KERALA TECHNOLOGICAL UNIVERSITY

Master of Technology

Curriculum, Syllabus and Course Plan

Cluster	:	*01*
Branch	:	*Electrical and Electronics Engineering*
Stream	:	*Power Systems*
Year	:	*2015*
No. of Credits	:	*67*

SEMESTER 1

Examination Slot	Course Number	Name	L-T-P	Internal Marks	End Semester Examination		Credits
					Marks	Duration (hours)	
A	01MA6021	Advanced Mathematics & Optimisation Techniques	3-0-0	40	60	3	3
B	01EE6401	Power Electronic Application in Power System	3-1-0	40	60	3	4
C	01EE6301	Modelling of Electrical Machines	3-1-0	40	60	3	4
D	01EE6405	Operation and Control of Power System	3-0-0	40	60	3	3
E	01EE6407	Power Quality	3-0-0	40	60	3	3
S	01EE6999	Research Methodology	0-2-0	100			2
T	01EE6491	Seminar I	0-0-2	100			2
U	01EE6493	Power System Lab I	0-0-2	100			1
		TOTAL	**15-4-4**	**500**	**300**	**-**	**22**

TOTAL CONTACT HOURS : 23
TOTAL CREDITS : 22

SEMESTER 2

Examination Slot	Course Number	Name	L-T-P	Internal Marks	End Semester Examination		Credits
					Marks	Duration (hours)	
A	01EE6402	Digital Protection of Power System	3-1-0	40	60	3	4
B	01EE6404	Power System Dynamics and Control	3-0-0	40	60	3	3
C		Elective I	3-0-0	40	60	3	3
D		Elective II	3-0-0	40	60	3	3
E		Elective III	3-0-0	40	60	3	3
V	01EE6492	Mini Project	0-0-4	100			2
U	01EE6494	Power System Lab II	0-0-2	100			1
		TOTAL	**15-1-6**	**400**	**300**	**-**	**19**

TOTAL CONTACT HOURS : 22
TOTAL CREDITS : 19

Elective I

01EE6412 New and Renewable Sources of Energy
01EE6414 Distributed Generation
01EE6424 Static VAR Controllers and Harmonic Filtering
01EE6416 Computer Aided Power System Analysis

Elective II

01EE6418 Flexible AC Transmission Systems
01EE6422 Power System Instrumentation
01EE6432 Sustainable and Translational Engineering
01ME6316 Advanced Numerical Techniques

Elective III

01EE6426 Smart grid Technologies and Applications
01EE6428 Distribution System Planning and Automation
01EE6126 Soft Computing Techniques

SEMESTER 3

Examination Slot	Course Number	Name	L-T-P	Internal Marks	End Semester Examination		Credits
					Marks	Duration (hours)	
A		Elective IV	3-0-0	40	60	3	3
B		Elective V	3-0-0	40	60	3	3
T	01EE7491	Seminar II	0-0-2	100			2
W	01EE7493	Project (Phase I)	0-0-12	50			6
		TOTAL	**6-0-14**	**230**	**120**	**-**	**14**

TOTAL CONTACT HOURS : 20
TOTAL CREDITS : 14

Elective IV

01EE7411 EHVAC and DC Transmission

01EE7413 Energy Auditing, Conservation and Management

01EE7415 Restructured Power System

Elective V

01EE7417 Transient Analysis in Power System

01EE7419 Power System Stability and Reliability

01EE7421 SCADA System and Applications

01EE7121 Biomedical Instrumentation

01EE7315 Hybrid Electric Vehicles

SEMESTER 4

Examination Slot	Course Number	Name	L-T-P	Internal Marks	End Semester Examination		Credit
					Marks	Duration (hours)	
W	01EE7494	Project (Phase 2)	0-0-23	70	30		12
		TOTAL	**0-0-23**	**70**	**30**	**-**	**12**

TOTAL CONTACT HOURS : 23
TOTAL CREDITS : 12

TOTAL NUMBER OF CREDITS: 67

SEMESTER - I

Syllabus and Course Plan

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01MA6021	Advanced Mathematics & Optimization Techniques	**3-0-0**	**3**	**2015**

Course Objectives

1. Develop a conceptual basis for Linear algebra.
2. Equip the Students with a thorough understanding of vector spaces and optimization techniques.

Syllabus

Vector Spaces - linear Transformations - orthogonality - least square solutions - matrix factorizations - Linear programming problems - Simplex Methods - Integer programming - Non-linear programming (Unconstrained and constrained) - quadratic programming - Convex programming - Dynamic programming

Expected Outcome

Upon successful completion of the course, students will have basic knowledge of vector spaces and optimization theory which are essential for higher studies and research in Engineering.

References

1. David C. Lay, Linear Algebra, Pearson Education, 4/e, 2012
2. Handy A. Taha, Operations Research an Introduction, PHI, 9/e, 2011
3. R. Hariprakash and B. Durga Prasad, Operations Research, Scitech. 1/e, 2010
4. B. S. Goel and S. K. Mittal, Operations Research, PragathiPrakashan, 25/e, 2009
5. Seymour Lipschulz, Linear Algebra, Tata McGraw Hill.
6. K. V. Mittal and C. Mohan, Optimization Methods in Operations Research and System Analysis, 3/e, New Age International Publishers.
7. Singiresu S Rao, Engineering Optimization Theory and Practice, 3/e, New Age International Publishers.

COURSE PLAN			
Module	**Contents**	**Hours Allotted**	**% of Marks in End-Semester Examination**
I	Vector spaces and subspaces, null space, column space of a matrix; linearly independent sets and bases; Coordinate systems; dimension of a vector space; rank; change of basis; linear transformations – properties - kernel and range - computing kernel and range of a linear transformation - matrix representation of a linear operator - Invertible linear operators	7	15
II	Inner product, length and orthogonality; orthogonal sets; orthogonal projections; Gram Schmidt process; least square solutions; Inner product spaces; QR factorization ; Singular value decomposition.	7	15
FIRST INTERNAL EXAM			
III	Linear programming problems - Simplex Methods - two phase simplex method-Dual simplex method, Integer linear programming; Graphical representation - Gomory's Cutting plane method, Zero – One Programming	7	15
IV	Unconstrained non-linear programming; Steepest descent method, Conjugate Gradient method, Powel's method, Hooke-Jeeves method.	7	15
SECOND INTERNAL EXAM			
V	Constrained non-linear programming - Complex method - Cutting plane method - method of feasible directions - Kuhn-Tucker conditions	7	20
VI	Convex programming problem - Exterior penalty method - Quadratic programming - Dynamic programming - representation of multi stage decision process – sub-optimization and principle of optimality - computational procedure in dynamic programming	7	20
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE6401	Power Electronic Application in Power System	**3-1-0**	**4**	**2015**

Course Objectives

1. Familiarize the power semiconductor switching devices for power conversion
2. Understand the principle of working of resonant converter and resonant switch converter
3. Understand different modulation techniques
4. Understand power electronic applications in FACTS

Syllabus

Power semiconductor switching devices - Switching characteristics, Application of DC-DC converters in renewable energy systems- Buck, boost, buck-boost and Ćuk Topologies, Inverters- VSI, CSI– switching scheme and harmonic elimination, Space Vector modulation - Current control methods in Voltage source inverters, multi-level inverters- topologies - principle of operation and modulation strategies, Resonant Converters, HVDC transmission– reactive power requirement – control of converters, Reactive power compensator, Flexible AC transmission systems (FACTS) - shunt and series compensators, Phase angle compensator

Expected Outcome

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

1. Choose a suitable power semiconductor device for a specific application
2. Develop ideal and nonideal model of power devices
3. Design and develop power converter topologies.

References

1. Ned Mohan, et al., Power Electronics: Converters, Design and Applications, John Wiley and Sons, 2010

2. L. Umanand, Power Electronics Essentials and Applications, John Wiley and Sons, 2010

3. G. K. Dubey, et al., Thyristorised Power Controllers, New Age International Publishers

4. Muhammed H. Rashid," Power Electronics",Prentice Hall of India, Ltd.2004

5. N.G. Hingorani and L.Gyugyi,"Understanding FACTS",IEEE Press, 2000.

6.K.R. Padiyar,"HVDC Power Transmission Systems", Wiley Eastern Ltd.

COURSE PLAN			
Module	**Contents**	**Hours Allotted**	**% of Marks in End-Semester Examination**
I	Power semiconductor switching devices - The ideal switch, characteristics of ideal switches – two quadrant and four quadrant switches.	4	15
	Switching characteristics of Power Diodes, SCRs, MOSFETs, IGBTs, GTOs thyristors	4	
II	Application of DC-DC converters in renewable energy systems: Introduction - Buck, boost, buck-boost and Ćuk Topologies- 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.	8	15
FIRST INTERNAL EXAM			
III	Inverters -Single phase VSI, CSI, Three Phase VSI, Pulse width modulated switching schemes-sinusoidal PWM and Selective Harmonic Elimination of Single phase Voltage source Inverters	5	15
	Space Vector modulation. Evaluation of dwell times Current control methods in Voltage source Inverters. Introduction to multi-level inverters. – Diode clamped, flying capacitor and cascaded multilevel inverter topologies - principle of operation and modulation strategies.	8	
IV	Resonant Converters : Series resonant inverter circuit with unidirectional and bidirectional switches – half bridge and full bridge configurations.	5	15
	Parallel resonant inverter. Resonant switch converters: Zero voltage and zero current switching resonant converters.	4	
SECOND INTERNAL EXAM			
V	HV DC transmission. Power flow control in DC link . Converter and inverter output equations , Graetz circuit. 12 pulse converter. Control of converters. Harmonics- characteristic-means of reducing harmonics. Reactive power requirements in HVDC substations.	6	20
	Reactive power compensator using instantaneous reactive power theory, stationary to rotating reference frame transformation.	3	

VI	Flexible AC transmission systems (FACTS) – AC transmission line model. Principle of shunt compensation – shunt compensators – switched reactor- switched capacitor – static VAR compensator. , direct and indirect control of STATCOM:	6	20
	Principle of series compensation – switched series compensators ; Principle of phase angle compensation – phase angle compensator	4	
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE6301	Modelling of Electrical Machines	3-1-0	4	2015

Course Objectives

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

Syllabus

Unified approach to the analysis of electrical machine performance - per unit system - basic two pole model of rotating machines- Primitive machine - transformer and rotational voltages in the armature voltage and torque equations resistance, inductance and torque matrix-Transformations - passive linear transformation in machines- invariance of power -Park's transformation-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-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-Induction Machines- Primitive machine representation- Steady state operation-Equivalent circuit-Double cage rotor representation - Equivalent circuit -Single phase induction motor- Voltage and Torque equations.

