KERALA TECHNOLOGICAL UNIVERSITY

(KOLAM CLUSTER - 02)

SCHEME AND SYLLABI

of

M. TECH. in

POWER SYSTEMS

OFFERING DEPARTMENT

ELECTRICAL & ELECTRONICS ENGINEERING

CLUSTER LEVEL GRADUATE PROGRAM COMMITTEE

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9	Principal, Travancore Engineering College, Parippally, Kollam
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CERTIFICATE

This is to certify that

1. The scheme and syllabi are prepared in accordance with the regulations 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 8.6.2015 have 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

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Date:
Place:

Dr S. Mohan,
Professor, IIT, Madras
Chairman

Programme Educational Objective

I. This Course aims at training graduate engineers in the field of Power Systems. This course deals with the state of the art techniques in Power System analysis, stability evaluation planning, reliability and forecasting.

II. The course also covers subjects on High Voltage DC Transmission, Industrial electronics and controls, Power electronics and drives and wind and solar energy electric conversion systems which are very much needed for today's power system engineer.

III. Projects of practical relevance in these areas are carried out in the final semester of the course.

Programme outcome

After successful completion of the programme the student should be able to

1. Evaluate and analyze problems related to Power Systems and be able to synthesize the domain knowledge and incorporate the principles in the state of art systems for further enrichment.
2. Be able to critically investigate the prevailing complex PS scenarios and arrive at possible solutions independently, by applying the acquired theoretical and practical knowledge
3. Be able to solve PS problems such as load flows, state estimation, fault analysis and stability studies
4. B e able to develop broad-based economically viable solutions for unit commitment and scheduling
5. Be able to identify optimal solutions for improvising power transfer capability, enhancing power quality and reliability
6. Be able to evolve new schemes based on literature survey, and propose solutions through appropriate research methodologies, techniques and tools, and also by designing and conducting experiments
7. Be able to interpret power system data and work on well-defined projects with well defined goals to provide real time solutions pertaining to PS
8. Be able to develop, choose, learn and apply appropriate techniques, various resources including hardware and IT tools for modern power engineering, including prediction

and modeling with an understanding of the limitations

9. Be able to develop dedicated software for analyzing and evaluating specific power system problems
10. Be able to participate in collaborative-multidisciplinary engineering / research tasks and work as a team member in such tasks related to PS domain, giving due consideration to economic and financial intricacies, and lead the team in specific spheres
11. Be able to confidently interact with the industrial experts for providing consultancy
12. Be able to pursue challenging professional endeavors based on acquired competence and knowledge
13. Be a responsible professional with intellectual integrity, code of conduct and ethics of research, being aware of the research outcomes and serve towards the sustainable development of the society
14. Be capable of examining critically the outcomes of research and development independently without any external drive.

Scheme of M. Tech Programme
in Power systems
SEMESTER 1 (Credits 21)

Exam Slot	Course No	Name of the Subject	L-T-P	Internal 02EErks	End Semester Exam		Credits
					02EEr ks	Duration (hrs)	
A	**02EE6111/ 02EE6211**	Advanced Engineering Mathematics	4-0-0	40	60	3	4
B	**02EE6221**	Computer Aided Power System Analysis	2-2-0	40	60	3	4
C	**02EE6131/ 02EE6231**	Dynamics of Linear Systems	4-0-0	40	60	3	4
D	**02EE6241**	Solid State Power Converters	3-0-0	40	60	3	3
E	**Elective 1 02EE6251**	**02EE6151.1./02EE6251.1.** Optimization Techniques in Electrical Engineering **02EE6151.3./02EE6251.2.** Advanced Digital Signal Processing **02EE6251.3.** Power Distribution Systems **02EE6251.4.** Modelling of Electrical Machines	3-0-0	40	60	3	3
	02CA6001	Research Methodology	0-2-0	100	0	0	2
	02EE6261	Seminar		100	0	0	2
	02EE6271	Power System Simulation Lab	0-0-2	100	0	0	1
Total Credits							**23**

Scheme of M. Tech Programme
in Power systems
SEMESTER 2 (Credits 21)

Exam Slot	Course No	Name of the Subject	L-T-P	Internal 02EErks	End Semester Exam		Credits
					02EErks	Duration (hrs)	
A	**02EE6212**	Digital Protection of Power Systems	4-0-0	40	60	3	4
B	**02EE6222**	Power System Dynamics and Control	3-0-0	40	60	3	3
C	**02EE6232**	Transient Analysis in Power Systems	3-0-0	40	60	3	3
D	**Elective2 02EE6242**	**02EE6142.1./02EE6242.1.** Soft Computing Techniques **02EE6242.2.** FACTS and Custom Power **02EE6242.3.** Power System Economics **02EE6142.4/02EE6242.4.** Electric Drives	3-0-0	40	60	3	3
E	**Elective3 02EE6252**	**02EE6252.1.** Power Quality **02EE6152.2./02EE6252.2.** Energy Auditing and Management **02EE6252.3.** Distributed Generation **02EE6252.4.**SCADA systems and Applications	3-0-0	40	60	3	3
	02EE6262	Mini Project	0-0-4	100	0	0	2
	02EE6272	Power Equipments Laboratory	0-0-2	100	0	0	1
Total Credits							**19**

Scheme of M. Tech Programme
in Power systems
SEMESTER 3 (Credits 14)

Exam Slot	Course No	Name of the Subject	L-T-P	Internal 02EErks	End Semester Exam		Credits
					02EErks	Duration (hrs)	
A	**Elective4 02EE7211**	**02EE7211.1.** Electric and Hybrid Vehicles **02EE7211.2.** Power System Reliability **02EE7211.3.** Digital Signal Processing Applications **02EE7111.4./02EE7211.4.** Power System Instrumentation	3-0-0	40	60	3	3
B	**Elective5 02EE7221**	**02EE7221.1.** EHV AC & DC Transmission System **02EE7221.2.** Grid Integration Technology of DG **02EE7221.3.** Dynamics of Power Converters **02EE7221.4.** Power System Operation and Control	3-0-0	40	60	3	3
	02EE7231	Seminar	0-0-2	100	0	0	2
	02EE7241	Project (Phase 1)	0-0-12	50	0	0	6
Total Credits							**14**

Scheme of M. Tech Programme
in Power systems
SEMESTER 4 (Credits 12)

Exam Slot	Course No	Name of the Subject	L-T-P	Internal 02EErks	End Semester Exam		Credits
					02EErks	Duration (hrs)	
-	02EE7212	Project (Phase 2)	0-0-21	70	30	0	12
Total Credits							**12**

SEMESTER 1

Course No.	Course Name	L-T-P-Credits	Year of Introduction
02EE6111/ 02EE6211	**Advanced Engineering Mathematics**	**4-0-0-4**	**2015**

Course Objective

1. To acquire basic ideas of linear transformation which help to provide a dynamic & graphical view of matrix vector multiplication
2. To determine the optimal solution of multivariable problem by dynamic programming.

Syllabus

Vector Space, Calculus of Variations, Special Functions, linear programming, Probability Distribution, Constrained non-linear programming.

Expected outcome

Upon successful completion of this course, students will be able to attain a thorough understanding in many problems of mathematical physics and engineering

References:

1. *David C. Lay, "Linear Algebra", Pearson Edn., 4th Edn., 2012*
2. *Richard Bronson, Gabriel B. Costa, "Linear Algebra - An Introduction", Elsevier-Academic Press, 2nd Edn.*
3. *Otto Bretsher, "Linear Algebra with Application"- Pearson Education., 4th edn.*
4. *R. Hariprakash and B. Durga Prasad, "Operations Research" , Scitech. 1st edn., 2010*
5. *Handy A. Taha, "Operations Research- an Introduction", PHI, 9th Edn., 2011*
6. *B. S. Goel and S. K. Mittal, "Operations Research", Pragathi Prakashan, 25th Edn., 2009.*
7. *K. V. Mittal and C. Mohan, "Optimization Methods in Operations Research and System Analysis", 3rd Edn., New Age International Publishers.*

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	Probability Distribution : Estimation (point and interval) of parameters, unbiased-consistency-efficiency and sufficiency, definition, problems of joint probability distribution of discrete and continuous random variables, normal distribution, Cauchy's distribution.	**08**	**09**
II	Constrained non-linear programming: Kuhn-Tucker conditions, Convex programming problem, Quadratic programming, gradient of a function, steepest descent method, conjugate gradient method, Dynamic Programming: Minimal path problems.	**09**	**09**
FIRST INTERNAL EXAM			

III	Special Functions: Bessel function, Recurrence relation, properties, generating function, orthogonality property, Legendre function, Rodrigues formulae, Legendre polynomials, Recurrence relations (without proof), orthogonality, generating function.	**10**	**09**
IV	Dual simplex method, Integer programming: Cutting plane method, Branch and bound method, Zero– One Programming, Unconstrained non-linear programming: Powel's method, Hooke-Jeeves method.	**08**	**09**
SECOND INTERNAL EXAM			
V	Vector Space: Vector space, subspace, linear independence of vectors, Dimension and basis (Definitions, theorems without proof and problems), linear transformations, Rank and nullity, Inner product, Norm of a vector, Orthogonal vectors, Gram Schmidst Orthogonalization process. Matrix factorization-QR factorization, Singular value decomposition and least square problems.	**11**	**12**
VI	Calculus of Variations : Basic problems of calculus of variations, other forms of Euler's equation, problems, Problems of the minimum surface of revolution, minimum energy problem Brachistochrone problem, isoperimetric problem.	**11**	**12**
END SEMESTER EXAM			

Course No.	Course Name	L-T-P-Credits	Year of Introduction
02EE6221	Computer Aided Power System Analysis	2-2-0-4	2015

Course Objective

1. To provide a strong foundation on classical and modern control theory.
2. To provide an insight into the role of controllers in a system.
3. To design compensators using classical methods.
4. To design controllers in the state space domain.
5. To impart an in-depth knowledge in observer design.

Syllabus

Analysis of Power Systems under normal conditions and faulty conditions. Estimation of missing data and finding the operating point of power systems considering the generator characteristics and cost functions

Expected Outcome

Upon successful completion of this course, students will be able to:

1. Model any power system for any timeframe of analysis.
2. Conduct load flow analysis of any power network,
3. Carry out short circuit and contingency analysis of any power system.
4. Perform state estimation on any power system from incomplete data.
5. Conduct scheduling of different types of generators.

