltage topologies – resonant DC Link inverters with zero voltage switching – High frequency link integral half cycle converter

REFERENCES

1. Ned Mohan ,Power Electronics ,John Wiley & Sons
2. Abraham I Pressman , Switching Power Supply Design , McGraw-Hill Publishing Company
3. R. W. Erickson , Fundamental of Power Electronics , Chapman & Hall Publishers

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

End semester Examination:100 marks

Question pattern

Answer any 5 questions by choosing at least one question from each module.

Module I

Question 1 : 20 marks

Question 2 : 20 marks

Module II

Question 3 : 20 marks

Question 4: 20 marks

Module III

Question 5 : 20 marks

Question 6: 20 marks

Module IV

Question 7 : 20 marks

Question 8: 20 marks

EPS10 205 ELECTIVE 2

EPS10205 (A) POWER SYSTEM PLANNING AND RELIABILITY

Credits: 4

Hours per week: Lecture-3 and Tutorial-1

Objective: At the end of the course students will be able to forecast loads and perform reliability analysis of generation and transmission systems.

MODULE 1

System Planning:

Objectives of system planning: Long term and short term planning-stages in planning -Policy studies -Planning standardization studies- System and Network Reinforcement studies

Load forecasting: Classification of loads-Forecast methodology- Energy forecasting-Non weather sensitive forecast-Weather sensitive forecast- Total forecast-Annual and monthly peak load forecast

MODULE 2

Generation system – Reliability analysis-Reliability Concepts- Exponential Distribution mean time to failure-Series and Parallel system – Markov Process- Recursive technique-Generator System reliability analysis-Probability Models for generator unit and loads-Reliability Analysis of isolated and inter connected system – Generator system cost analysis

Transmission system reliability analysis: Transmission system reliability model analysis – Capacity state classification- Average –Interruption rate method – LOLP method

MODULE 3

Generation system cost analysis-Production costing –Fuel inventories-Energy transaction and off-peak loading

MODULE 4

Transmission system Expansion Planning: Tellegen's theorem-Network sensitivity-Network Decision-Problem formulator solution using DC load flow

An overview of distribution system planning

REFERENCES

1. Endreni.J., Reliability modeling in electric power system, John Wiley 1980

2. Roy Billington and Ronald .N. Allan: Reliability evaluation of power systems, Plenum Press 1984

3. Sullivan.R.L, Power system planning, McGraw Hill New York 1977

4. Turen Gonen, Electric power distribution system engineering McGraw Hill New York 1986

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

End semester Examination:100 marks

Question pattern

Answer any 5 questions by choosing at least one question from each module.

Module I

Question 1 : 20 marks

Question 2 : 20 marks

Module II

Question 3 : 20 marks

Question 4: 20 marks

Module III

Question 5 : 20 marks

Question 6: 20 marks

Module IV

Question 7 : 20 marks

Question 8: 20 marks

EPS10 205(B) POWER DISTRIBUTION SYSTEMS

Credits:4

Hours per week: Lecture-3 and Tutorial-1

Objective: To study the load forecasting methods, planning, system economics, automation, protection and maintenance of distribution system.

MODULE 1

Distribution system general concepts: Distribution of power - Quality of supply - Electricity reforms – Electricity Act 2003 - Future distribution systems-area load preliminary survey - Load Forecasting – System planning criteria and standards- System Development-Dispersed generation-Distribution system economics and finance mapping-Enter price resource planning- Load flow in distribution networks - Fault studies - Urban distribution

MODULE 2

Distribution Automation: Project planning communications-sensors-SCADA Systems – Consumer Information Service- Geographical Information Systems –Automatic meter reading –Automation Systems

Optimization of Distribution systems: Introduction-Costing of network schemes-Voltage Loads- Synthesis of optimum line networks-Economic Distribution of Transformers-Worst case loading of distribution Transformers

Grounding systems: Grounding system-Earth and Safety – Nature of electrodes –Earth conductor size –Design of Earthing electrodes

MODULE 3

Overload Conductors and Under Ground cables: Choice of system – optimum design considerations-design and construction of overhead lines and underground systems-Determination of cable ratings-cause of failure- System fault location.