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. 2. To analyse the transient behaviour of machines.

REFERENCES:

1. P. S. Bhimbra, 'Generalized Theory Of Electrical Machines', Khanna Publishers, 2002
2. 2. Charles V. Johnes, 'Unified Theory Of Electrical Machines'.
3. 3. Adkins, Harley, 'General theory of ac machines'.
4. 4. C. Concordia, 'Synchronous Machines'.
5. 5. M. G. Say, 'Introduction to Unified Theory of Electrical Machines'
6. 6. E. W. Kimbark, 'Power System Stability - Vol. II'.

COURSE PLAN

Module	Course description	Hours	End semester exam % marks
1	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	15%
2	Transformations - passive linear transformation in machines-invariance of power –transformation from a displaced brush axis-transformation from three phase to two phase and from rotating axes to stationary axes-Park's transformation-Physical concept- Restrictions of the Generalized theory of machines	7	15%
	First Internal Exam		
3	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.	10	15%
4	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	12	15%
	Second Internal Exam		
5	Induction Machines: Primitive machine representation-Transformation- Steady state operation-Equivalent circuit-Torque slip characteristics- Double cage rotor representation-Equivalent circuit	10	20%
6	Single phase induction motor- Revolving Field Theory-equivalent circuit- Voltage and Torque equations-Cross field theory-Comparison between single phase and poly phase induction motor	10	20%
	End Semester Exam		

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE6405	Operation and Control of Power System	**3-0-0**	**3**	**2015**

Course Objectives

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

Syllabus

Optimum load dispatch-.Unit Commitment, Economic dispatch versus unit commitment, Generation with limited supply, Hydro-thermal coordination, Hydro-electric plant models, scheduling problems types of scheduling problems, Inter change evaluation and power pools, Introduction to State estimation in power system, Voltage control

Expected 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

1. 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.

COURSE PLAN			
Module	**Contents**	**Hours Allotted**	**% of Marks in End-Semester Examination**
I	Introduction- Optimum load dispatch-.Unit Commitment constraints. Review of Thermal units.-The Lambda iteration method (with and without losses)	3	15
	First order gradient method base point and participation factors. Economic dispatch versus unit commitment	4	
II	Generation with limited supply-Take or pay fuel contract-composite generation production cost function- solution of gradient search techniques .Hard limits and slack variables- Hydro-thermal coordination-Types of Scheduling-Long range and short range scheduling.	6	15
FIRST INTERNAL EXAM			
III	Hydro-electric plant models-scheduling problems types of scheduling problems- Scheduling energy -short-term hydrothermal scheduling problem	3	15
	Pumped storage hydro plants- pumped storage hydro scheduling λ-γ iteration	4	
IV	Inter change evaluation and power pools-Economy interchange evaluation with unit commitments. Types of interchange, Energy banking-power pools.	4	15
	Power system security-system monitoring-contingency analysis-security constrained optimal power flow- Factors affecting power system security.	4	
SECOND INTERNAL EXAM			

V	Introduction to State estimation in power system, Control of generation-Automatic Generation control Review-AGC implementation	4	20
	AGC features - Modeling exercise using SIMUL1NK.,AGC with optimal dispatch of Generation	3	
VI	Voltage control-using transformer- control by mid-line boosters-compensation of transmission line-AGC including excitation system .MVAR control	4	20
	Application of voltage regulator – synchronous condenser – transformer taps – static VAR compensators.	3	
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE6407	Power Quality	**3-0-0**	**3**	**2015**

Course Objectives

1. To discuss various power quality issues and different methods to control them.

Syllabus

Power quality issues in distribution systems, Need for power quality monitoring, IEEE guides, standards and recommended practices, Modeling of networks and components under non-sinusoidal conditions, Harmonic Analysis, Effects of Power System harmonics on Power System equipment and loads, Harmonic elimination, Power Quality Management in Smart Grid, Electromagnetic Interference.

Expected 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-Hill

2. . Jose Arillaga, Neville R. Watson, '"*ower System Harmonics*", Wiley, 1997

3. C. Sankaran, '"*ower 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

COURSE PLAN

Module	Contents	Hours Allotted	% of Marks in End-Semester Examination
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	3	15
	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	4	
II	IEEE guides, standards and recommended practices. Harmonics -mechanism of harmonic generation-harmonic indices (THD, TIF, DIN, C – message weights - Power Quality Costs Evaluation - Causes and effects of power quality disturbances. Harmonic sources - SMPS, Three phase power converters, arcing devices, saturable devices, fluorescent lamps.	6	15
	FIRST INTERNAL EXAM		
III	Modeling of networks and components under non-sinusoidal conditions-transmission and distribution systems-shunt capacitors-transformers-electric machines-ground systems-loads that cause power quality problems.	3	15
	Modeling of transformers-electric machines-ground systems-loads that cause power quality problems.	4	
IV	Harmonic Analysis - Fourier series and coefficients, the Fourier transforms, discrete Fourier transform, fast Fourier	4	15

	transform, Window function			
	Effects of Power System harmonics on Power System equipment and loads.	4		
SECOND INTERNAL EXAM				
V	Harmonic elimination - Design and analysis 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.	4	20	
	Dynamic Voltage Restorers for sag, swell and flicker problems	3		
VI	Power Quality Management in Smart Grid: Power Quality in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid.	4	20	
	Electromagnetic Interference (EMI -introduction -Frequency Classification - Electrical fields-Magnetic Fields - EMI Terminology - Power frequency fields - High frequency	3		
END SEMESTER EXAM				

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE6999	Research Methodology	0-2-0	2	2015

Course Objectives

1. To prepare the student to do the M. Tech project work with a research bias.
2. To formulate a viable research question.
3. To develop skill in the critical analysis of research articles and reports.
4. To analyze the benefits and drawbacks of different methodologies.
5. To understand how to write a technical paper based on research findings.

Syllabus

Introduction to Research Methodology-Types of research- Ethical issues- Copy right-royalty-Intellectual property rights and patent law-Copyleft- Openacess-
Analysis of sample research papers to understand various aspects of research methodology:
Defining and formulating the research problem-Literature review-Development of working hypothesis-Research design and methods- Data Collection and analysis- Technical writing- Project work on a simple research problem

Approach

Course focuses on students' application of the course content to their unique research interests. The various topics will be addressed through hands on sessions.

Expected Outcome

Upon successful completion of this course, students will be able to
1. Understand research concepts in terms of identifying the research problem
2. Propose possible solutions based on research
3. Write a technical paper based on the findings.
4. Get a good exposure to a domain of interest.
5. Get a good domain and experience to pursue future research activities.

References

1. C. R. Kothari, Research Methodology, New Age International, 2004
2. Panneerselvam, Research Methodology, Prentice Hall of India, New Delhi, 2012.
3. J. W. Bames, Statistical Analysis for Engineers and Scientists, Tata McGraw-Hill, New York.
4. Donald Cooper, Business Research Methods, Tata McGraw-Hill, New Delhi.
5. Leedy P. D., Practical Research: Planning and Design, McMillan Publishing Co.
6. Day R. A., How to Write and Publish a Scientific Paper, Cambridge University Press, 1989.
7. Manna, Chakraborti, Values and Ethics in Business Profession, Prentice Hall of India, New Delhi, 2012.
8. Sople, Managing Intellectual Property: The Strategic Imperative, Prentice Hall ofIndia, New Delhi, 2012.

COURSE PLAN			
Module	**Contents**	**Hours Allotted**	**% of Marks in End-Semester Examination**
I	Introduction to Research Methodology: Motivation towards research - Types of research: Find examples from literature. Professional ethics in research - Ethical issues-ethical committees. Copy right - royalty - Intellectual property rights and patent law - Copyleft-Openacess-Reproduction of published material - Plagiarism - Citation and acknowledgement. Impact factor. Identifying major conferences and important journals in the concerned area. Collection of at least 4 papers in the area.	5	
II	Defining and formulating the research problem -Literature Survey-Analyze the chosen papers and understand how the authors have undertaken literature review, identified the research gaps, arrived at their objectives, formulated their problem and developed a hypothesis.	4	
FIRST ASSESSMENT			
III	Research design and methods: Analyze the chosen papers to understand formulation of research methods and analytical and experimental methods used. Study of how different it is from previous works.	4	No end semester written examination
IV	Data Collection and analysis.Analyze the chosen papers and study the methods of data collection used. - Data Processing and Analysis strategies used– Study the tools used for analyzing the data.	5	
SECOND ASSESSMENT			
V	Technical writing - Structure and components, contents of a typical technical paper, difference between abstract and conclusion,layout,	5	

	illustrations and tables, bibliography, referencing and footnotes-use of tools like Latex.		
VI	Identification of a simple research problem – Literature survey- Research design- Methodology –paper writing based on a hypothetical result.	5	
END SEMESTER ASSESSMENT			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE6491	Seminar I	0-0-2	2	2015

Course Objectives

To make students

1. Identify the current topics in the specific stream.
2. Collect the recent publications related to the identified topics.
3. Do a detailed study of a selected topic based on current journals, published papers and books.
4. Present a seminar on the selected topic on which a detailed study has been done.
5. Improve the writing and presentation skills.

Approach

Students shall make a presentation for 20-25 minutes based on the detailed study of the topic and submit a report based on the study.

Expected Outcome

Upon successful completion of the seminar, the student should be able to

1. Get good exposure in the current topics in the specific stream.
2. Improve the writing and presentation skills.
3. Explore domains of interest so as to pursue the course project.

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE6493	Power System Lab I	**0-0-2**	**1**	**2015**

Course Objectives

1. Ability to write program for load flow analysis and conduct different types of stability analysis, harmonic analysis and tie line control of power systems.
2. To conduct high voltage testing of insulators, various studies on power line training systems and relays.

