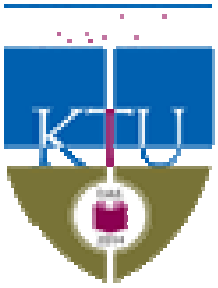
KERALA TECHNOLOGICAL UNIVERSITY



(THRISSUR CLUSTER - 07)

SCHEME AND SYLLABI

of

M. TECH.

in

POWER SYSTEMS

OFFERING DEPARTMENT

ELECTRICAL & ELECTRONICS ENGINEERING

CLUSTER LEVEL GRADUATE PROGRAM COMMITTEE

1.	Dr Devdas Menon, Professor, IIT Madras	Chairman
2	Principal, Government Engineering College Thrissur	Convener
3	Principal, AXIS College of Engineering & Technology, East Kodaly, Murikkingal, Thrissur	Member
4	Principal, IES College of Engineering, Chittilapally, Thrissur	Member
5	Principal, MET'S School of Engineering, Mala, Thrissur	Member
6	Principal, Royal College of Engineering & Technology, Akkikkavu, Thrissur	Member
7	Principal, Vidya academy of Science & Technology, Thalakkottukara, Thrissur	Member
8	Principal, Thejus Engineering College, Vellarakkad, Erumappetty, Thrissur	Member
9	Principal, Universal Engineering College, Vallivattom, Konathakunnu , Thrissur	Member
10	Principal, Sahrdaya College of Engineering & Technology, Kodakara, Thrissur	Member

CERTIFICATE

This is to certify that

1. The scheme and syllabi are prepared in accordance with the regulation and guidelines issued by the KTU from time to time and also as per the decisions made in the CGPC meetings.
2. The suggestions/modifications suggested while presenting the scheme and syllabi before CGPC on 25.6.2015 has been incorporated.
3. There is no discrepancy among the soft copy in MS word format, PDF and hard copy of the syllabi submitted to the CGPC.
4. The document has been verified by all the constituent colleges.

Coordinator in charge of syllabus revision of the programme

Dr.REJI P
Associate Professor
Dept. of Electrical & Electronics
Government Engineering College
Thrissur

Principal of the lead college

Dr K P INDIRADEVI
Government Engineering College
Thrissur

Principals of the colleges in which the programme is offered

No	Name of the college	Principal's Name	Signature
1	Government Engineering College Thrissur		
2	Thejus Engineering College, Vellarakkad, Erumappetty, Thrissur		

Date: Chairman
Place:

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

1) To mould the students with global standards, for successful career in power related areas, that meets the needs of Indian as well as Multinational Companies.
2) To impart knowledge in the effective use of modern problem solving and design methodologies and make them good researchers.
3) To produce innovative engineers who can hold leadership responsibilities and establish their own enterprises.
4) To promote students' awareness of lifelong learning and to introduce them to professional ethics and codes of professional practice.

PROGRAM OUTCOMES (POs)

A. To attain an appropriate mastery of the knowledge, techniques, skills and modern tools of the discipline.

B. To be able to apply current knowledge and adapt emerging applications of mathematics, science, engineering and technology

C. Initiate further research by making use of the mathematical theories in power engineering.

D. Attain the ability for building, testing, operation and maintenance of power systems.

E To analyse the various existing systems and suggest improvements to have more economical and energy efficient systems.

F Generate new innovative ideas in the Electrical power system field.

G To improve the communication and confidence level.

H To find new methods to improve power quality which is a great issue in the present scenario

I Understanding of the social, cultural, global and environmental responsibilities and ethics of a professional engineer and the need for sustainable development.

J Recognising the need to undertake lifelong learning and acquiring the capacity to do so.

SCHEME OF M .TECH. PROGRAMME IN POWER SYSTEMS

SEMESTER-1

Exam slot.	Course code	Subject	Hours/week			ICA	ESE	Total	Credits
			L	T	P				
A	07MA 6019	Applied Mathematics	3	1	0	40	60	100	4
B	07EE 62 01	System Dynamics	3	1	0	40	60	100	4
C	07 EE 62 03	Computer Applications in Power System	3	1	0	40	60	100	4
D	07EE 62 05	Analysis of Power Electronics circuit	3	0	0	40	60	100	3
E	07EE 6xxx	Elective I	3	0	0	50	50	100	3
	07GN 60 01	Research Methodology	0	2	0	100	-	100	2
	07 EE 62 09	Power System Lab I	0	0	2	100		100	1
	07 EE 62 11	Introduction to Seminar	0	0	1	0	0	0	0
TOTAL			15	5	3	410	290	700	21

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

Elective I

07 EE 62 07 Optimization Techniques

07 EE 62 17 High Voltage A C & D C Transmission

07 EE 62 27 Advanced Signal Processing

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

SEMESTER-2

Exam slot..	Course code	Subject	Hours/week			ICA	ESE	Total	Credits
			L	T	P				
A	07 EE 62 02	Advanced Power System protection	3	1	0	40	60	100	4
B	07 EE 62 04	Power System Dynamics	3	0	0	40	60	100	3
C	07 EE 62 06	Power System Operation and Control	3	0	0	40	60	100	3
D	07 EE 62 xx	Elective II	3	0	0	40	60	100	3
E	07 EE 62 xx	Elective III	3	0	0	40	60	100	3
	07 EE 62 14	Mini Project	0	0	2	100	-	100	2
	07 EE 62 16	Power system Lab-2	0	0	2	100	-	100	1
	07 EE 62 24	Seminar	0	0	2	100	-	100	2
TOTAL			15	1	6	500	300	800	21

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

Elective II

07 EE 62 08 Flexible AC Transmission Systems

07 EE 62 18 Power System Transients

07 EE 62 28 Power Distribution System

Elective III

07 EE 62 12 Power system Planning &Reliability

07 EE 62 22 Energy auditing and Management

07 EE 62 32 Distributed Generation and Smart Grid

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

SEMESTER-3

Exam slot.	Course code	Subject	Hours/week			ICA	ESE	Total	Credits
			L	T	P				
A	07 EE 72 xx	Elective - IV	3	0	0	40	60	100	3
B	07 EE 72 xx	Elective-V	3	0	0	40	60	100	3
	07 EE 72 05	Seminar	0	0	2	100	-	100	2
	07 EE 72 07	Project (Phase 1)	0	0	12	50	-	50	6
E			6	0	10	230	120	350	14

Elective IV

07 EE 72 01 Power System Security

07 EE 72 11 Power Quality

07 EE 72 21 Power System Monitoring and SCADA System

Elective V

07 EE 72 03 Power System Deregulation and Economics

07 EE 72 13 Soft Computing Techniques

07 EE 72 23 Automation and Instrumentation for Power Systems

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

SEMESTER-4

Exam slot	Course code	Subject	Hours/week			ICA	ESE	Total	Credits
			L	T	P				
1	07 EE 72 02	Project (Phase 2)	0	0	21	70	30	100	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: 68

SEMESTER 1

Course No.: 07MA 6019 COURSE TITLE: APPLIED MATHEMATICS

Credits: 3-1-0: 4 Year: 2015

Pre-requisites: A basic understanding of matrices and probability

Course Objectives:

To familiarize the students with the ideas and notions of eigen value problems, principle of least squares, geometry of Fourier series, wavelets, development of probability distributions and probability theory, aspects of inferential statistics, reliability modelling, stationary stochastic processes, discrete time Markov chains and its stationary distributions etc.

Syllabus:

Solution of system of linear equations, Eigen value problems in engineering, method of least squares, geometry of Fourier series, discrete wavelet transform, probability distributions, conditional probability, CLT, linear regression and correlation, statistical inference, reliability, stationary processes and Markov chains.

Course outcome:

These concepts will help the students to appreciate (*i*) matrix methods in engineering, structure of vector spaces applied to wavelets which is a tool in signal and image processing and (ii) probabilistic and statistical methods to understand and analyze uncertainty.

Text Books.

1. Datta, B N (2010), *Numerical Linear Algebra and Applications*, 2nd Edition, PHI Learning Pvt. Ltd., Delhi. (for Module 1).
2. Gubner J A (2006), *Probability and Random Processes for Electrical and Computer Engineers*, Cambridge University Press, Cambridge, New York. (for Modules 3 & 4).
3. Johnson, R A (2008), Miller & Freud's *Probability and statistics in Engineering,* 7th Edition, Pearson, Delhi. (for Modules 3, 4 & 5).
4. Medhi, J (2009), *Stochastic Processes*, 3rd Edn., New Age International (P) Ltd., New Delhi. (for Module 6).
5. Soman K P, Ramachandran, K I and Resmi N G (2013), *Insight into Wavelets, from Theory to Practice*, 3rd Edn., PHI Learning, Delhi. (for Module 2).
6. Kreyszig, E (1999/ 2007), *Advanced Engineering Mathematics*, 8th Edn, Wiley India Pvt. Ltd., Delhi. (for Module 1).

COURSE PLAN			
Course No	**Course Title**	**(L-T-P): Credits**	Year
07MA 6019	**APPLIED MATHEMATICS**	**(3-1-0): 4**	**2015**

MODULES	**Contact hours**	**Sem.Exam Marks;%**
MODULE : 1 **Matrices and Least squares** Solution of system of linear equations using LU factorization, Gauss-Siedel methods, Eigen value problems in engineering,Method of least squares Fitting a straight line and a second degree curve	8	15
MODULE : 2 **Discrete wavelet transform ,**Fourier series and geometry Discrete wavelet transform, Haar scaling function and wavelet function and their orthogonality, Haar bases	8	15
FIRST INTERNAL TEST		
MODULE : 3 **Probability distributions** ,Binomial and Poisson, Uniform, exponential, gamma and Weibull, Normal distributions	8	15
MODULE : 4 **Probability-**Conditional probability, Bayes' theorem, independence Lindeberg-Levy central limit theorem,Sampling distributions (*t*, $\chi 2$ and *F*),Linear regression and correlation	8	15
SECOND INTERNAL TEST		
MODULE : 5 **Statistics and Reliability** -unbiased estimators of mean and variance, Tests for mean and variance, Interval estimation of mean and variance, Reliability of series and parallel systems, failure time distributions, Exponential and Weibull models in reliability and life testing.	12	20
MODULE : 6 **Stochastic processes-** Specification/ classification of processes Strict and wide sense stationary processes, Discrete time Markov chains, higher transition probabilities, Communication classes, irreducible chains ,Classification of states, regular chains Stationary (invariant) distributions	12	20

Internal Continuous Assessment: 40%-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.