System Over voltages: causes- Lightening- Protection devices-Travelling waves Protection schemes

Rural Supply: rural system- reliability- Faults and Protection – Fault location – Auto reclosures

Power Capacitors: Reactive Power – Series and Shunt capacitors- System harmonics- HT shunt capacitor installation requirements-Size of capacitors for power factor improvement – LT capacitors

MODULE 4

System Protection: Time current characteristics – Fuses- Circuit Breakers –Switching Devices-Protective Relaying- Instrument Transformers- Unit Protection

System Maintenance: Successful maintenance-Failures and maintenance-Porcelain Insulators –Transformer oil maintenance- Transformer drying

Electrical Services for building: Standards -Electrical installations-reception of electric supply-Consumer power supply arrangements-Switch gears

Lighting Schemes: Road lighting-Flood lighting-Automatic fire alarms-Lightning Protection

TEXT BOOK

1. A. S. Pabla, Electric power distribution, Tata Mc Graw-Hill Publishing company Ltd. Fifth Edition, 2004.

REFERENCES

1. Turan Gonen, Electrical Power Distribution Engineering, Tata Mc Graw-Hill Publishing company Ltd, 1986.
2. Colin Bayliss, Transmission and Distribution Electrical Engineering, Butterworth Heinemann, 1996.
3. Electricity Act 2003 and National policies-www.powermin.nic.in

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern

Answer any 5 questions by choosing at least one question from each module.

Module I

Question 1 : 20 marks

Question 2 : 20 marks

Module II

Question 3 : 20 marks

Question 4: 20 marks

Module III

Question 5 : 20 marks

Question 6: 20 marks

Module IV

Question 7 : 20 marks

Question 8: 20 marks

EPS10 205(B) DISTRIBUTED GENERATION **Credits:4**

Hours per week: Lecture-3 and Tutorial-1

Objective: On completion of this course, the students will be able to design and develop different types of distributed power systems and controllers for grid connected induction generators

MODULE 1

Photo-voltaic, Fuel cells and MHD: Basic characteristics of sunlight- solar energy resource-photovoltaic cell – cell efficiency- characteristics- equivalent circuit- photo voltaic for battery charging- charge regulators- PV modules- battery backup-limitations- equipments and systems- types of fuel cells -losses in fuel cells- MHD generators- application of MHD generation.

MODULE 2

Wind Turbines and Embedded generation: Wind Source-wind statistics- energy in the wind- aerodynamics- rotor types – forces developed by blades- aerodynamic models- braking systems-tower- control and monitoring system- power performance- Wind driven induction generators-power circle diagram-steady state performance-modelling-integration issues-impact on central generation-transmission and distribution systems-wind farm electrical design.

MODULE 3

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

MODULE 4

Other Renewable Sources and Bio fuels: Micro- hydel electric systems-power potential -scheme layout-generation efficiency and turbine part flow isolated and parallel operation of generators- geothermal-tidal and OTEC systems-classification of bio fuels-Conversion process- applications.

TEXTBOOKS

1. John F.Walker & Jenkins ,N., ` Wind Energy Technology', John Wiley and sons, Chichester, U.K.,1997.
2. Van Overstraeton R. J and Mertens R P., ` Physics, Technology and use of Photovoltaics', Adem Hilger, Bristol, 1996.
3. Sukhatme,S.P.,`Solar Energy- Principles of Thermal Collection and Storage' Tata Mc-Graw-Hill, New Delhi.
4. S.L.Soo, 'Direct Energy Conversion', Prentice Hall Publication.

REFERENCES:

1. Freries L.L., 'Wind Energy Conversion Systems', Prentice Hall U .K., 1990.
2. Kreith,F., and Kreider,J.F., 'Principles of Solar engineering', Mc-Graw-Hill, Book Co.
3. Imamura M. S.et.al., 'Photo voltaic System Technology, European Hand Book',H S., Stephen and Associate, 1992.
4. James Larminie, Andrew Dicks,Fuel Cell Systems', John Wiley and Sons Ltd .
5. Chapman and E.J.Womack, 'MHD Power Generation Engineering Aspects',Hall Publication.

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern

Answer any 5 questions by choosing at least one question from each module.