Syllabus

Experiments

1. Load flow analysis (Programming)
2. Short Circuit and Transient stability Studies
3. Voltage Instability Analysis
4. Harmonic Analysis
5. Simulation of AVR and AGC with Tie line control
6. High Voltage Testing of Insulators
7. Determination of Transmission line parameters, SIL, Regulation, Efficiency and Voltage control of Transmission Line Training System
8. Experiments on Relays
9. Active and Reactive Power Control of Alternator
10. Simulation of Power Electronic Circuits using PSCAD
11. Simulation study on Power Line Series Compensator

In addition to the above, the Department can offer a few experiments in the **Electrical Machines**

SEMESTER – II

Syllabus and Course Plan

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE6402	**Digital Protection of Power System**	**3-1-0**	**4**	**2015**

Course Objectives

1. To understand different protection schemes and applications to transformer, busbar and generator armature winding protection.
2. To understand the role of Current and Voltage transformers in power system protection.
3. To understand application of DSP fundamentals and application to current and voltage phasor estimation.

Syllabus

Basic ideas of relay protection- Nature and causes of faults-types of faults – Current transformer and potential transformer- Static relays- Digital relay- Protection of generators- Protection of transformers- Bus zone protection - Causes of overvoltages-lightning phenomena

Expected Outcome

After studying this subject, students are able to Design various electronic circuits to implement various relaying functions It should be also useful to practicing engineers as well as the research community.

References

1. T. S.MadhavRao, "Power System Protection Static Relays With Microprocessor Applications", Tata McGraw Hill Publication, 1994
2. Badri Ram and DN Vishwakarma, "Power system protection and Switchgear", TataMcGrawHill, NewDelhi, 2003.
3. L.P.Singh, " Digital protection, Protective Relaying from Electromechanical to Microprocessor", John Wiley & Sons, 1995
4. A. T. John and A. K. Salman- "Digital Protection for Power Systems", IEE Power Series-15, Peter Peregrines Ltd., UK, 1997
5. Russeil C., Mason, "The Art and Science of Protective Relaying", John Wiley & Sons, 2002
6. Power System Protection Vol. I, II , III&IV, The Institution Of Electrical Engineers, Electricity Association Services Ltd., 1995
7. A. R. Warrington, "Protective Relays, Vol. 1&2", Chapman and Hall, 1973

COURSE PLAN

Module	Contents	Hours Allotted	% of Marks in End-Semester Examination
I	Basic ideas of relay protection- Nature and causes of faults-types of faults –zones of protection-classification of protective relays – basic relay elements and relay terminology .	5	15
	Classification of Relays – Construction and operation of Electromagnetic relays Current transformer and potential transformer for protection-types of construction-transient behavior	5	
II	Static relays- Solid state devices used in static protection -– Amplitude comparator and phase comparator classification-basic components- Static Overcurrent relays: Non-directional, Directional - Synthesis of Mho relay,Reactance relay, Impedance relay and Quadrilateral Distance relay using Static comparators, pilot relaying schemes-carrier current protection	8	15
	FIRST INTERNAL EXAM		
III	Digital relay-Basic components of digital relay- DSP fundamentals like aliasing, sampling theorem.	4	15
	Discrete Fourier Transform and application to current and voltage phasor estimation -sinusoidal wave based algorithms -least square based methods	5	
IV	Fundamentals of travelling wave based protection –Bergeran's equations-Discriminant functions	5	15
	Principles of internal fault detection –ultra high speed polarity comparison scheme-ultra high speed wave differential scheme	5	
	SECOND INTERNAL EXAM		
V	Protection of generators- stator and rotor protection-Transformer protection-differential protection-protection against magnetizing inrush current-earth fault protection	5	20
	Bus zone protection-differential current protection-high impedance relay scheme-frame leakage protection	4	
VI	Causes of overvoltages-lightning phenomena-overvoltages due to	5	20

	lightning-protection of transmission lines against direct lightning strokes-protection of substations		
	-Insulation coordination-basic impulse level- Protection of Long and short lines – Protection based on Artificial Intelligence – SCADA:	5	
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE6404	Power System Dynamics And Control	**3-0-0**	**3**	**2015**

Course Objectives

To discuss the importance of system dynamics in power system operation and control.

Syllabus

Analysis of Steady State Stability & Transient Stability, Modeling of Synchronous Machines, Excitation systems & Prime Mover Controllers, Stability Issues in Interconnected Power Systems, Small signal Stability, Enhancing system stability

Expected Outcome

Upon successful completion of this course, students will be able to model power system components , analyze the stability of single machine and multi-machine systems and suggest modifications to enhance stability

References

1. K. R. Padiyar, "Power System Dynamics – Stability & Control", II Edition, B.S.Publications.
2. P.M. Anderson and A.A. Fouad, "Power system control and stability" John Wiley & sons
3. I.J. Nagrath and M. Gopal, "Control system engineering", Wiley Eastern Ltd

   3rd edition, 2000.
4. Benjamin C. Kuo, "Automatic Control system", Prentice Hall of India Pvt Ltd
5. PrabhaKundur, "Power System Stability and Control", Tata McGraw Hill

COURSE PLAN			
Module	**Contents**	**Hours Allotted**	**% of Marks in End-Semester Examination**
I	Introduction to Power System Stability, States of operation & System Security,Stability Problems faced by Power Systems, Impact on Power System Operation and Control.	3	15
	Review of Classical Model Analysis of Steady State Stability & Transient Stability : Concept of Equilibria, Small and Large Disturbance Stability, Single Machine Infinite Bus System, Modal Analysis of Linear Systems, Analysis using Numerical Integration Techniques.	4	
II	Modeling of Synchronous Machines, armature and field structure, parks transformation, machine with multiple pole pairs-mathematical description, d-q transformation, per unit representation, equivalent circuit for d-q axes, steady state analysis- voltage-current and flux linkage, phasor representation, rotor angle – steady state equivalent circuit	6	15
FIRST INTERNAL EXAM			
III	Excitation systems & Prime Mover Controllers: Simplified Representation of Excitation Control, Excitation systems, Modeling, Prime Mover Control System	3	15
	Modeling of Transmission Lines and Loads: Transmission Line Physical Characteristics, Transmission Line Modeling, Load Models - induction machine model.	4	
IV	Stability Issues in Interconnected Power Systems: Single Machine Infinite Bus System, Multi-machine Systems, Stability of Relative Motion,	4	15
	Frequency Stability, Concept of Load Sharing, Voltage Stability in Single Machine Load Bus System, Torsional Oscillations	4	
SECOND INTERNAL EXAM			
V	Small signal Stability : State space representation concept, Eigen properties of the state vectors, analysis of stability- small signal stability of a single machine connected to infinite bus system. Classical representation of generator, small signal stability of a multi machine connected to infinite bus system. Characteristics of small - signal	4	20

	stability problems.		
	Heffron-Phillips constants – Effects on Excitation system – Block diagram representation with exciter and AVR – Power System Stabilizer (PSS) – State matrix including PSS.	3	
VI	Enhancing System Stability: Planning Measures, Stabilizing Controllers (Power System Stabilizers)	4	20
	Operational Measures- Preventive Control, Emergency Control.	3	
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE6412	New And Renewable Sources Of Energy	**3-0-0**	**3**	**2015**

Course Objectives

This subject provides sufficient knowledge about the promising new and renewable sources of energy so as to equip students capable of working with projects related to its aim to take up research work in connected areas.

Syllabus

Solar energy- Solar radiation measurements- Applications of solar energy- Energy from oceans- Tidal energy- Wind energy-Small Hydro Power (SHP) Stations- Biomass and bio-fuels- Geothermal energy-Power from satellite stations- Hydrogen energy

Expected Outcome

Upon successful completion of this course, students will be able to design and analyses theperformance of small isolated renewable energy sources.

References

1. John W. Twidell, Anthony D Weir, "*Renewable Energy Resources*", English Language Book
2. Society (ELBS), 1996
3. Godfrey Boyl, "*Renewable Energy -Power for Sustainable Future*", Oxford University Press, 1996
4. S. A. Abbasi, NaseemaAbbasi, "*Renewable energy sources and their environmental impact*", Prentice-Hall of India, 2001
5. G. D. Rai, "*Non-conventional energy sources*", Khanna Publishers, 2008
6. G. D. Rai, "*Solar energy utilization*", Khanna Publishers, 2000
7. S. L. Sah, "*Renewable and novel energy sources*", M.I. Publications, 1995
8. S. Rao and B. B. Parulekar, "*Energy Technology*", Khanna Publishers, 1999

COURSE PLAN

Module	Contents	Hours Allotted	% of Marks in End-Semester Examination
I	Direct solar energy-The sun as a perennial source of energy; flow of energy in the universe and the cycle of matter in the human ecosystem; direct solar energy utilization	3	15%
	Solar radiation measurements, solar radiation data, estimation of average solar radiation	4	
II	Applications of solar energy – water heating systems, space heating and cooling of buildings, solar cooking, solar ponds, solar green houses, solar thermal electric systems; solar photovoltaic power generation; solar production of hydrogen.	6	15%
FIRST INTERNAL EXAM			
III	Energy from oceans-Wave energy generation - potential and kinetic energy from waves; wave energy conversion devices	3	15%
	Tidal energy - basic principles; tidal power generation systems;- Ocean thermal energy conversion (OTEC); methods of ocean thermal electric power generation	4	
IV	Wind energy - basic principles of wind energy conversion; design of windmills; wind data and energy estimation	4	15%
	Site selection considerations. Types of wind machines-Horizontal axis and Vertical axis machines	4	
SECOND INTERNAL EXAM			
V	Classification of small hydro power (SHP) stations; description of basic civil works design considerations;Turbines and generators for SHP; advantages and limitations.	4	20%
	Biomass and bio-fuels; energy plantation; biogas generation; types of biogas plants; applications of biogas; energy from wastes, Chemical energy sources-Types of fuel cells-Batteries	3	
VI	Geothermal energy- Origin and nature of geothermal energy; classification of geothermal resources; schematic of geothermal power plants; operational and environmental problems;	4	20%
	Power from satellite stations, Hydrogen energy –production-storage-transportation –utilization, nuclear fusion energy, cold fusion	3	
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE6414	**Distributed Generation**	**3-0-0**	**3**	**2015**

Course Objectives

To attain a working knowledge of the emerging power generation technologies such as photovoltaic arrays, wind turbines, and fuel cells, Model renewable electrical energy systems for analysis and design, Calculate the basic performance parameters of these systems, such as efficiency and cost, Perform basic assessment and design of a renewable electrical energy system for a given application. Determine the requirements for interconnecting a renewable electrical energy system to the utility electric power grid.