Periodical Test 1 – 15%

Periodical Test 2 – 15%

Assignments/Term Paper/Seminar – 10%

End Semester Examination: 60 %

COURSE NO.: 07 EE 6201 COURSE TITLE: SYSTEM DYNAMICS

Credits: 3-1-0: 4 Year: 2015

Pre-requisites: Fundamental knowledge of Control system

Course Objectives:

To study the analysis of systems using state space model

To understand the concept of stability

To familiarize the optimal control problem

To familiarize robust control systems

Syllabus

State variable representation of systems - Equilibrium points – Stability - Solution of state equation - eigen values and eigen vectors – modes - modal decomposition - mode shape

State space representation of discrete time systems - Discretization of continuous time state equation. Case studies . Lyapunov stability - Lyapunov's stability analysis of LTI continuous time and discrete time systems - Stability analysis of non-linear systems-Krasovski's theorem -variable gradient method.Concepts of controllability and observability - controllability and observability tests for continuous time and discrete time systems - 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. Optimal control - formulation of optimal control problem - 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

.

Course Outcome: On completion of the course, the students will be able to

- Analyze the dynamics of a linear continuous/discrete system by developing state models.
- Investigate the stability of linear/nonlinear systems.
- Design state feedback controllers and state observers for continuous and discrete systems.
- Design an optimal control system.
- Design a robust control system.

.

REFERENCES

1. Thomas Kailath, "*Linear systems"*, Prentice Hall Inc
2. K.Ogata, "*Modern Control Engineering"* (Second Edition), Prentice Hall Inc, 1990
3. K.Ogata, "*Discrete-time Control Systems"*, PHI
4. M.Gopal, "*Digital Control and State Variable Methods"*, TMH, 1997
5. M.Gopal, "*Modern Control System Theory",* New Age International, 1993
6. P.Kundur, "*Power System Stability and Control"*, McGraw-Hill Publishing Company, 1994
7. C.T.Chen, "*Linear System Theory and Design"*, Holt Rinechart and Winston, 1984
8. Richard.C.Dorf and R.T Bishop, "*Modern Control System",* PHI

COURSE PLAN		
Course Title	**(L-T-P) :Credits**	Year
SYSTEM DYNAMICS	**(3-1-0) :4**	**2015**

MODULES	Contact Hours	Sem.Exam Marks
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 .	8	15
MODULE 2 State space representation of discrete time systems - Discretization of continuous time state equation.Case study- Development of discrete state model for a simple Power Electronics and Power system application.	8	15
FIRST INTERNAL EXAM		
MODULE 3 Lyapunov stability - definition of stability, asymptotic stability and instability - Lyapunov's second method - Lyapunov's stability analysis of LTI continuous time and discrete time systems - stability analysis of non-linear system - Krasovski's theorem - variable gradient method.	8	15
MODULE 4 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.Combined state feedback controller and observer.	10	15
SECOND INTERNAL EXAM		
MODULE 5 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.	10	20
MODULE 6 Robust control systems – introduction - sensitivity analysis of robustness - system with uncertain parameters - design of robust PID controlled systems – MATLAB Exercises	10	20

Internal Continuous Assessment: 40%

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.

Periodical Test 1 – 15%
Periodical Test 2 – 15%
Assignments/Term Paper/Seminar – 10%

End Semester Examination: 60%

COURSE NO.: 07 EE 6203 COURSE TITLE: COMPUTER APPLICATIONS IN POWER SYSTEMS

Credits: 3-1-0: 4 Year :2015

Pre-requisites: Nil

A basic knowledge on the subjects viz., Power System analysis, Matrix manipulations, Alternating machines and network analysis

Course Objectives:

To perform steady state analysis and fault studies for a power system of any size
To explore the nuances of estimation of different states of a power system.

Syllabus

Basic concepts of linear system, Network modelling, Y bus formulation, Z bus formulation, AC & DC analysis Power flow, sparsity oriented programming. L-u factorisation, and optimal ordering, 3-Φ AC Load flow analysis, 3-Φ AC-DC Load flow, Sparsity directed optimal ordering schemes, Short circuit analysis of a multi node system using bus impedance matrix, development of voltage and current equations under asymmetrical fault using symmetrical components. System optimization ,strategy for two generator systems, generalized strategies, Formulation of optimal power flow, Need of real time and computer control of power system, Energy Management Centres.

Course Outcome:

On completion of the course, the students will be able to investigate the state of a power system of any size and be in a position to analyze a practical system both under steady state and fault conditions. Also the students would be able to determine the operating condition of a system according to the demand without violating the technical and economic constraints.

Text Books

1. J Arrillaga and N R Watson Computer Modelling of Electric Power Systems: -, John Wiley and sons,2001
2. G W Stagg , A.H El. Abiad “Computer Methods in Power System Analysis”, McGraw Hill, 1968.
3. M.A.Pai,” Computer Techniques in Power System Analysis”,Tata McGraw Hill Publishing Company Limited, New Delhi, 2006

References

1. John J Grainger and William D Stevenson Jr: -Power System Analysis, McGraw Hill
2. A.J.Wood and B.F.Wollenberg,“Power Generation Operation and Control”, John Wiley and sons, New York, 1996.
3. W.F.Tinney and W.S.Meyer, “Solution of Large Sparse System by Ordered Triangular Factorization” IEEE Trans. on Automatic Control, Vol :8, pp:333-346, Aug 1973.
4. ..P.Kundur Power System Stability and Control: — McGraw Hill publications

COURSE PLAN			
Course No	**Course Title**	**(L-T-P): Credits**	**Year**
07 EE6203	**COMPUTER APPLICATIONS IN POWER SYSTEMS**	**(3-1-0) : 4**	**2015**

MODULES	Contact hours	Sem.Exam Marks;%
MODULE : 1 Basic concepts of linear system, Network modelling, Impedance and Admittance representation, Y bus formulation, Z bus formulation, Z bus buildup algorithm, Z bus formulation with mutual inductance	10	15
MODULE : 2 Power flow analysis – Gauss Siedel method – Newton Raphson method – DLF and FDLF method, DC Load flow, 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	10	15
FIRST INTERNAL TEST		
MODULE : 3 Sparsity directed Optimal Ordering Schemes, Solution Algorithms - LU Factorization, Bifactorization and Iterative Methods	5	15
MODULE : 4 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.	11	15
SECOND INTERNAL TEST		
MODULE : 5 System optimization -strategy for two generator systems -– generalized strategies -effect of transmission losses -Sensitivity of the objective function-Formulation of optimal power flow- solution by Gradient method-Newton's method.	10	20
MODULE : 6 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.	8	20

Internal Continuous Asse Internal Continuous Assessment: 40%

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.

Periodical Test 1 – 15%
Periodical Test 2 – 15%
Assignments/Term Paper/Seminar – 10%

End Semester Examination: 60%

Course No: 07 EE 6205 COURSE TITLE : ANALYSIS OF POWER ELECTRONICS CIRCUITS

Credits: 3-0-0: 3 Year :2015

Pre-requisites: Nil

Course Objectives:

To provide fundamental concepts of various power electronic converters and its detailed analysis

Syllabus

Review of Power Devices, Controlled rectifiers – single-phase half-wave converter full converter – semi converter, continuous & discontinuous conduction, inversion mode- continuous conduction only, single-phase dual converters DC-DC converters – Step-down chopper – step- up chopper - two-quadrant & four-quadrant chopper. Inverters – 1-phase half bridge and full bridge ,voltage control of inverters , PWM techniques —bipolar & unipolar voltage switching , AC voltage controllers – ON-OFF control – phase angle control – 1-phase full wave –integral cycle control - two stage sequence control with R load , Cycloconverter – single-phase to single-phase cyclo converter ,3-phase 3-pulse cycloconverter .

Course Outcome:

On completion of the course, the students will be able to analyze different power devices in power electronics circuits and its applications in power electronic converters

References

1 Ned Mohan, Undeland, Robbins, *Power Electronics Converters, Applications and Design*, John Wiley
2 M.H. Rashid, *Power Electronics Circuits, Design and Applications*, Pearson Education
3 Cyril W Lander, *Power Electronics*, McGraw Hill
4 M.D. Singh, K.B. Khanchandani, *Power Electronics*, Tata McGraw-Hill
5 Daniel W Hart, *Introduction to Power Electronics*, Prentice-Hall
6 Joseph Vithayathil , *Principles of Power Electronics*, Mc-Graw Hill
7 William Shepherd, Li Zhang, *Power Converter Circuits*, Marcell Dekker Inc

COURSE PLAN			
Course No	**Course Title**	**(L-T-P) : Credits**	Year
07 EE6205	**ANALYSIS OF POWER ELECTRONICS CIRCUITS**	**(3-0-0):3**	**2015**

MODULES	Contact hours	Sem.Exam Marks;%
MODULE : 1 **Review of Power Devices –** characteristics of Ideal and practical switches – Power diodes – reverse recovery characteristics - power transistors – power MOSFET – IGBT – Thyristor – GTO – switching characteristics – inductive load – switching losses – gate drive circuit - di/dt and dv/dt protection	7	15
MODULE : 2 **Controlled rectifiers** – single-phase half-wave converter full converter – semiconverter - analysis with RL & RLE loads – continuous & discontinuous conduction - input PF with continous and ripple free load current inversion mode , 3-phase - half-wave , full converter & semiconverter – analysis with RLE loads – continuous conduction only – inversion mode - single-phase dual converters – circulating & non circulating current operation	7	15
FIRST INTERNAL TEST		
MODULE : 3 **DC-DC converters** – Step-down chopper – step- up chopper - analysis with RL & RLE load – time ratio control – current limit control – two-quadrant & four-quadrant chopper	5	15
MODULE : 4 **Inverters –** 1-phase half bridge and full bridge – Anlysis with RL load - THD– 3-phase inverter – 180° mode –analysis with RL load –voltage control of inverters - PWM techniques – single pulse, sinusoidal pulse width modulation – linear & over modulation - bipolar & unipolar voltage switching	7	15
SECOND INTERNAL TEST		
MODULE : 5 **AC voltage controllers** – ON-OFF control – phase angle control – 1-phase full wave – analysis with R, L, RL load – input PF – integral cycle control - two stage sequence control with R	8	20
MODULE : 6 **Cycloconverter** – single-phase to single-phase cycloconverter with R & RL load - 3-phase 3-pulse cycloconverter – circulating current mode operation – circulating current-free mode operation.	8	20

Internal Continuous Assessment: 40%: 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.