References

1. *JohnJ.Grainger,WilliamD.Stevenson,Jr.,PowerSystemAnalysis,TataMcGraw-HillSeriesin Electrical and Computer Engineering, 1994*
2. *I. J. Nagrath and D. P. Kothari, Modern Power system Analysis, 3rd Edition, Tata McGraw-Hill Publishers, 1980.*
3. *J. Arriliga and N. R. Watson, Computer Modelling of Electrical Power Systems, Wiley Publications,2001*
4. *G.W .Stagg and El-Abiad, Computer Methods in Power System Analysis, McGraw Hill, 1968.*
5. *Hadi Saadat, Power System Analysis, McGraw-Hill Publisherss.*
6. *Jos Arrillaga, Bruce C. Smith, Neville R. Watson, Alan Wood, Power System Harmonic Analysis, John Wiley and Sons, 1997.*
7. *S.A. Soman, S.A. Khaparde, Shubha Pandit, Computational Methods For Large Sparse Power Systems Analysis: An Object Oriented Approach, Kluwer Academic Publishers*
8. *G. L. Kusic, Computer Aided Power System Analysis, Prentice Hall, 1986.*
9. *H.E. Brown, Large Networks by Matrix Methods, John Wiley & Sons.*

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	Review of solution of Linear System of equations by Gauss Jordan method, Gauss elimination, LU factorization and LDU factorization. Elementary linear graph theory – Incidence and network matrices. Development of network matrices from Graph theoretic approach, Building algorithm for Bus impedance matrix, Modification of Z_{BUS} matrix due to changes in primitive network.	10	9
II	Load Flow Studies: Overview of Gauss, Gauss-Seidel and Newton Raphson Methods, Decoupled Load Flow, Fast Decoupled Load Flow, DC load flow.	10	9

FIRST INTERNAL EXAM			
III	Short Circuit studies–Types of Faults–Short circuit study of a large power system – Algorithm for calculating system conditions after fault–three phase short circuit, three phase to ground, double line to ground, line to line and single line to ground fault	**8**	**9**
IV	State estimation – least square and weighted least square estimation methods for linear and non-linear systems. Static state estimation of power systems - injections only and line only algorithms, Treatment of bad data–detection, identification and suppression of bad data.	**8**	**9**
SECOND INTERNAL EXAM			
V	Contingency Analysis - adding and removing multiple lines, Analysis of single and multiple contingencies, Contingency Analysis by DC model, System reduction for contingency and fault studies.	**8**	**9**
VI	Three-phase Load Flow and Harmonic Load flow. Sparsity techniques, Triangular factorization and Optimal ordering. Incorporation of FACTS devices in Load Flow: Static Tap Changing, Phase Shifting (PS), Static VAR Compensator (SVC), Thyristor Controlled Series Compensator (TCSC) and Unified Power Flow Controller (UPFC). 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.	**12**	**15**
END SEMESTER EXAM			

Course No.	Course Name	L-T-P-Credits	Year of Introduction
02EE6131/ 02EE6231	**Dynamics of Linear Systems**	**4-0-0-4**	**2015**

Course Objective

1. To provide a strong foundation on classical and modern control theory.
2. To provide an insight into the role of controllers in a system.
3. To design compensators using classical methods.
4. To design controllers in the state space domain.
5. To impart an in-depth knowledge in observer design.

Syllabus

Design of feedback control systems, Compensator design, Lyapunov's stability theory for linear systems, State space analysis and design, Linear state variable feedback for SISO systems, Design of observers, MIMO systems

Expected Outcome

Upon successful completion of this course, students will be able to:

1. Analyse a given system and assess its performance.
2. Design a suitable compensator to meet the required specifications.
3. Design and tune PID controllers for a given system.
4. Realise a linear system in state space domain and to evaluate controllability and observability.
5. Design a controller and observer for a given system and evaluate its performance.

References:

1. Thomas Kailath, "Linear System", Prentice Hall Inc., Eaglewood Cliffs, NJ, 1998
2. Benjamin C. Kuo, "Control Systems", Tata McGraw-Hill, 2002
3. M. Gopal, "Control Systems-Principles and Design", Tata McGraw-Hill, 2002
4. Richard C. Dorf & Robert H. Bishop, "Modern Control Systems", Addison Wesley, 8th Edition, 1998.
5. Gene K. Franklin & J. David Powell, "Feedback Control of Dynamic Systems", Addison Wesley, 3rd Edition, 2009
6. Friedland B., "Control System Design: An Introduction to State Space Methods", Tata McGraw-Hill,2005

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	Design of feedback control systems- Approaches to system design-compensators-performance measures - cascade compensation networks-phase lead and lag compensator design using both Root locus and Bode plots-systems using integration networks, systems with pre-filter.	**10**	**9**
II	Lyapunov's stability theory for Linear Systems – Equilibrium points and stability concepts, Stability definitions, Linear system stability, The Direct method of Lyapunov, Use of Lyapunov's method in feedback design.	**9**	**9**
FIRST INTERNAL EXAM			
III	State Space Analysis and Design- Analysis of stabilization by pole cancellation – Canonical realizations - Parallel and cascade realizations - reachability and constructability stabilizability - controllability - observability -grammians.	**9**	**9**

IV	Linear state variable feedback for SISO systems, Analysis of stabilization by output feedback-modal controllability-formulae for feedback gain -significance of controllable Canonical form-Ackermann's formula- feedback gains in terms of Eigen values - Mayne-Murdoch formula - Transfer function approach – state feedback and zeros of the transfer function - non controllable realizations and stabilizability - controllable and uncontrollable modes - regulator problems - non zero set points - constant input disturbances and integral feedback.	**10**	**9**
SECOND INTERNAL EXAM			
V	Observers: Asymptotic observers for state measurement-open loop observer-closed loop observer-formulae for observer gain - implementation of the observer - full order and reduced order observers - separation principle - combined observer - controller – optimality criterion for choosing observer poles -	**09**	**12**
VI	Direct transfer function design procedures - Design using polynomial equations - Direct analysis of the Diophantine equation. MIMO systems: Introduction, controllability, observability, different companion forms.	**09**	**12**
END SEMESTER EXAM			

Course No.	Course Name	L-T-P-Credits	Year of Introduction
02EE6241	**Solid State Power Converters**	**3-0-0-3**	**2015**

Course Objective

To Familiarize various Power Electronic conversion techniques.

Syllabus

A better understanding of the merits and demerits of critical analytical solution methods which are the basis for valid techniques in solving power system problems

Expected outcome

1. A better understanding of the merits and demerits of critical analytical solution methods which are the basis for valid techniques in solving power system problems
2. To analyze the operation of Power electronic circuits involved in Renewable energy application
3. To learn the basics of state of art techniques used in mitigating power quality problems and to apply the same in higher learning.
4. To analyse the use resonant circuits in reducing the stress in power electronic circuits with improved efficieny .

References:

1. Ned Mohan, et. al., “Power Electronics: Converters, Design and Applications,” Wiley
2. V. Ramanarayanan, “Course Notes on Switched Mode Power Converters, “Department of Electrical Engineering, Indian Institute of Science, Bangalore
3. G. K. Dubey, et.al., “Thyristorised Power Controllers,” New Age International
4. John Vithayathil, “Power Electronics: Principles and Applications”, Tata McGraw Hill
5. Bin Wu, “High Power Converters and AC Drives,” IEEE Press, Wiley Interscience, 2006.
6. L. Umanand, “Power Electronics: Essentials and Applications,” Wiley, 2009
7. Thimothy L. Skvarenina, “The Power electronics handbook”, CRC press, 2002

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	AC voltage controllers: Analysis of single-phase ac voltage controller with R and RL load, Performance parameters, Sequential control of single-phase ac voltage controllers.	**7**	**9**
II	DC-DC converters: Buck, boost, buck-boost and C'uk Topologies-Representation with ideal switches, Steady state analysis in continuous conduction mode using inductor volt-sec balance-- current and voltage ripples. Design relations for inductor and capacitors. Discontinuous Conduction Mode operation of basic buck and boost converter-Isolated dc-dc converters: Steady-state analysis of fly back, forward, push-pull and bridge topologies.	**7**	**9**
FIRST INTERNAL EXAM			
III	Switched Mode Inverters: Topologies of single-phase half-bridge, full-bridge and three-phase bridge Voltage Source Inverters-Representation using ideal switches- stepped wave and PWM operation- Sine-Triangle PWM-Selective Harmonic Elimination	**7**	**9**
IV	Space Vector PWM- Evaluation of dwell times- Principles of Current Controlled VSI- Hysteresis control and PWM	**7**	**9**

	current control. Current Source Inverters: Analysis of capacitor commutated single phase CSI feeding resistive and pure-inductor loads		
SECOND INTERNAL EXAM			
V	Resonant Converters - Second-Order Resonant Circuits - Load Resonant Converters - Resonant Switch Converters – Resonant DC-Link Converters with ZVS Series-Resonant Inverters: Voltage-Source Series , Voltage-Source Parallel-	**7**	**12**
VI	The Resonant DC-Link Inverter - The Parallel-Resonant DC-Link Inverter - Current Research Trends Auxiliary Resonant Commutated Pole Inverters: Losses in Hard-Switched Inverters - Analysis of ARCP Phase Leg - Analysis of ARCP H-Bridge - Analysis of ARCP Three-Phase Inverter	**7**	**12**
END SEMESTER EXAM			

Course No.	Course Name	L-T-P-Credits	Year of Introduction
02EE6151.1/ 02EE6251.1	**Optimization Techniques In Electrical Engineering**	**3-0-0-3**	**2015**

Course Objective

1. Equip the Students with a thorough understanding of linear and non linear optimization techniques.
2. Equip the Students with a basic idea of optimal tuning of controller parameters in power system and control system applications.

Syllabus

Constrained and Uncontrained optimization using conventional and non-conventional techniques. Application to Electrical Engineering field with

Expected outcome

Upon successful completion of this course, students will be able to

1. Apply conventional and non conventional optimization techniques to all fields of research applications of Electrical Engineering
2. Determine optimal solutions to complex real life issues in Electrical Engineering using modern software tools

References:

1. Recent articles in power system optimization from IEEE journal, Elsevier etc.
2. Taha,H.A., Operations Research –An Introduction,Prentice Hall of India,2003. 3. Fox, R.L., „Optimization methods for Engineering Design‟, Addition Welsey, 1971.
3. R. Hariprakash and B. Durga Prasad, Operations Research , Scitech. 1st edn., 2010
4. Handy A. Taha, Operations Research an Introduction, PHI, 9th Edn., 2011
5. B. S. Goel and S. K. Mittal, Operations Research, Pragathi Prakashan, 25th Edn., 2009.
6. K. V. Mittal and C. Mohan, 'Optimization Methods in Operations Research and System Analysis', 3rd Edn., New Age International Publishers.
7. Singiresu S Rao, Engineering Optimization Theory and Practice, 3rd Edn, New Age International Publishers.

