KERALA TECHNOLOGICAL UNIVERSITY

Master of Technology

Curriculum, Syllabus and Course Plan

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

SEMESTER 1

Examination Slot	Course Number	Name	L-T-P	Internal Marks	End Semester Examination		Credits
					Marks	Duration (hours)	
A	01MA6021	Advanced Mathematics & Optimisation Techniques	3-0-0	40	60	3	3
B	01EE6101	Dynamics of Linear System	3-1-0	40	60	3	4
C	01EE6301	Modelling of Electrical Machines	3-1-0	40	60	3	4
D	01EE6303	Power Electronic Circuits	3-0-0	40	60	3	3
E	01EE6305	Operation and Control of Generators	3-0-0	40	60	3	3
S	01EE6999	Research Methodology	0-2-0	100			2
T	01EE6391	Seminar I	0-0-2	100			2
U	01EE6393	Power Electronics and Machines Lab	0-0-2	100			1
		TOTAL	**15-4-4**	**500**	**300**	**-**	**22**

TOTAL CONTACT HOURS : 23
TOTAL CREDITS : 22

SEMESTER 2

Examination Slot	Course Number	Name	L-T-P	Internal Marks	End Semester Examination		Credits
					Marks	Duration (hours)	
A	01EE6302	Electric Drives	3-1-0	40	60	3	4
B	01EE6304	Special Electrical Machines	3-0-0	40	60	3	3
C		Elective I	3-0-0	40	60	3	3
D		Elective II	3-0-0	40	60	3	3
E		Elective III	3-0-0	40	60	3	3
V	01EE6392	Mini Project	0-0-4	100			2
U	01EE6394	Electrical Drives Lab	0-0-2	100			1
		TOTAL	**15-1-6**	**400**	**300**	**-**	**19**

TOTAL CONTACT HOURS : 22
TOTAL CREDITS : 19

Elective I

01EE6312 Computer Aided Design of Electrical Machines

01EE6314 PWM Converters and Application

01EE6412 New and Renewable Sources of Energy

01EE6414 Distributed Generation

Elective II

01EE6316 Design of Power Electronic System

01EE6418 Flexible AC Transmission Systems

01EE6116 Sliding Mode Control

01EE6432 Sustainable and Translational Engineering

Elective III

01EE6318 Finite Element Methods for Electrical Machines

01EE6426 Smart Grid Technologies and Applications

01EE6126 Soft Computing Techniques

SEMESTER 3

Examination Slot	Course Number	Name	L-T-P	Internal Marks	End Semester Examination		Credits
					Marks	Duration (hours)	
A		Elective IV	3-0-0	40	60	3	3
B		Elective V	3-0-0	40	60	3	3
T	01EE7391	Seminar II	0-0-2	100			2
W	01EE7393	Project (Phase 1)	0-0-12	50			6
		TOTAL	**6-0-14**	**230**	**120**	**-**	**14**

TOTAL CONTACT HOURS : 20
TOTAL CREDITS : 14

Elective IV

01EE7311 Field Theory

01EE7313 Dynamics of Power Converters

01EE7411 EHVAC and DC Transmission

Elective V

01EE7315 Hybrid Electric Vehicles

01EE7421 SCADA System and Applications

01EE7121 Biomedical Instrumentation

SEMESTER 4

Examination Slot	Course Number	Name	L-T-P	Internal Marks	End Semester Examination		Credit
					Marks	Duration (hours)	
W	01EE7394	Project (Phase 2)	0-0-23	70	30		12
		TOTAL	**0-0-23**	**70**	**30**	**-**	**12**

TOTAL CONTACT HOURS : 23
TOTAL CREDITS : 12

TOTAL NUMBER OF CREDITS: 67

SEMESTER – I

Syllabus and Course Plan

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

Course Objectives

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

Syllabus

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

Expected Outcome

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

References

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

COURSE PLAN

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

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE6101	Dynamics of Linear Systems	**3-1-0**	**4**	**2015**

Course Objectives

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

Syllabus

Design of feedback control systems- Review of compensator design using Root locus and Bode plots- PID controllers , State Space Analysis and Design- Solution of Linear Time Varying Systems- Linear state variable feedback for SISO systems-formulae for feedback gain-Transfer function approach-controllable and uncontrollable modes - regulator problems,Asymptotic observers for state measurement-implementation of the observer-full order and reduced order observers- combined observer–controller-direct transfer function design procedures-MIMO systems: Introduction-controllability-observability- different companion forms for MIMO systems.