Periodical Test 1 – 15%
Periodical Test 2 – 15%
Assignments/Term Paper/Seminar – 10%

End Semester Examination: 60%

Course No:07 EE 6207 Course Title: OPTIMISATION TECHNIQUES

Credits: 3-0-0:3 Year :2015

Pre-requisites: Nil

Course Objectives:

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

Syllabus

Linear programming: overview of optimization techniques -Definitions and theorems-Simplex method-Revised simplex method-Duality and Dual simplex method-Sensitivity analysis. Unconstrained dimensional optimization techniques: Necessary and sufficient conditions-search methods(unrestricted Fibonacci and golden)-Direct search methods-Descent methods-Steepest descent - Constrained optimization techniques & dynamic programming: Equality and inequality constraints-Kuhn-Tacker conditions-Gradient projection method-cutting plane method-.Principle of optimality-recurrence relation-Computation procedure-continuous dynamic programming. Recent developments in optimization techniques.

Course Outcome:

After successful completion of this course the students should be able to apply linear programming methods to engineering problems, distinguish between constrain and non-constrain optimisation and know the principle of dynamic programming

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
8. Rao S.S, *Optimisation:Theory and Application*, Wiley Eastern Press

Recent literature should also be referred

COURSE PLAN			
Course No	**Course Title**	**(L-T-P) : Credits**	Year
07 EE6207	**OPTIMISATION TECHNIQUES**	**(3-0-0) : 3**	**2015**

MODULES	Contact hours	Sem.Exam Marks;%
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	7	15
MODULE : 2 Revised simplex method-Duality and Dual simplex method-Sensitivity analysis Unconstrained dimensional optimization techniques: Necessary and sufficient conditions-search methods (unrestricted Fibonacci and golden)-Interpolation methods (Quadratic, Cubic and direct root method).	7	15
FIRST INTERNAL TEST		
MODULE : 3 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.	7	15
MODULE : 4 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).	7	15
SECOND INTERNAL TEST		
MODULE : 5 Principle of optimality-recurrence relation-Computation procedure-continuous dynamic programming-case studies	7	20
MODULE : 6 Recent developments in optimization techniques:Rosenbrocks Rotating Coordinate Method-Tabu search-Simulated Annealing-Genetic Algorithm-Particle Swarm Optimization –Ant colony Optimization-Bees Algorithm-case studies	7	20

Internal Continuous Assessment: 40%: 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.

Periodical Test 1 – 15%

Periodical Test 2 – 15%

Assignments/Term Paper/Seminar – 10%

End Semester Examination: 60%

Course No: 07EE 6217 Course Title: HIGH VOLTAGE DC AND AC TRANSMISSION

Credits: 3-0-0: 3 Year :2015

Pre-requisites: Basic knowledge on Circuit theory, Control Systems and Power Electronics

Course Objectives:

To give the students an in depth knowledge the basic concepts and recent trends in HVDC& AC transmission and working of HVDC & AC systems.

Syllabus

Basics of HVDC and HVAC transmission- HVDC links – Equipments required- Economic, Technical performance– Reliability, Choice of EHVAC and UHVAC lines and substation-HVDC-VSC transmission system. Single phase and three phase converters- Six pulse and 12 pulse converters, transformer VA rating-VA rating of valve. Converter Inverter circuits for HVDC Transmission-stability of control. Converter disturbance, protection, Harmonics and filters. Ground Electrodes of HVDC systems, Parallel AC and DC Systems:

Course Outcome:

On completion of the course, the students will acquire knowledge in HVDC &AC transmission, converters and its protection .Also acquire knowledge in power transfer capabilities from AC to DC.

References

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

COURSE PLAN			
Course No	**Course Title**	**(L-T-P):Credits**	Year
07EE 6217	**HIGH VOLTAGE DC AND AC TRANSMISSION**	**(3-0-0) :3**	**2015**

MODULES	**Contact hours**	**Sem.Exam Marks;%**
MODULE : 1 **General Aspects,:** Basics of HVDC and HVAC transmission**-** Advantages and limitations-Applications of DC transmission-Economic factors- HVDC links – Equipments required-comparison of AC and DC transmission–Economic, Technical performance– Reliability, Choice of EHVAC and UHVAC lines and substation-HVDC-VSC transmission system	7	15
MODULE : 2 **Converter circuits, Analysis and Control-**Single phase and three phase converters-transformer connections-Choice of best circuit for HVDC converters. Six pulse and 12 pulse converters-Analysis without gate control-with gate control but no overlap-dc output voltage-PIV-PPR-valve current relation-transformer current on secondary side-transformer VA rating-VA rating of valve.	7	15
FIRST INTERNAL TEST		
MODULE : 3 Converter Inverter circuits for HVDC Transmission-basic means of control –Power reversal-limitations of manual control-desired features of control – actual control characteristics-stability of control, **Converter disturbance,** Bypass valves- arc back-commutation failure-arc through-misfire-quenching.	7	15
MODULE : 4 **Converter protection, -** Basics of protection-DC Reactors-Voltage and current oscillations-DC line oscillations-Circuit breakers-External and Internal over voltages-protection against lightning-protection against current chopping-dc lightning arrestors.	7	15
SECOND INTERNAL TEST		
MODULE : 5 **Harmonics and filters** Characteristics and uncharacteristic harmonics-troubles due to harmonics-harmonic filters-Converter charts of direct current and voltage- active and reactive power	6	20
MODULE : 6 Ground Electrodes of HVDC systems: Advantages and problems of ground return-resistance of electrodes- current field between electrodes-requirements-design parameters-design of land electrodes. Parallel AC and DC Systems: Power transfer capabilities-reliability conditions-power loss considerations-power conversion of ac lines into dc lines-DC and AC system interaction-parallel AC/DC systems.	8	20

Internal Continuous Assessment: 40%: 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.

Periodical Test 1 – 15%
Periodical Test 2 – 15%
Assignments/Term Paper/Seminar – 10%

End Semester Examination: 60%

Course No:07 EE 6227 Course Title: ADVANCED SIGNAL PROCESSING

Credits: 3-1-0: 4 Year :2015

Pre-requisites: Signals and Systems, Circuit Theory

Course Objectives:

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.

Syllabus

Discrete random processes-, Ensemble averages, correlation, covariance, power spectrum, cross power spectrum, Ergodicity, time averages, biased & unbiased estimators, consistent estimators, Linear prediction-Levinson algorithm, Linear prediction lattice filtering , Digital Wiener filtering -Constrained, linear MMSE filtering, Minimum variance beam forming, Least mean squares adaptive filter: LMS adaptive algorithm, Properties of LMS adaptive filter, Gradient adaptive lattice filter-, Adaptive IIR filtering, The constant modulus algorithm. Blind adaptive filtering

Course Outcome:

On completion of the course, the students will acquire knowledge in stochastic methods and adaptive filtering, and their applications in state estimation, control, protection of power systems

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

COURSE PLAN			
Course No	**Course Title**	**(L-T-P) : Credits**	Year
07EE 6227	**ADVANCED SIGNAL PROCESSING**	**(3-0-0):3**	**2015**

MODULES	Contact hours	Sem.Exam Marks; %
MODULE : 1 Discrete random processes: Random variables, random processes, filtered randomprocesses, Ensemble averages, correlation, covariance, power spectrum, cross power spectrum, Ergodicity, time averages, biased & unbiased estimators, consistent estimators.	7	15
MODULE : 2 Linear prediction: Direct form linear prediction filtering, Normal equations for linear prediction filtering, Levinson algorithm, Linear prediction lattice filtering. [Haykin (Chp. 6)]	7	15
FIRST INTERNAL TEST		
MODULE : 3 Digital Wiener filtering : Wiener smoothing and prediction filters, Application of Wienersmoothing to noise cancelling, Application of Wiener prediction filters, Constrained, linear MMSE filtering, Minimum variance beamforming, [Haykin (Chp. 5)]	8	15
MODULE : 4 Least mean squares adaptive filter: LMS adaptive algorithm, Properties of LMS adaptivefilter,[Haykin (Chps. 8,9,16 and 17)] Gradient adaptive lattice filter: Noisy gradient forms, Direct forms,[Haykin (App. G)] Least squares adaptive filters : Godard algorithm, lattice. [Haykin (Chps. 11,13,15)].	7	15
SECOND INTERNAL TEST		
MODULE : 5 **Other adaptive filtering techniques:** Neural networks and multi-layer perceptrons, Adaptive IIR filtering, The constant modulus algorithm. [Haykin (Chps. 18,19)]	7	20
MODULE : 6 **Blind adaptive filtering** : Cost functions, Higher- oder statistics Examples.[Haykin (Chp. 18)]	6	20

Internal Continuous Assessment: 40%: 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.

Periodical Test 1 – 15%
Periodical Test 2 – 15%
Assignments/Term Paper/Seminar – 10%

End Semester Examination: 60%

Course No:07GN 6001 Course Title: RESEARCH METHODOLOGY

Credits: 0-2-0 : 2 Year :2015

Prerequisites : Nil

Course Objectives

The main objective of the course is to provide a familiarization with research methodology and to induct the student into the overall research process and methodologies. This course addresses:

- The scientific research process and the various steps involved
- Formulation of research problem and research design
- Thesis preparation and presentation.
- Research proposals, publications and ethics
- Important research methods in engineering

As a tutorial type course, this course is expected to be more learner centric and active involvement from the learners are expected which encourages self study and group discussions. The faculty mainly performs a facilitator's role.

Syllabus

Overview of research methodology - Research process, scientific method, research design process.
Research Problem and Design - Formulation of research task, literature review, web as a source, problem solving approaches, experimental research, and ex post facto research.
Thesis writing, reporting and presentation -Interpretation and report writing, principles of thesis writing-format of reporting, oral presentation.
Research proposals, publications and ethics - Research proposals, research paper writing, considerations in publishing, citation, plagiarism and intellectual property rights.
Research methods – Modelling and Simulation, mathematical modeling, graphs, heuristic optimization, simulation modeling, measurement design, validity, reliability, scaling, sample design, data collection methods and data analysis

Course Outcome

At the end of course, the student will be able to:

- Discuss research methodology concepts, research problems, research designs, thesis preparations, publications and research methods.
- Analyze and evaluate research works and to formulate a research problem to pursue research
- Prepare a thesis or a technical paper, and present or publish them
- Apply the various research methods followed in engineering research for formulation and design of own research problems and to utilize them in their research project.