Module I

Question 1 : 20 marks

Question 2 : 20 marks

Module II

Question 3 : 20 marks

Question 4: 20 marks

Module III

Question 5 : 20 marks

Question 6: 20 marks

Module IV

Question 7 : 20 marks

Question 8: 20 marks

EPS10 206(P): POWER SYSTEM LAB -II

Credits: 2

Hours per week: 2

Objective: To *develop programs and to familiarize commercially available application software packages in power system field to solve power system problems. Also to enable the student to take measurements and conduct testing related to power system applications.*

1. Develop a program for WLS linear state estimation.
2. Develop a program for WLS Non –linear state estimation
3. Develop a program for DC load flow based WLS Sequential State Estimation.
4. Develop a program for Security constrained OPF using soft computing technique and simulate using application software.
5. Simulate various FACTS devices using application software.
6. Power quality analysis of various loads and UPS systems using Power Quality Analyser.
7. Insulation testing of UG cables.
8. Testing of transformer oil.
9. Model a closed loop buck converter and simulate using any application software.
10. Simulate FFT of three phase 6 pulse inverter using unipolar switching and bipolar switching.
11. Simulate various contingencies in power system.

12. Simulate various unsymmetrical faults in power system using application software.

Out of the above, a minimum of seven experiments are to be conducted.

In addition to the above, the department can offer a few newly developed experiments.

Internal continuous assessment: 100 marks

- **Regularity – 30%**
- **Record – 20%**
- **Test and Viva – 50%**

EPS10 207(P): SEMINAR

Credits: 2

Hours per week: 2

Objective: *To assess the debating capability of the student to present a technical topic. Also to impart training to a student to face audience and present his ideas and thus creating in him self esteem and courage that are essential for an engineer.*

Individual students are required to choose a topic of their interest from power system/ power system related topics preferably from outside the M.Tech syllabus. And give a seminar on that topic about 45 minutes. A committee consisting of at least three faculty members (preferably specialized in power systems) shall assess the presentation of the seminar and award marks to the students based on merits of topic of presentation. Each student shall submit two copies of a write up of his seminar topic. One copy shall be returned to the student after duly certifying it by the chairman of the assessing committee and the other will be kept in the departmental library. Internal continuous assessment marks are awarded based on the relevance of the topic, presentation skill, quality of the report and participation.

Internal continuous assessment: 100 marks

SEMESTER 3

EPS10 301: ELECTIVE 1

EPS10 301(A): SOFT COMPUTING TECHNIQUES

Credits:4

Hours per week: Lecture-3 and Tutorial-1

*Objectiv*e: *To acquaint the students with soft computing methodologies such as neural networks, fuzzy logic, genetic algorithms and hybrid algorithms and enable the students to implement real time intelligent and adaptive systems.*

MODULE 1:

Introduction to Fuzzy logic: Fuzzy sets- Fuzzy set operations- Fuzzy relations-Cardinality of Fuzzy relations-Operations on Fuzzy relations-Properties of Fuzzy relations-Membership Functions-Features of Membership functions- Fuzzification-Methods of Membership value Assignments- Fuzzy Rule Base-Defuzzification-Deffuzzification methods-Fuzzy logic controller(Block Diagram)

MODULE 2:

Artificial Neural Networks: Basic concepts-Neural network Architectures-Single layer feed forward network-Multilayer feed forward network-Recurrent Networks-Characteristics of Neural Networks-Learning methods. Perceptron networks-Back Propagation networks-Radial base function network-Hopfield network- Kohonen Self organizing maps-ART

MODULE 3

Fundamentals of genetic algorithms: Basic concepts- working principle – encoding – different methods – fitness function – reproduction-different methods. Genetic modelling-inheritance- Crossover mutation-convergence of genetic algorithm.

MODULE 4

Hybrid systems: Neural network, fuzzy logic and genetic algorithm hybrids – Neuro fuzzy hybrids- neuro genetic hybrids-Fuzzy genetic hybrids-Genetic algorithm based back propogation network- Fuzzy back propagation networks -fuzzy logic controlled genetic algorithms.

Specific Power System applications are to be covered along with the respective modules.