Expected Outcome

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

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

References

1. Thomas Kailath, Linear System, Prentice Hall Inc., Eaglewood Cliffs, NJ, 1998
2. M. Gopal, Control Systems-Principles and Design, Tata McGraw-Hill.
3. Richard C. Dorf& Robert H. Bishop, Modern Control Systems Pearson Education, Limited, 12th Ed., 2013
4. Gene K. Franklin & J. David Powell, Feedback Control of Dynamic Systems, Pearson Education, 5th Edition, 2008
5. Friedland B., Control System Design: An Introduction to State Space Methods, Courier Corporation, 2005

COURSE PLAN

Module	Contents	Hours Allotted	% of Marks in End-Semester Examination
I	Design of feedback control systems- Approaches to system design-compensators–performance measures- cascade compensation networks-phase lead and lag compensator design using both Root locus and Bode plots	7	15
II	PID controllers-effect of proportional, integral and derivative gains on system performance-PID tuning-integral windup and solutions	7	15
FIRST INTERNAL EXAM			
III	State Space Analysis and Design- Analysis of stabilization by pole cancellation- reachability and constructability - stabilizability - controllability - observability-grammians-Analysis of stabilization by output feedback-Transfer function approach - state feedback and zeros of the transfer function.Solution of Linear Time Varying Systems	10	15
IV	Linear state variable feedback for SISO systems, -modal controllability-formulae for feedback gain -significance of controllable Canonic form-Ackermann's formula feedback gains in terms of Eigen values - Mayne-Murdoch formula - non controllable realizations and stabilizability - controllable and uncontrollable modes - regulator problems .	12	15
SECOND INTERNAL EXAM			
V	Observers: Asymptotic observers for state measurement-open loop observer-closed loop observer-formulae for observer gain -implementation of the observer - full order and reduced order observers - separation principle - combined observer -controller – optimality criterion for choosing observer poles	10	20
VI	Direct transfer function design procedures – Design using polynomial equations - Direct analysis of the Diophantine equation. MIMO systems: Introduction, controllability, observability, different companion forms for MIMO systems	10	20
END SEMESTER EXAM			

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

Course Objectives

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

Syllabus

Unified approach to the analysis of electrical machine performance - per unit system - basic two pole model of rotating machines- Primitive machine - transformer and rotational voltages in the armature voltage and torque equations resistance, inductance and torque matrix-Transformations - passive linear transformation in machines- invariance of power -Park's transformation-DC Machines-Application of generalized theory to separately excited, shunt, series and compound machines-Steady state and transient analysis, transfer functions- Sudden short circuit of separately excited generator, sudden application of inertia load to separately excited dc motor-Synchronous Machines-synchronous machine reactance and time constants-Primitive machine model of synchronous machine with damper windings on both axes- Balanced steady state analysis-power angle curves-Transient analysis- sudden three phase short circuit at generator terminals – armature currents and torque - Transient power angle curve-Induction Machines- Primitive machine representation- Steady state operation-Equivalent circuit-Double cage rotor representation - Equivalent circuit -Single phase induction motor- Voltage and Torque equations.

Expected Outcome:

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

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

REFERENCES:

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

COURSE PLAN			
Module	**Course description**	**Hours**	**End semester exam % marks**
1	Unified approach to the analysis of electrical machine performance - per unit system - basic two pole model of rotating machines- Primitive machine -special properties assigned to rotor windings -transformer and rotational voltages in the armature voltage and torque equations resistance, inductance and torque matrix.	7	15%
2	Transformations - passive linear transformation in machines-invariance of power –transformation from a displaced brush axis-transformation from three phase to two phase and from rotating axes to stationary axes-Park's transformation-Physical concept- Restrictions of the Generalized theory of machines	7	15%
	First Internal Exam		
3	DC Machines: Application of generalized theory to separately excited, shunt, series and compound machines. Steady state and transient analysis, transfer functions. Sudden short circuit of separately excited generator, sudden application of inertia load to separately excited dc motor.	10	15%
4	Synchronous Machines: synchronous machine reactance and time constants-Primitive machine model of synchronous machine with damper windings on both axes. Balanced steady state analysis-power angle curves. Transient analysis- sudden three phase short circuit at generator terminals – armature currents and torque - Transient power angle curve	12	15%
	Second Internal Exam		
5	Induction Machines: Primitive machine representation-Transformation- Steady state operation-Equivalent circuit-Torque slip characteristics- Double cage rotor representation-Equivalent circuit	10	20%
6	Single phase induction motor- Revolving Field Theory-equivalent circuit- Voltage and Torque equations-Cross field theory-Comparison between single phase and poly phase induction motor	10	20%
	End Semester Exam		

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE6303	Power Electronic Circuits	3-0-0	3	2015

Course Objectives:

1. To develop a deep knowledge of Power Semiconductor Devices, Power Electronic Circuits and their applications.
2. To analyse AC/DC and DC/AC converters.
3. To analyse DC/DC converters.
4. To develop skills to use Power Electronic Circuits in energy conversion systems.

Syllabus

Power Electronic Elements – Switches, switching constraints, characteristics, losses, switch models. AC voltage controller – performance, sequential controller. DC/DC converter – Buck converter, boost converter, buck- boost converter, cuk converter, Volt-sec balance, ripples, discontinuous conduction mode. Isolated DC/DC converters- flyback, forward, push pull and bridge topology. Switched mode inverters – Topologies. Voltage source inverter- PWM operation, dwell time, current controlled voltage source inverter, current source inverter and analysis.

