APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

Master of Technology

Curriculum, Syllabus and Course Plan

Cluster	***: 10- Kannur***
Branch	***: Electrical and Electronics Engineering***
Stream	***: POWER SYSTEMS***
Year	***:*** *2018*
No. of Credits	***:*** *66*

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

Cluster No. 10 for PG Programs

(Engineering Colleges in Kannur, Wayand & Kasaragod Districts)

Curriculum, Scheme of Examinations and Syllabi for
M. Tech. Degree
Program with effect from Academic Year 2019 - 2020

Electrical & Electronics Engineering

M. Tech.

in

Power Systems

(No. of Credits: 66)

SEMESTER 1

Examination Slot	Course Code.	Name	L-T-P	Internal Marks	End Semester Examination		Credits
					Marks	Duration	
A	10EE6401	Advanced Mathematics and Optimisation Techniques	3-0-0	40	60	3	3
B	10EE6403	Power Electronic Application in Power System	3-0-0	40	60	3	3
C	10EE6405	Modelling of Electrical Machines	3-1-0	40	60	3	4
D	10EE6303	Power System Dynamics	3-0-0	40	60	3	3
E	10EE6xxx	Elective I	3-0-0	40	60	3	3
S	10GN6001	Research Methodology	0-2-0	100	-		2
T	10EE6409	Seminar I	0-0-2	100	-		2
U	10EE6411	Power System Lab I	0-0-2	100	-		1
		Total	15-3-4	500	300		21

TOTAL CONTACT HOURS : 22
TOTAL CREDITS : 21

Elective I

10EE6313 Power System Security
10EE6415 Power System Instrumentation
10EE6117 Power Quality Issues and Remedial Measures
10EE6417 Distribution System Planning and Automation

SEMESTER 2

Examination Slot	Course Code.	Name	L-T-P	Internal Marks	End Semester Examination		Credits
					Marks	Duration	
A	10EE6402	Digital Protection of Power System	3-1-0	40	60	3	4
B	10EE6404	Computer Aided Power System Analysis	3-0-0	40	60	3	3
C	10EE6306	Power System Operation and Control	3-0-0	40	60	3	3
D	10EE6xxx	Elective II	3-0-0	40	60	3	3
E	10EE6xxx	Elective III	3-0-0	40	60	3	3
V	10EE6408	Mini Project	0-0-4	100	-		2
U	10EE6412	Power System Lab II	0-0-2	100	-		1
Total			15-1-6	400	300		19

TOTAL CONTACT HOURS : 22
TOTAL CREDITS : 19

Elective II

10EE6414	Static VAR Controllers and Harmonic Filtering
10EE6416	Sustainable and Translational Engineering
10EE6116	Power Conversion in Renewable Energy Systems
10EE6124	High voltage DC and AC Transmission

Elective III

10EE6422	Smart Grid Technologies and Applications
10EE6424	Power System Stability and Reliability
10EE6126	Energy Management
10EE6132	Distributed Generation and Micro grid

SEMESTER 3

Examination Slot	Course Code.	Name	L-T-P	Internal Marks	End Semester Examination		Credits
					Marks	Duration	
A	10EE7xxx	Elective IV	3-0-0	40	60	3	3
B	10EE7xxx	Elective V	3-0-0	40	60	3	3
T	10EE7401	Seminar II	0-0-2	100			2
W	10EE7403	Project (Phase I)	0-0-12	50			6
Total			6-0-14	230	120	-	14

TOTAL CONTACT HOURS : 20
TOTAL CREDITS : 14

Elective IV

10EE7405	Flexible AC Transmission Systems
10EE7407	Restructured Power System
10EE7107	Electric Vehicle Systems
10EE7117	Soft Computing Technique

Elective V

10EE7411	Transient Analysis in Power System
10EE7413	SCADA System and Applications
10EE7415	Biomedical Instrumentation
10EE7111	Custom Power Devices

SEMESTER 4

Examination Slot	Course Code.	Name	L-T-P	Internal Marks	End Semester Examination		Credits
					Marks	Duration	
W	10EE7404	Project (Phase 2)	0-0-22	70	30		12
Total			0-0-22	70	30	-	12

TOTAL CONTACT HOURS : 22
TOTAL CREDITS : 12

TOTAL NUMBER OF CREDITS: 66

SEMESTER - I

Syllabus and Course Plan

Course No.	Course Name	L-T-P	Credits	Year of Introduction
10EE6401	Advanced Mathematics & Optimization Techniques	3-0-0	3	2018

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, Pragathi Prakashan, 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
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	7	15

	method , Zero – One Programming		
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**
10EE6403	**Power Electronic Application in Power System**	**3-0-0**	**3**	**2018**

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 - Single phase and Three phase 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 non-ideal model of power devices
3. Design and develop power converter topologies

References

1. Bin Wu, High Power Converters and AC Drives, IEEE Press, Wiley Interscience, 2006
2. Ned Mohan, et al., Power Electronics: Converters, Design and Applications, John Wiley and Sons, 2010

3. L. Umanand, Power Electronics Essentials and Applications, John Wiley and Sons, 2010
4. G. K. Dubey, et al., Thyristorised Power Controllers, New Age International

COURSE PLAN

Module	Contents	Hours Allotted	% of Marks in End -semester
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 , CCTs, GTOs thyristors	4	
II	Application of DC-DC converters in renewable energy systems Introduction - Buck, boost, buck-boost and Ćuk Topologies - Representation with ideal switches, Steady state analysis in continuous conduction mode using inductor volt-sec balance - current and voltage ripples - design relations for inductor and capacitors, Discontinuous Conduction Mode operation of basic buck and boost converter	6	15
FIRST INTERNAL EXAM			
III	Inverters -Single phase and Three phase VSI, CSI. Pulse width modulated switching schemes-sinusoidal PWM and Selective Harmonic Elimination of Single phase and Three phase Voltage source Inverters	4	15
	Space Vector modulation. 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	3	
IV	Resonant Converters : Series resonant inverter circuit with unidirectional and bidirectional switches - – half bridge and full bridge configurations	4	15
	Parallel resonant inverter. Resonant switch converters: Zero voltage and zero current switching resonant converters	3	
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	4	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	4	

	compensator, direct and indirect control of STATCOM		20
	Principle of series compensation – switched series compensators ; Principle of phase angle compensation – phase angle compensator	3	
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
10EE6405	**Modelling of Electrical Machines**	**3-1-0**	**4**	**2018**

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. Analyse machine behaviour based on the voltage and torque equations of the machine.
2. Analyse the transient behaviour of machines

References

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

COURSE PLAN

Module	Contents	Hours Allotted	% of Marks in End -semester
1	Unified approach to the analysis of 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
II	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			
III	DC Machines: Application of generalized theory to separately excited, shunt, series and compound machines. Steady state and transient analysis, transfer functions. Sudden short circuit of separately excited generator, sudden application of inertia load to separately excited dc motor	10	15
IV	Synchronous Machines: synchronous machine reactance and time constants-Primitive machine model of synchronous machine with damper windings on both axes. Balanced steady state analysis-power angle curves. Transient analysis- sudden three phase short circuit at generator terminals- Armature currents and torque - Transient power angle curve	12	15
SECOND INTERNAL EXAM			
V	Induction Machines: Primitive machine representation - Transformation- Steady state operation-Equivalent circuit - Torque slip characteristics- Double cage rotor representation - Equivalent circuit	10	20
VI	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
10EE6303	**Power System Dynamics**	**3-0-0**	**3**	**2018**
Course Prerequisites Numerical Methods , Electrical Machines, Power System Analysis				

Course Objectives

This course aims to give basic knowledge about the dynamic mechanisms behind angle and voltage stability problems in electric power systems, including physical phenomena and modelling issues.

Syllabus

Power system stability considerations, synchronous machine representation, stability of dynamic systems, d-q transformation, state space representation concept, transient stability, numerical integration method, voltage stability

Expected Outcomes

At the end of this course, students will be able to analyse and understand the electromagnetic and electromechanical phenomena taking place around the synchronous generator.