Reference Books

- C. R. Kothari, Research Methodology, Methods and Techniques, New Age International Publishers
- K. N. Krishnaswamy, Appa Iyer Sivakumar, M. Mathirajan, Management Research Methodology, Integration of principles, Methods and Techniques, Pearson Education
- R. Panneerselvam, Research Methodology, PHI Learning

- Deepak Chawla, Meena Sondhi, Research Methodology–concepts & cases, Vikas Publg House
- J.W Bames, Statistical Analysis for Engineers and Scientists, McGraw Hill, N.York
- Schank Fr., Theories of Engineering Experiments, Tata Mc Graw Hill Publication.
- Willktnsion K. L, Bhandarkar P. L, Formulation of Hypothesis, Himalaya Publication.
- Fred M Kerlinger , Research Methodology
- Ranjit Kumar, Research Methodology – A step by step guide for beginners, Pearson Education
- John W Best, James V Kahan – Research in Education , PHI Learning
- Donald R. Cooper, Pamela S. Schindler, Business Research Methods, 8/e, Tata McGraw-Hill Co Ltd
- Sinha, S.C. and Dhiman, A.K., 2002. Research Methodology, Ess Ess Publications. 2 volumes
- Trochim, W.M.K., 2005. Research Methods: the concise knowledge base, Atomic Dog Publishing. 270p.
- Coley, S.M. and Scheinberg, C. A., 1990, "Proposal Writing", Sage Publications.
- Day, R.A., 1992.How to Write and Publish a Scientific Paper, Cambridge University Press.
- Fink, A., 2009. Conducting Research Literature Reviews: From the Internet to Paper. Sage Publications
- Donald H.McBurney, Research Methods, 5th Edition, Thomson Learning, ISBN:81-315-0047-0,2006
- Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., 2002. An introduction to Research Methodology, RBSA Publishers..
- Wadehra, B.L. 2000. Law relating to patents, trademarks, copyright designs and geographical indications. Universal Law Publishing
- Carlos, C.M., 2000. Intellectual property rights, the WTO and developing countries: the TRIPS agreement and policy options. Zed Books, New York.
- Additional suitable web resources
- Guidelines related to conference and journal publications

COURSE PLAN			
Course No	**Course Title**	**(L-T-P):Credits**	**Year**
07GN 6001	**RESEARCH METHODOLOGY**	**(0-2-0) :2**	**2015**

Modules	**Contact hours**	**Int. Exam Marks %**
MODULE 1 **Overview of Research Methodology**Research concepts – meaning – objectives – motivation - types of research –research process – criteria for good research – problems encountered by Indian researchers - scientific method - research design process – decisional research	5	10%
MODULE 2 **Research Problem and Design**Formulation of research task – literature review – methods – primary and secondary sources – web as a source – browsing tools -formulation of research problems – exploration - hypothesis generation - problem solving approaches-introduction to TRIZ(TIPS)- experimental research – principles -Laboratory experiment - experimental designs - ex post facto research - qualitative research	5	10%
FIRST INTERNAL TEST		
MODULE 3 **Thesis writing, reporting and presentation-**Interpretation and report writing – techniques of interpretation – precautions in interpretation – significance of report writing – principles of thesis writing- format of reporting - different steps in report writing – layout and mechanics of research report - references – tables – figures – conclusions. oral presentation – preparation - making presentation – use of visual aids - effective communication	4	10%
Module 4 **Research proposals, publications, ethics and IPR-**Research proposals - development and evaluation – research paper writing – layout of a research paper - journals in engineering – considerations in publishing – scientometry-impact factor- other indexing like h-index – citations - open access publication -ethical issues - plagiarism –software for plagiarism checking- intellectual property right- patenting case studies	5	10%
SECOND INTERNAL TEST		
Module 5 Research methods – Modelling and Simulation : Modelling and Simulation – concepts of modelling – mathematical modelling - composite modelling – modelling with – ordinary differential equations – partial differential equations – graphs heuristics and heuristic optimization - simulation modelling	5	10%
Module 6 – Research Methods – Measurement, sampling and Data acquisition : Measurement design – errors -validity and reliability in measurement - scaling and scale construction - sample design - sample size determination - sampling errors - data collection procedures - sources of data - data collection methods - data preparation and data analysis	4	10%

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests and assignments. There are three tests for the course (3 x 20 = 60%) and assignments (40 marks). The assignments can be in the form of seminar, group tasks, case studies, research work or in a suitable format as decided by the teacher. The assessment details are to be announced to students at the beginning of the semester by the teacher.

Course No:07 EE 6209 Course Title: POWER SYSTEM LAB – I

Credits: 0-0-2: 2 Year :2015

Course Objectives :

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

Syllabus

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 ZBUS formation using building up algorithm.
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".

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

1. Practical Records /outputs- 40%
2. Regular Class Viva-Voce -20%
3. Final Test (Objective)- 40%

SEMESTER 2

Course No:07 EE 6202 Course Title: ADVANCED DIGITAL PROTECTION IN POWER SYSTEMS

Credits: 3-1-0: 4 Year :2015

Course Objectives:

To learn the principles and operations of digital relaying and,its application to modern power system and apparatus.

Syllabus

Briefing of Historical background of Digital relays, Computer relay architecture, A-D Converters, Anti-aliasing filters, substation computer hierarchy. Functions of protective system, Mathematical background to protection algorithms:- Fourier analysis – series, transforms, DFT, Walsh function analysis, Kalman filtering. Transmission line relaying algorithms Computers for relaying applications, substation environment, Industry environment standards, , Measurement of frequency and phase, sampling clock synchronization: Fundamentals of travelling wave based protection, travelling waves in assumed lossless single phase lines, transposed three phase lines travelling wave distance relay, travelling wave differential relay. Travelling wave protection schemes. WAMS architecture, WAMS bases protection concepts.

Course Outcome

On completion of the course, the students will acquire knowledge in various type of relaying schemes used for different components protection. WAMS bases protection concepts.

Text Books

1. Computer Relaying for power systems, Arun G Phadke and James S Thorp, John Wiley & Sons, Inc, New York.
2. Allen T Johns and Salman, S.K., Digital Protection for Power Systems, IEE Power Series (1995).
3. Rao, T.S.M., Power System Protection: Static Relays, Tata McGraw Hill Publishing Company (2008).

References:

1. An Introduction to the Digital Protection of Power Systems.DrYesriZakiMahammad, Wroclaw University of Technology Poland.
2. Wu, Q.H., Lu, Z., Ji, T.Y., Protective Relaying for Power Systems using Mathematical Morphology, Springer (2009).
3. Badri Ram & DN Viswakarma – Power System Protection & Switch Gear – McGraw Hill.
4. YG Paithankar and SR Bhide Fundamentals of power system protection – PHI 2003
5. A.R.VanC.Warrington – Protective Relays – Their Theory & Practice, Vol.I& II – John Wiley & Sons.
6. Power System Protection 4: Digital Protection and Signaling, By Electricity Training Association Services Ltd, IEEE, London.
7. Improved power transformer protection using numerical relays, BogdanKasztenny and MladenKezunovic Texas A&M University, USA.

COURSE PLAN			
Course No	**Course Title**	**(L-T-P) :Credits**	Year
07 EE6202	**ADVANCED DIGITAL PROTECTION IN POWER SYSTEMS**	**(3-1-0):4**	2015

MODULES	Contact hours	Sem.Exam Marks;%
MODULE : 1 Briefing of Historical background of Digital relays, performance and operational characteristics of digital protection, Basic structure of digital relays, Computer relay architecture, A-D Converters, Anti-aliasing filters, substation computer hierarchy. Functions of protective system, protection of generator, transformer, reactor, transmission line and Bus Bar (Basics only).	10	15
MODULE : 2 Mathematical background to protection algorithms:- Finite difference techniques, Interpolation formulas, curve fitting and smoothing, Fourier analysis – series, transforms, DFT, Walsh function analysis, Kalman filtering.	8	15
FIRST INTERNAL TEST		
MODULE : 3 Transmission line relaying algorithms: Introduction, sources of errors, Relay programs based upon fault classification, Symmetrical component distance relay, description of SymmetricalComponent Distance Relaying Program (SCDR). Protection of series compensated lines, protection of machines, Power transformer algorithms and Digital protection of buses.	10	15
MODULE : 4 Hardware Organization: Computers for relaying applications, substation environment, Industry environment standards, EMI, Counter measures against EMI, Redundancy and Back up, Measurement of frequency and phase, sampling clock synchronization. Use of line carrier and communication links, optical fibre.	8	15
SECOND INTERNAL TEST		
MODULE : 5 Developments in new relaying principles: Fundamentals of travelling wave based protection, travelling waves in assumed lossless single phase lines, transposed three phase lines. Behavior of relaying signals at the relay and fault locations, travelling waves due to faults, directional wave relay, travelling wave distance relay, travelling wave differential relay	10	20
MODULE : 6 Travelling wave protection schemes: Bergeron's equation based scheme-ultra high speed wave based scheme, Discriminant function based scheme.WAMS architecture, WAMS bases protection concepts.	6	20

Internal Continuous Assessment: 40 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.

Periodical Test 1 – 15%
Periodical Test 2 – 15%
Assignments/Term Paper/Seminar – 10%

End Semester Examination: 60%

Course No: 07EE6 204 Course Title: POWER SYSTEM DYNAMICS

Credits: 3-0-0: 3 Year :2015

Pre-requisites: Nil

Course Objectives:

To study the modelling of synchronous machine and stability analysis
To impart knowledge on dynamic modelling of a synchronous machine in detail.
To understand the fundamental concepts of stability of dynamic systems and its classification To understand and enhance small signal stability problem of power systems.

Syllabus

Stability of Dynamic systems, Synchronous machine theory and modelling- parks transformation, d-q transformation- steady state analysis- voltage-current and flux linkage, phasor representation, rotor angle – steady state equivalent circuit-State space representation concept, Eigen properties of the state vectors, analysis of stability- classical representation of generator-Characteristics of small - signal stability problems-Transient stability- Swing equation-critical clearing time and angle- methods for improving transient stability-Voltage stability- PV curve, QV curve and PQ curve- prevention of voltage collapse.

Course Outcome:

Text Books:

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.

COURSE PLAN			
Course No	**Course Title**	**(L-T-P):CREDITS**	Year
07EE6 204	**POWER SYSTEM DYNAMICS**	**(3-0-0) :3**	2015

MODULES	Contact hours	Sem.Exam Marks;%
MODULE : 1 Stability of Dynamic systems, Synchronous machine theory and modelling:- armature and field structure, parks transformation, machine with multiple pole pairs-mathematical description,	7	15
MODULE : 2 Synchronous Machine-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.	6	15
FIRST INTERNAL TEST		
MODULE : 3 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.	7	15
MODULE : 4 Transient stability:- Concept of transient stability, response to a step change in mechanical power input, Swing equation- multimachine analysis	6	15
SECOND INTERNAL TEST		
MODULE : 5 Factors influencing transient stability, numerical integration method – Euler method – R-K method (4rth order), critical clearing time and angle-methods for improving transient stability.	8	20
MODULE : 6 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.	8	20

Internal Continuous Assessment: 40 % : 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.