REFERENCES

1. S.Rajasekharan, G.A.Vijayalakshmi Pai, Neural Network, Fuzzy Logic and Genetic Algorithms Synthesis and Applications, Prentice Hall India.
9. S.N.Sivanandam, S.N.Deepa, Principles of Soft Computing, Wiley India.
10. Timothy J Ross, Fuzzy logic with Engineering Applications, Mc Graw Hill ,New York.
11. S.Haykins, Neural Networks a Comprehensive foundation,Pearson Education.
12. D.E.Goldberg, Genetic Algorithms in Search Optimisation and Machine Learning, Pearson Education.
13. Recent Literature.

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern

Answer any 5 questions by choosing at least one question from each module.

Module I

Question 1 : 20 marks

Question 2 : 20 marks

Module II

Question 3 : 20 marks

Question 4: 20 marks

Module III

Question 5 : 20 marks

Question 6: 20 marks

Module IV

Question 7 : 20 marks

Question 8: 20 marks

EPS10 301(B): RESEARCH METHODOLOGY

Credits:4

Hours per week: Lecture-3 and Tutorial-1

Objective: To impart knowledge about various methodologies followed in engineering research, formulation of research problems and to apply the same in project work. To make students aware of the problems faced by Indian researchers.

MODULE 1

Research Concepts – concepts – meaning – objectives – motivation. Types of research – descriptive research – conceptual research – theoretical research – applied research – experimental research. Research process – Criteria for good research – Problems encountered by Indian researchers.

MODULE 2

Formulation of Research Task – Literature Review – Importance & Methods – Sources – Quantification of Cause Effect Relations – Discussions – Field Study – Critical Analysis of Generated Facts – Hypothetical proposals for future development and testing, selection of Research task

MODULE 3

Mathematical modelling and simulation – Concepts of modelling – Classification of mathematical models – Modelling with – Ordinary differential equations – Difference equations – Partial differential equations – Graphs – Simulation – Process of formulation of model based on simulation.

MODULE 4

Interpretation and report writing – Techniques of interpretation – Precautions in interpretation – Significance of report writing – Different steps in report writing – Layout of research report – Mechanics of writing research report – Layout and format – Style of writing – Typing – References – Tables – Figures – Conclusion – Appendices.

REFERENCES

1. J.W Bames, Statistical Analysis for Engineers and Scientists, McGraw Hill, N.York
2. Schank Fr., Theories of Engineering Experiments, Tata Mc Graw Hill Publication.
3. C. R. Kothari, Research Methodology, New Age Publishers.
4. Willktnsion K. L, Bhandarkar P. L, Formulation of Hypothesis, Himalaya Publication.

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

End semester Examination:100 marks

Question pattern

Answer any 5 questions by choosing at least one question from each module.

Module I

Question 1 : 20 marks

Question 2 : 20 marks

Module II

Question 3 : 20 marks

Question 4: 20 marks

Module III

Question 5 : 20 marks

Question 6: 20 marks

Module IV

Question 7 : 20 marks

Question 8: 20 marks

EPS10 301(C): ENERGY AUDITING CONSERVATION AND MANAGEMENT

Credits:4

Hours per week: Lecture-3 and Tutorial-1

Objective: *Understanding, analysis and application of electrical energy management measurement and accounting techniques – consumption patterns – conservation methods-application in industrial cases.*

MODULE 1

Energy Auditing and Economics

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

MODULE 2

Energy efficient motors and transformers

Electric motors-Energy efficient controls- Motor Efficiency and Load Analysis-Energy efficient/high efficient Motors –Case study. Load Matching and selection of motors. Variable speed drives -Pumps and Fans- Efficient Control strategies- Optimal selection and sizing – Optimal operation and Storage.Tranformer Loading /Efficiency analysis, Feeder /cable Loss evaluation- Case study

MODULE 3

Reactive Power Management and Lighting

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

MODULE 4

Cogeneration and conservation in industries

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

REFERENCES

1. Giovanni Petrecca,Industrial Energy Management :Principles and Application,The Kluwer international series-207,(1999)

2. Anthony J.Pansini,Kenneth .D. Smalling ,Guide to Electric Load Management , Pennwell Pub;(1998)

3. Howard .E.Jordan.Energy – Efficient Electric Motors and Their Applications ,Pleneum Pub Corp.2nd edition(1994)

4. Turner ,Wayne C ,Energy Management /Handbook,Lilburn,The Fairmont Press,2001.

5. Albert Thumann ,Handbook of Energy Audits,Fairmont Press 5th Edition (1998)

6. IEEE Bronze book –Recommended Practice for Energy Conservation and Cost effective Planning in Industrial Facilities ,IEEE Inc ,USA

7. Albert Thumann P.W, Plant engineers and Managers Guide to Energy Conservation -7th Edition –TWI Press Inc Terre Haute.