Text books

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

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	Power system stability considerations – definitions-classification of stability-rotor angle and voltage stability-synchronous machine representation –classical model-load modelling concepts-modelling of excitation systems-modelling of prime movers.	6	15
II	Stability of Dynamic systems, Synchronous machine theory and modelling- armature and field structure, parks transformation, machine with multiple pole pairs-mathematical description, d-q transformation, per unit representation, equivalent circuit for d-q axes, steady state analysis- voltage-current and flux linkage, phasor representation, rotor angle – steady state equivalent circuit	8	15
First Internal Examination			
III	State space representation concept, Eigen properties of the state vectors, analysis of stability- small signal stability of a single machine connected to infinite bus system, classical representation of generator, small signal stability of a multi machine connected to infinite bus system. Characteristics of small - signal stability problems	8	15
IV	Transient stability:- Concept of transient stability, response to a step change in mechanical power input, Swing equation- multi-machine analysis, factors influencing transient stability	6	15
Second Internal Examination			
V	Numerical integration methods – Euler method – R-K method (4th order), critical clearing time and angle-	8	20

	methods for improving transient stability.		
VI	Voltage stability**:-** Basic concept, transmission system characteristics, generator characteristics, load characteristics, PV curve, QV curve and PQ curve, characteristics of reactive power compensating devices. Voltage collapse and prevention of voltage collapse.	6	20
	TOTAL	42	100
End Semester Examination			

Elective I

Course No.	**Course Name**	**L-T-P**	**Credits**	**Year of Introduction**
10EE6313	**Power System Security**	**3-0-0**	**3**	**2018**

Course Prerequisites

Basic Knowledge on power system at UG level

Course Objectives

To give the Student:-

- To understand about power system state estimation.
- To be familiar with the power system security issues and contingency studies.

Syllabus

Power system stability-security-observability and reliability **;** Power system state estimation; Power system security assessment; Basis of evolutionary optimization techniques; Security in Deregulated Environment, Contingency analysis

Expected Outcomes

Students who successfully complete this course will have demonstrated an ability to understand the fundamental concepts of power system security and to adopt contingency analysis and selection methods to improve system security

Text books

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

Course plan

Module	**Content**	**Hours**	**Semester Exam Marks (%)**
I	Basic concepts: Power system stability-security-observability and reliability, deregulation, factors affecting power system security, decomposition and	8	15

	multilevel approach, state estimation, system monitoring, security assessment, static and dynamic – online and offline, security enhancement.		
II	Power system state estimation: DC and AC network, orthogonal decomposition algorithm, detection identification of bad measurements, network observability and pseudo measurements, application of power system state estimation, introduction to supervisory control and data acquisition.	6	15
First Internal Examination			
III	State space representation concept, Eigen properties of the state vectors, analysis of stability- small signal stability of a single machine connected to infinite bus system, classical representation of generator, small signal stability of a multi machine connected to infinite bus system. Characteristics of small - signal stability problems	8	15
IV	Basis of evolutionary optimization techniques, preventive, emergency and restorative controls though non- linear programming (NLP) and linear programming(LP)methods.	6	15
Second Internal Examination			
V	Security in Deregulated Environment: Need and conditions for deregulation, electricity sector structure model, power wheeling transactions, congestion management methods, available transfer capability (ATC), system security in deregulation.	8	20
VI	Contingency analysis – linear sensitivity factors – AC power flow methods – contingency selection – concentric relaxation – bounding-security constrained optimal power flow-Interior point algorithm-Bus incremental costs.	6	20
		42	100
Cluster Level End Semester Examination			

Course No.	**Course Name**	**L-T-P**	**Credits**	**Year of Introduction**
10EE6415	**Power System Instrumentation**	**3-0-0**	**3**	**2018**

Course Objectives

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
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
	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	
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.	6	15
	FIRST INTERNAL EXAM		
III	Transducers, classification & selection of transducers, strain gauges, inductive & capacitive transducers, piezoelectric and		15

	Hall-effect transducers, thyristors, thermocouples, photo-diodes & photo-transistors, encoder type digital transducers	7	
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
10EE6117	**Power Quality Issues and Remedial Measures**	**3 - 0- 0**	**3**	**2018**

Course Prerequisites

Basic knowledge of Electrical power systems & power Electronics at UG Level.

Course Objectives

To give the Student:-

- An introduction to various power quality problems in the electrical power systems.
- Analyse the power quality problem and identify the remedial measures.
- Design and development of power electronics based solutions to power quality problems.

Syllabus

Introduction to power quality- power quality measures and standards- Important harmonic introducing devices- Harmonics and measurements-Power quality Improvement-DSTATCOM-DVR-UPQC- Active Power Factor Correction.

Expected Outcomes

Students who successfully complete this course will have demonstrated an ability to understand the power quality problems in the electrical systems ; Apply the basics of electrical engineering to identify the remedial measures to power quality problems; Design and development of power electronics based solutions to power quality problems.

REFERENCES:

1. G T Heydt, Power Quality, Star in a circle publications.

2. Dugan, Electric Power Systems Quality, Tata Mc Graw Hill.
3. K R Padiyar, FACTS controllers in Power Transmission and Distribution, New Age publications, New Delhi, 2007.
4. R Sastry Vedam, power quality VAR compensation in power systems, CRC press, NewYork, 2009.
5. A Ghosh and G Ledwich, "power quality improvement using custom power devices", IEEE Press, 2001.
6. NedMohan et al "power Electronics"

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	**Introduction**-power quality-voltage quality-overview of power quality phenomena classification of power quality issues-power quality measures and standards-THD-TIF-DIN-C message weights-flicker factor-transient phenomena-occurrence of power quality problems power acceptability curves-	8	15
II	**Important harmonic introducing devices**- SMPS-Three phase power converters – arcing devices- saturable devices-fluorescent lamps- effect of power system harmonics on equipment and loads.	6	15
	First Internal Examination		
III	Balancing of source currents- Steinmetz network. **Harmonics and measurements**: Power factor reduction due to harmonics-Distortion power-distortion power factor and displacement power factor- Triplen harmonics. Power Quality Analysers-Voltage, Current, Power and Energy measurements	8	15
IV	**Power quality Improvement:-DSTATCOM for** Harmonic Filtering, reactive power compensation and load balancing-d-q domain control and IRPT control of three phase DSTATCOM- Three-phase four-wire systems.	6	15
	Second Internal Examination		
V	**Dynamic Voltage Restorers** for sag, swell and flicker problems – structure and control- Series active power filtering techniques for harmonic cancellation and isolation-Uninterruptible power supplies-constant voltage transformers	8	20
VI	**UPQC:** Structure and control-Left shunt UPQC-Right shunt UPQC **Active Power Factor Correction:** Single Phase Front End, Control Methods for Single Phase APFC, Three Phase APFC and Control Techniques.	6	20
		42	100
	End Semester Examination		

Course No.	Course Name	L-T-P	Credits	Year of Introduction
10EE6417	Distribution System Planning and Automation	3-0-0	3	2018

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; Distribution automation; 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, student will be able to do

1. Distribution system expansion planning
2. Distribution automation

References

1. 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
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–Parallel Systems 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 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
10GN6001	**Research Methodology**	**0-2-0**	**2**	**2018**

Course Prerequisites

(1) Basic skill of analyzing data earned through the project work at UG level;
(2) Basic knowledge in technical writing and communication skills earned through seminar at UG level.

Course Objectives

(1) To attain a perspective of the methodology of doing research;
(2) To develop skills related to professional communication and technical report writing.

As a tutorial type course, this course is expected to be more learner centric and active involvement from the learners are expected which encourages self-study and group discussions.

The faculty mainly performs a facilitator's role

Syllabus

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

Expected Outcomes

The students are expected to :

(1) Be motivated for research through the attainment of a perspective of research methodology;

(2) Analyze and evaluate research works and to formulate a research problem to pursue research;

(3) Develop skills related to professional communication, technical report writing and publishing
papers.