Periodical Test 1 – 15%

Periodical Test 2 – 15%

Assignments/Term Paper/Seminar – 10%

End Semester Examination: 60%

Course No: 07EE6 206 Course Title: POWER SYSTEM OPERATION AND CONTROL

Credits: 3-0-0: 3 Year :2015

Pre-requisites: Nil

Course Objectives:

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

Syllabus

Economic operation: The economic dispatch problem-Thermal system dispatching with network losses considered-Loss Formula calculations.,Hydro thermal coordination: Hydro electric Plant Models-Scheduling Problems-short term hydro thermal scheduling problem-Pumped storage hydro plants,Unit Commitment: Constraints in unit commitment-Unit commitment solution methods.,Automatic Generation Control: Basic generator control loops -Models for generator, Load,Prime movers ,Governor-.AGC with optimal dispatch-Introductory modern control application.,Reactive Power and Voltage Control: Reactive power generation by synchronous machines-Effect of excitation- Static and dynamic response stability compensators-power system stabiliser(PSS)-Methods of system voltage control-FACTS devices(introduction only)

Course Outcome:

On completion of the course, the students will acquire knowledge in generation dispatching schemes for thermal and hydro units and oad frequency control and its modeling. Also acquire knowledge in reactive and voltage control using compensation devices

References:

5. Wood and Wollenberg, “Power generation, operation and control, John Wiley & Sons, 2000.
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.

COURSE PLAN			
Course No	**Course Title**	**(L-T-P) : Credits**	Year
07EE6 206	**POWER SYSTEM OPERATION AND CONTROL**	**(3-0-0) : 3**	**2015**

MODULES	Contact hours	Sem.Exam Marks; %
MODULE : 1 The economic dispatch problem-Thermal system dispatching with network losses considered-Loss Formula calculations	6	15
MODULE : 2 Hydro electric Plant Models-Scheduling Problems-short term hydro thermal scheduling problem-gradient approach-Pumped storage hydro plants- Hydro scheduling using linear programming.	7	15
FIRST INTERNAL TEST		
MODULE : 3 **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	6	15
MODULE : 4 **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	7	15
SECOND INTERNAL TEST		
MODULE : 5 AGC with optimal dispatch-Introductory modern control application -Pole placement design and optimal control design. **Reactive Power :**Impedance and reactive power-System voltage andreactive power-Reactive power generation by synchronous machines-Effect of excitation control.	8	20
MODULE : 6 **Voltage 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)	8	20

Internal Continuous Assessment: 40 %s : 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.

Periodical Test 1 – 15%
Periodical Test 2 – 15%
Assignments/Term Paper/Seminar – 10%

End Semester Examination: 60%

ELECTIVE II

Course No: 07EE6 2 08 Course Title: FLEXIBLE AC TRANSMISSION SYSTEMS

Credits: 3-0-0: 3 Year :2015

Pre-requisites: Nil

Course Objectives:

Operation, control and application of different FACTS devices ,Power-electronic controllers for active and reactive power control in transmission lines

Syllabus

FACTS and preliminaries: FACTS concept and general system considerations - power flow in AC system - Static Shunt Compensators - SVC and STATCOM - Compensator Control - Comparison between SVC and STATCOM - STATCOM for transient and dynamic stability enhancement, case studies.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, case studies.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.

Course Outcome:

On completion of the course, the students will acquire knowledge in different type of FACTS devices and their applications of in power flow control, voltage control and stability improvement.

References:

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

COURSE PLAN			
Course No	**Course Title**	**(L-T-P): Credits**	Year
07EE6 208	**FLEXIBLE AC TRANSMISSION SYSTEMS**	**(3-0-0) :3**	**2015**

MODULES	Contact Hours	Sem.Exam Marks
MODULE : 1 FACTS and preliminaries: FACTS concept and general system considerations - power flow in AC system - definitions on FACTS - basic types of FACTS controllers –dynamic brake	6	15
MODULE : 2 Static Shunt Compensators - SVC and STATCOM - operation and control of TSC, TCR, STATCOM - Compensator Control - Comparison between SVC and STATCOM	6	15
FIRST INTERNAL EXAM		
MODULE : 3 STATCOM for transient and dynamic stability enhancement, case studies.Static Series Compensators: Static Series Compensation - GCSC, TSSC, TCSC and SSSC - operation and control - external system control for series compensators	6	15
MODULE : 4 SSR and its damping - static voltage and phase angle regulators - TCVR and TCPAR - operation and control, case studies	6	15
SECOND INTERNAL EXAM		
MODULE : 5 UPFC and IPFC: The Unified Power Flow Controller - operation, comparison with other FACTS devices - control of P and Q - dynamic performance	6	20
MODULE : 6 Special Purpose FACTS Controllers - Interline Power Flow Controller - operation and control – case studies	6	20

Internal Continuous Assessment: 40 %s: 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.

Periodical Test 1 – 15%
Periodical Test 2 – 15%
Assignments/Term Paper/Seminar – 10%

End Semester Examination: 60%

Course No: 07EE6 2 18 Course Title: POWER SYSTEM TRANSIENTS

Credits: 3-0-0: 3 Year :2015

Pre-requisites: Nil

Course Objectives:

To study theoretical basis for various forms of over voltages such as lighting strokes, surges, switching transients., To study Modeling of power apparatus under transient conditions: and the protection measures against such over voltages

Syllabus

Transients in electric power systems -Internal and external causes of over voltages---Lightning strokes –Mathematical model to represent lightning. Abnormal switching transients: Current chopping – Capacitance switching –Symmetrical components for solving three phase switching transients. Travelling waves in transmission lines —Travelling waves at different line terminations. Bewley–Lattice diagram. Electromagnetic Phenomena under transient conditions: steady state penetration of magnetic flux and current into conductors – transient penetration of magnetic flux and current . Modeling of power apparatus under transient conditions. Protection of system against transients.

Course Outcome:

On completion of the course, the students will acquire knowledge in simple switching transients, abnormal switching transients. and analysis of travelling wave using Bewley–Lattice diagram.. Also students will be able to model power apparatus under transient conditions and acquire knowledge in Protection of system against transients.

Text Books

1. .Allen Greenwood, „Electrical transients in power systems", Wiley Interscience, 1991.
2. 2Bewley, L.W., „Travelling waves and transmission systems", Dover publications, New York, 1963.
3. Gallaghar, P.J. and Pearmain, A.J., 'High voltage measurement, Testing and Design', John Wiley and sons, New York, 2001

References

1. Harold A Peterson: Transient in Power Systems, McGraw Hill, 1966.
2. Kuffel and Abdullah: High Voltage Engineering, PHI, 2000.
3. Rakesh D. Begamudre: EHV AC Transmission Engineering, PHI, 2006.

COURSE PLAN			
Course No	**Course Title**	**(L-T-P): Credits**	Year
07EE6 218	**POWER SYSTEM TRANSIENTS**	**3-0-0) :3**	**2015**
MODULES		**Contact Hours**	**Sem.Exam Marks**
MODULE : 1 Transients in electric power systems The circuit closing transient – Recovery transient initiated by removal of short circuit – double frequency transient – Damping of transients.– Internal and external causes of over voltages---–Lightning strokes –Mathematical model to represent lightning		7	15
MODULE : 2 Abnormal switching transients: Current chopping – Capacitance switching – Re-striking phenomena – Ferro Resonance – Switching off of capacitor banks and reactor banks – Symmetrical components for solving three phase switching transients.		7	15
FIRST INTERNAL EXAM			
MODULE : 3 Travelling waves in transmission lines –Circuits with distributed constants–Wave equations –Reflection and refraction of travelling waves –Travelling waves at different line terminations. effect of short length of cables- Bewley–Lattice diagram		7	15
MODULE : 4 Electromagnetic Phenomena under transient conditions: Introduction – steady state penetration of magnetic flux and current into conductors – transient penetration of magnetic flux and current – electromagnetic shielding – Implications		7	15
SECOND INTERNAL EXAM			
MODULE : 5 Modeling of power apparatus under transient conditions: Modeling of transformers – Generators – Motors – Overhead lines and cables – case studies.		7	20
MODULE : 6 Protection of system against transients: Lightning shielding – Surge Suppressors – Lightning arrester – Surge capacitors – Effect of grounding practices		7	20

Internal Continuous Assessment: 40 %s : 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.

Periodical Test 1 – 15%
Periodical Test 2 – 15%
Assignments/Term Paper/Seminar – 10%

End Semester Examination: 60%

Course No: 07EE6 2 28 Course Title: POWER DISTRIBUTION SYSTEMS

Credits: 3-0-0: 3 Year :2015

Pre-requisites: Nil

Course Objectives:

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

Syllabus

Transients in electric power systems -Internal and external causes of over voltages-–Lightning strokes –Mathematical model to represent lightning. Abnormal switching transients: Current chopping – Capacitance switching –Symmetrical components for solving three phase switching transients. Travelling waves in transmission lines —Travelling waves at different line terminations. Bewley–Lattice diagram. Electromagnetic Phenomena under transient conditions: steady state penetration of magnetic flux and current into conductors – transient penetration of magnetic flux and current . Modeling of power apparatus under transient conditions. Protection of system against transients.

Course Outcome:

On completion of the course, the students will acquire knowledge in simple switching transients, abnormal switching transients. and analysis of travelling wave using Bewley–Lattice diagram.. Also students will be able to model power apparatus under transient conditions and acquire knowledge in Protection of system against transients.

Text Books

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

References

1. Anthony J. Pansini "*Electrical Distribution Engineering*", CRC Press, 2005.
2. H Lee Willis, "*Distributed Power Generation Planning and Evaluation*", CRC Press, 2000.
3. James A Momoh, "*Electric Power Distribution Automation Protection and Control*" CRC Press, 2007.
4. James J. Burke "*Power distribution engineering: fundamentals and applications*", CRC Press, 2004.