Syllabus

Non conventional and renewable energy sources, Power quality requirements and source switching using SCR based static switches, Intentional and unintentional islanding of distribution systems, Grid Interconnection options

Expected Outcome

Upon successful completion of this course, students will be able to choose the right renewable energy source and storage method Design various interconnecting options of DG with the grid and its control Address the problems of islanding, reactive power management and harmonics in a DG systems and its economic aspects

References

1. Lee Willis & Walter G. Scott, 'Distributed Power Generation, Planning & Evaluation', 2000 Edition, CRC Press Taylor & Francis Group.
2. Godfrey Boyle, 'Renewable Energy Power for A Sustainable Future', 2004 Oxford University, Press in association with the Open University.
3. D. Mukherjee, S.Chakrabarti, 'Fundamentals of Renewable Energy Systems', New Age International Publishers.
4. W. Kramer, S. Chakraborty, B. Kroposki, and H. Thomas, Advanced Power Electronic Interfaces for Distributed Energy Systems Part 1: Systems and Topologies, March 2008, Technical Report NREL/TP-581-42672

COURSE PLAN

Module	Contents	Hours Allotted	% of Marks in End-Semester Examination
I	Distributed Generation (DG)-Definition, advantages, challenges and needs .Introduction to distribution systems. Radial distribution system protection: Fuse, circuit breakers, reclosers, sectionalizers, Hybrid energy systems.	3	15
	Economic aspects of DG- Generation cost, investment, tariffs analysis. Feed-in- tariff, Net metering	4	
II	Non conventional and renewable energy sources-Wind Power- wind turbine and rotor types, wind speed –power curve, power coefficient, tip speed ratio, wind energy distribution, environmental impact. Photovoltaic and Thermo-solar power –Solar cell technology, Photovoltaic power characteristics and Thermo-solar power generation. Biomass Power, Fuel cells types, types of Tidal power generation schemes, mini and micro hydro power schemes, and Micro turbines for DG, bulb and tubular turbines.	6	15
FIRST INTERNAL EXAM			
III	Energy Storage for use with Distributed Generation-Battery Storage, Capacitor Storage, ultra capacitors	3	15
	Mechanical Storage: Flywheels, Pumped and Compressed Fluids.	4	
IV	Grid Interconnection Options, Pros and Cons of DG – Grid Interconnection, Standards of Interconnection, General Power electronic DG interconnection topologies for various sources and control.	4	15
	Control of DG inverters, current control and DC voltage control for standalone and grid parallel operations. Protection of the converter, Control of grid interactive power converters, phase locked loops , synchronization and phase locking techniques, current control	4	
SECOND INTERNAL EXAM			
V	DC bus control during grid faults, converter faults during grid parallel and standalone operation, DG interconnection standards,Low voltage ride through –standards and requirements,Power quality requirements and source switching using SCR based static switches	4	20

	Relaying and protection, distributed generation interconnection relaying, sensing using CTs and PTs.	3	
VI	Intentional and unintentional islanding of distribution systems-Passive and active detection of unintentional islands,-non detection zones,	4	20
	Reactive power support using DG, Power quality improvement using DG.	3	
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE6424	**Static VAR Controllers & Harmonic Filtering**	**3-0-0**	**3**	**2015**

Course Objectives

To familiarize the different control schemes for Static VAR Compensators to mitigate power quality problems in Power System

Syllabus

Review of transmission lines, Steady-State Reactive Power Control in Electric Transmission Systems, Converters for Static Compensation, The Static Var Compensator (SVC); TCR, FC-TCR and TSC-TCR variants: STATCOMs and their control, Sub-Synchronous Resonance and damping, Passive Harmonic Filtering, Hybrid Filtering using Shunt Active Filters, The Dynamic Voltage Restorer (DVR)

Expected Outcome

To familiarize the different control schemes for Static VAR Compensators to mitigate power quality problems in Power System

References

1. 1. T. J. E. Miller, :"Reactive Power Control in Electric Systems", John Wiley & Sons, 1982.
2. 2. N. G. Hingorani& L. Gyugyi, "Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems", IEEE Press, 2000.
3. 3. Ned Mohan et.al, "Power Electronics" John Wiley and Sons, 2006

COURSE PLAN

Module	Contents	Hours Allotted	% of Marks in End-Semester Examination
I	Review of transmission lines; surge impedance loading; voltage profile along radial and symmetrical lines, effect of load, Ferranti effect; role of reactive power compensators; series, shunt and unified compensation; effect on power flow and voltage profile.	3	15
	Steady-State Reactive Power Control in Electric Transmission Systems, Reactive Power Compensation and Dynamic Performance of Transmission Systems.	4	
II	Converters for Static Compensation, Single Phase and Three Phase Converters and Standard Modulation Strategies (Programmed Harmonic Elimination and SPWM). GTO Inverters, Multi-Pulse Converters and Interface Magnetics Multi-Level Inverters of Diode Clamped Type and Flying Capacitor Type and suitable modulation strategies. Multi-level inverters of Cascade Type and their modulation. Current Control of Inverters	6	15
FIRST INTERNAL EXAM			
III	The Static Var Compensator (SVC); TCR, FC-TCR and TSC-TCR variants: circuits, characteristics	3	15
	Transmission line compensation capability; dynamic model.	4	
IV	STATCOMs and their control, Series Compensators of Thyristor Switched and Controlled Type and their Control, SSSC and its Control	4	15
	Use of STATCOMs and SSSCs for Transient and Dynamic Stability Improvement in Power Systems	4	
SECOND INTERNAL EXAM			
V	Passive Harmonic Filtering . Single Phase Shunt Current Injection Type Filter and its Control, Three Phase Three-wire Shunt Active Filtering and their control using p-q theory and d-q modelling .Three phase four-wire shunt active filters .	4	20
	Hybrid Filtering using Shunt Active Filters . Series Active Filtering in Harmonic Cancellation Mode . Series Active Filtering in Harmonic Isolation Mode.	3	

VI	The Dynamic Voltage Restorer (DVR); circuit and steady-state characteristic; effect on transmission line compensation; advantages over TCSC; DVR for power quality compensation; modes of control.	4	20
	DVR for power quality compensation; modes of control.	3	
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE6416	Computer Aided Power System Analysis	**3-0-0**	**3**	**2015**

Course Objectives

1. To introduce computer applications in analysis of power systems

2. To understand the solution methods and techniques involved in power system studies

3. To understand the state space analysis and contingency analysis of different power system

Syllabus

Different load flow studies-harmonics load flow-incorporation of FACTS devices in load flow studies-Elementary graph theory-Short circuit studies-State estimation-Contingency analysis-contingency analysis by DC Model.

Expected Outcome

Upon successful completion of this course, students will have 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.

References

1. G. L. Kusic, "*Computer Aided Power System Analysis*", Prentice Hall.

2. HadiSaadat, "*Power System Analysis*", McGraw-Hill Publisherss.

3. J. Arriliga and N. R. Watson, "*Computer Modelling of Electrical Power Systems*", Wiley

Publications.

4. John J. Grainger, William D. Stevenson, Jr., *Power System Analysis*, Tata McGraw-Hill Series in Electrical and Computer Engineering.

5. H. E. Brown, *Large Networks by Matrix Methods*, John Wiley & Sons.

COURSE PLAN

Module	Contents	Hours Allotted	% of Marks in End-Semester Examination
I	Load Flow Studies: Overview of Gauss, Gauss- Seidel and Newton Raphson Methods, Decoupled Load Flow, Fast Decoupled Load Flow,	3	15
	DC load flow, Three-phase Load Flow and Harmonic Load flow. Sparsity techniques, Triangular factorization and Optimal ordering.	4	
II	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).	6	15
	FIRST INTERNAL EXAM		
III	Elementary linear graph theory –Incidence and network matrices.	3	15
	Development of network matrices from Graph theoretic approach, matrix Building algorithm for Bus impedance matrix, Modification of Z_{BUS} due to changes in primitive network.	4	
IV	Short Circuit studies – Types of Faults – Short circuit study of a large power system Algorithm for calculating system conditions after fault	4	15
	Three phase short circuit, three phase to ground, double line to ground, line to line and single line to ground fault.	4	
	SECOND INTERNAL EXAM		
V	State estimation – least square and weighted least square estimation methods for linear and non-linear systems.	4	20
	Static state estimation of power systems- injections only and line only algorithms, Treatment of bad data – detection, identification and suppression of bad data.	3	
VI	Contingency Analysis- adding and removing multiple lines, Analysis of	4	20

	single and multiple contingencies		
	Contingency Analysis by DC model, System reduction for contingency and fault studies.	3	
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE6418	**Flexible AC Transmission Systems**	**3-0-0**	**3**	**2015**

Course Objectives

Advances in Power electronics Industry led to rapid development of Power Electronics controllers for fast real and reactive power control The aim of the course is to familiarise these advancements to the students

Syllabus

Power flow control - Benefits of FACTS -Transmission line compensation. Uncompensated line -shunt and series compensation .Reactive power compensation .Converters for Static Compensation. Static shunt and series compensators - Variable impedance type. Static Voltage and Phase AngleRegulators (TCVR &TCPAR). Switching Converter type shunt and series Compensators - principle of operation, configuration and control. Unified Power Flow Controller –.Modelling and simulation of FACTS controllers -

Expected Outcome

After studying this subject , students are able to design a power system with proper control for real and reactive power using FACTS devices

References

1. N G Hingorani and L Gyugyi, “Understanding FACTS”, IEEE Press, 2000
2. T J E Miller, "Reactive Power Control in Power Systems", John Wiley, 1982
3. J Arriliga and N R Watson, "Computer modeling of Electrical Power Systems”, Wiley, 2001
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.