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	Linear programming –formulation-Graphical and simplex methods-Big-M method. Two phase method-Dual simplex method-Primal Dual problems. Numerical examples based on power system/control system applications and implementation using Software packages	**7**	**9**
II	Unconstrained one dimensional optimization techniques - Necessary and sufficient conditions –Unrestricted search methods-Fibonacci and golden section method Quadratic Interpolation methods, cubic interpolation and direct root methods. Numerical examples based on power system/control system applications and implementation using Software packages	**7**	**9**
FIRST INTERNAL EXAM			

III	Dynamic programming- principle of optimality- numerical solution of unit commitment problems - implementation using software packages. Genetic Algorithm -Introduction - basic concepts –application	**7**	**9**
IV	Transportation problems- application to shortest route, cargo-loading, allocation and production schedule problems. Allocation of shortest path for Electrical Engineering	**7**	**9**
SECOND INTERNAL EXAM			
V	Unconstrained n dimensional optimization techniques – direct search methods – Random search –pattern search and Rosen brooch’s hill claiming method. Descent methods-Steepest descent, conjugate gradient, quasi -Newton method. Any two numerical examples like economic load dispatch problems, harmonic eliminations of inverters and implementation of the problems using software packages.	**7**	**12**
VI	Constrained optimization Techniques- Necessary and sufficient conditions – Equality and inequality constraints-Kuhn-Tucker conditions-Gradient projection method-cutting plane method- penalty function method. Numerical examples based on tuning of excitations controllers, Controller parameters for Automatic Generation Controllers of Generators of Power stations.	**7**	**12**
END SEMESTER EXAM			

Course No.	Course Name	L-T-P-Credits	Year of Introduction
02EE6151.3/ 02EE6251.2	**Advanced Digital Signal Processing**	**3-0-0-3**	**2015**

Course Objective

To learn about modern signal processing techniques, theory and implementation of FFT algorithms, digital filters, mathematical basis of discrete time signal analysis.

Syllabus

Review of DTS, Structures for discrete time system, Digital Filter Design Techniques, Spectral estimation, Time frequency analysis, Introduction to Digital Signal Processors

Expected outcome

Upon successful completion of this course, students will be able to

1. Solve various types of practical problems in DSP
2. Apply signal processing strategies.
3. Design FIR and IIR filters.

References:

1. Emmanuel C. Ifeachor, Barrie W. Jervis, "Digital Signal Processing: A Practical Approach", Pearson Education India Series, New Delhi, 2nd Edition, 2004

2. Sanjit K. Mitra, "Digital Signals Processing: A Computer Based Approach", Tata McGraw- Hill Publishing Company Limited, 2nd Edition, 2004.

3. Alan Oppenheim V., Ronald W. Schafer, "Digital Signal Processing", Prentice Hall of India Private. Limited. New Delhi, 1989.

4. John G. Proakis and Manolakis. D.G,"Digital Signal Processing: Principles Algorithms and Applications", Prentice Hall of India, New Delhi, 2004.

5. Oppenheim V. and Ronald W. Schafer, "Discrete Time Signal Processing", Prentice Hall of India Private Limited., New Delhi, 2001.

6. Leon Cohen, "Time Frequency Analysis", Prentice Hall, 1995.

7. P. P. Vaidyanathan, "Multirate systems and Filter Banks", Prentice Hall, 1993

8. Avatar Singh and Srinivasan S., "Digital Signal Processing: Implementation using DSP", 2004

9.M. H. Hayes: "Statistical Signal Processing and Modeling", John Wiley and Sons, 1996

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	Review of DTS-Discrete time Signals-Sequences –Stability and Causality –Frequency domain Representation of Discrete time Systems and Signals –Two-dimensional Sequences and Systems –Z-Transform –Z- Transform Theorems and Properties –Two-dimensional Z-Transform.	**7**	**9**
II	Structures for discrete time system– Direct, cascade and parallel forms –Lattice structure. Representation of Periodic Sequences-the Discrete Fourier Series –Properties of the discrete Fourier series –Sampling, Z-transform –discrete Fourier transform –properties of discrete Fourier Transform –Linear Convolution –Decimation –in- Time and Decimation in- Frequency –FFT Algorithms.	**7**	**9**

FIRST INTERNAL EXAM			
III	Digital Filter Design Techniques-Introduction – Design of IIR Digital Filters from Analog Filters-Analog–Digital Transformation–Properties of FIR Digital Filters–Design of FIR Filters Using Windows–A Comparison of IIR and FIR Digital Filters. Finite Register Length Effects- Introduction-Effects of coefficient on Quantization–Quantization in Sampling-Analog Signals-Finite Register Length effects in realizations of Digital Filters-discrete Fourier Transform Computations.	**7**	**9**
IV	Spectral estimation: Periodogram, Bartlett's method, Welch's method, Blackman-Tukey method, ARMA modeling, Yule-Walker equation and solution	**7**	**9**
SECOND INTERNAL EXAM			
V	Time frequency analysis, the need for time frequency analysis, Time frequency distribution, Short time Fourier Transform, Wigner distribution. Multi rate digital signal processing: Basic multi rate operation (up sampling, down sampling), Efficient structures for decimation and interpolation, Decimation and interpolation with poly phase filters, Non integer sampling rate conversion , Efficient multi rate filtering Applications, Oversampled A/D and D/A converter.	**8**	**12**
VI	Introduction to Digital Signal Processors-Commercial DSP devices – TMS C240 processor and ADSP 2181 processor – Architecture – Addressing modes – Program control – Instruction and programming –Simple programs.	**7**	**12**
END SEMESTER EXAM			

Course No.	Course Name	L-T-P-Credits	Year of Introduction
02EE6251.3	**Power Distribution Systems**	3-0-0-3	2015

Course Objective

Objective of the course is to introduce various advancements in the distribution systems

Syllabus

Power Distribution system planning, reliability and pricing

Expected outcome

Upon successful completion of this course, students will be able to do:
1. Distribution system planning
2. Distribution automation

References:

1. A. S. Pabla, '*Electrical Power Distribution Systems*', 4th edn., TMH, 1997
2. Turan Gonen, '*Electrical Power Distribution Engineering*', McGraw-Hill, 1986
3. Colin Bayliss, '*Transmission and Distribution Electrical Engineering*', Butterworth Heinemann, 1996
4. Pansini, '*Electrical Distribution Engineering*'
5. E. Lakervi & E. J. Holmes, '*Electricity Distribution Network Design*', 2ndEdition, Peter Peregrimus Ltd.
6. Dhillon B. S.,'*Power System Reliability, Safety and Management*', An Arbor Sam 1981

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	Power System: General Concepts - Distribution of power - Management - systems study - Loads and Energy Forecasting: Power loads - Area Preliminary survey load forecasting - Regression analysis - Correlation analysis - Analysis of time series - Factors in power system loading -Technological forecasting— Sources of error	7	9
II	Planning, Design and Operation methodology: System calculations, Network elements - Distribution load flow: Radial systems, distribution systems with loops - fault studies - effect of abnormal loads, Voltage control - line circuits - harmonics- urban distribution - load variations Distribution system expansion planning – load characteristics – load forecasting – design concepts – optimal location of substation – design of radial lines – solution technique.	7	9
FIRST INTERNAL EXAM			
III	Optimization of distribution systems: Introduction, Costing of Schemes, Typical network configurations - Long and Short term planning, network cost modelling, voltage levels - Synthesis of optimum line networks -Application of linear programming to network synthesis -Optimum Phase sequence – Economic loading of distribution transformers- Worst case loading of distribution transformers	7	9
IV	Distribution automation: Distribution automation - Definitions - Project Planning - Communication, Sensors, Supervisory Control and Data Acquisition (SCADA), Consumer Information systems (CIS), Geographical Information Systems (GIS)	7	9
SECOND INTERNAL EXAM			

V	Power System reliability: Basic Reliability Concepts and Series, Parallel, Series-Parallel Systems- Development of State Transition Model to Determine the Steady State Probabilities Consumer Services: Supply industry - Natural monopoly - Regulations - Standards – Consumer load requirements — Cost of Supply - load management - theft of power ~ Energy metering	**7**	**12**
VI	Tariffs: Costing and Pricing, Classification of Tariffs – Deregulated Systems: Reconfiguring Power systems- Unbundling of Electric Utilities- Competition and Direct access Voltage control –Application of shunt capacitance for loss reduction – Harmonics in the system – static VAR systems –loss reduction and voltage improvement.	**7**	**12**
END SEMESTER EXAM			

Course No.	Course Name	L-T-P-Credits	Year of Introduction
02EE6251.4	**Modeling of Electrical Machines**	**3-0-0-3**	**2015**

Course Objective

To develop the basic elements of generalized theory and to derive the general equations for voltage and torque of all type of rotating machines and to deal with their steady state and transient analysis.

Syllabus

Power Distribution system planning, reliability and pricing

Expected outcome

Upon successful completion of this course, students will be able to:

1. To analyse machine behaviour based on the voltage and torque equations of the machine.
2. To analyse the transient behaviour of machines.

References:

1. P. S. Bhimbra, *'Generalized Theory Of Electrical Machines'*, Khanna Publishers, 2002
2. *Charles V. Johnes, 'Unified Theory Of Electrical Machines' Butterworth & Co Publishers Ltd (December 1967).*
3. Adkins, Harley, *'General theory of ac machines',Chapman and Hall, 1957*
4. C. Concordia, *'Synchronous Machines' Theory and Performance, John Wiley & Sons, New York, 1951.*
5. M. G. Say, *'Introduction to Unified Theory of Electrical Machines' Pitman 1971.*
6. E. W. Kimbark, *'Power System Stability - Vol. II' Wiley, New York, 1948.*

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	Unified approach to the analysis of electrical machine performance - per unit system - basic two pole model of rotating machines- Primitive machine -special properties assigned to rotor windings -transformer and rotational voltages in the armature voltage and torque equations resistance, inductance and torque matrix.	**7**	**9**
II	Transformations - passive linear transformation in machines- invariance of power -transformation from three phase to two phase and from rotating axes to stationary axes-Park's Transformation	**7**	**9**
FIRST INTERNAL EXAM			
III	DC Machines: Application of generalized theory to separately excited, shunt, series and compound machines. Steady state and transient analysis, transfer functions. Sudden short circuit of separately excited generator, sudden application of inertia load to separately excited dc motor.	**7**	**9**
IV	Synchronous Machines: synchronous machine reactance and time constants-Primitive machine model of synchronous machine with damper windings on both axes. Balanced steady state analysis-power angle curves. Transient analysis- sudden three phase short circuit at generator terminals - armature currents and torque. - Transient power angle curve	**7**	**9**
SECOND INTERNAL EXAM			
V	Induction Machines: Primitive machine representation- Steady state operation-Equivalent circuit-Double cage rotor	**7**	**12**

	representation - Equivalent circuit -Single phase induction motor- Voltage and Torque equations.		
VI	Traction systems: Electrification, 1- j system and its problems. Traction mechanics: Speed-time curve. Traction motors: Characteristics, series motor, Traction motor control: Series-parallel control.	**7**	**12**
END SEMESTER EXAM			

Course No.	Course Name	L-T-P-Credits	Year of Introduction
02EE6261	**Seminar**	**0-0-2-2**	**2015**

Syllabus

The student is expected to present a seminar in one of the current topics in Power and Energy Systems and related areas. The student will undertake a detailed study based on current journals, published papers, books, on the chosen subject and submit seminar report at the end of the semester.