COURSE PLAN			
Course No	**Course Title**	**(L-T-P) : Credits**	Year
07EE6 2 28	**POWER DISTRIBUTION SYSTEMS**	**3-0-0) :3**	**2015**

MODULES	Contact hours	Sem.Exam Marks;%
MODULE : 1 **Distribution system planning and design** Distribution system planning Short term planning, Long term planning, dynamic planning, Sub-transmission and substation design. Sub-transmission networks configurations, Substation bus schemes, Distribution substations ratings, Service areas calculations, Substation application curves.	6	15
MODULE : 2 **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	7	15
FIRST INTERNAL TEST		
MODULE : 3 **Power Capacitors**: Reactive Power – Series and Shunt capacitors- System harmonics- HT shunt capacitor installation requirements-Size of capacitors for power factor improvement – LT capacitors	6	15
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	7	15
SECOND INTERNAL TEST		
MODULE : 5 **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	8	20
MODULE : 6 **Distribution Automation**: Project planning communications-sensors-SCADA Systems – Consumer Information Service- Geographical Information Systems –Automatic meter reading –Automation Systems **Grounding systems**: Grounding system-Earth and Safety – Nature of electrodes –Earth conductor size –Design of Earthing electrodes	8	20

Internal Continuous Assessment: 40 %s : 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.

Periodical Test 1 – 15%
Periodical Test 2 – 15%
Assignments/Term Paper/Seminar – 10%
End Semester Examination: 60%

ELECTIVE III

Course No: 07EE6 212 Course Title: POWER SYSTEM PLANNING AND RELIABILITY
Credits: 3-0-0: 3 Year :2015

Pre-requisites: Nil

Course Objectives:

To understand the importance of planning and maintaining reliability of power system components

Syllabus

System Planning: Objectives of system planning: Long term and short term planning-Load forecasting : Classification of loads-Forecast methodology.Generation system Reliability analysis: Reliability Concepts- Exponential Distribution mean time to failure-Series and Parallel system –Generator System reliability analysis-Probability Models for generator unit and loads. Transmission system reliability analysis: Average Interruption rate method – LOLP method.Generation system cost analysis-Production costing –Fuel inventories-Energy transaction and off-peak loading.Transmission system Expansion Planning: Tellegen's theorem-Network sensitivity-An overview of distribution system planning.

Course Outcome:

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

References:

1. Endreni.J., Reliability modeling in electric power system, John Wiley 2005
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

COURSE PLAN			
Course No	**Course Title**	**(L-T-P) : Credits**	Year
07EE6 212	**POWER SYSTEM PLANNING AND RELIABILITY**	**3-0-0) :3**	**2015**

MODULES	Contact hours	Sem.Exam Marks;%
MODULE : 1 Objectives of system planning: Long term and short term planning-stages in planning -Policy studies -Planning standardization studies- System and Network Reinforcement studies	6	15
MODULE : 2 **Load forecasting** : Classification of loads-Forecast methodology-Energy forecasting-Non weather sensitive forecast-Weather sensitive forecast- Total forecast-Annual and monthly peak load forecast	7	15
FIRST INTERNAL TEST		
MODULE : 3 **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	6	15
MODULE : 4 **Transmission system reliability analysis:** Transmission system reliability model analysis – Capacity state classification- Average –Interruption rate method – LOLP method	7	15
SECOND INTERNAL TEST		
MODULE : 5 **Generation system cost analysis-**Production costing –Fuel inventories-Energy transaction and off-peak loading	8	20
MODULE : 6 **Transmission system Expansion Planning:** Tellegen's theorem-Network sensitivity-Network Decision-Problem formulator solution using DC load flow An overview of distribution system planning	8	20

Internal Continuous Assessment: 40 % : 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.

Periodical Test 1 – 15%
Periodical Test 2 – 15%
Assignments/Term Paper/Seminar – 10%

End Semester Examination: 60%

Course No: 07EE6 222 Course Title: ENERGY AUDITING CONSERVATION AND MANAGEMENT

Credits: 3-0-0: 3 Year :2015

Pre-requisites: Nil

Course Objectives:

To Understand, analyze and application of electrical energy management measurement and accounting techniques ,consumption patterns and conservation methods and application in industrial cases

Syllabus

Energy Auditing and Economics-System approach and End use approach to efficient use of Electricity- Electricity tariff types - Energy auditing- audit instruments –ECO assessment and Economic methods - Energy efficient motors and transformers- Efficient Control strategies-Optimal selection and sizing – Optimal operation and Storage-Tranformer Loading /Efficiency analysis- Feeder /cable Loss evaluation- Reactive Power Management Capacitor losses-Location-Placement-Maintenance- Economics of power factor improvement- Lightning-Energy efficient light sources-Energy Conservation in Lighting schemes-Cogeneration-Types and Schemes-Optimal operation of cogeneration plants- Electric loads of Air conditioning and Refrigeration – Energy conservation measures-Cool storage- Types- Optimal operation -Electric water heating-Geysers-Solar Water Heaters-Power Consumption in Compressors, Energy conservation measures-

Course Outcome:

At the end of the course students will be able to Apply energy management schemes in electrical systems and - Perform economic analysis and load management

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

COURSE PLAN			
Course No	**Course Title**	**(L-T-P) : Credits**	Year
07EE62 22	**ENERGY AUDITING CONSERVATION AND MANAGEMENT**	**3-0-0) :3**	**2015**

MODULES	Contact hours	Sem.Exam Marks;%
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, - specific energy analysis-Minimum energy paths- consumption models- Case study.	8	15
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.T ranformer Loading /Efficiency analysis, Feeder /cable Loss evaluation- Case study	8	15
FIRST INTERNAL TEST		
MODULE : 3 **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.	6	15
MODULE : 4 **Lighting-** Energy efficient light sources-Energy Conservation in Lighting schemes. Electronic Ballast-Power quality issues-Luminaries-Case study.	6	15
SECOND INTERNAL TEST		
MODULE : 5 **Cogeneration-**-Types and Schemes-Optimal operation of cogeneration plants- Case study. Electric loads of Air conditioning and Refrigeration	6	20
MODULE : 6 **Energy conservation in industries-** 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.	8	20

Internal Continuous Assessment:40 % : 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.

Periodical Test 1 – 15%
Periodical Test 2 – 15%
Assignments/Term Paper/Seminar – 10%
End Semester Examination: 60%

Course No: 07EE62 32 Course Title: SMART GRID & DISTRIBUTED GENERATION

Credits: 3-0-0: 3 Year :2015

Pre-requisites: Nil

Course Objectives:

To give the Student:-

- An Introdution to Smart grid;
- Componenets and Performance Ananlysis of Smart grid
- Familiarize the implementation technology of Smart grid;

Syllabus

Smart grid : Introduction, Representative Architecture,Components, Microgrid, Smart grid Communications and Measurement Technology, Performance Analysis tools for smart grid design : Load flow methods , Distribution load flow, Stability Analysis tools for smart grid, state estimation,Renewable energy resources, modeling and basic architecture of wind generation systems, Fuel cell, Small and micro hydropower.,, Plug in Hybrid vehicles, Demand response and Demand side management,, Computational tools for smart grid design, Interoperability, standards, cyber security, Case studies and literature survey on Development of Smart grid.

Course Outcome:

Students who successfully complete this course will have the fundamental concepts of Smart grid. Components of smart grid, Performance Analysis, stability analysis etc. will be explored. Integration of renewable energy sources and impact are studied. Case study and literature survey will enable to get in touch with the development of this state of art technology.

Text Books:

1. James Momoh, " Smart grid : Fundamentals of Design and Analysis" IEEE Press.

References:

1. Krzysztof iniwski, " Smart grid : Infrastructure & Networking: McGrawHill Edn
2. Sioshansi, Fereidoon P., ed. Smart grid: integrating renewable, distributed & efficient energy. Academic Press, 2011.
3. Clark, C. W., and PE GELLINGS. "The smart grid: enabling energy efficiency and demand response." (2009).

COURSE PLAN			
Course No	**Course Title**	**(L-T-P) : Credits**	Year
07EE62 32	**SMART GRID & DISTRIBUTED GENERATION**	**3-0-0) :3**	**2015**

MODULES	Contact hours	Sem.Exam Marks;%
MODULE : 1 Smart grid : Introduction, Representative Architecture,Components, Functions of Smart grid components., Microgrid Smart grid Communications and Measurement Technology : Monitoring, WAMS, PMU, Smart meters and Measurement technologies, Multi agent system technology.	6	15
MODULE : 2 Performance Analysis tools for smart grid design : Load flow methods and challenges, Distribution load flow, congestion management, Stochastic Dynamic Optimal Power flow Assignment : MATLAB program for Load flow / power flow	8	15
FIRST INTERNAL TEST		
MODULE : 3 Stability Analysis tools for smart grid : Voltage stability assessment, voltage stability indexing, Angle stability assessment, state estimation	8	15
MODULE : 4 Renewable energy resources : Solar Power, Modeling PV system, Voltage current characteristic Wind turbine systems : modeling and basic architecture of wind generation systems, Fuel cell, Small and micro hydropower. Assignment : Case study on Different DG sources	8	15
SECOND INTERNAL TEST		
MODULE : 5 Penetration and variability issues. Integration of Renewable energy resources in Smart grid , Plug in Hybrid vehicles, Impact of PHEV on grid. , Demand response and Demand side management, Literature survey on Demand response	6	20
MODULE : 6 Computational tools for smart grid design : classical optimization, Heuristic optimization, Evolutionary computational techniques. Interoperability, standards, cyber security Case studies and Literature survey on Smart grid	6	20

Internal Continuous Assessment: 40 % : 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.

Periodical Test 1 – 15%

Periodical Test 2 – 15%

Assignments/Term Paper/Seminar – 10%

End Semester Examination: 60%

Course Title: 07EE72 14 Course Title :MINI PROJECT

Credits: 0-0-2: 2 Year :2015

Objectives

To estimate the ability of the student in transforming the theoretical knowledge studied so far into a working model of a power system. For enabling the students to gain experience in organisation and implementation of a mini project and thus acquire the necessary confidence to carry out hardware implementation of main project.

Syllabus

This is a hardware based mini project and each student is expected to develop a power system based with practical applications .Student has to design, fabricate, test and assemble a power system based system in an enclosure with appropriate terminals and control mounted on an enclosure. This should be a working model. The basic concepts of product design may be taken into consideration while designing the project.

Internal Continuous Assessment: 100 marks

Course Title: 07EE72 16 Course Title :POWER SYSTEM LAB II

Credits: 0-0-2: 2 Year :2015

Objectives:

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.

Syllabus

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. Develop a programme to detect bad measurements
6. Power quality analysis of various loads and UPS systems using Power Quality Analyser.