8. Donald R W, Energy efficiency Manual, Energy Institute Press

9. Partab H' Art and Science of Utilisation of Electrical Energy' Dhanpat Rai and Sons ,Newdelhi

10. Tripathy S.C 'Electrical Energy Utilisation and Conservation' Tata Mcgrwaw Hill

11. NESCAP- Guide Book on Promotion of Sustainable Energy Consumption

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

End semester Examination:100 marks

Question pattern

Answer any 5 questions by choosing at least one question from each module.

Module I

Question 1 : 20 marks

Question 2 : 20 marks

Module II

Question 3 : 20 marks

Question 4: 20 marks

Module III

Question 5 : 20 marks

Question 6: 20 marks

Module IV

Question 7 : 20 marks

Question 8: 20 marks

EPS10 302: ELECTIVE 2

EPS10 302(A): COMPUTER NETWORKING **Credits:4**

Hours per week: Lecture-3 and Tutorial-1

Objective: To impart knowledge about techniques and terminologies regarding computer networking so that power engineering students can apply them in applications like distributed computing, parallel computing, SCADA, WAPS, WAM etc

MODULE 1

General: Structure of networks and the internet, circuit, packet and message switching, routing, physical media, types of delay, internet protocol stack, internet backbone, NAPs (Network Access Points) and ISPs

Application Layer: Structure of networking applications, Web and Web caching, FTP (File Transfer Protocol), Electronic mail, DNS (Domain Name Service), socket programming

MODULE 2

Transport layer: Transport layer principles, multiplexing and demultiplexing, UDP (User Datagram Protocol), principles of reliable data transport, TCP (Transmission Control Protocol), flow control, principles of congestion control, TCP congestion control

MODULE 3

Network Layer: Network layer services, datagram and virtual circuits, routing principles, link state routing algorithms, distance vector routing algorithms, hierarchical routing, Internet Protocol (IP), IP addressing, IP transport, fragmentation and assembly, ICMP (Internet Control Message Protocol), routing on the internet, RIP (Routing Information Protocol), OSPF (Open Shortest Path First), router internals, IPv6

MODULE 4

Link Layer: Link layer services, error detection and correction, multiple access protocols, LAN addressing and ARP (Address Resolution Protocol), Ethernet, CSMA/CD multiple access protocol, Hubs, Bridges, and Switches, Wireless LANs, PPP (Point to Point Protocol), Wide area protocols

Selected topics from multimedia networking, network security and real-life networks.

REFERENCES

1. Computer Networking, A top down approach. James F. Kurose and Keith W. Ross, Addison Wesley, 2003.

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern

Answer any 5 questions by choosing at least one question from each module.

Module I

Question 1 : 20 marks

Question 2 : 20 marks

Module II

Question 3 : 20 marks

Question 4: 20 marks

Module III

Question 5 : 20 marks

Question 6: 20 marks

Module IV

Question 7 : 20 marks

Question 8: 20 marks

EPS10 302(B): POWER SYSTEM ECONOMICS

Credits:4

Hours per week: Lecture-3 and Tutorial-1

Objectives:

1. *To impart basic knowledge of the power system restructuring, market structure, relation between demand and supply costs and Electricity price*
2. *To give basic ideas of factors affecting the electricity price in the restructured market and generation capacity evaluation.*
3. *To provide basic concepts and an overview of transmission price and distributed generation in restructured markets*
4. *To give ideas of reactive power requirements under voltage stability studies, impact of reactive power in power tariff and the requirements of the utilities.*

MODULE 1

Power system restructuring: - Introduction, Market Structure and operation:- Objective of market operation, Electricity market models, Power market types, Market power, Key components in market operation. Demand and supply, Demand analysis - theory of demand, Elasticity of demand, Demand forecasting types- techniques of forecasting.
Costs: short run –long run- relation ship between short run and long run costs, perfect competition-Monopoly- Monopolistic and Oligopolistic, Determination of market price, Price discrimination.