Course No.	Course Name	L-T-P-Credits	Year of Introduction
02EE6271	**Power System Simulation Lab**	**0-0-2-2**	**2015**

Course Objective

Familiarizing the students with various simulation software tools for power system simulation and power electronic circuit simulations

List of Experiments/ Exercises

- Simulation of Single Area and Two Area Systems using Matlab Package.
- Study of load frequency control problem of (i) uncontrolled and (ii) controlled cases-
- Economic Dispatch of (i) Thermal Units and (ii) Thermal Plants using Conventional and ANN and GA algorithms
- MVAR Compensation studies on normal and heavily loaded power systems using software package
- Contingency evaluation and analysis of power system
- Development of single line diagram of power system components
- State estimation of power systems.
- Use of Essential Software tools for Power system Simulation
- Simulation of Power Electronic Circuits using PSCAD
- Simulation study on Power Line Series Compensator

Course No.	Course Name	L-T-P-Credits	Year of Introduction
02CA6001	**RESEARCH METHODOLOGY**	**1-1-0-2**	**2015**

Course objective:
Students should get the ability to identify problem related to research topic and to characterize the research problems.
To developed physical insight about the research design and to develop a more reliable design.
To study about the research by the methods of data analysis and to develop report and thesis according to the data

Course Outcome:
Students will develop an understanding of the potential benefits and technical challenges associated with conducting a research and the development of thesis and reports according to the research carried out.

References:

1. *Donald R. Cooper, Pamela s. Schindler, Business Research Methods, Tata McGraw-Hill.*
2. *Stuart Melville and Wayne Goddard, Research Methodology: An Introduction for Science and Engineering Students, Wiley*
3. *C. R. Kothari, Research Methodology Methods and Technique, Tata McGraw-Hill.*
4. *Leedy, P.D. and Ormirod, J.E., Practical Research : Planning and Design, Prentice Hall*
5. *Donald H. McBurney, Research Methods, Thomson Learning.*
6. *Turabian, K.L Revised by Gross02EEn, J. and Bennert, A., A Manual for writers of term papers, thesis and dissertation, University of Chicago press.*
7. *J. W James, Statistical Analysis for Engineers and Scientist, McGraw Hill.*
8. *Donald H. McBurney, Research Methods, Thomson Asia Pvt. Ltd. Singapore*

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	Meaning and definition of Research- Motivation and Objectives of research-Types of research- fundamental – applied descriptive-analytical– qualitative-quantitative-conceptual-empirical-research and scientific methods-research process-criteria for good research	**7**	**9**
II	Features of good design- different research designs – Laboratory and field experiments- measurement concepts-scales and levels- Measurement of variables- Factors affecting validation- Internal and external validation- Reliability-Stability methods- Development of experimental and sample designs.	**7**	**9**
FIRST INTERNAL EXAM			
III	Features of good design- different research designs – Laboratory and field experiments- measurement concepts-scales and levels- Measurement of variables- Factors affecting validation- Internal and external validation- Reliability-Stability methods- Development of experimental and sample designs.	**7**	**9**
IV	Methods of data collection- Data sources – Surveys and questionnaires- Methods of data collection and their utility-Concepts of statistical population- Sampling techniques –	**7**	**9**

	Probabilistic and non-probabilistic samples- Sample size determination issues- Pri02EEry and secondary data analysis- Use of computers, internet and library- Data analysis with statistical packages- Preparation of data for analysis		
SECOND INTERNAL EXAM			
V	Purpose of written reports- Concept of audience- Types of reports- Structure and components of reports- Technical report and thesis- Features of a good thesis- Layout and language of reports- Illustrations- Tables- Referencing- Footnotes- Intellectual contents of the thesis- 02EEking oral presentations- Effective communications- Publishing research findings-Defending the thesis.	**7**	**12**
VI	Application of results of research outcome- environmental impacts- Professional ethics- Ethical issues and committees- Copy right- Royalty- Intellectual property rights- Patent laws and patenting- Reproduction of published 02EEterial- Plagiarism- Citation and acknowledgement- Reproducibility and accountability- Developing research proposals.	**7**	**12**
END SEMESTER EXAM			

SEMESTER 2

Course No.	Course Name	L-T-P-Credits	Year of Introduction
02EE6212	DIGITAL PROTECTION OF POWER SYSTEM	**4-0-0-4**	**2015**

Course objective:

Objective of the course is to discuss various power quality issues and different methods to control them

Course Outcome:

Upon successful completion of this course, students will be able to identify the power quality problems, causes and suggest suitable mitigating techniques.

References:

1. UTS Madhava Rao, * Power system protection Static relays' , T M H, 1991
2. Badri Ram DM & Viswakarma,'Power system protection and switchgear , TMH, 1999
3. C R Mason. 'The art and science of protective relays', Wiley Eastern
4. M V Deshpande, 'Switchgear Protection', TMH, 1993
5."Power system protection. Volume-1,11 & 111 edited by the Electricity Council"
6 . J.L. Blackburn,, Marcel Dekker, ''Protective Relaying : Principles and Applications' New York, 1987.
7, A.G. Phadke and J.S. Thorp, 'Computer Relaying for Power Systems', John Wiley & Sons, New York, 1988.

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	Need for protective systems – nature and causes of faults – types of faults – Zones of Protection – Primary and backup protection – Performance and Classification of protective relays – Components of a protective system – Classification of protective schemes – Current transformers for protection. Static relays: Merits and demerits-Comparators-Amplitude and Phase Comparators-Duality between Amplitude and phase Comparators - Types of Amplitude and Phase Comparators	**7**	**9**
II	Over current protection: Time current characteristic-Over current Protective Schemes – Reverse power or directional Relay – Earth fault and Phase fault protection – Combines Earth Fault and phase fault protective – different types of static over current relays-Static over voltage and under voltage relays-Static directional relays	**7**	**9**
FIRST INTERNAL EXAM			

III	Differential Protection: Differential Relays – Some basic differential Protection Transformer Protection – Bus zone protection – Frame leakage protection – Numerical Relay – Numerical Over current Protection – Numerical Distance Protection – Numerical Differential Protection	**7**	**9**
IV	Distance protection scheme: Standard 3 zone protection – Types of static distance relays-impedance, reactance, Mho, quadrilateral, elliptical, Distance Relay characteristics – Effect of arc resistance and power surges in the performance of distance relays – Pilot Relaying Scheme – wire pilot protection – carrier current protection	**7**	**9**
SECOND INTERNAL EXAM			
V	Microprocessor based protective relays: Over current relay-Impedance relay-Directional relay-reactance relay – Generalized mathematical expression for distance relays – Measurement of R and X.	**7**	**12**
VI	Computer application to protected relays: Digital computer-Digital simulation of power system disturbances – Digital simulation of CT and PT – Digital simulation of distance relay during transients-On line and Offline application of digital computers to protection - Relaying system for preventive control of power system disturbances.		
END SEMESTER EXAM			

Course No.	Course Name	L-T-P-Credits	Year of Introduction
02EE6222	**POWER SYSTEM DYNAMICS AND CONTROL**	**3-0-0**	**2015**

Course objective:

To introduce various types of small signal stability problems that will encounter in power systems and also to introduce means to overcome them

Syllabus:

Power System Stability and Synchronous machine modeling-Modeling of other components-Turbine modeling-Small Signal Analysis-Power System Stabilizer-Active Power and Frequency control-Reactive Power &Voltage control

Course Outcome:

Upon successful completion of this course, students will be able to identify the small signal and stability problems, analyse them and to design power system stabilizers which can improve small signal stability in a power system.

References:

1. Kundur P, "Power System Stability and Control", TMH.

2.Anderson and Fouad, "Power System Control and Stability", Galgotia Publications, Compensation 1981. 3. Ramanujam R, "Power System Dynamics- Analysis & Simulation", PHI learning Private Limited.

4. Padiyar K R, "Power System Dynamics", 2 nd Edition, B.S. Publishers, 2003.

5. Sauer P W & Pai M A," Power System Dynamics and Stability", Pearson, 2003.

6. Olle I Elgerd, "Electric Energy Systems Theory an Introduction", 2nd Edition, McGraw-Hill, 1983.

7. Kimbark E W, "Power System Stability", McGraw-Hill Inc., 1994, Wiley & IEEE Press, 1995.

8. Yao-Nan-Yu, "Electric Power Systems Dynamics", Academic Press, 1983

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	Power System Stability and Synchronous machine modeling Power System Stability- Concept of Power system stability-Types of stability. Synchronous machine modeling: Synchronous Machine - Mathematical Description of a Synchronous Machine - Basic equations of a synchronous machine - dq0 Transformation- per unit representation- equivalent circuits for direct and quadrature axes. Equations of motion - Swing Equation, H-constant calculation - Representation in system studies.	**7**	**9**

II	Excitation System Modeling - Excitation System Requirements – Functional block diagram. Turbine modeling: Functional block diagram of Power Generation and Control – Schematic of a hydroelectric plant – Classical transfer function of a hydraulic turbine – special characteristic of hydraulic turbine – electrical analogue of hydraulic turbine. Load modeling concepts	**7**	**9**
FIRST INTERNAL EXAM			
III	Fundamental Concepts of Stability of Dynamic Systems: State-space representation- stability of dynamic system - Linearisation, Eigen properties of the state matrix – eigenvalue and stability - Small Signal Stability of Single Machine Infinite Bus(SMIB) System: Generator represented by the classical model Effect of field flux variation on system stability-Effects of Excitation System - Block diagram representation with exciter and AVR- Effect of AVR on synchronizing and damping torque components	**7**	**9**
IV	Power System Stabilizer (PSS): State matrix including PSS-Small Signal Stability of Multi Machine Systems. Special Techniques for analysis of very large systems- Analysis of Essentially Spontaneous Oscillations in Power Systems (AESOPS) algorithms-Modified Arnoldi Method (MAM). Small Signal Stability Enhancement: Using Power System Stabilisers-Supplementary control of Static VAR Compensators	**7**	**9**
SECOND INTERNAL EXAM			
V	Active Power and Frequency control Active Power and Frequency control:-Fundamentals of speed governing-Control of Generating unit power output-composite regulating characteristic of Power system-Responds rates of turbine-Governing systems-Fundamentals of Automatic Generation control (AGC) -implementation of AGC	**7**	**12**
VI	Reactive Power &Voltage control:-Production and absorption of Reactive power-Methods of voltage Control-Shunt reactors-Shunt capacitors-series capacitors-synchronous condensers - Static Var systems-Principles of transmission system compensation – Modelling of reactive compensating devices-Application of tap-changing transformers to transmission systems distribution system voltage regulation.	**7**	**12**
END SEMESTER EXAM			

Course No.	Course Name	L-T-P-Credits	Year of Introduction
02EE6232	**TRANSIENT ANALYSIS IN POWERSYSTEM**	**3-0-0-3**	**2015**

Course Objective

To introduce various types of transient over-voltages in power system and the methods to overcome them.