7. Model a closed loop buck converter and simulate using any application software.
8. Simulate FFT of three phase 6 pulse inverter using unipolar switching and bipolar switching.
9. Simulate various contingencies in power system.
10. Simulate various unsymmetrical faults in power system using application software.
11. Draw the PV Characteristics of solar panel
12. . Simulation of STATCOM & DSTATCOM
13. Simulation of Active Power Filter, DVR
14. Simulation of TCSC, UPQC

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

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

.

Internal Continuous Assessment: 100 marks

Marks for the report: 30%
Presentation: 40%
Ability to answer questions on the topic: 30%

Course Title: 07EE72 24 Course Title :SEMINAR

Credits: 0-0-2: 2 Year :2015

Course Objectives:

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

.

Syllabus

Students have to register for the seminar and select a topic in consultation with any faculty member offering courses for the programme. A detailed write-up on the topic of the seminar is to be prepared in the prescribed format given by the Department. The seminar shall be of 30 minutes duration and a committee with the Head of the department as the chairman and two faculty members from the department as members shall evaluate the seminar based on the report and coverage of the topic, presentation and ability to answer the questions put forward by the committee.
Faculty member in charge of the seminar and another faculty member in the department nominated by the Head of the Department are the evaluators for the seminar.

Internal Continuous Assessment: 100 marks

Marks for the report: 30%
Presentation: 40%
Ability to answer questions on the topic: 30%

SEMESTER 3

ELECTIVE IV

Course Title: 07EE72 01 Course Title :POWER SYSTEM SECURITY

Credits: 3-0-0: 3 Year :2015

Pre-requisites: Nil

Course Objectives:

1. To understand the need for power system security, security measurement and assessment.
2. To study the techniques for security enhancement.

Syllabus

Basic concepts: Power system stability-security-observability and reliability, deregulation, factors affecting power system security. Power system state estimation-introduction to supervisory control and data acquisition. Power system security assessment: contingency analysis, security constrained optimisation, basis of evolutionary optimization techniques, preventive, emergency and restorative control.Security in Deregulated Environment: Need and conditions for deregulation, electricity sector structure model

Course Outcome:

Students who successfully complete this course will have knowledge of power system state estimation. , contingency analysis and knowledge on bad data deduction and identification

References:

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

COURSE PLAN			
Course No	**Course Title**	**(L-T-P) : Credits**	Year
07EE72 01	**POWER SYSTEM SECURITY**	**3-0-0) :3**	**2015**

MODULES	**Contact hours**	**Sem.Exam Marks;%**
MODULE : 1 **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.	6	15
MODULE : 2 **Power system state estimation**: DC and AC network, orthogonal decomposition algorithm, Maximum likelihood Weighted Least Square Estimation – Weighted Least Square (WLS) SE. SE of AC networks:	7	15
FIRST INTERNAL TEST		
MODULE : 3 Detection and Identification of bad measurements – Network Observability and Pseudo–measurements – observability by Graphical technique and Triangularisation approach – Optimal meter placement – Application of power system state estimation, introduction to supervisory control and data acquisition.	7	15
MODULE : 4 **Power system security assessment:** contingency analysis, network sensitivity factors, contingency selection, performance indices, security constrained optimisation,	7	15
SECOND INTERNAL TEST		
MODULE : 5 SCOPF, basis of evolutionary optimization techniques, preventive, emergency and restorative controls though non- linear programming (NLP) and linear programming(LP)methods.	7	20
MODULE : 6 **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.	8	20

Internal Continuous Assessment: 40 % : 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.

Periodical Test 1 – 15%
Periodical Test 2 – 15%
Assignments/Term Paper/Seminar – 10%

End Semester Examination: 60%

Course Title: 07EE72 11 Course Title : POWER QUALITY

Credits: 3-0-0: 3 Year :2015

Pre-requisites: Nil

Course Objectives:

To familiarize with power quality problems and measurements.
To study the impact of and on the device and different mitigation techniques, application of custom power devices

Syllabus

Overview of power quality phenomena-classification of power quality issues-power quality measures and standards- Harmonics -IEEE guides, standards and recommended practices. Power factor reduction due to harmonics- Loads that cause power quality problems-Power Quality Measurement and Analysis - event recorders, Measurement Error – Analysis: Analysis in the periodic steady state, Time domain methods, Frequency domain methods: Laplace's, Fourier and Wavelet Transform. Utility-Customer interface – Harmonic filters: passive, Active and hybrid filters –Custom Power devices: Network reconfiguring Devices, Load compensation, Voltage regulation using DSTATCOM, protecting sensitive loads using DVR, UPQC –control strategies: - series active power filtering techniques for harmonic cancellation and isolation – case studies

Course Outcome:

Students who successfully complete this course will have knowledge of At the end of course, the student will be able to know about power quality issues, Cause of poor power quality, Understand mitigation techniques

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

COURSE PLAN			
Course No	**Course Title**	**(L-T-P) :Credits**	Year
07EE7211	**POWER QUALITY**	**3-0-0) :3**	**2015**

MODULES	Contact hours	Sem.Exam Marks;%
MODULE : 1 Overview of power quality phenomena-classification of power quality issues-power quality measures and standards-flicker-transient phenomena- THD-TIF-DIN-C message weights-flicker factor. Harmonics -sources of harmonics-occurrence of power quality problems-power acceptability curves-IEEE guides, standards and recommended practices.	6	15
MODULE : 2 Power factor reduction due to harmonics-Distortion power-distortion power factor and displacement power factor. Loads that cause power quality problems-power quality problems created by drives and its impact on drives - case studies	6	15
FIRST INTERNAL EXAM		
MODULE : 3 Single phase AC/DC converters, SMPS, three phase AC/DC converters, Battery chargers, Arc furnaces, Fluorescent lighting, pulse modulated devices, Adjustable speed drives.	6	15
MODULE : 4 Power Quality Measurement and Analysis -Voltage, Current, Power and Energy measurements, power factor measurements and definitions, event recorders, Measurement Error – Analysis: Analysis in the periodic steady state, Time domain methods	6	15
SECOND INTERNAL EXAM		
MODULE : 5 Frequency domain methods: Laplace's, Fourier and Wavelet Transform. Utility-Customer interface –Harmonic filters: passive, Active and hybrid filters	6	20
MODULE : 6 Custom Power devices: Network reconfiguring Devices, Load compensation using DSTATCOM, Voltage regulation using DSTATCOM, protecting sensitive loads using DVR, UPQC – control strategies: P-Q theory, Synchronous detection method - series active power filtering techniques for harmonic cancellation and isolation - case studies.	6	20

Internal Continuous Assessment: 40 %s : 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.

Periodical Test 1 – 15%
Periodical Test 2 – 15%
Assignments/Term Paper/Seminar – 10%

End Semester Examination: 60%

Course Title: 07EE72 31 Course Title : POWER SYSTEM MONITORING AND SCADA SYSTEMS
Credits: 3-0-0: 3 Year :2015

Pre-requisites: Nil

Course 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

Syllabus

Introduction to SCADA: Evolution of SCADA-SCADA Applications in Utility Automation-Industries. SCADA Systems Components: Schemes – Remote Terminal Unit(RTU),SCADA Architecture: Various SCADA Architectures,SCADA Communication : Various industrial communication technologies, SCADA Applications: Utility Applications-Operations-Monitoring - Substation automation structure- architecture, Introduction to role of wide area measurement-power system phenomenon with possible WAMS solution- Implementation of wide area protection

Course Outcome:

Students who successfully complete this course will have knowledge of SCADA Applications SCADA Communication, SCADA Applications and various industrial communication technologies power system. Also students will acquire knowledge in role of wide area measurement- and implementation of wide area protection in power system

References:

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

COURSE PLAN			
Course No	**Course Title**	**(L-T-P) :Credits**	Year
07EE7231`	**POWER SYSTEM MONITORING AND SCADA SYSTEMS**	**3-0-0) :3**	**2015**

MODULES	Contact hours	Sem.Exam Marks;%
MODULE : 1 **Introduction to SCADA**: Data acquisition Systems-Evolution of SCADA – Communication Technologies-Monitoring and Supervisory Functions-SCADA Applications in Utility Automation-Industries.	6	15
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	7	15
FIRST INTERNAL TEST		
MODULE : 3 **SCADA Architecture**: Various SCADA Architectures-Advantages and Disadvantages ofeach system-single unified standard architecture- IEC 61850	7	15
MODULE : 4 **SCADA Communication**: Various industrial communication technologies- wired andireless methods and fibre optics	6	15
SECOND INTERNAL TEST		
MODULE : 5 **SCADA Applications**: Utility Applications- Transmission and distribution sector-Operations-Monitoring -Analysis and improvement- Substation automation structure- substation automation architecture.	8	20
MODULE : 6 **Introduction to role of wide area measurement**- power system phenomenon with possibleWAPS solution-Implementation of wide area protection- interaction of WAMS with SCADA System	8	20

Internal Continuous Assessment: 40 %s : 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.

Periodical Test 1 – 15%
Periodical Test 2 – 15%
Assignments/Term Paper/Seminar – 10%

End Semester Examination: 60%

ELECTIVE V

Course No: 07EE7203 Course Title: POWER SYSTEM DEREGULATION AND ECONOMICS

Credits: 3-0-0: 3 Year :2015

Pre-requisites: Nil

Course Objectives:

To give the Student the basic knowledge of the power system restructuring, market structure, relation between demand and supply costs and Electricity price,f factors affecting the electricity price in the restructured market and generation capacity evaluation, basic concepts and an overview of transmission pricing and congestion management **,** ideas of reactive power requirements under voltage stability studies and impact of reactive power in power tariff and the requirements of the utilities in restructured markets

Syllabus

Power system restructuring- deregulation of power industry- Reasons and objectives of deregulation of various power systems across the world- Market Structure and operation- Costs- relationship between short run and long run costs- Monopolistic and Oligopolistic- Determination of market price- Electricity price- automatic generation control and its pricing- Generation assets valuation and risk analysis.- Transmission Congestion Management and Pricing- Role of FACTS devices in competitive power market- Available Transfer Capability, Distributed Generation in restructured markets- Reactive power requirements under steady state voltage stability and dynamic voltage stability- System losses and loss reduction methods, Power tariffs -Market Forces shaping of reactive power- reactive power requirement of the utilities.

Course Outcome:

At the end of the course students will acquire knowledge in basics of the power system restructuring, market structure, relation between demand and supply costs and Electricity price, factors affecting the electricity price in the restructured market and generation capacity evaluation. Also students will acquire knowledge in concept of transmission pricing and congestion management , stability and impact of reactive power in power tariff in restructured markets

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.