Expected Outcome:

Upon successful completion of this course, students will be able to analyse and design various types of Power Electronics Circuits. They will acquire skills to apply Power Electronic Circuits in Power Converters to improve the performance and efficiency.

REFERENCES

1. Ned Mohan, et al., Power Electronics: Converters, Design and Applications, Wiley
2. Joseph Vithayathil, “Power Electronics: Principles and Applications”, Tata McGraw Hill.
3. V. Ramanarayanan, “Course Notes on Switched Mode Power Converters”, Department of Electrical Engineering, Indian Institute of Science, Bangalore.
4. G. K. Dubey, et.al., “Thyristorised Power Controllers”, New Age International
5. Bin Wu, High Power Converters and AC Drives, IEEE Press, Wiley Interscience, 2006.

COURSE PLAN			
Module	**Contents**	**Hours**	**End semester exam % marks**
1	Power Electronic Elements: The ideal switch, Characteristics of ideal switches, two-quadrant and four-quadrant switches- Switching constraints in power electronic circuits-Practical switches: Static and dynamic characteristics of Power Diodes, MOSFETs, IGBTs and GTOs-implementations of different configurations of switches using semiconductor devices.	7	15%
2	Losses in practical switches: Models of diode, MOSFET and IGBTs for evaluating conduction and switching losses. AC voltage controllers: Analysis of single-phase ac voltage controller with R and RL load, Performance parameters, Sequential control of single-phase ac voltage controllers.	8	15%
	First Internal Exam		
3	DC-DC converters: Buck, boost, buck-boost and Ćuk Topologies-Steady state analysis in continuous conduction mode using inductor volt-sec balance - current and voltage ripples. Design relations for inductor and capacitors. Discontinuous Conduction Mode operation of basic buck and boost converter.	8	15%
4	Isolated DC-DC converters: Steady-state analysis of flyback, forward, push-pull and bridge topologies.	7	15%
	Second Internal Exam		
5	Switched Mode Inverters: Topologies of single-phase half-bridge, full-bridge and three-phase bridge Voltage Source Inverters-stepped wave and PWM operation- Sine-Triangle PWM-Selective Harmonic Elimination--Space Vector PWM-Evaluation of dwell times.	6	20%
6	Principles of Current-Controlled VSI- Hysteresis control and PWM current control. Current Source Inverters: Analysis of capacitor commutated single phase CSI feeding resistive and pure-inductor loads.	6	20%
	End Semester Exam		

Course No	Course Name	L-T-P	Credits	Year of Introduction
01EE6305	Operation and Control of Generators	3-0-0	3	2015

Course Objectives:

1. To understand the broad classification and construction of various electric generator topologies.
2. To equip with the operation and control of constant speed synchronous generator, variable speed induction generators and permanent magnet synchronous generators.

Syllabus

Electric generators-types, applications, review, Excitation systems-block diagram, components, classification, compensation of excitation systems, IEEE type, Control of active and reactive power-active power and frequency control, automatic generation control, reactive power and voltage control, Synchronous machine dynamics-stability, swing equation, Induction generators-operation at power grid, Self excited induction generators, Permanent magnet synchronous generators-field distribution, emf and torque, autonomous PMSG.

Expected Outcome:

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

Understand the operation and control of various electric generators so that, students are able to work with electric machine, power system and industrial people.

References:

1. P.S.Bhimbra, *'Generalized theory of electrical machines '*, Khanna Publishers, 2002
2. C. Concordia, *'Synchronous Machines'*
3. E W.Kimbark, *'Power System Stability Vol. II P'*
4. P. Kundur, *'Power system stability and control'*McGraw-Hill, 1994
5. W.D Stevenson, *'Elements of Power system analysis'*, 1995
6. A.E Fitzgerald and Kingsley. *'Electric Machinery'*, Fifth edition, McGraw-Hill, 1990.
7. HadiSaddat, *'Power System Analysis'*, McGraw-Hill, 2002.

COURSE PLAN			
Module	**Contents**	**Hours**	**End semester exam % marks**
1	Electric Generators, types of electric generators, generator applications Synchronous generators, review of basic principle of working, construction and different types. Excitation system-block diagram, classification-DC,AC and static systems, components-voltage regulator, power system stabilizer(PSS)	6	15%
2	Compensation of excitation systems-IEEE type excitation systems, instability problem of exciter, solution to the instability of exciter, need of the power system stabilizer(PSS) Co-ordinated AVR, PSS and speed governor control, FACTS added control of synchronous generators.	6	15%
	First Internal Exam		
3	Control of active power and reactive power Active power and frequency control-fundamentals of speed governing, control of generating unit power output, fundamentals of automatic generation control. Reactive power and voltage control-production and absorption of reactive power, methods of voltage control, shunt reactors, shunt capacitors, series capacitors, synchronous condensers, static var systems.	6	15%
4	Synchronous machine dynamics: basic dynamics of synchronous generators in transient situations, factors affecting transient stability, swing equation, models for stability studies, synchronous machine model including saliency, steady-state stability-small disturbances, transient stability-equal area criterion-application to sudden increase in power output.	6	15%
	Second Internal Exam		
5	Wound rotor induction generators-construction elements, steady state equations, equivalent circuit, phasor diagrams, operation at the power grid. Self excited induction generators: cage rotor induction machine principle, self excitation-a qualitative view, steady state performance of three phase SEIGs.	9	20%
6	Permanent magnet synchronous generator systems: practical configuration and their characterization- air-gap field distribution, emf and torque, stator core loss modelling, circuit model, autonomous PMSGs with controlled constant speed and AC load.	9	20%
	End Semester Exam		