Expected outcome

Upon successful completion of this course, students will be able to

1. Identify different types of transient over-voltages.
2. Model different equipments for transient study.
3. Design protective devices against transient over-voltages.

References:

1. Allen Greenwood, 'Electrical Transients in Power Systems', Wiley Interscience, 1971
2. Bewely 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, 1982.
4. Klaus Ragallea, 'Surges and High Voltage Networks', 1980.
5. Diesendrof W., 'Overvoltages on High Voltage Systems', Rensselaer Book Store, Roy, New York, 1971.

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	Lightning and travelling waves -Transients in electric power systems - internal and external causes of over voltages - lightning strokes - mathematical model to represent lightning - stroke to tower and midspan - travelling waves in transmission lines selection of typical wave to represent over voltages	**7**	**9**
II	Switching Transients : Switching transients - the circuit closing transient - the recovery transient initiated by the removal of the short circuit — double frequency transients	**7**	**9**
FIRST INTERNAL EXAM			
III	Abnormal switching transients - current suppression - capacitance switching - arcing ground - transformer inrush current – ferro resonance - neutral connections - transients in switching a three phase reactor- three phase capacitor.	**7**	**9**
IV	Surges in transformers: Step voltage - voltage distribution in transformer winding -winding oscillations - Travelling wave solutions - Transformer core under surge conditions. Voltage surges -Transformers - Generators and motors -Transient parameter values for transformers - Reactors - Generators	**7**	**9**
SECOND INTERNAL EXAM			
V	Transmission lines Protective Devices and Systems: Basic idea about protection - surge diverters - surge absorbers -	**7**	**12**

	ground fault neutralizers - protection of lines and stations by shielding -ground wires - counter poises - driven rods - modern lightning arrestors - insulation coordination - protection of alternators- industrial drive systems.		
VI	Generation of high AC and DC-impulse voltages,currents-measurement using sphere gaps-peak voltmeters-potential dividers and CRO.	**7**	**12**
END SEMESTER EXAM			

Course No.	Course Name	L-T-P-Credits	Year of Introduction
02EE6142.1/ 02EE6242.1	**Soft Computing Techniques**	**3-0-0-3**	**2015**

Course Objective

● To initiate the students into the pervasive field of soft computing.

● To understand the nuances of conventional mathematical approaches and unorthodox soft computing methods in vogue.

● To be able to apply some important soft computing methods to different facets of problems encountered in Electrical Engineering.

Syllabus

Introduction to Soft computing, Fuzzy Sets, Set operations, Member Functions, Fuzzy Rules, reasoning and inference Systems, Mamdani, Sugeno and Tsukamoto Fuzzy Models, Genetic Algorithms, Derivative-based Optimization methods, Derivative-free methods, Neural Networks – Introduction, Supervised Learning Neural Networks, Radial Basis Function Networks, Unsupervised networks, Competitive Learning Networks, Hebbian Learning, Applications

Expected outcome

The student will be in a position to tackle problems in the field of Electrical Engineering, Power Systems with a deeper insight of alternate solutions extracted from Soft Computing techniques.

References:

1. 1 S. R. Jang, C. T. Sun and E. Mizutani, 'Neuro-Fuzzy and Soft Computing', PHI, Pearson Education 2004.
2. 2. Davis E. Goldberg, 'Genetic Algorithms: Search, Optimization and Machine Learning' Addison Wesley, N.Y., 1989.
3. S.Rajasekaran and G.A.V.Pai, 'Neural Networks, Fuzzy Logic and Genetic Algorithms',PHI, 2003.

4.. R.Eberhart, P.Simpson and R.Dobbins, 'Computational Intelligence PC Tools', AP Professional, Boston 1996.

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	Soft Computing terminology, Introduction to Fuzzy Sets, Set theoretic operations, Member Function Formulation and parameterization, Fuzzy rules and reasoning, Extension principle and fuzzy relations, Fuzzy If-Then rules, Fuzzy reasoning	**7**	**9**
II	Fuzzy inference systems, Mamdani fuzzy model, Sugeno fuzzy models, Tsukamoto fuzzy model, Input space partitioning and fuzzy modeling	**7**	**9**
FIRST INTERNAL EXAM			

III	Derivative-based optimization, Descent methods, method of steepest descent, Classical Newton's Method, step size determination, Derivativefree optimization	**7**	**9**
IV	Genetic Algorithms, Simulated Annealing, Random Search, Downhill simplex search Neural networks- Introduction, Supervised learning neural networks	**7**	**9**
SECOND INTERNAL EXAM			
V	Neural networks contd., Perceptrons, Adaline, Back propagation, Multilayer perceptrons, Radial Basis Function Networks, Numerical examples, Unsupervised learning, other neural networks, Competitive learning networks, Numerical examples	**7**	**12**
VI	Kohonen self-organizing networks, Learning vector quantization, Hebbian learning, Numerical examples Applications – Inverse kinematics problem, Printed character recognition, Automobile fuel efficiency prediction, Power system Unit Commitment problem, Electronics applications, Soft computing for colour recipe prediction.	**7**	**12**
END SEMESTER EXAM			

Course No.	Course Name	L-T-P-Credits	Year of Introduction
02EE6242.2	FACTS and Custom Power	**3-0-0-3**	**2015**

Course objective:

Advances in Power electronics Industry led to rapid development of Power Electronics controllers for fast real and reactive power control and to introduce these advancements.

Course Outcome:

Upon successful completion of this course, students will be able to select suitable FACTS device for the enhancement of power transfer capability and to control the power flow in an efficient manner.

References:

1. T. J. E. Miller, *'Reactive Power Control in Power Systems'*, John Wiley, 1982
2. J. Arriliga and N. R. Watson, *'Computer Modelling of Electrical Power Systems'*, Wiley, 2001
3. N.G. Hingorani and L. Gyugyi, *'Understanding FACTS'*, IEEE Press, 2000
4. K. R. Padiyar, '*FACTS Controllers in Power Transmission and Distribution'*, New Age International Publishers, 2007
5. Y.H. Song and A.T. Johns, *'Flexible ac Transmission Systems (FACTS)'*, IEE Press, 1999
6. Ned Mohan et al., '*Power Electronics*', John Wiley and Sons.
7. Dr. Ashok S. & K. S. Suresh Kumar, *'FACTS Controllers and Application'* Course Book for STTP2003
8. Ghosh, Arindam, and Gerard Ledwich. *Power quality enhancement using custom power devices*. Springer Science & Business Media, 2012.
9. Current Literature

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	Power flow in Power Systems-Benefits of FACTS Transmission line compensation- Uncompensated line -shunt compensation - Series compensation -Phase angle control. Reactive power compensation – shunt and series compensation principles – reactive compensation at transmission and distribution level – Static vs. Passive VAR Compensators – Converters for Static Compensation.	**7**	**9**
II	Static shunt Compensator - Objectives of shunt compensations, Methods of controllable VAR generation - Variable impedance type VAR Generators - TCR, TSR, TSC, FC-TCR Principle of operation, configuration and control.	**7**	**9**

III	Static Series compensator - Objectives of series compensations, Variable impedance type series compensators - GCSC. TCSC, TSSC - Principle of operation, configuration and control.Application of TCSC for mitigation of SSR. Switching converter type Series Compensators (SSSC)- Principle of operation, configuration and control.	**7**	**9**
IV	Static Voltage and Phase Angle Regulators (TCVR &TCPAR): Objectives of Voltage and Phase angle regulators, Thyristor controlled Voltage And Phase angle Regulators	**7**	**9**
V	Unified Power Flow Controller: Circuit Arrangement, Operation and control of UPFC- Basic principle of P and Q control- independent real and reactive power flow control- Applications - Introduction to interline power flow controller. Modelling and simulation of FACTS controllers	**7**	**12**
VI	Custom Power Devices- Introduction-Utility Customer Interface-Distribution STATCOM (DSTATCOM)- Dynamic voltage restorer (DVR)-Unified power quality conditioner (UPQC)-Custom Power Park	**7**	**12**

Course No.	Course Name	L-T-P-Credits	Year of Introduction
02EE6242.3	Power System Economics	**3-0-0-3**	**2015**

Course objective:
1. To impart basic knowledge of the power system restructuring, market structure, relation between demand and supply costs and Electricity price
2. To give basic ideas of factors affecting the electricity price in the restructured market and generation capacity evaluation.
3. To provide basic concepts and an overview of transmission price and distributed generation in restructured markets

Course Outcome:
To give ideas of reactive power requirements under voltage stability studies, impact of reactive power in power tariff and the requirements of the utilities.

References:
REFERENCES
1. Maket Operations in Electric Power Systems (IEEE)- Mohammad Shahidehpour,Hatim Yamin, Zuyi Li ,A John Wiley & Sons, Inc., Publications
2. Understanding electric utilities and de-regulation, Lorrin Philipson, H. Lee Willis, Marcel Dekker Pub., 1998.
3. Power system economics: designing markets for electricity Steven Stoft, John Wiley & Sons, 2002.
4. Operation of restructured power systems. Kankar Bhattacharya, Jaap E. Daadler, Math H.J. Boolen, Kluwer Academic Pub., 2001.
5. Restructured electrical power systems: operation, trading and volatility Mohammad Shahidehpour, Muwaffaq Alomoush, Marcel Dekker Pub., 2001.
6. W. H. J. R. Dunn, M. A. Rossi, B. Avaramovic: Impact of market restructuring on power systems operation, IEEE computer Applications on Power Engineering, vol. 8, January 1995, pp 42–47.
7. M. A. Olson, S. J. Rassenti, V. L. Smith: Market design and motivated human trading behaviors in electricity markets, in Proceedings of 34th Hawaii International Conference Systems Science, Hawaii, January 5–8, 1999
8. X. Guan, P. B. Luh: Integrated resource scheduling and bidding in the deregulated electric power market: New challenges, Special Issue J. Discrete Event Dynamical Systems, Vol. 9, No. 4, 1999, pp 331–350.
9. Turner,Wayne.C., Energy Management Hand Book.,2nd Edition
10. Industrial Economics-an Introductory text book.. RR Barathwal- Professor IIT Kanpur
11. Micro Economics-Theory and Application by Aninydya Senpplied economics for Engineers and Managers by S.K.Jain – Vikas Publishing House.