References

1. C.R Kothari, *Research Methodology: Methods & Techniques*, New Age International Publishers, 2004.
2. R. Panneerselvam, Research *Methodology*, Prentice Hall of India, New Delhi, 2012.
3. K. N. Krishnaswamy, Appa Iyer Sivakumar, and M. Mathirajan, *Management Research Methodology, Integration of Principles*, Pearson Education, 2009.
4. Deepak Chawla, and MeenaSondhi, *Research Methodology – Concepts & Cases,* Vikas Publishing House, 2011.
5. J.W. Bames, *Statistical Analysis for Engineers and Scientists*, McGraw Hill, New York, 1994.
6. Schank Fr., *Theories of Engineering Experiments*, Tata McGraw Hill Publication.
7. Willktnsion K. L, Bhandarkar P. L, *Formulation of Hypothesis*, Himalaya Publication.
8. Douglas C Montgomery, *Design and analysis of experiments,* Wiley International
9. Ranjit Kumar, *Research Methodology: A step by step guide for beginners,* Pearson Education.
10. Donald Cooper, *Business Research Methods*, Tata McGraw Hill, New Delhi.
11. Leedy P D, *Practical Research : Planning and Design,* 4th Edition, N W MacMillan Publishing Co
12. Day R A, *How to Write and Publish a Scientific Paper,* Cambridge University Press, 1989
13. Coley S M and Scheinberg C A, *Proposal Writing,* 1990, Newbury Sage Publications.
14. Sople, *Managing Intellectual Property: The Strategic Imperative*, Prentice Hall of IndiaNew Delhi, 2012
15. Manna, Chakraborti, *Values and Ethics in Business Profession*, Prentice Hall of India, New Delhi, 2012.
16. Vesilind, *Engineering, Ethics and the Environment*, Cambridge University Press.
17. Wadehra, B.L. *Law relating to patents, trademarks, copyright designs and geographical indications,* Universal Law Publishing

COURSE PLAN

Module	Contents	Hours Allotted	% of Marks in End -semester Examination
I	**Overview of Research Methodology**: Research concepts, meaning, objectives, motivation, types of research, research process, criteria for good research, problems encountered by Indian researchers, scientific method, research design process.	5	No end semester examina Tion
II	**Research Problem and Design** : Formulation of research task, literature review, methods, primary and secondary sources, web as a source, browsing tools, formulation of research problems, exploration, hypothesis generation, problem solving approaches, introduction to TRIZ (TIPS), experimental research, principles, laboratory experiment, experimental designs, ex post facto research, qualitative research.	5	
FIRST ASSESSMENT			
III	**Thesis Writing, Reporting and Presentation** : Interpretation and report writing, techniques of interpretation, precautions in interpretation, significance of report writing, principles of thesis writing, format of reporting, different steps in report writing, layout and mechanics of research report, references, tables, figures, conclusions, oral presentation, preparation, making presentation, use of visual aids, effective communication, preparation for presentation in seminars and conferences..	4	
IV	**Research proposals, Publications, Ethics and IPR** : Research proposals, development and evaluation, research paper writing, layout of a research paper, journals in engineering, considerations in publishing, scientometry, impact factor, other indexing like h-index, citations, open access publication, ethical issues, plagiarism, software for plagiarism checking, intellectual property right (IPR), patenting case studies.	5	
SECOND ASSESSMENT			
V	**Research Methods - Modeling and Simulation** : Modeling and simulation, concepts of modeling, mathematical modeling, composite modeling, modeling with ordinary differential equations, partial differential equations (PDE), graphs, heuristics and heuristic optimization, simulation modeling.	5	
VI	**Research Methods - Measurement, Sampling and Data Acquisition** : Measurement design, errors, validity and reliability in measurement, scaling and scale construction, sample design, sample size determination, sampling errors, data collection procedures, sources of data, data collection methods, data preparation and data analysis..	5	
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
10EE6409	Seminar I	0-0-2	2	2018

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.

Syllabus

Individual students are required to choose a topic of their interest in consultation with faculty and present for about 30 minutes. They will be guided about sound modulation, sequence of presentation, eye contact and writing on the black board.

Students have to submit a report on the topic in the prescribed format.

Expected Outcomes

Upon the completion of this course, students will have the ability:

- To enhance the reading ability required for the literature review
- To identify hot research topics in the relevant field
- To analyze technical problems in a critical way;
- To develop skills regarding professional communication
- To write technical reports
- □ To make effective power point presentation

Internal Continuous Assessment: 100 marks

Presentation (Verbal & Nonverbal Communication skills) : 20 Marks

Breadth of the topic (Coverage : Content of the slides and speech) : 20 Marks

Depth of knowledge (Ability to answer questions) : 30 Marks

Seminar Report in the prescribed format given by the Institution : 30 marks

Course No.	Course Name	L-T-P	Credits	Year of Introduction
10EE6411	Power System Lab I	0-0-2	1	2018

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. Formation of YBUS matrix (programming) by step by step method and singular transformations method
2. Load flow analysis (Programming) using Gauss Seidal method by polar and

rectangular

3. Load flow analysis (Programming) using Newton-Raphson and fast decoupled methods
4. Z BUS formation (Programming) using building up algorithm
5. Economic Dispatch (Programming)
6. Unit commitment problem (Programming)
7. Load frequency control (Programming)
8. Optimal Load Flow (Programming)
9. Develop program for weighted least squares (WLS) linear state estimation and non-linear state estimation
10. Develop program for DC load flow weighted least squares (WLS) sequential state estimation
11. Measurement of sequence reactance of three phase alternator and three phase transformer
12. Measurement of parameters of three phase alternator
13. Active and Reactive Power Control of Alternator
14. Determination of Transmission line parameters, SIL, Regulation, Efficiency and Voltage control of Transmission Line Training System

Out of the above a minimum of nine experiments are to be conducted. In addition to the above, the Department can offer a few newly developed experiments

Internal Continuous Assessment: 100 marks

1. Practical Records / Results summing to a total of 40 Marks
2. Regular Class Viva-Voce summing to a total of 20 Marks
3. Final Test (Internal) having 40 Marks

SEMESTER – II

Syllabus and Course Plan

Course No.	Course Name	L-T-P	Credits	Year of Introduction
10EE6402	Digital Protection of Power System	3-1-0	4	2018

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 over voltages-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", Tata Mc Graw Hill, 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
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 behaviour	5	
II	Static relays- Solid state devices used in static protection -– Amplitude comparator and phase comparator classification-basic	8	15

	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		
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 over voltages-lightning phenomena-over voltages due to lightning-protection of transmission lines against direct lightning strokes-protection of substations	5	20
	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
10EE6404	**Computer Aided Power System Analysis**	**3-0-0**	**3**	**2018**

Course Objectives

1. To introduce computer applications in analysis of power system
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 Publishers.
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 ZBUS 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 single and multiple contingencies	4	20
	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
10EE6306	Power System Operation and Control	3-0-0	3	2018

Course Prerequisites

Optimization Techniques and Power System Analysis

Course Objectives

To understand the economics of power system operation with thermal and hydro units

To realize the requirements and methods of real and reactive power control in power system

Syllabus

Economic operation- optimal load flow- Hydro thermal coordination- unit commitment - Automatic Generation Control - AGC with optimal dispatch- Reactive Power and Voltage Control - Static and dynamic response stability compensators

Expected Outcomes

Upon completion of this course , students will be able to

- Develop generation dispatching schemes for thermal and hydro units
- Apply control and compensations schemes on a power system

Text books

1.Allen J. Wood and Bruce Wollenberg, Power Generation Operation and Control, 2nd edition, John Wiley&Sons,Inc.,

2. P Kundur, Power system Stability and Control, McGraw-Hill, Inc.,1994.

3. PSR Murthy, Operation and Control of Electric Power systems, BS publications, Hyderabad, 2005.

4. Hadi Saadat, Power System Analysis , Tata McGra-Hill, Edition, 2002.

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	Economic operation: The economic dispatch problem-Thermal system dispatching with network losses considered-Loss Formula calculations. Optimal Load Flow**:** Problem statement and formulation. Solution of OPF, Gradient method-Newton's method and LP method.	8	15
II	Hydro thermal coordination**:** Hydroelectric Plant Models-Scheduling Problems-short term hydro thermal scheduling problem-gradient approach-Pumped storage hydro plants- Hydro scheduling using linear programming.	6	15
	First Internal Examination		
III	Unit Commitment: Constraints in unit commitment-Unit commitment solution methods-Priority list methods-DP approach.	8	15
IV	Automatic Generation Control: Basic generator control loops -Models for generator, Load, Prime movers ,Governor-Block diagram models for single area and Two area system-Tie line bias control .AGC with optimal	6	15

	dispatch-Introductory modern control application -Pole placement design and optimal control design.		
Second Internal Examination			
V	Reactive Power and Voltage Control: Impedance and reactive power-System voltage and reactive power-Reactive power generation by synchronous machines-Effect of excitation control-Voltage regulation and power transfer-Exciter and voltage regulator-Block schematics of excitation control AVR for alternator	8	20
VI	Static and dynamic response stability compensators-Stability compensation power system stabiliser(PSS)-Methods of system voltage control-Tap changing transformer-Shunt reactors-Shunt capacitors-Series capacitors-Synchronous condensers-Static VAR Systems-FACTS devices(introduction only)	6	20
		42	100
End Semester Examination			