MODULE 2

Electricity price: price volatility, ancillary services in electricity power market, automatic generation control and its pricing, Generation assets valuation and risk analysis.- introduction, Va R for Generation Asset Valuation, Generation Capacity Valuation

MODULE 3

Transmission Congestion Management and Pricing- transmission cost allocation methods, LMP, FTR and Congestion Management. Role of FACTS devices in competitive power market**,** Available Transfer Capability, Distributed Generation in restructured markets,

MODULE 4

Reactive power requirements under steady state voltage stability and dynamic voltage stability, reactive power requirements to cover transient voltage stability, System losses and loss reduction methods, Power tariffs and Market Forces shaping of reactive power, reactive power requirement of the utilities.

REFERENCES

1. Maket Operations in Electric Power Systems (IEEE)- Mohammad Shahidehpour,Hatim Yamin, Zuyi Li ,A John Wiley & Sons, Inc., Publications
2. Understanding electric utilities and de-regulation, Lorrin Philipson, H. Lee Willis, Marcel Dekker Pub., 1998.
3. Power system economics: designing markets for electricity Steven Stoft, John Wiley & Sons, 2002.
4. Operation of restructured power systems. Kankar Bhattacharya, Jaap E. Daadler, Math H.J. Boolen, Kluwer Academic Pub., 2001.
5. Restructured electrical power systems: operation, trading and volatility Mohammad Shahidehpour, Muwaffaq Alomoush, Marcel Dekker Pub., 2001.

6. W. H. J. R. Dunn, M. A. Rossi, B. Avaramovic: Impact of market restructuring on power systems operation, IEEE computer Applications on Power Engineering, vol. 8, January 1995, pp 42–47.
7. M. A. Olson, S. J. Rassenti, V. L. Smith: Market design and motivated human trading behaviors in electricity markets, in Proceedings of 34th Hawaii International Conference Systems Science, Hawaii, January 5–8, 1999
8. X. Guan, P. B. Luh: Integrated resource scheduling and bidding in the deregulated electric power market: New challenges, Special Issue J. Discrete Event Dynamical Systems, Vol. 9, No. 4, 1999, pp 331–350.
9. Turner,Wayne.C., Energy Management Hand Book.,2nd Edition
10. Industrial Economics-an Introductory text book.. RR Barathwal- Professor IIT Kanpur
11. Micro Economics-Theory and Application by Aninydya Senpplied economics for Engineers and Managers by S.K.Jain – Vikas Publishing House.
12. Series on Electrical Power capacitors Reactive power Management, D.M.Tagare, Madhav Electricals, Pune, Tata McGraw Hill Publishing Company Ltd

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern

Answer any 5 questions by choosing at least one question from each module.

Module I

Question 1 : 20 marks

Question 2 : 20 marks

Module II

Question 3 : 20 marks

Question 4: 20 marks

Module III

Question 5 : 20 marks

Question 6: 20 marks

Module IV

Question 7 : 20 marks

Question 8: 20 marks

EPS10 302(C): POWER SYSTEM MONITORING **Credits:4**

AND SCADA SYSTEMS

Hours per week: Lecture-3 and Tutorial-1

Objectives: *T o acquaint the students with SCADA nomenclature, architecture, substation automation, wide area protection(WAPS) and to understand when a SCADA system would be beneficial to a System*

MODULE1

Introduction to SCADA: Data acquisition Systems- Evolution of SCADA - Communication Technologies-Monitoring and Supervisory Functions-SCADA Applications in Utility Automation-Industries.