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	Power system restructuring: - Introduction, Market Structure and operation:- Objective of market operation, Electricity market models, Power market types, Market power, Key components in market operation.	**7**	**9**

II	Demand and supply, Demand analysis - theory of demand, Elasticity of demand, Demand forecasting types- techniques of forecasting. 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. .	**7**	**9**
FIRST INTERNAL EXAM			
III	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	**7**	**9**
IV	Transmission Congestion Management and Pricing- transmission cost allocation methods, LMP, FTR and Congestion Management.	**7**	**9**
SECOND INTERNAL EXAM			
V	Role of FACTS devices in competitive power market, Available Transfer Capability, Distributed Generation in restructured markets.	**7**	**12**
VI	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.	**7**	**12**
END SEMESTER EXAM			

Course No.	Course Name	L-T-P-Credits	Year of Introduction
02EE6152.4/ 02EE6252.4	Electric Drives	3-1-0-4	2015

Course Objective

1. To familiarize students with the concepts of electric drives
2. To provide in-depth knowledge of power converters fed dc and ac drives in open and closed loop, and mathematical modeling of drives.

Syllabus

Vector Space, Calculus of Variations, Special Functions, linear programming, Probability Distribution, Constrained non-linear programming.

Expected outcome

Upon successful completion of this course, students will be able to attain a thorough understanding of electric drives and its applications.

References:

1. *Dubey G. K., "Fundamentals of Electric Drives", 2nd Ed., Narosa Publishing House, 2007.*
2. *Pillai S. K., "A First Course in Electric Drives", 2nd Ed., New Age International Private Limited, 2008.*
3. *Mohan N., Undeland T.M. and Robbins W.P., "Power Electronics Converters, Applications and Design", 3rd Ed., Wiley India*, 2008.
4. *Dubey G. K., "Power Semiconductor Controlled Drives", Prentice-Hall International Editions, 2001.*
5. *Murphy J. M. D. and Turnbull F. G., "Power Electronics Control of AC Motors", Pregamon Press, 1990.*
6. *Bose B. K., "Power Electronics and Variable Frequency Drives", IEEE Press, Standard Publisher Distributors,2001.*
7. *Krishnan R., "Electric Motor Drives – Modeling, Analysis and Control", Prentice Hall of India Private Limited, 2007.*

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	Introduction: Definition of electric drive, types of load; Speed-torque characteristic of driven unit/loads, motors, steady state and transient stability of drives; Classification and components of load torque; Selection of motor power capacity for different duty cycles. Speed Control of Motors: Review of braking and speed control of dc motor and induction motor, multi-quadrant operation, loss minimization in adjustable speed drives.	06	09
II	Converter fed DC Drives: Principle of operation of converter fed separately excited dc motor drives, operation of dc drive under continuous and discontinuous armature current, armature voltage and current waveforms, effect of free-wheeling diode, analysis and performance evaluation, expression for speed-torque characteristic; Dual converter fed	06	09

	dc drives, MATLAB simulation.		
FIRST INTERNAL EXAM			
III	Inverter fed AC Drives: Constant V/f controlled induction motors, controlled current and controlled slip operations; variable frequency controlled induction motor drives; PWM inverter drives, operation of closed loop slip-speed controlled VSI and CSI fed ac drives, multiquadrant operation, MATLAB simulation.	**08**	**09**
IV	Slip Power Controlled AC Drives: Static rotor resistance control, static Kramer drive. Stability Analysis: Mathematical modeling of induction motor drives, transient response and stability analysis.	**08**	**09**
SECOND INTERNAL EXAM			
V	Resonant-Link Converter fed Drive: Principle of soft switching in inverters and converters utilizing resonant circuits, modulation strategies and application in IM drives. Synchronous Motor Drives: Adjustable frequency operations, voltage fed and current fed self controlled drives.	**07**	**12**
VI	Modern Control Theory Applications: Fundamental of Fuzzy Logic Control; Fuzzy control of closed loop dc drive; Fundamentals of ANN control; Neural current and speed control of induction motor, field oriented control of induction motor drives.	**07**	**12**
END SEMESTER EXAM			

Course No.	Course Name	L-T-P-Credits	Year of Introduction
02EE6252.1.	Power Quality	**3-0-0-3**	**2015**

Course objective:

Objective of the course is to discuss various power quality issues and different methods to control them.

Course Outcome:

Upon successful completion of this course, students will be able to identify the power quality problems, causes and suggest suitable mitigating techniques.

References:

1. R. C. Durgan, M. F. Me Granaghen, H. W. Beaty, *'Electrical Power System Quality'*, McGraw
2. Jose Arillaga, Neville R. Watson, *'Power System Harmonics'*, Wiley, 1997
3. C. Sankaran, *'Power Quality'*, CRC Press, 2002
4. G. T. Heydt, *'Power Quality'*, Stars in circle publication, Indiana, 1991
5. Math H. Bollen, *'Understanding Power Quality Problems'*
6. *Power Quality Handbook*
7. J. B. Dixit & Amit Yadav, *'Electrical Power Quality'*
8. Recent literature

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Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	Understanding Power Quality - Power quality issues in distribution systems - Sources and Effects of power quality problems, Power quality monitoring: Need for power quality monitoring,	**7**	**9**
II	Types of power quality disturbances - Voltage sag (or dip), Transients, short duration voltage variation, Long duration voltage variation, voltage imbalance, waveform distortion, and voltage flicker- methods of characterization- Power Quality Costs Evaluation - Causes and effects of power quality disturbances.	**7**	**9**

III	Harmonics -mechanism of harmonic generation-harmonic indices (THD, TIF, DIN, C – message weights). standards and recommended practices - Harmonic sources - SMPS, Three phase powerconverters, arcing devices, saturable devices, fluorescent lamps.	**7**	**9**
IV	Harmonic Analysis - Fourier series and coefficients, the Fourier transforms, discrete Fourier transform, fast Fourier transform, Window function- Effects of Power System harmonics on Power System equipment and loads	**7**	**9**
V	Modeling of networks and components under non-sinusoidal conditions-transmission anddistribution systems-shunt capacitors-transformers-electric machines-ground systems-loads that cause power quality problems-power quality problems created by drives and its impact on drives.	**7**	**12**
VI	Harmonic elimination - Design philosophy of filters to reduce harmonic distortion - Power conditioners ,passive filter, active filter - shunt , series, hybrid filters, Computation of harmonic flows- Voltage regulation- devices for voltage regulation-capacitors for voltage regulation. Dynamic Voltage Restorers for sag, swell and flicker problems	**7**	**12**

Course No.	Course Name	L-T-P-Credits	Year of Introduction
02EE6152.2/ 02EE6252.2.	Energy Auditing and Management	**3-0-0-3**	**2015**

Course objective:

Objective of the course is to discuss various about energy auditing and management.

Course Outcome:

Upon successful completion of this course, students will be able to understand importance of energy and energy security.

References:
1. Success stories of Energy Conservation by BEE (www. Bee-india.org)
2. Utilization of electrical energy by S.C. Tripathi, Tata McGraw Hill.
3. Energy Management by W.R. Murphy and Mackay, B.S. Publication.
4. Generation and utilization of Electrical Energy by B.R. Gupta, S. Chand Publication.
5. Energy Auditing made simple by Balasubramanian, Bala Consultancy Services.

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Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	Energy Scenario ;Classification of Energy resources, Commercial and non-commercial energy, primary and secondary sources, commercial energy production, final energy consumption, Energy needs of growing economy, short terms and long terms policies, energy sector reforms, distribution system reforms and up-gradation, energy security, importance of energy conservation, energy and environmental impacts, emission check standard, United nations frame work convention on climate change, Global Climate Change Treaty, Kyoto Protocol, Clean Development Mechanism, salient features of Energy Conservation Act 2001 and Electricity Act 2003. Indian and Global energy scenario. Introduction to IE Rules. Study of Energy Conservation Building Code (ECBC), Concept of Green Building	**7**	**9**
II	Demand Management ; Supply side management (SSM), various measures involved such as use of FACTS, VAR Compensation, Generation system up gradation, constraints on SSM. Demand side management (DSM), advantages and Barriers, implementation of DSM, areas of development of demand side management in agricultural, domestic and commercial consumers. Demand management through tariffs (TOD). Power factor penalties and incentives in tariff for demand control.	**7**	**9**

	Apparent energy tariffs. Role of renewable energy sources in energy management, direct use (solar thermal, solar air conditioning, biomass) and indirect use (solar, wind etc.)		
III	Energy Audit ; Definition, need of energy audit, types of audit, procedures to follow, data and information analysis, energy audit instrumentation, energy consumption – production relationship, pie charts. Sankey diagram, Cusum technique, least square method and numerical based on it. Outcome of energy audit and energy saving potential, action plans for implementation of energy conservation options. Bench- marking energy performance of an industry. Energy Audit Report writing as per prescribed format. Audit case studies of sugar, steel, paper and cement industries.	**7**	**9**
IV	: Energy Conservation in Applications (09 hrs) Motive power (motor and drive system). b) Illumination c) Heating systems (boiler and steam systems) c) Ventilation(Fan, Blower, Compressors) and Air Conditioning systems d) Pumping System e) Cogeneration and waste heat recovery systems f) Utility industries (T and D Sector) g) Diesel generators.	**7**	**9**
V	Energy Conservation in Applications ; Motive power (motor and drive system). b) Illumination c) Heating systems (boiler and steam systems) c) Ventilation(Fan, Blower, Compressors) and Air Conditioning systems d) Pumping System e) Cogeneration and waste heat recovery systems f) Utility industries (T and D Sector)	**7**	**12**
VI	Financial Analysis and Case Studies ; Costing techniques; cost factors, budgeting, standard costing, sources of capital, cash flow diagrams and activity chart. Financial appraisals; criteria, simple payback period, return on investment, net present value method, time value of money, break even analysis, sensitivity analysis and numerical based on it, cost optimization, cost of energy, cost of generation, Energy audit case studies such as IT sector, Textile, Municipal corporations, Educational Institutes, T and D Sector and Thermal Power station.	**7**	**12**
END SEMESTER EXAM			

Course No.	Course Name	L-T-P-Credits	Year of Introduction
02EE6252.3	Distributed Generation	**3-0-0-3**	**2015**

Course objective:

1.Have a working knowledge of the emerging power generation technologies such as photovoltaic arrays, wind turbines, and fuel cells.