Elective II

Course No.	Course Name	L-T-P	Credits	Year of Introduction
10EE6414	**Static VAR Controllers and Harmonic Filtering**	**3-0-0**	**3**	**2018**

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

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. Hadi Saadat, “Power System Analysis”, McGraw-Hill Publishers.
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**
1	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 ZBUS 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 single and multiple contingencies	4	20
	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
10EE6416	Sustainable And Translational Engineering	3-0-0	3	2018

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 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

Upon successful completion of this course 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. Mackenthun, K.M., Basic Concepts in Environmental Management, Lewis Publication, London, 1998.
4. S.S Purohit ,Green Technology-An approach for sustainable environment, Agrobios publication, India, 2008.
5. 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
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		
	Global environmental issues: - desertification – greenhouse		15

III	gases-greenhouse effect, ozone layer depletion- global warming – acid rain – deforestation.	7	
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
10EE6116	**Power Conversion in Renewable Energy Systems**	**3 – 0 – 0**	**3**	**2018**

Course Prerequisites

Basic knowledge in Electrical power systems and Power electronics at UG level.

Course Objectives

1. To give an idea about the renewable energy sources and the application of power electronic devices and converters in renewable energy systems.

Syllabus

solar photo voltaic systems, bioenergy, wind energy, fuel cells, ocean energy, MHD, Geothermal and Small hydro systems.

Expected Outcomes

Students who complete this course will have an ability to understand the fundamental concepts of generating electrical energy from renewable energy systems.

References:

1. D P Kothari and Nagrath, “Modern Power System Analysis”, Mcgraw Hill, , Chapter 1,2011.
2. Thomas Ackerman, “Wind power in power systems”, John Wiley& Sons, Chapter 4, London, 2005..
3. M G Simoes and F A Farret, “Alternate energy systems,” CRC Press, Chapter7, London, 2008.
4. Domkundvar , “Solar Energy Resources” ,Dhanpatrai& Sons , New Delhi.
5. J P Lyons and V Vlatkovic, “power electronics and alternative energy generation”, in proc IEEE power electronics specialist conference, vol.1, no 1, pp.16-21, Aachen 2004.
6. P F Rebeiro, B K Jhonson, M L Crow, A Arsoy and Y Liu, “Energy Storage systems for advanced power application”, in proc IEEE conf. vol.89, no 12, Dec. 2001.

Course plan			
Module	**Content**	**Hours**	**Semester Exam Marks (%)**
I	**Introduction** of renewable energy sources and potential- **Solar energy** needs and its utilization-Solar thermo mechanical systems-direct conversion to electricity- grid interactive PV systems-Isolated PV systems- requirement for maximum power tracking (MPPT) - dc to dc converter topologies for MPPT- control algorithms for MPPT	8	15
II	Introduction to biomass -Resource potential –technology and applications - Biomass gasifiers.-–Electrical energy conversion methods–biomass conversion process. Biogas plants- Technology and status- Biogas generation-types of biogas plant-community biogas plants.	6	15
First Internal Examination			
III	**Wind energy** – Resonance potential –Vertical axis and horizontal axis wind turbines –Gilberts limit- Power coefficient – wind farms –Power plants –Generators for WECS- Induction Generators- Solid state converters and control	8	15
IV	**Fuel cells:** Introduction – working –efficiency – classification –performance characteristics – dc- dc converters and control	6	15
Second Internal Examination			
V	**Geothermal Energy-** Resources of Geothermal –vapour dominant system-liquid dominant binary cycle. Total flow of geothermal power unit**-** energy conversion systems. **MHD**: Principle –simplified analysis of MHD- factors affecting the efficiency of MHD-types-present status of MHD generation.	8	20
VI	**Ocean energy conversion: OTEC** –Principle –cycle, operation of OTEC systems .Location of plants –types – technology and applications- Tidal and wave energy. **Small hydropower generation**-turbines and generators- grid tied systems- stand alone systems- induction generators-Electronic load controllers.	6	20
	TOTAL	42	100
End Semester Examination			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
10EE6124	High Voltage DC and AC Transmission	3-0-0	3	2018

Prerequisite:

Fundamental Knowledge about the power flow in transmission line.

Course Objectives

To understand the concept, planning of DC power transmission and comparison with AC Power transmission
To analyze HVDC converters
To study about compounding and regulation
To analyze harmonics and design of filters
To learn about HVDC cables and simulation tools

Syllabus

INTRODUCTION - Introduction of DC Power transmission technology –Description of DC transmission system – Planning for HVDC transmission –Analysis of HVDC Converters– Choice of converter configuration –Converter bridge characteristics – Detailed analysis of converters. Compounding and Regulations - General –Inverter compounding – Transmission characteristics with the rectifier and inverter compounding – Communication link – Transformer tap changing. Harmonics and filters and Simulation – Generation of harmonics – Design of AC filters and DC filters –Introduction to system simulation – Modeling of HVDC systems for digital dynamic simulation.

Course Outcome

After successful completion of this course the students able to understand principals and technology of DC transmission, know about HVDC converter and control of power flow, model HVDC lines and converters & the effects of harmonic in DC lines

References

1. Padiyar, K. R., "*HVDC Power Transmission System*", Wiley Eastern Limited, New Delhi 1990, First edition.
2. Edward Wilson Kimbark, "*Direct Current Transmission*", Vol. I, Wiley Interscience, New York, London, Sydney, 1971.
3. Colin Adamson and Hingorani N G, "*High Voltage Direct Current Power Transmission*",Garraway Limited, London, 1960.
4. Arrillaga, J., "*High Voltage Direct Current Transmission*", Peter Pregrinus, London, 1983.
5. Rakosh Das Begamudre, "*Extra High Voltage AC Transmission Engineering*", New Age International (P) Ltd., New Delhi, 1990.

COURSE PLAN

Module	Contents	Hours	Sem. Exam Marks (%)
I	INTRODUCTION - Introduction of DC Power transmission technology – Comparison of AC and DC transmission – Application of DC transmission – Description of DC transmission system	6	15
II	Planning for HVDC transmission – Modern trends in DC transmission. ANALYSIS OF HVDC	6	15

	CONVERTERS - Pulse number – Choice of converter configuration		
FIRST INTERNAL EXAM			
III	Simplified analysis of Graetz circuit – Converter bridge characteristics – Characteristics of a twelve pulse converter – Detailed analysis of converters.	6	15
IV	COMPOUNDING AND REGULATIONS - General – Required regulation – Inverter compounding – Uncompounded inverter – Rectifier compounding – Transmission characteristics with the rectifier and inverter compounding –	6	15
SECOND INTERNAL EXAM			
V	Communication link – Current regulation from the inverter side – Transformer tap changing. HARMONICS AND FILTERS and SIMULATION - Introduction – Generation of harmonics – Design of AC filters and DC filters	6	20
VI	Interference with neighbouring communication lines. Introduction to system simulation – Philosophy and tools – HVDC system simulation – Modeling of HVDC systems for digital dynamic simulation.	6	20
End Semester Examination			

Elective III

Course No.	Course Name	L-T-P	Credits	Year of Introduction
10EE6422	**Smart Grid Technologies and Applications**	**3-0-0**	**3**	**2018**

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

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

COURSE PLAN

Module	Contents	Hours Allotted	% of Marks in End -semester
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		
	Load Frequency Control (LFC) in Micro Grid System – Voltage	4	

V	Control in Micro Grid System		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
10EE6424	**Power System Stability and Reliability**	**3-0-0**	**3**	**2018**

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

Upon completion of this course, students will be able to

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

1. Singh C., Billinton R. 'System Reliability Modelling and Evaluation',Hutchinston.

COURSE PLAN

Module	Contents	Hours Allotted	% of Marks in End -semester
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	6	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.	7	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
10EE6126	Energy Management	3 - 0 - 0	3	2018

Course Prerequisites

Basic knowledge of Electrical & Mechanical Engineering at UG Level.

Course Objectives

The course is designed to provide students knowledge and ability to understand the principles of energy management and apply this to practical systems.