COURSE PLAN

Module	Contents	Hours Allotted	% of Marks in End-Semester Examination
I	Power flow in Power Systems – Steady-state and dynamic problems in AC systems – Voltage regulation and reactive power flow control in Power Systems – control of dynamic power unbalances in Power System	3	15
	Power flow control -Constraints of maximum transmission line loading - Benefits of FACTS Transmission line compensation- Uncompensated line -shunt compensation - Series compensation - Phase angle control.	4	
II	Reactive power compensation – shunt and series compensation principles – reactive compensation at transmission and distribution level – Static versus passive VAr Compensators – Converters for Static Compensation - Three Phase Converters and Standard Modulation Strategies. GTO Inverters. Transformer Connections for 12 , 24 and 48 pulse operation. Multi-level inverters and their modulation	6	15
	FIRST INTERNAL EXAM		
III	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	3	15
	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	4	
IV	Static Voltage and Phase Angle Regulators (TCVR &TCPAR): Objectives of Voltage and Phase angle regulators	4	15
	Thyristor controlled Voltage And Phase angle Regulators - Switching converter type Voltage and Phase Angle Regulators- Applications	4	
	SECOND INTERNAL EXAM		
V	Switching converter type shunt Compensators.- Principle of operation, configuration and control , SVC and STATCOM - Regulation slope – Transfer functions and Dynamic	4	20

	performance Var Reserve Control		
	Comparison between SVC and STATCOM- Applications Switching converter type Series Compensators-(SSSC)- Principle of operation, configuration and control	3	
VI	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	4	20
	Introduction to interline power flow controller. Modeling and simulation of FACTS controllers	3	
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE6422	**Power System Instrumentation**	**3-0-0**	**3**	**2015**

Course Objectives

1. To impart principles of different measurement systems and methods of various electrical parameters.

Syllabus

Generalized performance characteristics of instruments, Classification of instruments based on their order;
Dynamic response and frequency response studies of zero order, first order and second order instruments.
Signal Conditioning; Signal Processing and its Components
Measurement of voltage, current, phase angle, frequency, active power and reactive power in power plants.
Transducers, classification & selection; Introduction, Signal Processing and its Components; Measurement of voltage, current, phase angle, frequency, active power and reactive power in power plants.
Introduction to SCADA; SCADA applications in Utility Automation, Industries

Expected Outcome

1. Upon successful completion of this course, students will be able to analyse the performance of measuring instruments and use it for different applications.

References

1. B. D. Doeblin, '*Measurement systems - Application and Design',* McGraw-Hill, New York.
2. John P. Bentley, '*Principles of Measurement System',* Pearson Education.
3. Power System Instrumentation By Ramnath .Author Ramnath Publisher Genius Publication
4. J. W. Dally, W. F. Reley and K. G. McConnel, '*Instrumentation for Engineering Measurements'* Second Edition, John Wiley & Sons Inc. New York, 1993
5. K. B. Klaasen, '*Electronic Measurement. And Instrumentation',* Cambridge University Press.
6. Helfrick and Cooper, '*Modern Electronic Instrumentation and Measurement Techniques*', *Prentice-Hall of India*
7. Jones, B. E., '*Instrumentation Measurement and Feedback',* Tata McGraw-Hill*, 1986.*
8. Golding, E. W., *'Electrical Measurement and Measuring Instruments',* 3rd Edition
9. Stuart A. Boyer, '*SCADA-Supervisory Control and Data Acquisition*', Instrument Society of America Publications,USA,2004

COURSE PLAN

Module	Contents	Hours Allotted	% of Marks in End-Semester Examination
I	Generalized performance characteristics of instruments – Static and dynamic characteristics, development of mathematical model of various measurement systems. Classification of instruments based on their order.	6	15
II	Dynamic response and frequency response studies of zero order, first order and second order instruments. Theory of errors: systematic and random errors, limits of error, probable error and standard deviation. Gaussian error curves, combination of errors.	7	15
FIRST INTERNAL EXAM			
III	Transducers, classification & selection of transducers, strain gauges, inductive & capacitive transducers, piezoelectric and Hall-effect transducers, thyristors, thermocouples, photo-diodes & photo-transistors, encoder type digital transducers	6	15
IV	Signal Conditioning Introduction, Signal Processing and its Components, Operational Amplifier (Op-Amp), Instrumentation Amplifiers, Isolation Amplifiers, Charge Amplifier, Analog Multipliers, Analog Dividers, Function Generator, Timers, Sample and Hold Circuits, Electrical Isolators, Frequency to Voltage Converters, Grounding and Shielding.	7	15
SECOND INTERNAL EXAM			
V	Measurement of voltage, current, phase angle, frequency, active power and reactive power in power plants. Energy meters and multipart tariff meters. Capacitive voltage transformers and their transient behaviour, Current Transformers for measurement and protection, composite errors and transient response.	8	20
VI	Introduction to SCADA: Data acquisition systems, Evolution of SCADA, Communication technologies, Monitoring and supervisory functions, SCADA applications in Utility Automation, Industries	6	20
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE6432	Sustainable and Translational Engineering	3-0-0	3	2015

Course Objectives

The purpose of this course is:-

1. To bring in to focus the basics aspects of sustainable development.
2. To have a general understanding on global environmental issues and the different aspects involved in Green Technology.

Syllabus

History and emergence of the concept of Sustainable Development; Economic dimensions,

Environmental dimension; Framework for sustainability, assessment of sustainable performance;

Industrialization, Globalization and Environment; Global environmental issues; Waste land

reclamation, Resource degradation, carbon credits and Carbon trading – Carbon footprint;

Energy: Conventional and renewable sources,
Green buildings, green materials, Technology and sustainable development, Sustainable urbanization, Industrial Ecology.

Expected Outcome

The student will be able to

1. Understand the concept of sustainable development
2. To have an insight in to global environmental issues
3. Understand the different aspects of green Technology

References

1. Kurian Joseph & R. Nagendran' Essential Environmental studies'. Pearson education, New Delhi, 2004.

2. S.C Bhatia, Environmental Pollution and Control in Chemical Process Industries, Khanna Publishers, Delhi, 2005.
3. Kirkby, J.O' Keefe, P. and Timberlake, Sustainable Development, Earthscan Publication, London, 1996.
4. Mackenthun, K.M., Basic Concepts in Environmental Management, Lewis Publication, London, 1998.
5. S.S Purohit ,Green Technology-An approach for sustainable environment, Agrobios publication, India, 2008.
6. Twidell, J. W. and Weir, A. D., Renewable Energy Resources, English Language Book Society (ELBS).

Course Plan			
Module	**Contents**	**Hours Allotted**	**% of Marks in End Semester Examination**
I	History and emergence of the concept of Sustainable Development – Framework of Sustainability, economic dimensions-environmental dimension	7	15
II	Framework for achieving sustainability, assessment of sustainable performance-Industrialization – Globalization and Environment	7	15
First Internal Exam			
III	Global environmental issues: - desertification –– green house gases-greenhouse effect, ozone layer depletion- global warming – acid rain – deforestation.	7	15
IV	Waste land reclamation-Resource degradation, carbon credits and Carbon trading-International summits- conventions-agreements-trans boundary issues- Carbon footprint	7	15
Second Internal Exam			
V	Energy sources: Basic concepts-Conventional and non-conventional, solar energy, Fuel cells, Wind energy, Small hydro plants, bio-fuels, Energy derived from oceans, Geothermal energy.	7	20
VI	Green buildings, Sustainable cities, Sustainable Urbanisation Sustainable transport, Green Engineering, Industrial Ecology, Industrial symbiosis.	7	20
End Semester Exam			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE6426	Smart Grid Technologies and Applications	**3-0-0**	**3**	**2015**

Course Objectives

Objective of the course is to develop a conceptual basis for Smart Grid and to equip the students with a thorough understanding of various communication technologies and power management issues with smart grid.

Syllabus

Evolution of Electric Grid, Smart meters, Smart Substations, Substation Automation, Smart energy efficient end use devices-Smart distributed energy resources- Energy management-Role of technology in demand response- Demand Side Management; Load Frequency Control (LFC) in Micro Grid System, Advanced metering Infrastructure

Expected Outcome

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

1. Understand features and scope of smart grid technology.
2. Assess the role of automation in substation.
3. Understand operation and importance of demand side management, voltage and frequency control in smart micro grid

References

- A Stuart Borlase, "Smart Grids, Infrastructure, Technology and Solutions", CRC Press, 2013
- Ali Keyhani, Mohammad N. Marwali, Min Dai "Integration of Green and Renewable Energy in Electric Power Systems", Wiley
- Clark W. Gellings, "The Smart Grid: Enabling Energy Efficiency and Demand Response", CRC Press
- James Momoh, "Smart Grid:Fundamentals of Design and Analysis", Wiley, IEEE Press, 2012.
- A.G. Phadke and J.S. Thorp, "Synchronized Phasor Measurements and their Applications", Springer Edition, 2010.
- Iqbal Hussein, "*Electric and Hybrid Vehicles: Design Fundamentals*", CRC Press, 2003.
- JanakaEkanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama, "Smart Grid: Technology and Applications", Wiley 2012.
- Gautam Shroff, Enterprise Cloud Computing Technology Architecture Applications [ISBN: 978-0521137355]

COURSE PLAN

Module	Contents	Hours Allotted	% of Marks in End-Semester Examination
I	Evolution of Electric Grid, Concept, Definitions and Need for Smart Grid, Smart grid drivers, functions, opportunities, challenges and benefits	3	15
	Present development & International policies in Smart Grid. Indian Smart Grid. Components and Architecture of Smart Grid Design	4	
II	Introduction to Smart Meters, Real Time Pricing- Models, Smart Appliances, Automatic Meter Reading(AMR), Plug in Hybrid Electric Vehicles(PHEV), Vehicle to Grid, Smart Sensors, Home & Building Automation.	6	15
FIRST INTERNAL EXAM			
III	Smart Substations, Substation Automation, Introduction to IEC 61850, Feeder Automation. Geographic Information System(GIS)	3	15
	Intelligent Electronic Devices(IED) & their application for monitoring & protection, Wide Area Measurement System(WAMS), Phase Measurement Unit(PMU).	4	
IV	Smart energy efficient end use devices-Smart distributed energy resources- Energy management-Role of technology in demand response- Demand Side Management	4	15
	Load Curves-Load Shaping Objectives-Methodologies-Barriers. Peak load saving-Constraints-Problem formulation- Case study	4	
SECOND INTERNAL EXAM			
V	Load Frequency Control (LFC) in Micro Grid System – Voltage Control in Micro Grid System	4	20
	Reactive Power Control in Smart Grid.	3	
VI	Advanced Metering Infrastructure (AMI), Home Area Network (HAN), Bluetooth, Zig-Bee, GPS, Wi-Fi, Wi-Max based communication	4	20
	Cloud computing in smart grid. Private, public and Hybrid cloud. Cloud architecture of smart grid.	3	
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE6428	Distribution System Planning and Automation	**3-0-0**	**3**	**2015**

Course Objectives

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

Syllabus

Power System Concepts; Loads and Energy Forecasting Analysis - Analysis of time series; Planning, Design and Operation methodology; Distribution load flow; load forecasting ; optimal location of substation;Optimization of distribution systems; Optimum phase sequence;Distributionautomation;Power System reliability; Consumer Services; theft of power; Energy metering – Tariffs; Deregulated Systems; Static VAR system; loss reduction and voltage improvement.