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

Course Objectives

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

Syllabus

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

Approach

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

Expected Outcome

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

References

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

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

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE6391	Seminar I	0-0-2	2	2015

Course Objectives

To make students

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

Approach

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

Expected Outcome

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

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

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE6393	Power Electronics and Machines Lab	0-0-2	1	2015

Course Objectives

1. To develop the Power electronic circuits and gate drive circuits for various drive system
2. To design and develop various type of Converter circuits.
3. To deal with the steady state and transient analysis of rotating machines.
4. To study the computer simulation of electrical machines and drives.

Expected Outcome

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

1. To design and develop different type of converters and its gate control circuits.
2. To analyse the transient behaviour of machines.
3. To model machines and drives using MAT LAB

LIST OF EXPERIMENTS

Power Electronics:

1. Gate Drive circuits for SCR, MOSFET and IGBTs: Gate Drive ICs and discrete component based circuits.
2. Study of PWM ICs: TL 494/SG 3525: Design of PWM generation with TL 494 and SG 3535 Series ICs.
3. Buck Converter using MOSFETs, driven with SMPS control ICs.
4. Boost converter using MOSFETs, driven with SMPS control ICs.
5. Transformer and Inductor Design.
6. Inductance measurement using different methods.
7. Performance evaluation of Rectifiers and Controlled rectifiers.
8. Performance evaluation of Inverters: Stepped wave and PWM inverters.
9. Study of Sine-Triangle PWM: Analog and Digital Implementation.
10. Current Sensing using Hall Effect Sensors. Design and testing of LEM/equivalent make current sensor based sensing circuit.

Machines:

1. Modeling of dc machines using computer simulation packages.
2. Modeling of ac machines using computer simulation packages
3. Modeling of DC drive systems
4. Modeling of AC drive systems.
5. Determination of Sub Transient and Transient Reactance of Synchronous machine.
6. Performance testing of Induction Generator.

References:

1. Ned Mohan, *et. Al.*, “Power Electronics: Converters, Design and Applications,” Willey
2. V. Ramanarayanan, “Course Notes on Switched Mode Power Converters,” Department of Electrical Engineering, Indian Institute of Science, Bangalore
3. L. Umanand, “Power Electronics: Essentials and Applications,” Wiley, 2009
4. M.B. Patil*et. al.*, “Simulation of Power Electronic Circuits,” Naorsa Publications.
5 P. S. Bhimbra, ‘Generalized Theory of Electrical Machines’, Khanna Publishers, 2002

SEMESTER – II

Syllabus and Course Plan

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE6302	Electric Drives	3-1-0	4	2015

Course Objectives:

1. The improvement in converters and development of new drive control strategies such as field oriented (vector) control of AC drives, sliding mode control, energy saving strategies etc.
2. To provide an opportunity to bring about another revolution in drive technology and performance.

Syllabus

Drive system mechanics, DC drives, Transfer functions of controlled rectifiers and choppers, Four quadrant operation of dc drives, Induction Motor Drives, Slip-power recovery schemes, Space Vector Model of Induction motor, CSI fed induction motor drives, Synchronous motor Drives, Line Commutated Inverter fed Synchronous motor drives, CSI fed synchronous motor drives, Vector control of Permanent Magnet Brushless DC Motors

Expected Outcome:

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

1. Select a suitable drive for particular application.
2. Analyse the steady state operation and dynamic behaviour of DC and AC drive systems.
3. Design and implement basic algorithms for speed control for DC and AC motors in all four quadrants.
4. Use the concepts learned to further explores and do research in advanced topics in electric drives.