Syllabus

Importance of energy management. Energy auditing-Electric motors- Variable speed drives; Pumps and Fans-Reactive Power management-Lighting- Compressed Air Systems, Refrigeration & air conditioning systems-Boiler -Cogeneration- Electric water heating-Solar Water Heaters- solar PV systems.

Expected Outcomes

The students are expected to apply the general principles of energy management to industrial systems.

Text books

1. Guide Book for National Certification Examination for Energy Managers & Energy Auditors – Bureau of Energy Efficiency, Ministry of Power, Govt of India.
2. Handbook on Energy Audit and Environment Management , Y P Abbi and Shashank Jain, TERI, 2006
3. Utilization, Generation & Conservation of Electrical Energy, Sunil S.Rao, Khanna publishers, 2007.
4. Anthony J. Pansini, Kenneth D. Smalling, .Guide to Electric Load Management., Pennwell Pub; (1998)
5. Partab H., 'Art and Science of Utilisation of Electrical Energy', Dhanpat Rai and Sons, New Delhi. 1975
6. Tripathy S.C.,'Electric Energy Utilization And Conservation', Tata McGraw Hill, 1991
7. L.C.Witte, P.S.Schmidt, D.R.Brown , Industrial Energy Management and Utilisation, Hemisphere Publ, Washington,1988.

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	Importance of energy management. Energy auditing: methodology System approach and End use approach to efficient use of Electricity; Electricity tariff types; Types and objectives-audit instruments-specific energy analysis-Minimum energy paths-consumption models-Case study. Demand side management.	8	15
II	Electric motors- Energy efficient controls and starting -Motor Efficiency and Load Analysis-Energy efficient motors-Case study; Load Matching and selection of motors-Variable speed drives.	6	15
	First Internal Examination		
III	Reactive Power management-Capacitor Sizing-	8	15

	Degree of Compensation-Capacitor losses-Location-Placement-Maintenance, case study. Peak Demand controls- Methodologies- Types of Industrial loads-Optimal Load scheduling-case study.		
IV	ECO assessment and Economic methods- Simple payback period- time value of money-Net Present value- Internal rate of return- Lighting- Energy efficient light sources-Energy conservation in Lighting Schemes- Electronic ballast-Power quality issues-Luminaries, case study	6	15
Second Internal Examination			
V	Energy conservation in **Pumps**- Optimal selection and sizing -Case study- Fans (flow control), Refrigeration & air conditioning systems. **Boiler** -efficiency testing, excess air control, Steam distribution & use- steam traps, condensate recovery, flash steam utilization **Cogeneration**-Types and Schemes-Optimal operation of cogeneration plants-case study;	8	20
VI	Power Consumption in Compressors, Energy conservation measures. **water heating**-Gysers-Solar Water Heaters- solar PV systems.	6	20
		42	100
End Semester Examination			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
10EE6132	**Distributed Generation and Micro Grid**	**3-0-0**	**3**	**2018**

Course Prerequisites

Basic knowledge in Electrical power systems and Power electronics at UG level.

Course Objectives

2. To give an idea about the renewable energy sources and the integration with grid.

Syllabus

Need for Distributed generation, Grid integration of DGs –Energy storage elements-Technical impacts of DGs –Impact of DGs upon transient and dynamic stability of existing distribution systems.

Economic and control aspects of DGs –Power quality issues-Reliability of DG based systems – Steady-state and Dynamic analysis-Introduction to micro-grids – Micro grids with power electronic interfacing units.

Expected Outcomes

Students who complete this course will have an ability to understand the fundamental concepts of generating electrical energy from renewable energy systems and connecting with electrical grid.

References:

1. H. Lee Willis, Walter G. Scott ,'Distributed Power Generation – Planning and Evaluation', Marcel Decker Press, 2000.
2. M.GodoySimoes, Felix A.Farret, 'Renewable Energy Systems – Design and Analysis with Induction Generators', CRC press.
3. Robert Lasseter, Paolo Piagi, ' Micro-grid: A Conceptual Solution', PESC 2004, June 2004.
4. F. Katiraei, M.R. Iravani, 'Transients of a Micro-Grid System with Multiple Distributed Energy Resources', International Conference on Power Systems Transients (IPST'05) in Montreal, Canada on June 19-23, 2005.

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	Need for Distributed generation, renewable sources in distributed generation, current scenario in Distributed Generation, Planning of DGs – Siting and sizing of DGs – optimal placement of DG sources in distribution systems.	8	15
II	Grid integration of DGs – Different types of interfaces - Inverter based DGs and rotating machine based interfaces - Aggregation of multiple DG units. Energy storage elements: Batteries, ultra-capacitors, flywheels	6	15
	First Internal Examination		
III	Technical impacts of DGs – Transmission systems, Distribution systems, De-regulation –Impact of DGs upon protective relaying – Impact of DGs upon transient and dynamic stability of existing distribution systems.	8	15
IV	Economic and control aspects of DGs –Market facts, issues and challenges - Limitations of DGs. Voltage control techniques, Reactive power control, Harmonics, Power quality issues. Reliability of DG based systems – Steady-state and Dynamic analysis	6	15
	Second Internal Examination		
V	Introduction to micro-grids – Types of micro-grids – autonomous and non-autonomous grids – Sizing of micro-grids- modeling& analysis- Micro-grids with multiple DGs.	8	20
VI	Micro grids with power electronic interfacing units. Transients in micro-grids - Protection of micro-grids – Case studies.	6	20
	TOTAL	42	100
	End Semester Examination		

Course No.	Course Name	L-T-P	Credits	Year of Introduction
10EE6408	Mini Project	0-0-4	2	2018

Course Prerequisites

(1) The habit of reading technical magazines, conference proceedings and journals;
(2) Skills in hardware/software implementation techniques earned through UG studies;
(3) The course Seminar-1 in the first semester..

Course Objectives

(1) To support the problem based learning approach and to enhance the reading habit among students;
(2) To enhance the skills regarding the implementation aspects of small hardware/software projects..

Guidelines

Each student has to do a mini project related to the branch of specialization under the guidance of a faculty member. It has to be approved by a committee constituted by the institute concerned. It is recommended that the same faculty member may serve as his/her Project Supervisor during 3rd& 4th semesters. The mini project is conceptualized in such a way that, some the outcomes of the work can be utilized in the selection of the thesis. Hence on completion of mini project the student can suggest possible list of their thesis topic in the second semester itself. The implementation of the mini project can be software and/or hardware based one. Mini project is envisaged as a way for implementing *problem based learning*. Problems of socially relevance and/or problems identified by the institute/ research organizations/ industry/ state should be given high priority. In such interdisciplinary and inter institutional projects, a student can have coguide(s) from other department/ institute/ research organizations/ industry. The university encourages *interdisciplinary projects* and *problem based learning strategy*. The references cited for the mini project shall be *authentic*.

Expected Outcomes

The students are expected to :

- Develop skills regarding enumerating and selecting hot research problems
- Develop skills for subsequent design and analysis
- Implement the hardware/software building blocks of the system
- Be motivated and successful in the selection of the topic for the main project
- Communicate in an effective way and to write technical reports
- Apply various tools for the analysis of the results and performance of the work.

References

1. J.W. Bames, *Statistical Analysis for Engineers and Scientists*, McGraw Hill, New York.
2. Schank Fr., *Theories of Engineering Experiments*, Tata McGraw Hill Publication.
3. Douglas C Montgomery, *Design and analysis of experiments,* Wiley International
4. Leedy P D, *Practical Research : Planning and Design,* 4th Edition, N W MacMillan Publishing Co

Course plan

Item	Description	Time
1	Abstract Submission	2 Weeks
2	Allotment of Topic	1 Week
3	Preliminary Presentation Sessions	1 Week
4	Implementation Phase	9 Weeks
5	Final Presentation-cum Demonstration	1 Weeks

1. Preliminary Presentation evaluated by the Progress Evaluation Committee (PEC) : 20 Marks
2. Progress Evaluation (Guide and/or Co-guide): 30 Marks
3. Final Presentation-cum-demonstration evaluated by the PEC: 30 Marks
4. Report (Mandatory): 20 Marks

Course No.	Course Name	L-T-P	Credits	Year of Introduction
10EE6412	**Power System Lab II**	**0-0-2**	**1**	**2018**

Course Objectives

Ability to conduct advanced experiments in power systems

Syllabus

1. Transient stability Studies
2. Short circuit analysis- symmetrical faults
3. Short circuit analysis- unsymmetrical faults
4. Simulation of AVR and AGC with Tie line control
5. Voltage instability studies
6. Relay Coordination
7. Simulation of HVDC systems
8. Simulation of SVC, STATCOM
9. Simulation study on Power Line Series Compensator
10. Harmonic Analysis using any software
11. Power quality anzlysis of non-linear loads using power quality analyser
12. Measurement and testing of square wave and PWM Inverter
13. Experiment on solar PV fed dc-dc converter
14. Lab practice on LABVIEW software for power monitoring and control

Out of the above a minimum of nine experiments are to be conducted. The simulation may be conducted using MATLAB simulink/ MiPower/PSCAD/ETAP or any dedicated software.