Expected Outcome

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

1. Distribution system expansion planning
2. Distribution automation

References

1. A. S. Pabla, "*Electrical Power Distribution Systems*", 4th edn., TMH, 1997
2. TuranGonen, "*Electrical Power Distribution Engineering*", McGraw-Hill.
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*", 2nd Edition, Peter Peregrimus Ltd.
6. Dhillan B. S., *"Power System Reliability, Safety and Management"* , An Arbor Sam 1981

COURSE PLAN

Module	Contents	Hours Allotted	% of Marks in End-Semester Examination
I	Power System: General Concepts - Distribution of power - Management - systems study - Loads and Energy Forecasting: Power loads - Area Preliminary survey load forecasting	3	15
	Regression analysis - Correlation analysis - Analysis of time series - Factors in power system loading -Technological forecasting— Sources of error	4	
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.	6	15
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	3	15
	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	4	
IV	Distribution automation: -Definitions - Project Planning - Communication, Sensors, Supervisory Control and Data Acquisition (SCADA), Consumer Information systems (CIS), Geographical Information Systems (GIS)	4	15
	Power System reliability: Basic Reliability Concepts- Series,Parallel,Series–ParallelSystems Development of State Transition Model to determine the Steady State Probabilities.	4	
SECOND INTERNAL EXAM			

V	Consumer Services: Supply industry - Natural monopoly - Regulations - Standards - Consumer load requirements	4	20
	Cost of Supply - load management - theft of power - Energy metering - Tariffs: Costing and Pricing, Classification of Tariffs.	3	
VI	Deregulated Systems: Reconfiguring Power systems- Unbundling of Electric Utilities- Competition and Direct access Voltage control	4	20
	Application of shunt capacitance for loss reduction – Harmonics in the system – static VAR systems – loss reduction and voltage improvement.	3	
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE6126	**Soft Computing Techniques**	**3-0-0**	**3**	**2015**

Course Objectives

1. To provide concepts of soft computing and design controllers based on ANN and Fuzzy systems.
2. To identify systems using soft computing techniques.
3. To give an exposure to optimization using genetic algorithm.
4. To provide a knowledge on hybrid systems.

Syllabus

Biological foundations; ANN models; Feed Forward Network; Radial Basis Function; Learning process; Supervised and unsupervised learning; Least mean square algorithm; Back propagation algorithm; Applications in pattern recognition and other engineering problems; Case studies; Identification and control of linear and nonlinear systems; Fuzzy set operations; Fuzzy control systems; Classical fuzzy control problems; Genetic Algorithm; Adaptive fuzzy systems; Hybrid Systems; Application of soft computing techniques in physical systems.

Expected Outcome

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

1. To design a complete feedback system based on ANN or Fuzzy control.
2. To identify systems using softcomputing techniques.
3. To use genetic algorithm to find optimal solution to a given problem.
4. To design systems by judiciously choosing hybrid techniques.

REFERENCES

2. J. M. Zurada, Introduction to artificial neural systems, Jaico Publishers, 1992.
3. Simon Haykins, Neural Networks - A comprehensive foundation, Macmillan College, Proc, Con, Inc, New York. 1994.
4. D. Driankov. H. Hellendorn, M. Reinfrank, Fuzzy Control - An Introduction, Narosa Publishing House, New Delhi, 1993.
5. H J Zimmermann, Fuzzy set theory and its applications, 11th ed., Academic Publishers, London.
6. G. J. Klir, Boyuan, Fuzzy sets and fuzzy logic, Prentice Hall of India (P) Ltd, 1997.
7. Stamatios V Kartalopoulos, Understanding neural networks and fuzzy logic basic concepts and applications, Prentice Hall of India (P) Ltd, New Delhi, 2000.
8. Timothy J. Ross, Fuzzy logic with Engineering Applications, McGraw Hill, New York.
9. SuranGoonatilake, SukhdevKhebbal (Eds,), Intelligent hybrid systems, John Wiley & Sons, New York, 1995.
10. Vose Michael D., Simple Genetic Algorithm - Foundations and Theory, Prentice Hall of India.
11. Rajasekaran&Pai, Neural Networks, Fuzzy Logic, and Genetic Algorithms: Synthesis and Applications, Prentice-Hall of India, 2007.
12. J. S. Roger Jang, C. T. Sun and E. Mizutani, Neuro Fuzzy and Soft Computing, prentice Hall inc., New Jersey, 1997.

COURSE PLAN			
Module	**Contents**	**Hours Allotted**	**% of Marks in End-Semester Examination**
I	Biological foundations - ANN models - Types of activation function - Introduction to Network architectures - Multi Layer Feed Forward Network (MLFFN) - Radial Basis Function Network (RBFN) - Recurring Neural Network (RNN).	6	15
II	Learning process : Supervised and unsupervised learning - Error-correction learning - Hebbian learning – Boltzmenlearning - Single layer and multilayerperceptrons - Least mean square algorithm – Back propagation algorithm - Applications in pattern recognition and other engineering problems Casestudies - Identification and control of linear and nonlinear systems.	9	15
FIRST INTERNAL EXAM			
III	Fuzzy sets: Fuzzy set operations - Properties - Membership functions, Fuzzy to crisp conversion, fuzzification and defuzzification methods, applications in engineering problems.	9	15
IV	Fuzzy control systems: Introduction - simple fuzzy logic controllers with examples - Special forms of fuzzy logic models, classical fuzzy control problems, inverted pendulum, image processing, home heating system, Adaptive fuzzy systems.	6	15
SECOND INTERNAL EXAM			
V	Genetic Algorithm: Introduction - basic concepts of Genetic Algorithm, applications.	6	20
VI	Hybrid Systems: Adaptive Neuro fuzzy Inference System (ANF1S), Neuro –Genetic, Fuzzy-Genetic systems.	6	20
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE6492	Mini Project	0-0-4	2	2015

Course Objectives

To make students

Design and develop a system or application in the area of their specialization.

Approach

The student shall present two seminars and submit a report.The first seminar shall highlight the topic, objectives, methodology, design and expected results. The second seminar is the presentation of the work / hardwareimplementation.

Expected Outcome

Upon successful completion of the miniproject, the student should be able to

1. Identify and solve various problems associated with designing and implementing a system or application.
2. Test the designed system or application.

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE6494	Power System Lab II	**0-0-2**	**1**	**2015**

Course Objectives

Ability to conduct advanced experiments in power systems.

Syllabus

Experiments

1. Three phase unbalanced Load flow analysis Short Circuit and Transient stability Studies
2. Economic Dispatch (Programming)
3. Optimal Load Flow
4. Relay Coordination
5. Simulation of SVC, STATCOM etc using PSCAD/MATLAB
6. Simulation of HVDC systems using PSCAD
7. Behaviour of Power System Components for different harmonic over voltages
8. Lab practice on LABVIEW software for power monitoring and control
9. String efficiency of insulators
10. Partial discharge measurement of dielectrics

In addition to the above, the Department can offer a few experiments in the ***Electrical Machines*** Laboratory

Expected Outcome

The students are able to perform advanced experimental works for industrial projects

SEMESTER - III

Syllabus and Course Plan

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE7411	EHVAC and DC Transmission	**3-0-0**	**3**	**2015**

Course Objectives

To enable the students gain a fair knowledge on the concepts and technology of Extra High Votage AC and DC transmission systems

Syllabus

EHV AC transmission- interconnected AC networks-HVDC transmission system- Power flow in AC and HVDC lines-steady state U_d/I_dcharacteristics;Converter circuits- analysis of converters- control characteristics; Harmonics and filters.Reactive power requirements in HVDC substations- planning of HVDC; DC line oscillations and line dampers-over voltage protection;Earth electrode;EHV AC Transmission; Corona; Insulation requirements of EHV AC and DC transmission lines ; insulation coordination; switching over voltage.

Expected Outcome

1. Upon successful completion of this course, students will be able to analyse the problems faced in EHV AC and DC transmission and for protection of EHV AC-DC substation and transmission equipment.

References

1. Rakosh Das Begamudre, *'EHV AC Transmission Engineering'*, New Age International Pvt. Ltd., 2nd Edition, 1997
2. S. Rao, *'EHV AC and HVDC Transmission Engineering & Practice'*, Khanna Publishers
3. E. W. Kimbark, *'Direct Current Transmission Volume'* , John Wiley, New York
4. K. R. Padiyar, *'HVDC Power Transmission Systems'*, Wiley Eastern Ltd.

COURSE PLAN			
Module	**Contents**	**Hours Allotted**	**% of Marks in End-Semester Examination**
I	EHV AC transmission-configuration-features-intermediate substations-applications- interconnected AC networks-HVDC system-classification-configuration-equipment in HVDC substations-	3	15
	Power flow in AC and HVDC lines-EHV AC vs. HVDC-economic comparison-HVDC power flow- power conversion principle-power loss in DC system-steady state U_d/I_d characteristics	4	
II	Converter circuits-single phase and three phase circuits-analysis of bridge converter-with and without overlap-grid control - control characteristics-constant minimum ignition angle control-constant current control-extinction angle control	6	15
FIRST INTERNAL EXAM			
III	Harmonics-characteristics of harmonics-means of reducing harmonics-telephone interference-filters-single frequency and double frequency-tuned filters-DC harmonic filter	3	15
	Reactive power requirements in HVDC substations-effect of delay angle and extinction angle-short circuit ratio in planning of HVDC	4	
IV	DC line oscillations and line dampers - Over voltage protection-DC lightning arresters-DC circuit breakers -basic concepts types & characteristics	4	15
	Earth electrode-location and configuration-earth return-materials of anode-sea electrode –shore electrode-troubles by earth currents and remedial measures	4	
SECOND INTERNAL EXAM			

V	EHV AC Transmission-Components of transmission system-voltage gradients of conductor-single and bundled conductor	4	20
	Corona & corona losses in EHVAC and HVDC-critical surface gradient-Peeks law-critical disruptive voltage and critical electric stress for visual corona	3	
VI	Insulation requirements of EHV AC and DC transmission lines - Electrostatic field of EHV lines-biological effects-live wire maintenance	4	20
	insulation coordination-insulation for power frequency-voltage-switching, over voltage-lightning performance	3	
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE7413	Energy Auditing, Conservation and Management	**3-0-0**	**3**	**2015**

Course Objectives

1. To understand and analyse electrical energy consumption patterns and accounting techniques.
2. To understand and analyse energy management and conservation methods.