Restructured electrical power systems: operation, trading and volatility Mohammad

COURSE PLAN			
Course No	**Course Title**	**(L-T-P) :Credits**	Year
07EE7203		**3-0-0) :3**	**2015**
MODULES		**Contact hours**	**Sem.Exam Marks;%**
MODULE : 1 **Power system restructuring& Deregulation** - Introduction,Reasons for restructuring / deregulation of power industry ,Understanding the restructuring process, Introduction to issues involved in deregulation, Reasons and objectives of deregulation of various power systems across the world		5	15
MODULE : 2 **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.		6	15
FIRST INTERNAL TEST			
MODULE : 3 **Costs:** short run –long run- relationship between short run and long run costs, perfect competition-Monopoly- Monopolistic and Oligopolistic, Determination of market price, Price discrimination.		6	15
MODULE : 4 **Electricity price:** price volatility, ancillary services in electricity power market, automatic generation control and its pricing, Generation assets valuation and risk analysis.-introduction, VaR for Generation Asset Valuation, Generation Capacity Valuation		8	15
SECOND INTERNAL TEST			
MODULE : 5 **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.		9	20
MODULE : 6 **Reactive power requirements**- 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.		8	20

Internal Continuous Assessment: 40 % : 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.

Periodical Test 1 – 15%
Periodical Test 2 – 15%
Assignments/Term Paper/Seminar – 10%
End Semester Examination: 60%

Course No: 07EE7213 Course Title: SOFT COMPUTING TECHNIQUES

Credits: 3-0-0: 3 Year :2015

Pre-requisites: Nil

Course Objectives:

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.

Syllabus

Introduction to Fuzzy logic - Membership Functions- Fuzzification-Methods of Membership value Assignments- Fuzzy Rule Base-Defuzzification- Fuzzy logic controller (Block Diagram)Artificial Neural Networks-Neural network Architectures- Feed forward network-Characteristics of Neural Networks-Learning methods. Perceptron networks-Back Propagation networks-Radial base function network-Hopfield network- Kohonen Self organizing maps-ART. Fundamentals of genetic algorithms: working principle – encoding – different methods – fitness function – reproduction- Genetic modelling-inheritance-Crossover - mutation-convergence of genetic algorithm.Hybrid systems: Neural network, fuzzy logic and genetic algorithm hybrids – Neuro fuzzy hybrids- neuro genetic hybrids-Fuzzy genetic hybrids- Fuzzy back propagation networks -fuzzy logic controlled genetic algorithms

Course Outcome:

At the end of course, the student will be able to understand different soft computing techniques, application of soft computing techniques in control systems & optimizations

References:

1. S.Rajasekharan, G.A.Vijayalakshmi Pai, "*Neural Network, Fuzzy Logic and Genetic Algorithms Synthesis and Applications"*, Prentice Hall India.
2. S.N.Sivanandam, S.N.Deepa, "*Principles of Soft Computing"*, Wiley India.
3. Timothy J Ross, "*Fuzzy logic with Engineering Applications"*, McGraw Hill, New York.
4. S.Haykins, "*Neural Networks a Comprehensive foundation"*, Pearson Education.
5. D.E.Goldberg, "*Genetic Algorithms in Search Optimisation and Machine Learning"*, Pearson Education.
6. Recent Literature.

COURSE PLAN			
Course No	**Course Title**	**(L-T-P) :Credits**	Year
07EE7213	**SOFT COMPUTING TECHNIQUES**	**3-0-0) :3**	**2015**

MODULES	Contact hours	Sem.Exam Marks;%
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	7	15
MODULE : 2 Defuzzification-Deffuzzification methods- Fuzzy logic controller (Block Diagram). Artificial Neural Networks: Basic concepts-Neural network Architectures-Single layer feed forward network-Multilayer feed forward network-Recurrent Networks	7	15
FIRST INTERNAL TEST		
MODULE : 3 Characteristics of Neural Networks-Learning methods. Perceptron networks-Back Propagation networks-Radial base function network-Hopfield network- Kohonen Self organizing maps-ART	7	15
MODULE : 4 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.	7	15
SECOND INTERNAL TEST		
MODULE : 5 Hybrid systems: Neural network, fuzzy logic and genetic algorithm hybrids – Neuro fuzzy hybrids- neuro genetic hybrids-Fuzzy genetic hybrids	7	20
MODULE : 6 Genetic algorithm based back propogation network- Fuzzy back propagation networks -fuzzy logic controlled genetic algorithms	7	20

Internal Continuous Assessment: 40 % : 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.

Periodical Test 1 – 15%
Periodical Test 2 – 15%
Assignments/Term Paper/Seminar – 10%

End Semester Examination: 60%

Course No: 07EE7223 Course Title: AUTOMATION AND INSTRUMENTATION FOR POWER SYSTEMS

Credits: 3-0-0: 3 Year :2015

Pre-requisites: Nil

Course Objectives:

To impart basic concept of with power system automation and its architechures ,substation automation subsystem, recent measurement of electrical quantities, PLC and its programming , communication in automation and Stansards for substation automation

Syllabus

Introduction to power system automation -historical development of power system automation, Substation Automation Subsystems -Protective relays, Remote terminal unit, PLC,SCADA and other intelligent devices. Power System Automation Architechures -Types of power system automation architecture, Automation of HV substations, automation of MV substations.
Recent Trends In Measurement Of Electrical Quantities - Digital techniques of measurement of voltage, current, power, energy and , power factor Hall effect sensors, Measurement of THD and harmonics. Introduction to PLC PLC architecture, PLC Hardware,. PLC Programming Introduction to ladder diagrams, hard wired relay logic, ladder logic ,Programming of arithmetic instructions, programming of analog inputs and outputs. Communication in Power System Automation -Basics of data communication, CSMA/CD Ethernet MAC, Full duplex Ethernet, Communication protocols. IEC 61850 Standard For Substation Automation .

Course Outcome:

At the end of course, the student will be able to understand power system automation and its architechures ,substation automation subsystem, recent measurement of electrical quantities, PLC and its programming , communication in automation and Stansards for substation automation

Text Books

1. Helfrick – Cooper, Modern electric instrumentation and measurement technique, PHI 1994.
2. T.S. Rathore, Digital measurement techniques, Narosa publishing House, 1996.
3. John Webb, Ronald Reis - Programmable Logic Controllers , PHI, 2003.
4. Klaus-Peter and Others – Substation Automation Handbook, Utility Automation Consulting Lohmann, ISBN 3-85758-951-5.

COURSE PLAN			
Course No	**Course Title**	**(L-T-P) :Credits**	**Year**
07EE7223	**AUTOMATION AND INSTRUMENTATION FOR POWER SYSTEMS**	**3-0-0) :3**	**2015**

MODULES	Contact hours	Sem.Exam Marks;%
MODULE : 1 Introduction to power system automation -Historical development of power system automation, Fundamentals of electrical protection, development of protective relays, numeric (microprocessor based relays). Substation Automation Subsystems -Protective relays, Remote terminal unit, PLC,SCADA and other intelligent devices. Power System Automation Architechures Types of power system automation architecture, Automation of HV substations, automation of MV substations.	7	15
MODULE : 2 **Recent Trends In Measurement Of Electrical Quantities** Current Voltage measurement with instrument transformers, Digital techniques of measurement of voltage, current, power, energy and , power factor Hall effect sensors, Measurement of THD and harmonics.	8	15
FIRST INTERNAL TEST		
MODULE : 3 **Introduction to PLC-** PLC architecture, modular and micro PLCs, PLC Hardware, Input-Output modules, CPU Module, PLC scan cycle.	4	15
MODULE : 4 **Introduction To PLC Programming** Introduction to ladder diagrams, hard wired relay logic, ladder logic symbols Boolean logic programming examples, timers, counters, Registers, Programming of arithmetic instructions, programming of analog inputs and outputs.	8	15
SECOND INTERNAL TEST		
MODULE : 5 **Communication In Power System Automation** control rinciples, CSMA/CD Ethernet MAC, Full duplex Ethernet, Communication protocols, Mode bus and Mode bus TCP/IP, Profibus, TCP/IP, DNP3.	8	20
MODULE : 6 **IEC 61850 Standard For Substation Automation** Logical Nodes (LN), Logical Device (LD), Intelligent Electronic Devices(IEDs), Process level functions, Bay level functions, Station Level Functions**,** Station Bus and Process	7	20

Internal Continuous Assessment: 40 % : 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.

Periodical Test 1 – 15%
Periodical Test 2 – 15%
Assignments/Term Paper/Seminar – 10%
End Semester Examination: 60%

Course No: 07EE7205 Course Title: SEMINAR

Credits: 0-0-2: 2 Year :2015

Course Objectives:

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

.

Syllabus

Students have to register for the seminar and select a topic in consultation with any faculty member offering courses for the programme. A detailed write-up on the topic of the seminar is to be prepared in the prescribed format given by the Department. The seminar shall be of 30 minutes duration and a committee with the Head of the department as the chairman and two faculty members from the department as members shall evaluate the seminar based on the report and coverage of the topic, presentation and ability to answer the questions put forward by the committee.

Faculty member in charge of the seminar and another faculty member in the department nominated by the Head of the Department are the evaluators for the seminar.

Internal Continuous Assessment: 100 marks

Marks for the report: 30%
Presentation: 40%
Ability to answer questions on the topic: 30%

Course No: 07EE7207 Course Title: PROJECT -PHASE 1

Credits: 0-0-12: 8 Year :2015

Course Objectives:

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.

Syllabus

The project work can be a design project/experimental project and/or computer simulation project on any of the 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 carry out their project outside the parent institute, subject to the conditions specified in the MTech regulations.

The student is required to undertake the Project phase 1 during the third semester and the same is continued in the 4^{th}semester (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 4^{th} semester.

Marks:50

Progress evaluation by the Project Supervisor : 20 %
Presentation and evaluation by the committee : 30 %

SEMESTER 4

Course No: 07EE7207 Course Title: PROJECT -PHASE 2

Credits: 0-0-21: 12 Year :2015

Course Objectives:

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.

Syllabus.

Project Phase 2 is a continuation of project phase 1 started in the third semester. There would be two reviews in the fourth semester, first in the middle of the semester and the second 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. . 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.

Mraks:100

Project evaluation by the supervisor/s :	**30 %**
Presentation & evaluation by the Committee :	**40 %**
Evaluation by the External expert :	**30 %**