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

Expected Outcome

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

Internal Continuous Assessment: 100 marks

1. Practical Records / Results summing to a total of 40 Marks
2. Regular Class Viva-Voce summing to a total of 20 Marks
3. Final Test (Internal) having 40 Marks

SEMESTER - III

Syllabus and Course Plan

Elective IV

Course No.	Course Name	L-T-P	Credits	Year of Introduction
10EE7405	Flexible AC Transmission Systems	3-0-0	3	2018

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 Angle Regulators (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

Upon successful completion of this course, students will be familiarized with the different control schemes for Static VAR Compensators to mitigate power quality problems in Power System

References

1. NG Hingorani and L Gyugyi, “Understanding FACTS”, IEEE Press, 2000
2. T J E Miller, "Reactive Power Control in Power Systems'', John Wiley, 1982
3. Ned Mohan et. al "Power Electronics”, John Wiley and Sons.

COURSE PLAN

Module	Contents	Hours Allotted	% of Marks in End -semester
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		
	The Static Var Compensator (SVC); TCR, FC-TCR and TSC-	3	15

III	TCR variants: circuits, characteristics		
	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
10EE7407	**Restructured Power System**	**3-0-0**	**3**	**2018**

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, Muwaffaq Alomoush, 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 various power systems.	3	15
	Fundamentals of Economics: Consumer behaviour, Supplier behaviour, Market equilibrium, Short and long run costs, Various costs of production.	3	
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 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 adequacy – FTR issuance process: FTR auction, FTR allocation – Treatment of revenue shortfall – Secondary trading of FTRs – Flow gate rights – FTR and market power - FTR and merchant transmission investment.	6	15
	SECOND INTERNAL EXAM		
	Ancillary service management- Introduction of ancillary services – Types of Ancillary services –Classification of Ancillary services – Load generation balancing related services	3	20

V	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
10EE7107	**Electric Vehicle Systems**	**3 - 0 – 0**	**3**	**2018**

Course Prerequisites

Basic knowledge of four stroke and two storke engines, Various type of motors used for traction purpose; DC series, Slip ring IM, Basics of Electrical Drives, Fuel Cell - UG Level.

Course Objectives

This course is designed to understand electric vehicles and to develop design skills for electric vehicles. This course will introduce general aspects of Electric Vehicles (HEV), including architectures, modeling, sizing, vehicle control. It will cover vehicle dynamics, energy storage sources, electric propulsion systems, power electronics design, and EV drives.

Syllabus

Fundamentals of Vehicle Propulsion and Brake: - Vehicle Resistance - Dynamic Equation - Tire–Ground Adhesion and Maximum Tractive Effort - Power Train Tractive Effort and Vehicle Speed - Vehicle Power Plant and Transmission Characteristics - Vehicle Performance

Internal Combustion Engines – 4 stroke spark ignited and compression ignited engines – 2 stroke engines – Wankel rotary engines – strirling engines – gas turbine engines – quasi isothermal brayton cycle engines

Electric vehicles: configuration – performance – tractive effort in normal driving – energy consumption

Hybrid electric vehicles: series and parallel electric drive trains

Electric propulsion systems: DC motor drives – Induction motor drives – permanent

magnet BLDC motor drives – SRM drives – SRM design
Parallel (Mechanically Coupled) Hybrid Electric Drive Train Design - Design and Control Methodology of Series–Parallel (Torque and Speed Coupling) Hybrid Drive Train - Statistics of Daily Driving Distance - Energy Management Strategy - Energy Consumed in Braking and Transmission - Regenerative Breaking - Control Strategy for Optimal Energy Recovery
Fuel Cells - Fuel Cell Hybrid Electric Drive Train Design - Power and Energy Design of Energy Storage

Expected Outcomes

1. Identify the various fundamentals in the traction design problems
2. Understand the various factors that influence the vehicle tractive power and performance.
3. Able to design hybrid electric vehicle system depending on the power requirement, input available, energy management requirement, alternate fuel system etc.
4. Propose various electric driving motors and Power electronics drives systems for electrical vehicle.

Text books

1. Modern Electric Vehicles, Hybrid Electric and Fuel Cell Vehicles – 2nd Edition – Meherdad Ehsani, Yimin Gao, Ali Emadi – CRC Press
2. Electric Vehicle Technology Explained – James Larminie, John Lowry – John Wiley & Sons
3. Batteries for Electric Vehicles (Electronic & Electrical Engineering Research Studies Power Sources Technology) - D Rand - Wiley-Blackwell (21 January 1998)
4. Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design, Second Edition (Power Electronics and Applications Series) - Mehrdad Ehsani, Yimin Gao, Ali Emadi, Standardsmedia (2009)

References

1. Propulsion System for Hybrid Vehicle" 2nd Edition" by John M. Miller
2. History of Electric Vehicles Bellis

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	Fundamentals of Vehicle Propulsion and Brake: - Vehicle Resistance - Dynamic Equation - Tire–Ground Adhesion and Maximum Tractive Effort - Power Train Tractive Effort and Vehicle Speed - Vehicle Power Plant and Transmission Characteristics - Vehicle Performance.	6	15
II	Internal Combustion Engines – 4 stroke spark ignited and compression ignited engines – 2 stroke engines – Wankel rotary engines – strirling engines – gas turbine engines – quasi isothermal brayton cycle engines Electric vehicles: configuration – performance – tractive effort in normal driving – energy consumption Hybrid electric vehicles: series and parallel electric drive trains	8	15

First Internal Examination			
III	Electric propulsion systems: DC motor drives – Induction motor drives – permanent magnet BLDC motor drives – SRM drives – SRM design	6	15
IV	Parallel (Mechanically Coupled) Hybrid Electric Drive Train Design - Design and Control Methodology of Series–Parallel (Torque and Speed Coupling) Hybrid Drive Train - Statistics of Daily Driving Distance	8	15
Second Internal Examination			
V	Energy Management Strategy - Energy Consumed in Braking and Transmission - Regenerative Breaking - Control Strategy for Optimal Energy Recovery Fuel Cells -	8	20
VI	Fuel Cell Hybrid Electric Drive Train Design - Power and Energy Design of Energy Storag	6	20
Total		42	100
	Assignments	2 to 4	
	Group task design – (6 to 8 Students per group)	1	
End Semester Examination			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
10EE7117	**Soft Computing Technique**	**3 - 0 - 0**	**3**	**2018**

Course Prerequisites

Basic knowledge of Engineering at UG Level.

Course Objectives

1. Learn the various soft computing techniques
2. Be familiar with design of various neural networks.
3. Learn genetic programming.
4. Be exposed to hybrid systems.

Syllabus

Fuzzy Set Theory, Regression and Optimization, Neural Networks, Neuro-Fuzzy Modeling, Advanced Neuro-Fuzzy Modeling, Neuro-Fuzzy Control, Advanced Applications.

Expected Outcomes

The students are expected to apply the soft computing techniques in Electrical Engineering control applications.

References

1) S.Rajasekaran and G.A.Vijayalakshmi Pai, "Neural Networks, Fuzzy Logic and Genetic Algorithm: Synthesis & Applications", Prentice-Hall of India Pvt. Ltd., 2006.

2) George J. Klir, Ute St. Clair, Bo Yuan, “Fuzzy Set Theory: Foundations and Applications” Prentice Hall, 1997.
3) David E. Goldberg, “Genetic Algorithm in Search Optimization and Machine Learning” Pearson Education India, 2013.
4) James A. Freeman, David M. Skapura, “Neural Networks Algorithms, Applications, and Programming Techniques, Pearson Education India, 1991.
5) Simon Haykin, “Neural Networks Comprehensive Foundation” Second Edition, Pearson Education, 2009
6) J.S.R.Jang, C.T. Sun and E.Mizutani, “Neuro-Fuzzy and Soft Computing”, PHI / Pearson Education 2004.
7) S.N.Sivanandam and S.N.Deepa, "Principles of Soft Computing", Wiley India Pvt Ltd, 2011.