Syllabus

Energy Auditing and Economics, Electricity tariff types, Energy economics, Reactive Power Management, Energy conservation in lighting and electric drives. Peak Demand controls, Energy management opportunities with electric drives and electric heating, management of heating, ventilating and air-conditioning (HVAC) systems, Energy conservation in compressors and electrolytic processes, Computer aided energy management, Cogeneration.

Expected Outcome

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

1. To understand the concept of analysis and application of electrical energy management and measurement techniques.
2. To understand the various energy conservation methods in industries.

References

1. Giovanni Petrecca, "Industrial Energy Management: Principles and Application", The Kluwer International Series-207, 1999
2. Anthony J. Pansini, Kenneth D. Smalling, "Guide to Electric Load Management", Pennwell Pub.,1998
3. Howard E. Jordan, "Energy-Efficient Electric Motors and their Applications", Pleneum Pub Corp. 2nd edition, 1994
4. Turner, Wayne C., "Energy Management Handbook", Lilburn, The Fairmont Press, 2001.
5. Albert Thumann, "Handbook of Energy Audits", Fairmont Press 5th Edition, 1998
6. IEEE Bronze Book, "Recommended Practice for Energy Conservation and Cost

effective Planning in Industrial Facilities" ,IEEE Inc ,USA

7. Albert Thumann P.W, "Plant Engineers and Managers Guide to Energy Conservation", 7th Edition, TWI Press Inc. Terre Haute.
8. Donald R. W., "Energy Efficiency Manual", Energy Institute Press
9. Partab H., "Art and Science of Utilization of Electrical Energy", Dhanpat Rai & Sons , New Delhi
10. Tripathy S. C., "Electrical Energy Utilization and Conservation", Tata McGraw -Hill
11. NESCAP- "Guide Book on Promotion of Sustainable Energy"

COURSE PLAN

Module	Contents	Hours Allotted	% of Marks in End-Semester Examination
I	Energy Auditing and Economics: System approach and End use approach to efficient use of Electricity; Electricity tariff types; Energy auditing-Types and objectives-audit instruments.	3	15
	ECO assessment and Economic methods-cash flow model, time value of money, evaluation of proposals, pay-back method, average rate of return method, internal rate of return method, present value method, profitability index, life cycle costing approach, investment decision and uncertainty, consideration of income taxes, depreciation and inflation in investment analysis. specific energy analysis-Minimum energy paths- consumption models- Case study.	4	
II	Reactive Power Management and Lighting: Reactive Power management - Capacitor Sizing-Degree of Compensation-Capacitor losses-Location-Placement-Maintenance-Case study. Economics of power factor improvement.	6	15
FIRST INTERNAL EXAM			
III	Peak Demand controls- Methodologies –Types of Industrial Loads-Optimal Load scheduling-Case study.	3	15
	Energy management opportunities with electric drives and electric heating	4	
IV	Lightning-Energy efficient light sources-Energy Conservation in Lighting schemes.	4	15
	Electronic Ballast-Power quality issues-Luminaries-Case study.	4	
SECOND INTERNAL EXAM			
V	Electric loads of Air conditioning and Refrigeration –Energy conservation measures-Cool storage- Types- Optimal operation-	4	20

	Case study .		
	Power Consumption in Compressors, Energy conservation measures. Electrolytic Process-Computer Control-Software – EMS.	3	
VI	Computer aided energy management.	2	20
	Cogeneration and conservation in industries: Cogeneration-Types and Schemes-Optimal operation of cogeneration plants-Case study.	5	
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE7415	**Restructured Power System**	**3-0-0**	**3**	**2015**

Course Objectives

1. To introduce the restructuring of power industry and market models.
2. To impart knowledge on fundamental concepts of congestion management.
3. To analyze the concepts of locational marginal pricing and financial transmission rights.
4. To illustrate about various power sectors in India

Syllabus

Restructuring of power industry- Introduction- Deregulation of power industry, Restructuring process-Fundamentals of economics- Market models; Transmission congestion management- Features– Classification; Locational marginal pricing- LMP calculation; Financial Transmission rights- Simultaneous feasibility test and revenue adequacy – FTR issuance process- Treatment of revenue shortfall – Flow gate rights – FTR and market power; Ancillary services management- Classification– Load generation balancing related services – Voltage control and reactive power support devices – Black start capability service; Transmission pricing: principles-methods – Marginal transmission pricing paradigm. – Rolled in transmission pricing ; Reforms in Indian power sector- Framework of Indian power sector – Availability based tariff – Reforms in the near future

Expected Outcome

Upon successful completion of this course, students will be able to understand the operation of a restructured power system and the concept of congestion management, marginal pricing and financial transmission rights.

References

1. Steven Stoft," Power system economics: designing markets for electricity", John Wiley & Sons, 2002.
2. Mohammad Shahidehpour, MuwaffaqAlomoush, Marcel Dekker, "Restructured electrical power systems: operation, trading and volatility" Pub., 2001
3. Sally Hunt," Making competition work in electricity John Willey and Sons Inc. 2002
4. Kankar Bhattacharya, Jaap E. Daadler, Math H.J. Boolen," Operation of restructured power systems", Kluwer Academic Pub., 2001.

COURSE PLAN			
Module	**Contents**	**Hours Allotted**	**% of Marks in End-Semester Examination**
I	**Introduction to restructuring of power industry** Introduction: Deregulation of power industry, Restructuring process, Issues involved in deregulation, Deregulation of various power systems.	3	15
	Fundamentals of Economics: Consumer behaviour, Supplier behaviour, Market equilibrium, Short and long run costs, Various costs of production.	3	
	Market models: Market models based on Contractual arrangements, Comparison of various market models, Electricity vis – a – vis other commodities, Market architecture, Case study.	4	
II	**Transmission congestion management** Introduction: Definition of Congestion, reasons for transfer capability limitation, Importance of congestion management, Features of congestion management – Classification of congestion management methods – Calculation of ATC - Non – market methods – Market methods – Nodal pricing – Inter zonal and Intra zonal congestion management – Price area congestion management – Capacity alleviation method.	6	15
FIRST INTERNAL EXAM			
III	**Locational marginal prices:** Mathematical preliminaries: - Locational marginal pricing– Lossless DCOPF model for LMP calculation – Loss compensated DCOPF model for LMP calculation – ACOPF model for LMP calculation.	6	15
IV	**Financial Transmission rights** – Risk hedging functionality - Simultaneous feasibility test and revenue adequency – FTR issuance process: FTR auction, FTR allocation – Treatment of	6	15

	revenue shortfall – Secondary trading of FTRs – Flow gate rights – FTR and market power - FTR and merchant transmission investment.		
SECOND INTERNAL EXAM			
V	**Ancillary service management** Introduction of ancillary services – Types of Ancillary services – Classification of Ancillary services – Load generation balancing related services	3	20
	Voltage control and reactive power support devices – Black start capability service – method to obtain ancillary service –Co-optimization of energy and reserve services - International comparison	4	
VI	**Pricing of transmission network** Transmission pricing – Principles – methods – Marginal transmission pricing paradigm Merits and demerits of different paradigm.– Rolled in transmission pricing – Composite pricing paradigm – Merits and demerits of different paradigm.	4	20
	Reforms in Indian power sector Introduction – Framework of Indian power sector – Reform initiatives - Availability based tariff – Electricity act 2003 – Open access issues – Power exchange – Reforms in the near future	3	
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE7417	**Transient Analysis in Power System**	**3-0-0**	**3**	**2015**

Course Objectives

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

Syllabus

Lightning, Travelling waves, switching transients, Abnormal switching transients, Transformer model for switching on open circuit, surges in transformer, Voltage surges - Transformers - Generators and motors, Transmission lines Protective Devices and Systems, protection of lines and stations

Expected Outcome

Upon completion of this course, students will be able to

1. Identify different types of transient over-voltages,
2. Model different equipment's 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.
6. V.Kamaraju and M.S. Naidu , 'High Voltage Engineering

COURSE PLAN

Module	Contents	Hours Allotted	% of Marks in End-Semester Examination
I	Lightning : Transients in electric power systems - internal and external causes of over voltages - lightning strokes - mathematical model to represent lightning - stroke to tower and midspan- prevention of lightning over voltages.	6	15
II	Travelling waves - travelling waves in transmission lines, selection of typical wave to represent over voltages.	4	15
	Switching Transients: - the circuit closing transient - the recovery transient initiated by the removal of the short circuit — double frequency transients	4	
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 , symmetrical –component method for solving three phase switching transients	7	15
IV	Transformer model for switching on open circuit, surges in transformer- Step voltage - voltage distribution in transformer winding –winding oscillations - Travelling wave solutions - Transformer core under surge conditions.	6	15
SECOND INTERNAL EXAM			
V	Voltage surges -Transformers - Generators and motors -Transient parameter values for transformers - Reactors - Generators.- motors-transmission lines and cables, characteristics of bus work, measurement of transient recovery voltages in a power plant	7	20
VI	Transmission lines Protective Devices and Systems: Basic idea about protection - surge diverters - surge absorbers - ground fault	4	20

	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	4	
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE7419	**Power System Stability and Reliability**	**3-0-0**	**3**	**2015**

Course Objectives

To equip the engineers for operating power systems more effectively and reliably utilizing the resources in an optimal manner.

Syllabus

Concept of Power system stability; Transient stability analysis; Voltage Stability Analysis; Static Analysis; Determination of Shortest distance to instability; The continuation load flow analysis-Important voltage stability indices-Prevention of Voltage Collapse. Concept of reliability, System reliability, Methods of system reliability, fault free analysis. Generating capacity reserve evaluation; generation expansion planning, uncertainties in generating unit Failure rates and in load forecasts. Operating reserve evaluation; the security function approach.Interconnected systems.