References:

1. Werner Leonhard, "Control of Electrical Drives,", 3rd Ed., Springer
2. R. Krishnan, "Electric Motor Drives: Modeling , Analysis and Control"
3. Bimal K. Bose, "Modern Power Electronics and AC Drives," Prentice Hall
4. Fitzgerald, Kingsley and Umans, "Electric Machinery," Tata McGrawhill
5. Joseph Vithayathil, "Power Electronics", McGrawhill
6. Bin Wu, "High Power Converters and AC Drives,"

COURSE PLAN			
Module	**Contents**	**Hours**	**End semester exam % marks**
1	Drive system mechanics – experimental determination of drive system inertia – Steady state characteristics of different types of motors and loads—Stability of drive systems . DC drives – Separately excited dc motor drives – dynamic behaviour in constant flux mode – Closed-loop control of separately excited dc motor drives – transfer functions of motor	8	15%
2	Transfer functions of controlled rectifiers and choppers ––two quadrant operation with controlled single-phase and three-phase converters – continuous and discontinuous current operation—Four quadrant operation of dc drives with Dual converter and four-quadrant bridge dc-dc converter – PWM control of four-quadrant dc-dc converter.	8	15%
	First Internal Exam		
3	Induction Motor Drives: Steady state equivalent circuit of 3-phase Induction motor-- Stator voltage control – constant v/f speed control with VSI -v/f control with slip compensation–Slip-power recovery schemes –sub synchronous and super synchronous speed operation (Static Kramer and Static Scherbius drives).	10	20%
4	Space Vector Model of Induction motor: Concept of Space Vectors – Basic transformations in reference frame theory- Field Orientation Principle- Direct and Indirect vector control. CSI fed induction motor drives – features of high-power medium voltage drives.	10	20%
	Second Internal Exam		
5	Synchronous motor Drives: VSI fed synchronous motor drives – v/f control and vector control—Line Commutated Inverter fed Synchronous motor drives—CSI fed synchronous motor drives	10	15%
6	Vector control of Permanent Magnet Brushless DC Motors. Speed Control of Trapezoidal EMF machines (Brushless DC motors)- Basic principles and Control schemes.	10	15%
	End Semester Exam		

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE6304	Special Electrical Machines	3-0-0	3	2015

Course Objectives

1. To introduce some of the special machines such as switched reluctance motor, brushless machines etc.
2. To study the construction and basic working principle of special machines.
3. To learn the various control and industrial applications of these machines.

Syllabus

Reluctance Motors: Principle of Operation-Conventional and special types of rotor construction analysis and equivalent circuit-applications; Switched Reluctance Motors-Principle of Operation-structure-Torque production-Torque/speed characteristics-Rotor position sensing methods-different types- comparison; Stepper Motors-construction-theory of operation-windings in stepper motor-torque equation- static and dynamic characteristics-different types-comparison-applications; Linear Motors-linear induction motor- linear synchronous motors- linear reluctance motor; Brushless Machines: Brushless DC motors-construction-principle of operation-motor characteristics- position sensing- drive circuits-power circuits-applications; Permanent Magnet Synchronous Machine: Construction-principle of operation-types- performance characteristics- advantages- applications.

Expected Outcome:

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

1. Understand the construction and principle of operation of certain special machines
2. Choose the appropriate machine suitable for different applications

REFERENCES:

1. Gene F. Franklin, J. David Powell, Michael Workman, “Digital Control of Dynamic Systems”, Pearson, Asia.
2. T. J. E. Miller, ‘Brushless PM and Reluctance Motor Drives’, C. Larendon Press, Oxford
3. Takashi Kenjo, ‘Stepping Motor and Microprocessor Control’, Oxford Science Publications.
4. Vienott & Martin, ‘Fractional & Sub-fractional hp Electric Motors’, McGraw-Hill International Edn.
5. Bimal K. Bose, ‘Modern Power Electronics & AC Drives’. Prentice Hall India Ltd.
6. Sake Yamamura, ‘Theory of Linear Induction motors’, University of Tokyo press.
7. Irving L. Kossow, ‘Electrical Machinery & Transformers ‘, Oxford Science Publications.
8. Theodore Wildi, Electric Machines, Drives & Power Systems, Prentice Hall India Ltd.
9. E. V. Armensky& G. B. Falk, ‘Fractional hp Electric Machines’, MIR Publishers.
10. Laithwaite, ‘Induction Machine for Special Purposes’.

COURSE PLAN			
Module	**Course description**	**Hours**	**End semester exam % marks**
1	Reluctance Motors: Principle of Operation-Conventional and special types of rotor construction analysis and equivalent circuit-phasor diagram-circular loci of current and voltage components maximum pf-power expression-pull-in characteristics-factors affecting pulling in-applications	6	15%
2	Switched Reluctance Motors: Principle of Operation-structure-inductance profile-Torque production- static and dynamic-Energy conversion loops-partition of energy and effects of saturation-control- Torque/speed characteristics-Rotor position sensing methods-different types- comparison	9	15%
	First Internal Exam		
3	Stepper Motors: construction-theory of operation-windings in stepper motor-monofilar and bifilar windings modes of excitation-torque equation- static and dynamic characteristics-no of teeth-steps per revolution and no of poles-single phase stepping motors- different types-comparison-applications.	9	15%
4	Linear Motors: linear induction motor-construction-different types- thrust equation of LIM-end effect -goodness factor-equivalent circuit of LIM – applications- linear synchronous motors- types and construction of LSM-thrust equation- applications- linear reluctance motor-construction, working and features of LRM.	6	15%
	Second Internal Exam		
5	Brushless Machines: Brushless DC motors-construction, types, torque generation, principle of operation, motor characteristics-torque equation, position sensing, drive circuits-power circuits variable speed operation, applications.	6	20%
6	Permanent Magnet Synchronous Machine: Construction-principle of operation-types-EMF equation of PMSM-torque equation- phasor diagram- circle diagram- performance characteristics- advantages- applications.	6	20%
	End Semester Exam		

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE6312	Computer Aided Design of Electrical Machines	3-0-0	3	2015

Course Objectives

1. To give an introduction to the analysis of time-varying and spatially dependant quantities of electric machines leading to better design.