MODULE 2

SCADA Systems Components: Schemes – Remote Terminal Unit(RTU)-Intelligent Electronic Devices(IED)-Programmable Logic Controller(PLC)- Communication Network-SCADA server, SCADA/ HMI Systems

MODULE 3

SCADA Architecture: Various SCADA Architectures- Advantages and Disadvantages of each system-single unified standard architecture- IEC 61850

SCADA Communication: Various industrial communication technologies- wired and wireless methods and fibre optics

MODULE 4

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

Introduction to role of wide area protection- power system phenomenon with possible WAPS solution- Implementation of wide area protection- interaction of WAPS with SCADA System

REFERENCE

1. Stuart.A. Boyer: SCADA – Supervisory Control and Data Acquisition, Instrument Society of America Publication, USA, 1999.

2. Gordon Clarke, Deon Reynders: Practical Modern SCADA Protocol:DNP3, 60870.5 and Related Systems, Newnes Publications, Oxford UK,2004

3. ABB –Substation automation handbook

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced to students' right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern

Answer any 5 questions by choosing at least one question from each module.

Module I

Question 1 : 20 marks

Question 2 : 20 marks

Module II

Question 3 : 20 marks

Question 4: 20 marks

Module III

Question 5 : 20 marks

Question 6: 20 marks

Module IV

Question 7 : 20 marks

Question 8: 20 marks

EPS10 303(P): INDUSTRIAL TRAINING **Credits: 1**

Hours per week -30 (during the period of training)

Objective: To enable the student to correlate theory and industrial practice.

The students have to arrange and undergo an industrial training of minimum two weeks in an industry preferably dealing with power generation /transmission/distribution during the semester break after semester 2 and complete within 15 calendar days from the start of semester 3.The students are requested to submit a report of the training undergone and present the contents of the report before the evaluation committee. Evaluation committee will award the marks of end semester

Examination based on training quality, contents of the report and presentation.

End semester Examination: Marks 50

EPS10 304(P): MASTER RESEARCH PROJECT PHASE 1

Credits: 6

Hours per week: 22

Objective:

To improve the professional competency and research aptitude by touching the areas which otherwise not covered by theory or laboratory classes. The project work aims to develop the work practice in students to apply theoretical and practical tools/techniques to solve real life problems related to industry and current research.

The project work can be a design project/experimental project and/or computer simulation project on any of the topics in power system or power system related topics. The project work is allotted individually on different topics. The students shall be encouraged to do their project work in the parent institute itself. If found essential, they may be permitted to continue their project outside the parent institute, subject to the conditions in clause 10 of MTech regulations. Department will constitute an Evaluation Committee to review the project work. The Evaluation committee consists of at least three faculty members of which internal guide and another expert in the specified area of the project shall be two essential members.

The student is required to undertake the master research project phase 1 during the third semester and the same is continued in the 4thsemester (Phase 2). Phase 1 consist of preliminary thesis work, two reviews of the work and the submission of preliminary report. First review would highlight the topic, objectives, methodology and expected results. Second review evaluates the progress of the work, preliminary report and scope of the work which is to be completed in the 4th semester. The Evaluation committee consists of at least three faculty members of which internal guide and another expert in the specified area of the project shall be two essential members.

Internal Continuous assessment:

	Guide	Evaluation Committee
First Review	**50**	**50**
Second Review	**100**	**100**
Total	**150**	**150**

SEMESTER 4

EPS10 401: MASTERS RESEARCH PROJECT PHASE 2

Credits: 12

Hours per week: 30

Objective:

To improve the professional competency and research aptitude by touching the areas which otherwise not covered by theory or laboratory classes. The project work aims to develop the work practice in students to apply theoretical and practical tools/techniques to solve real life problems related to industry and current research.

Master Research project phase 2 is a continuation of project phase 1 started in the third semester. There would be two reviews in the fourth semester, one in the middle of the semester and at the end of the semester. First review is to evaluate the progress of the work, presentation and discussion. Second review would be a pre-submission presentation before the evaluation committee to assess the quality and quantum of the work done. This would be a pre qualifying exercise for the students for getting approval by the departmental committee for the submission of the thesis. At least one technical paper is to be prepared for possible publication in journal or conferences. The technical paper is to be submitted along with the thesis. The final evaluation of the project will be external evaluation.

Internal Continuos assessment:

	Guide	Evaluation Committee
First Review	**50**	**50**
Second Review	**100**	**100**
Total	**150**	**150**

End Semester Examination:

Project Evaluation by external examiner: 150 marks
Viva Voce by external / internal examiner: 150 marks