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	Introduction to Neuro-Fuzzy and Soft Computing, Fuzzy Set Theory, Fuzzy Sets Fuzzy Rules and Fuzzy Reasoning, Fuzzy Inference Systems.	8	15
II	Regression And Optimization, Least-Squares Methods for System Identification, Derivative-Based Optimization, Derivative-Free Optimization.	6	15
First Internal Examination			
III	Neural networks, Adaptive Networ, Supervised Learning Neural Networks, Learning from Reinforcement, Unsupervised Learning and Other Neural Networks.	8	15
IV	Neuro-fuzzy modeling, ANFIS: Adaptive-Networks-based Fuzzy Inference System, Coactive Neuro-Fuzzy Modeling: Towards Generalized ANFIS.	6	15
Second Internal Examination			
V	Advanced Neuro-fuzzy modeling, Classification and Regression Trees, Data Clustering Algorithms, Rule base Structure Identification, Neuro-Fuzzy Control, Neuro-Fuzzy Control.	8	20
VI	Advanced applications, ANFIS Applications, Fuzzy-Filtered Neural Networks, Fuzzy Theory and Genetic Algorithms in Game Playing, Soft Computing for Color Recipe Prediction.	6	20
		42	100
End Semester Examination			

Elective V

Course No.	Course Name	L-T-P	Credits	Year of Introduction
10EE7411	**Transient Analysis in Power System**	**3-0-0**	**3**	2018

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
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 mid span-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			
	Abnormal switching transients - current suppression - capacitance switching - arcing ground - transformer inrush		15

III	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	
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 neutralizers	4	20
	protection of lines andstations 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
10EE7413	**SCADA System and Applications**	**3-0-0**	**3**	**2018**

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.

References

1. Stuart A Boyer. SCADA-Supervisory Control and Data Acquisition', Instrument Society of America Publications. USA. 1999.
2. Gordan Clarke, Deon RzynAzvs, Practical Modern SCADA Protocols: DNP3, 60870J 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
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 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 fibre 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	7	20
	End Semester Exam		

Course No.	Course Name	L-T-P	Credits	Year of Introduction
10EE7415	Biomedical Instrumentation	3-0-0	3	2018

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 equipment 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
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	Electrode theory, Different types of electrodes, reference electrodes, hydrogen, calomel, Ag-AgCl, pH electrode, selection criteria of electrodes.	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. Electro encephalogram 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
10EE7111	**Custom Power Devices**	**3 - 0 - 0**	**3**	**2018**

Course Prerequisites

Basic knowledge of Electrical power systems and power electronics at UG Level.

Course Objectives

The course is designed to provide students a strong background in the design and development of custom power devices for power quality improvement

Syllabus

Power quality –Power electronic application in Transmission systems and distribution systems-Custom power devices-Network configuring and compensating devices- SSCL, SSB, SSTS, custom power park- DSTATCOM-compensator for single phase and three phase loads - DVR-Rectifier and capacitor supported-DVR structure-UPQC structure and control of left shunt and right shunt UPQC-Active filters-shunt, series, hybrid filters

Expected Outcomes

The students are expected to apply the general principles of power quality improvement using custom power devices.

References

1) L Ghosh and G Ledwich,"Power quality enhancement using custom power Devices," Kluwer Publications, London, 2003
2) K R Padiyar, "FACTS controllers in Power Transmission and Distribution," New Age publications, New Delhi, 2007
3) R Sastry Vedam,"Power quality VAR compensation in power systems," CRC press, NewYork,2009
4) H Akagi, New Trends in active filters for power conditioning, IEEE TIA, vol.32,no.6,pp1312-1322,1996.
5) B Singh, P Jayaprakash, R Somayajulu, D P Kothari, "Reduced Rating VSC With a Zig-Zag Transformer for Current Compensation in a Three-Phase Four-Wire Distribution System", IEEE Transactions on Power Delivery, Vol. 24, Jan. 2009.

Course plan

Module	Content	Hours	Semester Exam Marks (%)
I	Power quality –Power electronic application in Transmission systems and distribution systems-distributed generation- Power quality terms -transients, over voltage, under voltage, sag, swell, harmonics, flicker- PQ problems-poor power factor, unbalanced loads, disturbances in supply voltage.	8	15
II	Custom power devices-Network configuring and compensating devices- SSCL, SSB, SSTS, custom power park- Structure and control of power converters-open loop voltage control and closed loop voltage control- custom power park	6	15
	First Internal Examination		
III	DSTATCOM-compensator for single phase and three phase loads -generating reference current using instantaneous reactive power theory and SRF theory-reference signal generation-	8	15
IV	Neutral current compensation in three phase four wire systems- zig-zag transformers- active techniques- -three phase four wire DSTATCOM – Various structures-design and simulation methods- A case study	6	15
	Second Internal Examination		
V	DVR-Rectifier supported and capacitor supported-DVR structure – DVR control- reference signal generation-design and simulation methods- A case study	8	20
VI	UPQC structure and control of left shunt and right shunt UPQC-Active filters-shunt, series, hybrid filters-Uninterrupted Power supplies- Constant Voltage Transformers	6	20
		42	100
	End Semester Examination		

Course No.	Course Name	L-T-P	Credits	Year of Introduction
10EE7401	Seminar II	0-0-2	2	2018

Course Prerequisites

(1) The habit of reading technical magazines, conference proceedings, journals etc.;
(2) Knowledge in technical writing and communication skills earned through seminar at UG level and in first semester;
(3) The course Seminar-I in the first semester

Course Objectives

1) To enhance the reading ability required for identification of the thesis area and its literature review.
2) To develop skills regarding professional communication and technical report writing;
3) To establish the fact that student is not a mere recipient of ideas, but a participant in discovery and inquiry.
4) To arrive at a conclusion for doing Project Phase I.
5) To learn how to prepare and publish technical papers.

Guidelines

Students have to present a second seminar in 3rd semester. It is highly recommended that seminar- 2 may report the literature survey being conducted as a requirement for doing the main project. Since the topic for the main project topic is to be finalized at the end of the second semester/ in the beginning of the 3rd semester, one can perform the literature search and present it as a seminar towards the middle of the semester. The Progress Evaluation Committee (PEC) formed in the second semester itself, may be the panel of evaluators for Seminar-II also. The presentation of seminar-II shall be of 20 minutes duration with another 5 minutes allocated for a discussion session. The committee shall evaluate the seminar based on the style of presentation, technical context, and coverage of the topic, adequacy of references, depth of knowledge and the overall quality. Moreover, each student has to submit a seminar report in the prescribed format given by the Institution. It is recommended that the report for seminar-II may be in the form of a technical paper which is suitable for publishing in Conferences / Journals as a review paper. This makes a
student learn how to publish a paper and consequently develops a publishing culture among the PG student community. The references cited in the report shall be *authentic*.

Expected Outcomes

At the end of the course students will be able to:
 Be motivated in reading which equip them in identification of thesis area and its literature review;
 Develop the capacity to observe intelligently and propose and defend opinions and ideas with tact and conviction;
 Develop skills regarding professional communication and oral presentation;
 Arrive at a conclusion for doing Project Phase 1;
 Develop skills for technical report writing
 Learn the methodology of publishing technical papers..

References

1. M. Ashraf Rizvi, *Effective Technical Communication*, Tata McGraw Hill, New Delhi, 2005
2. Day R A, *How to Write and Publish a Scientific Paper,* Cambridge University Press, 1989
3. Coley S M and Scheinberg C A, *Proposal Writing,* 1990, Newbury Sage Publications.

Course plan

Item	Description	Time
1	Abstract Submission	3 Weeks
2	Allotment of Topic and Scheduling Seminars	1 Week
3	Literature Review and Presentation Sessions	6 Weeks
4	Report Submission	3 Weeks
5	Publishing Grades	1 Week

1. Presentation (Verbal & Nonverbal Communication skills) : 20 Marks
2. Breadth of the literature review (Coverage : Content of the slides and speech) : 20 Marks
3. Depth of knowledge (Ability to answer questions) : 30 Marks
4. Seminar Report / Paper in the prescribed format given by the Institution : 30 marks

Course No.	Course Name	L-T-P	Credits	Year of Introduction
10EE7403	**Project (Phase 1)**	**0-0-12**	**6**	**2018**

Course Prerequisites

(1) The habit of reading technical magazines, conference proceedings and journals;
(2) Interest solving in socially relevant or research problems;
(3) Skills in hardware/software implementation techniques earned from UG studies and the mini project done in second semester;
(4) The courses Research Methodology, Mini Project, and Seminar-2 done in previous semesters.