2. To study MATLAB software for the analysis.

Syllabus

Computer aided design- different approaches- analysis and synthesis methods- Hybrid method-Feasible design-Design optimization- general procedure for optimization- mathematical formulation of the objective function- Different objective functions-Non-linear constrained optimization techniques for design of electrical equipment- Exterior penalty function techniques-Geometric programming- comparison-Torque produced in electric machines -Steady state performance of induction machines, synchronous machines and commutator machines-Effect of flux harmonics-single phase induction machines-Transient phenomena in electric machines-Transformer design-Design considerations-core section and yoke section design- multistep core design-computation of step dimension for optimum fill-Design of insulation and windings-Example case for computerized design.

Expected Outcome:

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

1.To design electrical machines in a better way

2. To perform analysis of electrical machines using MATLAB software.

REFERENCES:

1. P. S. Bhimbra, M Ramamoorthy, '*Computer aided Design of Electrical Equipments*', Affiliated East West Press
2. A. K Sawhney , '*A Course in Electrical Machine Design*'
3. S K Sen, '*Principles of Electrical Machine Design* '-.Oxford and 1BH Publishing Co.
4. Matlab Reference Manual

COURSE PLAN			
Module	**Course description**	**Hours**	**End semester exam % marks**
1	Computer aided design- different approaches- analysis and synthesis methods- Hybrid method-Feasible design	6	15%
2	Design optimization- general procedure for optimization- mathematical formulation of the objective function- Different objective functions.	9	15%
	First Internal Exam		
3	Non-linear constrained optimization techniques for design of electrical, equipments- Exterior penalty function techniques, Geometric programming- comparison. Representation of B.H curves, wire tables etc.	9	15%
4	Torque produced in electric machines - torque as a function of air gap quantities. Steady state performance of induction machines, synchronous machines and commutator machines. Effect of flux harmonics, single phase induction machines Transient phenomena in electric machines.	6	15%
	Second Internal Exam		
5	Transformer design- Design considerations, core section and yoke section design- Design of insulation and windings	6	20%
6	Multistep core design of transformers-computation of step dimension for optimum fill. Example case for computerized design.	6	20%
End Semester Examination			

Course No	Course Name	L-T-P	Credits	Year of Introduction
01EE6314	PWM Converters and Applications	3-0-0	3	2015

Course Objectives:

1. To learn about different switches and implementation of various switch scheme using available power semiconductor devices.
2. To learn about different topologies of rectifiers and inverters.
3. To study about the modulation methods in three phase inverters.
4. To learn about the space vector PWM
5. To study about the Synchronised and non-synchronised PWM-Multilevel Converters
6. To learn about different topologies of multilevel converters and their modulation techniques
7. To familiarize about the various application of PWM converters
8. To study about the current control in PWM inverters
9. To learn about the harmonic elimination in PWM current source inverters
10. To analyse and develop selective harmonic elimination strategies for converters.
11. To develop control strategies for PWM converters with applications to drives, active front-end rectifier and shunt active filters.
12. To provide an opportunity to implement space vector modulation for CSI.

Syllabus

Use of Single-Pole-Double-Throw Single-Pole-Multi-Throw switches to describe Converter Topologies: Implementation of various switch schemes using available power semiconductor devices. Topologies of Inverters and Rectifiers--relation between Pole voltages, Line voltages and Line-to-load neutral voltages in multi-phase two-level inverters- Basic modulation methods--duty ratio--sine-triangle modulation--implementation of unipolar and bipolar modulation--three-phase inverters- Space vector PWM - conventional sequence- 30 degree and 60 degree bus clamped PWM—relation between sine-triangle and space vector PWM--dc bus utilisation of SPWM and SVPWM. Synchronised and non-synchronised PWM-Multilevel Converters: Topologies. Neutral Point Clamped and Flying Capacitor Topologies. Cascaded Multilevel Inverters-Multilevel Converters Modulation - Conventional Space Vector Modulation for 3-level inverters. Applications of PWM converters-Active front end rectifier--vector control of front-end rectifier- Control of Shunt active filter - Current Control in inverters: Current controlled PWM VSI -Hysteresis Control - fixed band and variable band hysteresis. Selective Harmonic Elimination-Derivation of simultaneous transcendental equations for elimination of harmonics- PWM Current Source Inverters--Current Space Vectors- Space Vector Modulation of CSI-Application of CSI in high-power drives-Fundamental principles of Hybrid schemes with CSI and VSI

Expected Outcome:

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

1. Represent complex power converters using simple switch elements and analyse their steady state behaviour.
2. Create simulation models of advanced PWM converters including multilevel converters.
3. Design and implement modulation/control strategies such as sine-triangle PWM, Space

Vector PWM and hysteresis control.