2. Model renewable electrical energy systems for analysis and design.

3. Calculate the basic performance parameters of these systems, such as efficiency and cost.

4. Perform basic assessment and design of a renewable electrical energy system for a given application.

Course Outcome:

Upon successful completion of this course, students will be able to choose the right renewable energy source and storage method

References:

1. Twidell J N& Weir A D, "Renewable Energy Sources", University press, Cambridge.
2. Sukhatme, S.P., "Solar Energy -Principles of Thermal Collection and Storage", Tata McGraw-Hill, New Delhi.
3. Kreith F and Kreider J F, "Principles of Solar Engineering", Mc-Graw-Hill Book 4. Soo S L, "Direct Energy Conversion", Prentice Hall Publication.
5. James Larminie, Andrew Dicks, "Fuel Cell Systems", John Weily & Sons Ltd.
6. Manwell J F, Mcgowan J G, Rogers A L, "Wind Energy Explained", John Weily & SonsLtd.
7. Chapman and Womack E J, "MHD Power Generation Engineering Aspects", Hall Publication.
8. G.D, Rai "Non Conventional Energy Sources", Khanna Publications,

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Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	Energy conversion –Introduction - Principle of Renewable energy systems-Technical and social implications. Solar energy: Overview of solar energy utilization methods- Solar energy collectors - Flat plate collectors –Different type of flat plate collectors - Energy balance equation-Collector efficiency-Concentrating collector –Focusing type-Advantage and Disadvantage of concentrating collectors.	**7**	**9**
II	Solar energy storage systems-solar pond-Extraction of thermal energy-Applications of solar ponds-solar thermal applications–Water heating - space cooling-water distillation-solar thermal electric power generation systems- Drying and cooking	**7**	**9**
FIRST INTERNAL EXAM			

III	DEC devices-Solar PV modules from Solar cells-Upper limits of cell parameters.-Design and structure of PV modules -Rating of PVmodules-Batteries of PV system- water pumping applications.	**7**	**9**
IV	Fuel cells: Classification -Types- Advantages-Disadvantages Conversion efficiency-Work output and EMF of fuel cell Applications; MHD systems-Advantages-Design problems-Electrical conditions -voltage and power output of MHD generator	**7**	**9**
SECOND INTERNAL EXAM			
V	Wind energy: Characteristics-Wind energy extraction-Classification wind turbines-Types of rotors-Design of wind turbine rotor –Wind power generation curve-Modes of wind power generation –Advantages –Disadvantages.	**7**	**12**
VI	Biomass conversion technologies-Methods for obtaining energy from biomass. Ocean thermal energy conversion systems; open cycle system-limitations-Modified OTEC plant plant Cogeneration of electricity and Fresh water from open cycle OTEC closed cycle OTEC	**7**	**12**
END SEMESTER EXAM			

Course No.	Course Name	L-T-P-Credits	Year of Introduction
02EE6252.4	SCADA systems and Applications	**3-0-0-3**	**2015**

Course objective:
To introduce SCADA systems, its components, architecture, communication and applications.

Course Outcome:

Upon successful completion of this course, students will be able to use SCADA systems in different engineering applications such as utility, communication, automation, control, monitoring etc .

References:

1. Stuart A Boyer. *SCADA-Supervisory Control and Data Acquisition*', Instrument Society of America Publications. USA. 1999.
2. Gordan Clarke, Deon RzynAzvs, *Practical Modern SCADA Protocols:* DNP3, 60870J

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	Introduction to SCADA Data acquisition systems - Evolution of SCADA, Communication technologies-. Monitoring and supervisory functions- SCADA applications in Utility Automation, Industries	**7**	**9**
II	- SCADA System Components: Schemes- Remote Terminal Unit (RTU), Intelligent Electronic Devices (IED),Programmable Logic Controller (PLC), Communication Network, SCADA Server, SCADA/HMI Systems		
	FIRST INTERNAL EXAM		
III	SCADA Architecture: Various SCADA architectures, advantages and disadvantages of each system - single unified standard architecture -IEC 61850-SCADA	**7**	**9**
IV	Communication:Various industrial communication technologies -wired and wireless methods and fibre optics-Open standard communication protocols.	**7**	**9**
	SECOND INTERNAL EXAM		
V	Operation and Control of Interconnected power system – Automatic substation control –SCADA configuration-Energy management system,system operating states ,system security,state estimation unit.		

VI	SCADA Applications: Utility applications- Transmission and Distribution sector -operations, monitoring, analysis and improvement. Industries - oil, gas and water. Case studies, Implementation. Simulation Exercises	**7**	**9**
		7	**12**
END SEMESTER EXAM			

Course No.	Course Name	L-T-P-Credits	Year of Introduction
02EE6271	**Power Equipments Laboratory**	**0-0-2-2**	**2015**

Course Objective

Familiarizing the students with various hardware tools for power system

List of Experiments/ Exercises

- Testing the dielectric strength of given sample of Transformer oil.
- Testing the dielectric strength of given solid dielectric samples.
- Electromechanical type under voltage relay
- Electromechanical earth fault relay
- Flash over voltage
- Measurement of soil resistivity and earth resistance.
- Measurement of insulating resistance
- String Efficiency
- Electromechanical type overvoltage relay
- Static Over current relay

Course No.	Course Name	L-T-P-Credits	Year of Introduction
02EE7211.1.	Electric and Hybrid Vehicles	**3-0-0-3**	**2015**

Course objective:
To present a comprehensive overview of Electric and Hybrid Electric Vehicle.

Course Outcome:
Upon successful completion of this course, students will be able to:
1. Choose a suitable drive scheme for developing an electric of hybrid vehicle depending on resources.
2. Design and develop basic schemes of electric vehicles and hybrid electric vehicles.
3. Choose proper energy storage systems for vehicle applications.
4. Identify various communication protocols and technologies used in vehicle networks..

References:

1. Iqbal Hussein, *Electric and Hybrid Vehicles: Design Fundamentals*, CRC Press, 2003.
2. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, *Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design*, CRC Press, 2004.
3. James Larminie, John Lowry, *Electric Vehicle Technology Explained*, Wiley, 2003.

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	Introduction to Hybrid Electric Vehicles: History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies.Conventional Vehicles: Basics of vehicle performance, vehicle power source characterization, transmission characteristics, mathematical models to describe vehicle performance.	**7**	**9**
II	Hybrid Electric Drive-trains: Basic concept of hybrid traction, introduction to various hybrid drivetrain topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis. Electric Drive-trains: Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis.	**7**	**9**
	FIRST INTERNAL EXAM		
III	Electric Propulsion unit: Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, drive system efficiency.	**7**	**9**
IV	Energy Storage: Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Super Capacitor based energy storage and its analysis, Flywheel based energy storage and its analysis, Hybridization of different energy storage devices.	**7**	**9**

SECOND INTERNAL EXAM			
V	Sizing the drive system: Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology,Communications, supporting subsystems: In vehicle networks- CAN	**7**	**12**
VI	Energy Management Strategies: Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy management strategies. Case Studies: Design of a Hybrid Electric Vehicle (HEV), Design of a Battery Electric Vehicle (BEV).	**7**	**12**
END SEMESTER EXAM			

Course No.	Course Name	L-T-P-Credits	Year of Introduction
02EE7211.2	Power system Reliability	**3-0-0-3**	**2015**

Course Objective: To equip ike engineers for operating power systems more effectively and reliably utilizing the resources in an optimal manner

Course Outcome:

References:

1. K R Padiyar, 'Power System Dynamics', 2003
2. P Kundur, 'Power system Stability and Control\ McGraw-Hill Inc., 1994
3. T Van Cutsem, C Vournas, ' Voltage Stability of Electric Power Systems', Kluwer Academic Publishers, 1998
4. J JEndrenyi, 'Reliability modeling in electric power systems' , John Wiley & Sons
5. Singh C, and Billinton R. 'System reliability modeling and evaluation', Hutchinston, London, 1977

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Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	Concept of Power system stability-Types of stability Transient stability analysis: An Elementary View of Transient Stability-Structure of a complete power system model for transient stability analysis-Transient Stability Enhancement	**7**	**9**
II	Voltage Stability Analysis-Definition and Criteria-Mechanism of Voltage Collapse-Static Analysis: V-Q sensitivity analysis, Q-V modal analysis-Determination of Shortest distance to instability-The continuation load flow analysis-Important voltage stability indices-Prevention of Voltage Collapse.	**7**	**9**
FIRST INTERNAL EXAM			
III	Concept of reliability, non-repairable components, hazard models, components with preventive maintenance, ideal repair and preventive maintenance, repairable components, normal repair and preventive maintenance	**7**	**9**
IV	System reliability, monotonic structures, reliability of series-parallel structures, the V out of 'rf configuration, the decomposition methods, minimal tie and cut method, state space method of system representation, system of two independent components, two components with dependent failures, combining states, non-exponential repair times failure effects analysis, State enumeration method, application to non-repairable systems.	**7**	**9**
SECOND INTERNAL EXAM			

V	Other methods of system reliability, fault free analysis. Monte Carlo simulation, planning for reliability, outage definitions, construction of reliability models. Generating capacity reserve evaluation, the generation model, the probability of capacity deficiency, the frequency and duration method, comparison of the reliability indices, generation expansion planning, uncertainties in generating unit failure rates and in load forecasts. Operating reserve evaluation, state space representation of generating units, rapid start and hot-reserve units, the security function approach.	**7**	**12**
VI	Interconnected systems, two connected systems with independent loads, two connected system with correlated loads, more than two systems interconnected	**7**	**12**
END SEMESTER EXAM			

Course No.	Course Name	L-T-P-Credits	Year of Introduction
02EE7211.3	DSP Applications	**3-0-0-3**	**2015**

Course Objective: To equip ike engineers for operating power systems more effectively and reliably utilizing the resources in an optimal manner

Course Outcome:

References:

1. John G. Proakis, and Dimitris G. Manolakis, Digital Signal Processing (third edition), Prentice-Hall of India Pvt. Ltd, New Delhi, 1997.
2. Emmanuel C. Ifeachor, Barrie W. Jervis, Digital Signal Processing-A practical Approach, Addison. Wesley, 1993.
3. Abraham Peled and Bede Liu, Digital Signal Processing, John Wiley and Sons, 1976.
4. Oppenheim and Schaffer, „Discrete time Signal processing‟, PHI, 1999.