Course Objectives

(1) To start experimentation based on the background knowledge acquired through the literature survey performed for seminar-II;
(2) To work on the topic, familiarize with the design and analysis tools required for the project work and plan the experimental platform, if any, required for project work;
(3) To develop the skill of identifying research problems/ socially relevant projects;
(4) To enhance the skills regarding the implementation aspects of hardware/ software projects.

Guidelines

Each student has to identify a topic related to the branch of specialization for his/her main project under the guidance of a faculty member and the related experimentations namely project – phase I, should be started in the 3rd semester. The project topic has to be approved by a committee constituted by the department. This committee, namely Progress Evaluation Committee (PEC), should study the feasibility of each project work before giving consent. It is recommended that students should execute the project work using the facilities of the institute itself. However, external projects can be taken up in the 4th semester, if that work solves a technical problem of the external firm. Prior sanction should be obtained from the Head of Institution before taking up external project work.

Project work is to be carried out in the 3rd and 4th semesters and also to be evaluated in both semesters. It is recommended that the same faculty member may serve as his/her Project Supervisor during 4th semester also. This project phase is conceptualized in such a way that, the outcomes of the work may be continued for the project - phase II. Hence on completion of this project phase, the student will make a presentation based on the work and suggest future plan for his project - phase II. The implementation of the project -

phase I can be software and/or hardware based one. This project phase is also envisaged as a way for implementing *problem based learning*. Problems of socially relevance and/or problems identified by the institute/ research organizations/ industry/ state should be given high priority. In such interdisciplinary and inter institutional projects, a student can have co-guide(s) from other department/ institute/ research organizations/ industry. The university encourages *interdisciplinary projects* and *problem based learning strategy.* The following guidelines also have to be followed.

1. The student will submit a detailed *project report* for project -phase I;
2. The student will present *at least* two seminars;
3. The *first one* in the beginning of the semester will highlight the topic, objectives and methodology;
4. A *progress seminar* can be conducted in the middle of the semester (optional);
5. The *third seminar* will be an end-semester presentation of the work they have completed till the end of the 3rd semester and the scope of the work which is to be accomplished in the 4^{th} semester, mentioning the expected results.

All such presentations are to be evaluated internally by the progress evaluation committee (PEC).

All the references cited in the report for project - phase I shall be *authentic*.

Expected Outcomes

The students are expected to :

(1) Develop the skill of identifying industrial/ research problems/ socially relevant projects;

(2) Develop skills regarding enumerating and selecting problems, subsequent analysis, and.effective implementation of the solution;

(3) Have hands on experience in design and analysis tools required for the project work;

(4) Plan the experimental platform, if any, required for project work, which will be helpful in actual real life project planning;

(5) Enhance the skills regarding the implementation aspects of hardware/ software projects;

(6) Acquire documentation and problem solving skills;

(7) Develop professionalism;

(8) Effectively communicate technical information by means of written and oral reports

References

1. J.W. Bames, *Statistical Analysis for Engineers and Scientists*, McGraw Hill, New York.
2. Schank Fr., *Theories of Engineering Experiments*, Tata McGraw Hill Publication.
3. Douglas C Montgomery, *Design and analysis of experiments,* Wiley International
4. Leedy P D, *Practical Research : Planning and Design,* 4th Edition, N W MacMillan Publishing Co.

Course plan

Item	Description	Time
1	Abstract Submission	2 Week
2	Allotment of Topic	1 Week
3	Preliminary Presentation Sessions	1 Week
4	Implementation Phase	9 Weeks
5	Final Presentation-cum Demonstration	1 Week

Marks: 50 for Project Progress Evaluation

1. Preliminary presentation, evaluated by the PEC: 15 Marks
2. Progress evaluation by the Project Supervisor/s: 20 Marks
3. End-semester presentation, evaluated by the PEC: 15 Marks

SEMESTER – IV

Syllabus and Course Plan

Course No.	Course Name	L-T-P	Credits	Year of Introduction
10EE7404	**Project (Phase I1)**	**0-0-22**	**12**	**2018**

Course Prerequisites

(1) The habit of reading technical magazines, conference proceedings and journals;
(2) Interest in solving socially relevant or research problems;
(3) Skills in hardware/ software implementation techniques earned from UG studies and mini project in the second semester;
(4) The courses Research Methodology, Seminar-II and Project - Phase I done in previous semesters.

Course Objectives

(1) To implement and complete the M. Tech. thesis work, which is normally based on Project - Phase 1;
(2) To have a continuous work on the topic, and get improved results;
(3) To develop the skill of achieving specific research target in a limited time;
(4) To develop skills regarding professional communication and technical report writing.

Guidelines

Each student has to complete the project - phase II under the guidance of a faculty member, as specified in phase-I, since this phase is generally an extension of the previous phase. It is recommended that students should execute the project work using the facilities of the institute itself. However, external projects can be taken up in this semester, if that work solves a technical problem of the external firm. Prior sanction should be obtained from the Head of Institution before taking up external project work. This project phase is also envisaged as a way for implementing *problem based learning*. Problems of socially relevance and/or problems identified by the institute/ research organizations/ industry/ state should be given high priority. In such interdisciplinary and inter institutional projects, a student can have co-guide(s) from other department/ institute/ research organizations/ industry. The university encourages *interdisciplinary projects* and *problem based learning strategy*. The following guidelines also have to be followed.

1. The student will submit a detailed report for project - phase II;
2. The student will present at least *three* seminars
3. The *first seminar* in the beginning of the semester will highlight the topic, objectives, methodology and the background knowledge and preliminary results carried over from the phase I;
4. A *progress seminar* can be conducted in the middle of the semester;
5. The *third seminar*, could be a *pre-submission seminar*, will be a presentation of the work they have completed till the end of 4th semester and the scope for future work. The presubmission seminar has to be presented before the Progress evaluation committee (PEC) for being assessed for the quality and quantum of the work. This would be the qualifying exercise for the students for getting approval from the Department Committee for the submission of the Thesis.

6. Incorporating the suggestions by the PEC, each student has to convert the project - phase II report to a Thesis and to submit to the University (Cluster) for external evaluation. At least one technical paper is to be published in Journals / Conferences so as to meet the requirements for final external submission.
7. The University will appoint an External Expert to evaluate the Thesis through a final presentation by the student.
The comments of the examiners during this presentation should be incorporated in the work and the approved Thesis is to be submitted to the Institution as hard bound copies, before the program exit by the student.
All the references cited in the Thesis shall be *authentic*.

Expected Outcomes

The students are expected to :
(1) Develop the skill of identifying industrial/ research problems/ socially relevant projects;
(2) Develop skills regarding enumerating and selecting problems, subsequent analysis, and effective implementation of the solution;
(3) Have hands on experience in design and analysis tools required for the project work ;
(4) Plan the experimental platform, if any, required for project work, which will be helpful in actual real life project planning;
(5) Enhance the skills regarding the implementation aspects of hardware/ software projects;
(6) Acquire documentation and problem solving skills;
(7) Develop professionalism;
(8) Effectively communicate technical information by means of written and oral reports.

References

1. J.W. Bames, *Statistical Analysis for Engineers and Scientists*, McGraw Hill, New York.
2. Schank Fr., *Theories of Engineering Experiments*, Tata McGraw Hill Publication.
3. Douglas C Montgomery, *Design and analysis of experiments,* Wiley International
4. Leedy P D, *Practical Research : Planning and Design,* 4th Edition, N W MacMillan Publishing Co

Course plan

Item	Description	Time
1	Implementation Phase	10 Weeks
2	Thesis Preparation	3 Weeks
3	Pre-submission seminar-cum Demonstration	1 Week
4	Evaluation by the External expert	4 Weeks

Marks: 100 for Final Evaluation
1. Preliminary presentation, evaluated by the PEC: 20 Marks
2. Project evaluation by the supervisor/s: 30 Marks
3. Pre-submission seminar evaluated by the PEC: 20 Marks
4. Evaluation of the thesis presentation by an External Expert: 30 Marks