4. Develop control strategies for PWM converters with applications to drives, active front-end rectifier and shunt active filters.
5. Analyse and develop selective harmonic elimination strategies for converters.
6. Implement space vector modulation for CSI.

Textbooks:

1. Joseph Vithayathil, "Power Electronics", McGrawhill
2. Bin Wu, "High Power Converters and AC Drives,"
3. Ned Mohan, *et. al.,* "Power Electronics: Converters, Design and Applications," Wiley
4. L. Umanand, "Power Electronics: Essentials and Applications," Wiley, 2009.
5. Werner Leonhard, "Control of Electrical Drives,", 3rd Ed., Springer
6. Bimal K. Bose, "Modern Power Electronics and AC Drives," Prentice Hall

References:

1. J.Holtz, "Pulsewidth modulation - a survey", IEEE Trans. IE, Vol. IE-39(5), 1992, pp.
2. J.Holtz, "Pulsewidth modulation for electronic power conversion", Proc. IEEE, Vol.82(8), 1994, pp. 1194-1214.
3. V.T.Ranganathan, "Space vector modulation - a status review", Sadhana, Vol. 22(6),1997, pp. 675-688.
4. L.M.Tolbert, F.Z.Peng and T.G.Habelter, "Multilevel inverters for large electric drives, IEEE Transactions on Industry Applications, Vol.35, No.1, pp. 36-44, Jan./Feb. 1999.
5. SangshinKwak, Hamid A. Toliyat, "A Hybrid Solution for Load-Commutated-Inverter-Fed Induction Motor Drives," IEEE Trans. on Industry Applications, vol. 41, no. 1, January/February 2005.
6. SangshinKwak, Hamid A. Toliyat, "A Hybrid Converter System for High-Performance Large Induction Motor Drives," IEEE Trans. on Energy Conversion, vol. 20, no. 3, September 2005.
7. SangshinKwak, Hamid A. Toliyat, "A Current Source Inverter With Advanced External Circuit and Control Method," IEEE Trans. on Industry Applications, vol. 42, no. 6, November/December 2006.
8. A.R. Beig, and V.T. Ranganathan, "A novel CSI-fed Induction Motor Drive," IEEE Trans. on Power Electronics, vol. 21, no. 4, July 2006.
9. H.Stemmler, "High-power industrial drives," Proc. IEEE, Vol. 82(8), 1994, pp. 1266-1286.

COURSE PLAN			
Module	**Course description**	**Hours**	**End semester exam % marks**
1	Use of Single-Pole-Double-Throw Single-Pole-Multi-Throw switches to describe Converter Topologies: Basic switch constraints-Implementation of various switch schemes using available power semiconductor devices. Topologies of Inverters and Rectifiers--relation between Pole voltages, Line voltages and Line-to-load neutral voltages in multi-phase two-level inverters	7	15%
2	Basic modulation methods--duty ratio--sine-triangle modulation--implementation of unipolar and bipolar modulation--three-phase inverters- Harmonic performance of Unipolar and Bipolar modulation schemes in single phase and three phase inverters-linear modulation and over modulation	8	15%
	First Internal Exam		
3	Space vector PWM - conventional sequence- 30 degree and 60 degree bus clamped PWM--relation between sine-triangle and space vector PWM-dc bus utilisation of SPWM and SVPWM. Over modulation in SVPWM-Over modulation zones. Synchronised and non-synchronised PWM	8	20%
4	Multilevel Converters: Topologies. Neutral Point Clamped and Flying Capacitor Topologies. Cascaded Multilevel Inverters. Multilevel Converters Modulation -Carrier based approach-Conventional Space Vector Modulation for 3-level inverters.	7	20%
	Second Internal Exam		
5	Applications of PWM converters--Active front end rectifier--vector control of front-end rectifier-Control of Shunt active filter- PWM converters in AC drives-Current Control in inverters: Current controlled PWM VSI -Hysteresis Control -fixed band and variable band hysteresis.	6	15%
6	Selective Harmonic Elimination-Derivation of simultaneous transcendental equations for elimination of harmonics PWM Current Source Inverters--Current Space Vectors- Space Vector Modulation of CSI--Application of CSI in high-power drives-Fundamental principles of Hybrid schemes with CSI and VSI.	6	15%
	End Semester Exam		