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	Analysis of Discrete Time Signalsand LTI systems:Discrete time signals- Linear shift invariant systems- Stability and causality- Convolution and correlation-Sampling of continuous time signals	**7**	**9**
II	Discrete time Fourier transform- Discrete Fourier series- Discrete Fourier Transform- Z- transform and Properties of different transforms. LTI systems- FIR and IIR systems-Unit sample response- system function-difference equation – frequency response representations and their relations.	**7**	**9**
FIRST INTERNAL EXAM			
III	Computation of DFT and Spectrum Analysis: Computation of Discrete Fourier Transform of elementary and arbitrary sequences. Fast Fourier transform: Radix-2 FFT-Decimation in time and decimation in frequency algorithms- Circular and linear convolution and correlation of two finite length sequences using DFT/FFT -linear convolution through circular convolution and implementation	**7**	**9**
IV	Sectioned convolutions, overlap add and overlap save method: Spectral analysis of deterministic signals – bias-frequency resolution-Windowing of data. Estimation of power spectrum of stationary random signals:-periodogram methods-Bartlett’s method and Welch method of Power spectrum estimation.	**7**	**9**
SECOND INTERNAL EXAM			
V	Digital Filter Design and Realization Structures: Design of IIR digital filters –Butterworth and Chebyshev filters- from	**7**	**12**

	analog filters- Impulse invariance method and Bilinear transformation method- FIR linear phase filter design using window functions- Comparison of IIR and FIR digital filters – Basic IIR and FIR filter realization structures-direct, cascade and parallel realizations.		
VI	Analysis of Finite Word-length Effects: Quantization process and errors- Coefficient quantization effects in IIR and FIR filters- A/D conversion noise- Arithmetic round-off errors – Dynamic range scaling- Overflow oscillations and zero input limit cycles in IIR filters. Effect of quantization noise in cascade and parallel operations	**7**	**12**
END SEMESTER EXAM			

Course No.	Course Name	L-T-P-Credits	Year of Introduction
02EE7111.4/ 02EE7211.4	Power system Instrumentation	**3-0-0-3**	**2015**

Course Objective: To equip ike engineers for operating power systems more effectively and reliably utilizing the resources in an optimal manner

Course Outcome:

References:

1. "Modern Power Station Practice, Volume F: Control and Instrumentation", British Electricity International, Peragmon Press. 1990
2. Elliott T. C., "Standard Hand Book of Power Plant Engineering", McGraw-Hill International Book Company. 1989
3. Van A. R. and Warrington C., "Protective Relays- Their Theory and Practice", Vol. 1, Chapman and Hall Ltd. 1968
4. Rao T. S. M., "Power System Protection – Static Relays with Microprocessor Applications", 2nd Ed., Tata McGraw-Hill Publishing Company Limited. 2008

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	Measurement of Electrical Quantities: Measurement of voltage, current, phase angle, frequency, active power and reactive power in power plants; Energy meters and multipart tariff meters	**7**	**9**
II	Voltage and Current Transformers: Voltage transformers for measurement and protection, errors, transient performance; capacitive voltage transformers and their transient behavior; Current transformers for measurement and protection, composite errors, transient response.	**7**	**9**
FIRST INTERNAL EXAM			
III	Hydro Electric Power-Plant Instrumentation: Measurement of flow, level, pressure, temperature, hydraulic head and mechanical vibrations; Temperature scanners; Alarm annunciators.	**7**	**9**
IV	Thermal Power-Plant Instrumentation: Measurement of gas flow; Gas and feed-water analysis; Flame monitoring; Steam turbine instrumentation.	**7**	**9**
SECOND INTERNAL EXAM			
V	Nuclear Power-Plant Instrumentation: Reactor safety, neutron flux measurement; Reactor power level and coolant measurements.	**7**	**12**

VI	Proactive Relays: Organization of protective relay; Single input, two-input and multi-input relays; Electromagnetic, electronic and digital relays.	**7**	**12**
END SEMESTER EXAM			

Course No.	Course Name	L-T-P-Credits	Year of Introduction
02EE7221.1	EHV AC & DC TRANSMISSION SYSTEM	3-0-0-3	2015

Course Objective

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Syllabus

Expected outcome

References:

1. Begemudre R.D,"EHVAC Transmission Engineering", Willy Eastern Ltd
2. P.Kundur,"Power System Stability and Control", Mc Graw Hill Publication.
3. Arrillaga J,"HVDC Transmission", Peter Peregrinus Pub.
4. Rao S,"EHV AC & HVDC Transmission Systems", Khanna Publishers.
5. Padiyar K.R.,"HVDC Power Transmission Systems", Willy Eastern Ltd.

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	Analysis of long line theory Long line theory- long distance transmission problems-corona power loss- Charge Voltage Diagram with corona-Attenuation of travelling waves due to corona	7	9
II	Audible noise: Generation and characteristics-Limits for audible noise- AN measurement and Meters-Relation between single phase and three phase AN levels- day Night Equivalent Noise level. Radio Interference RIV and excitation functions: Generation and properties of corona pulses-Limits for radio interference fields- The CIGRE Formula- Rules for addition of RI levels of three phases-S/CS Line-Rules for addition of RI Levels for a D/C Line	7	9
FIRST INTERNAL EXAM			
III	Over voltages Sequential impedances of AC systems - EHVAC transmission over voltages- Short Circuit Current and The Circuit Breaker- Recovery voltage and Circuit breaker-Over voltages caused by interruption of Low induction current-Interruption of Capacitive currents-Ferro resonance. Over voltages- Calculation of switching surges-single phase equivalents.	7	9
IV	Reduction of switching surges on EHV systems - High voltage testing of AC equipments: Measurement of High Voltages- Voltage dividers-High speed oscilloscope-Peak voltmeter and sphere gap- Digital Recorder-Measurement of Partial Discharge.-Layout of EHV Laboratory	7	9
SECOND INTERNAL EXAM			
V	Introduction to HVDC system Comparison of EHV AC & DC transmission -HVDC system configuration and components -	7	12

	conversion and inversion- Analysis of three phase bridge converter and Performance equations - abnormal operations of converter.		
VI	Control of HVDC system Control of HVDC system- Principle of DC link control- current and Extinction angle control power and reactive power control- alternative inverter control modes. Harmonics and AC/DC filtersInfluence of AC system strength on AC/DC system interaction. Responses to DC and AC system faults	**7**	**12**
END SEMESTER EXAM			

Course No.	Course Name	L-T-P-Credits	Year of Introduction
02EE7221.3	DYNAMICS OF POWER CONVERTERS	**3-0-0-3**	**2015**

Course objective:
To equip the students with the dynamic aspect of different converters and their analysis.

Course Outcome:
Upon successful completion of this course, students will be able to:
1. Develop dynamic models of switched power converters using state space averaging and circuit averaging techniques.
2. Develop converter transfer functions.
3. Design closed loop controllers for DC-DC power converters.
4. Design and implement current mode control for DC-DC converters.

References:

1. Robert Erickson and Dragan Maksimovic, '*Fundamentals of Power Electronics*', Springer India
2. John G. Kassakian*, et al., 'Principles of Power Electronics', Pearson Education*

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	Fundamentals of Steady state converter modelling and analysis, Steady-state equivalent circuits, losses and efficiency. Inclusion of semiconductor conduction losses in converter model.Small-signal AC modelling- Averaging of inductor/capacitor waveforms- perturbation and linearisation.	**7**	**9**
II	State-Space Averaging-Circuit Averaging and averaged switch modelling- Canonical Circuit Model Manipulation of dc-dc converters' circuit model into Canonical Form-Modelling the pulse width Modulator.	**7**	**9**
	FIRST INTERNAL EXAM		
III	Converter Transfer Functions:-Review of frequency response analysis techniques- Bode plots Converter transfer functions-graphical construction. Measurement of ac transfer functions and impedances.	**7**	**9**
IV	Controller Design: Effect of negative feedback on the network transfer functions-loop transfer function-Controller design specifications- PD, PI and PID compensators - applications to the basic dc -dc topologies - Practical methods to measure loop gains: Voltage and current injection.	**7**	**9**
	SECOND INTERNAL EXAM		

V	DC-DC converter with isolation: Fly back converters- other fly back converter topologies, forward converter, The forward converter switching transistor-Variation of the basic forward converter, Push pull converter-Push pull converter transistor-Limitation of the Push Pull circuit-circuit variation of the push pull converter-the half bridge and full bridge DC-DC converters. High frequency inductor design and transformer design considerations, magnetic core, current transformers.	**7**	**9**
VI	Converters in Discontinuous Conduction Mode: AC and DC equivalent circuit modelling of the discontinuous conduction mode-Generalised Switch Averaging-small-signal ac modelling of the dcm switch network- Current-Mode Control: Average Current-mode Control, Peak Current-mode control-first order modelsaccurate models for current-mode control-application to basic dc-dc converter topologies-Subharmonic oscillation for $d > 0.5$; Slope compensation- Discontinuous conduction mode in current-mode control.	**7**	**12**
END SEMESTER EXAM			

Course No.	Course Name	L-T-P-Credits	Year of Introduction
02EE7221.4	**POWER SYSTEM OPERATION AND CONTROL**	**3-0-0-3**	**2015**

Course objective:

Objective of the course is to make the students aware the importance of Economic operation as well as control of power system.

Course Outcome: Upon successful completion of this course, students will be able to:

□□□ Dispatch a power system economically considering take or pay fuel contract unit commitment and security constraints.

□□□Model an AGC including excitation system and voltage regulators.

References:
Allen J.Wood, Wollenberg B.F., *Power Generation Operation and Control,* John Wiley & Sons, Second Edition, 1996.
2. S S. Vadhera, *Power System Analysis and Stability*, Khanna Publishers
3. Kirchmayer L.K., *Economic Control of Interconnected Systems,* John Wiley & Sons, 1959.
4. *Nagrath, I.J. and Kothari D.P., Modern Power System Analysis*, TMH, New Delhi, 2006.
5. B. M. Weedy, *'Electric Power Systems'*, John Wiley and Sons, New York, 1987
6. A Montieelli., *State Estimation in Electric Power System-A Generalised Approach*
7. Ali Abur & Antonio Gomez Exposito, Marcel Dekkerjnc, *Power System State Estimation-Theory and Implementation.*
8. Hadi Sadat, *Power System Analysis*, Tata McGraw-Hill
9. Recent literature.

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Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	Introduction-Review of Thermal units.-The Lambda iteration method-First order gradient method base point and participation factors. Generation with limited supply-Take or pay fuel contract-composite generation production cost function- solution of gradient search techniques. Hard limits and slack variables	**7**	**9**
II	Hydro-thermal coordination-Long range and short range scheduling- Hydro-electric plant models- scheduling problems types of scheduling problems. Scheduling energy -short-term hydrothermal scheduling problem- Pumped storage hydro plants- pumped storage hydro scheduling λ-γ iteration. Inter change evaluation and power pools-Economy interchange evaluation with unit commitments.	**7**	**9**

III	Types of interchange. Energy banking-power pools. Power system security-system monitoring-contingency analysis- security constrained optimal power flow- Factors affecting power system security. monitoring-contingency analysis- security constrained optimal power flow- Factors affecting power system security. State estimation in power system- Introduction..	**7**	**9**
IV	Control of generation-Automatic Generation control Review- AGC implementation - AGC features - Modelling exercise using SIMUL1NK. AGC with optimal dispatch of Generation- Voltage control-AGC including excitation system. MVAR control - Application of voltage regulator – synchronous condenser – transformer taps – static VAR compensators .	**7**	**9**
V	Optimal power flow –solution-grdient method -newton method –linear sensitivity analysis-sensitivity coefficients of an AC networksecurity constrained optimal powerflow Interior point algorithm –Bus incremental costs.	**7**	**12**