Expected Outcome

1. Analyse transient stability and voltage stability
2. Operate power systems more effectively and reliably.

References

1. K. R. Padiyar, '*Power System Dynamics*',2nd Edition, B.S. Publishers, 2003
2. P. Kundur, '*Power System Stability and Control'*, McGraw-Hill Inc., 1994
3. T. Van Cutsem, C. Vournas, ' *Voltage Stability of Electric Power System'*, Kluwer Academic Publishers, 1998
4. J. J. Endrenyi, *'Reliability Modelling in Electric Power Systems'* , John Wiley & Sons
5. Singh C., Billinton R. *'System Reliability Modelling and Evaluation'*,Hutchinston

COURSE PLAN

Module	Contents	Hours Allotted	% of Marks in End-Semester Examination
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	15
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	15
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.	6	15
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	4	15
	Other methods of system reliability, fault free analysis. Monte Carlo simulation, planning for reliability, outage definitions, construction of reliability models.	4	

SECOND INTERNAL EXAM			
V	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	20
VI	Interconnected systems, two connected systems with independent loads, two connected system with correlated loads, more than two systems interconnected.	7	20
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE7421	**SCADA Systems and Applications**	**3-0-0**	**3**	**2015**

Course Objectives

To introduce SCADA systems, its components, architecture, communication and applications

Syllabus

Introduction to SCADA systems, Fundamental Principle of Modern SCADA Systems, Monitoring and supervisory functions ,Application area of SCADA system, SCADA System Components, Remote Terminal Unit-(RTU), Intelligent Electronic Devices (IED), Programmable Logic Controller (PLC), Communication Network, SCADA Server, SCADA/HMI Systems.
SCADA Architecture: Various SCADA architectures, advantageous and disadvantageous, SCADA Communication: Various industrial communication, Open standard communication protocols, Operation and control of interconnected power system, Automatic substation control, SCADA configuration, Energy management system, System operating states, System security, state estimation, SCADA Applications, Case studies, Implementation. Simulation exercises.

Expected Outcome

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

1. Use SCADA systems in different engineering applications such as utility, communication, automation, control, monitoring etc.

Reference

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 and Related Systems', Newnes Publications, Oxford, UK,2004
3. David Bailey, Edwin Wright, *Practical SCADA for Industry*, Newnes (an imprint of Elsevier), 2003
4. KLS Sharma, *Overview of Industrial Process Automation*, Elsevier Publication

COURSE PLAN			
Module	**Contents**	**Hours Allotted**	**% of Marks in End-Semester Examination**
I	Introduction to SCADA systems: • Evolution of SCADA • Fundamental Principle of Modern SCADA Systems, Monitoring and supervisory functions • Application area of SCADA Consideration and benefits of SCADA system	6	15
II	SCADA System Components: • Remote Terminal Unit-(RTU), Intelligent Electronic Devices (IED) • PLC: Block diagram, programming languages, Ladder diagram, Functional block diagram, Applications, Interfacing of PLC with SCADA. • Communication Network • SCADA Server, SCADA/HMI Systems	8	15
FIRST INTERNAL EXAM			
III	SCADA Architecture: • Various SCADA architectures, advantages and disadvantages of each system • Single unified standard architecture, IEC 61850 SCADA / HMI Systems	7	15

IV	SCADA Communication: • Various industrial communication technologies -wired and wireless methods and fiber optics Open standard communication protocols	7	15
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	8	20
VI	SCADA Applications: • Utility applications Transmission and Distribution sector operations, monitoring, analysis and improvement. • Industries - oil, gas and water. • Case studies: • Implementation. Simulation Exercises	6	20
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE7121	Biomedical instrumentation	**3-0-0**	**3**	**2015**

Course Objectives

To provide an introduction to the modern Biomedical instruments and systems, features and applications.

Syllabus

Introduction to the physiology of cardiac, nervous; muscular and respiratory systems; Action potentials -De-polarization; repolarization; Absolute and relative refractory periods; Generation propagation and transmission; Measurement of electrical activities in heart, Electrocardiography; Measurement of electrical activities in brain, Electroencephalogram; Measurement of electrical activities in muscles; Determination of conduction velocity in a nerve fiber. Important applications of EMG; Measurement of blood flow; Direct and Indirect methods; Therapeutic Equipment - Cardiac pace-makers, Types of pace-makers; Defibrillators, Types of defibrillators, Electrodes used in defibrillators, diathermy machines, Micro wave and short wave diathermy machines. Introduction to Biomedical signal processing; Analysis of x-rays; CT and MRI images; Basic methods; Instrumentation for clinical laboratory; Measurement of pH value of blood, ESR measurements, GSR measurement, modern imaging modalities ; X-ray machines, Diagnostic X-rays- Computed Tomography; Ultra sonography; Magnetic resonance imaging. Nuclear medicine; Radio isotopic instrumentation; Medical uses of isotopes; Applications of robotics in medical field; Cyber knife.

Expected Outcome

Upon successful completion of this course, students will have insight into operation and maintenance of modern biomedical equipments used in clinical practice.

References

1. R. S. Khandpur, *Handbook of Biomedical Instrumentation*, TMH Publishing Company Ltd., New Delhi.
2. Joseph J. Carr, John M Brown, *Introduction to Biomedical Equipment Technology*, Pearson Education (Singapore) Pvt. Ltd.
3. Leslie Cromwell, "*Biomedical Instrumentation and Measurements*", Prentice Hall India, New Delhi.

COURSE PLAN			
Module	**Contents**	**Hours Allotted**	**% of Marks in End-Semester Examination**
I	Introduction to the physiology of cardiac, nervous, muscular and respiratory systems. Transducers and Electrodes, Action potentials- De-polarization – repolarization- Absolute and relative refractory periods- generation propagation and transmission. Significance of after potentials, Different types of transducers and their selection for biomedical applications.	6	15
II	Electrodes used in Biomedical engineering. Electrodes for ECG, EEG, EMG, etc. Biomaterials-Metals, Ceramics, Polymeric materials and their applications.	6	15
FIRST INTERNAL EXAM			
III	Measurement of electrical activities in heart, brain and muscles - Electrocardiography- EEG machine, Disease diagnosis from ECG, Computer aided electro cardiographs- Applications of ECG. Electroencephalogram and their interpretation. EEG machine applications, Rapid eye movement- Electromyography, EMG machines, Conduction velocity in a nerve fiber. Important applications of EMG.	9	15
IV	Electromagnetic and ultrasonic measurement of blood flow, various methods, Therapeutic Equipment - Cardiac pace-makers, Types of pace-makers, Defibrillators, Types of defibrillators, Electrodes used in defibrillators, diathermy machines, Microwave and short wave diathermy machines.	9	15
SECOND INTERNAL EXAM			
V	Introduction to Biomedical signal processing, Methods of signal processing – Digital and analogue. Introduction to Biomedical image processing- Analysis of x-rays, CT and MRI images – Basic methods.	6	20
VI	Instrumentation for clinical laboratory - Measurement of pH value of blood, ESR, and GSR measurement, modern imaging modalities - X-ray machines, Diagnostic x-rays - Computed Tomography – Ultrasonography - Magnetic resonance imaging - Nuclear medicine - Radio isotopic instrumentation - Medical uses of isotopes – Applications of robotics in medical field- Cyber knife.	6	20
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE7315	Hybrid Electric Vehicles	3-0-0	3	2015

Course Objectives:

To present a comprehensive overview of Electric and Hybrid Electric Vehicle

Syllabus

Introduction to Hybrid Electric Vehicles, Conventional Vehicles, Hybrid Electric Drive-trains, Electric Propulsion unit, Configuration and control of DC Motor drives, Induction Motor drives, Permanent Magnet Motor drives, switched reluctance motor, Energy Storage Requirements in Hybrid and Electric Vehicles, Sizing the drive system, Design of a Hybrid Electric Vehicle , Energy Management Strategies.

Expected Outcome:

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

1. Choose a suitable drive scheme for developing an electric 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

1 MehrdadEhsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.

2 James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.

COURSE PLAN			
Module	**Course description**	**Hours**	**End semester exam % marks**
1	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	15%
2	Hybrid Electric Drive-trains: Basic concept of hybrid traction, introduction to various hybrid drive-train 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.	8	15%
	First Internal Exam		
3	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	8	15%
4	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	15%
	Second Internal Exam		
5	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	6	20%

	storage technology, Case Studies: Design of a Hybrid Electric Vehicle (HEV), Design of a Battery Electric Vehicle (BEV).		
6	Communications, supporting subsystems: In vehicle networks- CAN, 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.	6	20%
	End Semester Exam		

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE7491	Seminar II	0-0-2	2	2015

Course Objectives

To make students

1. Identify the current topics in the specific stream.
2. Collect the recent publications related to the identified topics.
3. Do a detailed study of a selected topic based on current journals, published papers and books.
4. Present a seminar on the selected topic on which a detailed study has been done.
5. Improve the writing and presentation skills.

Approach

Students shall make a presentation for 20-25 minutes based on the detailed study of the topic and submit a report based on the study.

Expected Outcome

Upon successful completion of the seminar, the student should be able to

1. Get good exposure in the current topics in the specific stream.
2. Improve the writing and presentation skills.
3. Explore domains of interest so as to pursue the course project.

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE7493	Project (Phase 1)	0-0-12	6	2015

Course Objectives

To make students

1. Do an original and independent study on the area of specialization.
2. Explore in depth a subject of his/her own choice.
3. Start the preliminary background studies towards the project by conducting literature survey in the relevant field.
4. Broadly identify the area of the project work, familiarize with the tools required for the design and analysis of the project.
5. Plan the experimental platform, if any, required for project work.

Approach

The student has to present two seminars and submit an interim Project report. The first seminar would highlight the topic, objectives, methodology and expected results. The first seminar shall be conducted in the first half of this semester. The second seminar is the presentation of the interim project report of the work completed and scope of the work which has to be accomplished in the fourth semester.

Expected Outcome

Upon successful completion of the project phase 1, the student should be able to

1. Identify the topic, objectives and methodology to carry out the project.
2. Finalize the project plan for their course project.

SEMESTER - IV

Syllabus and Course Plan

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE7494	Project (Phase 2)	0-0-23	12	2015

Course Objectives

To continue and complete the project work identified in project phase 1.

Approach

There shall be two seminars (a mid term evaluation on the progress of the work and pre submission seminar to assess the quality and quantum of the work). At least one technical paper has to be prepared for possible publication in journals / conferences based on their project work.

Expected Outcome

Upon successful completion of the project phase II, the student should be able to

1. Get a good exposure to a domain of interest.
2. Get a good domain and experience to pursue future research activities.