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

Course Objectives

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

Syllabus

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

Expected Outcome

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

References

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

<table>
<tr><th colspan="4">COURSE PLAN</th></tr>
<tr><th>Module</th><th>Contents</th><th>Hours Allotted</th><th>% of Marks in End-Semester Examination</th></tr>
<tr><td rowspan="2">I</td><td>Direct solar energy-The sun as a perennial source of energy; flow of energy in the universe and the cycle of matter in the human ecosystem; direct solar energy utilization</td><td>3</td><td rowspan="2">15%</td></tr>
<tr><td>Solar radiation measurements, solar radiation data, estimation of average solar radiation</td><td>4</td></tr>
<tr><td>II</td><td>Applications of solar energy – water heating systems, space heating and cooling of buildings, solar cooking, solar ponds, solar green houses, solar thermal electric systems; solar photovoltaic power generation; solar production of hydrogen.</td><td>6</td><td>15%</td></tr>
<tr><td colspan="4">FIRST INTERNAL EXAM</td></tr>
<tr><td rowspan="2">III</td><td>Energy from oceans-Wave energy generation - potential and kinetic energy from waves; wave energy conversion devices</td><td>3</td><td rowspan="2">15%</td></tr>
<tr><td>Tidal energy - basic principles; tidal power generation systems;- Ocean thermal energy conversion (OTEC); methods of ocean thermal electric power generation</td><td>4</td></tr>
<tr><td rowspan="2">IV</td><td>Wind energy - basic principles of wind energy conversion; design of windmills; wind data and energy estimation</td><td>4</td><td rowspan="2">15%</td></tr>
<tr><td>Site selection considerations. Types of wind machines-Horizontal axis and Vertical axis machines</td><td>4</td></tr>
<tr><td colspan="4">SECOND INTERNAL EXAM</td></tr>
<tr><td rowspan="2">V</td><td>Classification of small hydro power (SHP) stations; description of basic civil works design considerations;Turbines and generators for SHP; advantages and limitations.</td><td>4</td><td rowspan="2">20%</td></tr>
<tr><td>Biomass and bio-fuels; energy plantation; biogas generation; types of biogas plants; applications of biogas; energy from wastes, Chemical energy sources-Types of fuel cells-Batteries</td><td>3</td></tr>
<tr><td rowspan="2">VI</td><td>Geothermal energy- Origin and nature of geothermal energy; classification of geothermal resources; schematic of geothermal power plants; operational and environmental problems;</td><td>4</td><td rowspan="2">20%</td></tr>
<tr><td>Power from satellite stations, Hydrogen energy –production-storage-transportation –utilization, nuclear fusion energy, cold fusion</td><td>3</td></tr>
<tr><td colspan="4">END SEMESTER EXAM</td></tr>
</table>

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

Course Objectives

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

Syllabus

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

Expected Outcome

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

References

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

COURSE PLAN

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

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

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE6316	Design of Power Electronic System	3-0-0	3	2015

Course Objectives

To familiarize the standard design practices followed the industry for power electronic systems.

Syllabus

Designing with Power Semiconductors - Gate Drive requirements- High-side switch driving using isolated gate drives- Boot-strap power supply technique for high-side Gate drives- Power circuit design- Passive elements in Power electronics- Inductors, Capacitors, Capacitors- Magnetics design- Sensors- Design of current transformers for Power Electronics Applications- Typical design based on hall-effect sensors- Design of protection elements- Snubbers and Snubber design- Design of filters- System integration issues-Parasitics and noise in Power Electronics- Power circuit assembly- Creepage.

Expected Outcome:

Upon successful completion of this course, students will able to design entire power electronic systems including power circuits, protection and sensing, auxiliary device (inductor, filter) etc

REFERENCES:

1. V. Ramanarayanan, "Switch Mode Power Conversion," e-book, Department of Electrical Engineering, Indian Institute of Science, Bangalore, Available at : http://www.ee.iisc.ernet.in/new/people/faculty/vram (For Thermal Design, Magnetics design, Reactive elements, Drive circuits, etc).
2. L. Umanand, "Power Electronics: Essentials & Applications," New Delhi, Wiley India Pvt. Ltd, (Chapter 2 : Drive Circuits, Chapter 7 - Magnetics design; Chapter 13: Thermal design).
3. Ned Mohan et. al, "Power Electronics: Converters, Design and Applications," John Wiley and sons, (Power circuit design, assembly, parasitics, current sensors, etc,
4. Robert Erickson and DraganMaksimovic, "Fundamentals of Power Electronics," Springer India
5. Daniel W. Hart, "Power Electronics", TMH
6. International Rectifiers Application Notes. AN 936, AN 937, AN 941, AN 944, AN 978, AN 1084, AN 1092
7. Data sheets EPCOS, ALCON etc., for capacitors, ferrite cores etc. (Available on http://www.epcos.com, and http://www.alconelectronics.com)

COURSE PLAN			
Module	**Course description**	**Hours**	**End semester exam % marks**
1	Designing with Power Semiconductors: Gate Drive requirements of SCRs, BJTs, MOSFETs and IGBTs. Precautions- Typical gate drive circuits using discrete components and Integrated Circuits- High-side switch driving using isolated gate drives : Pulse transformers and Opto-isolator based circuits and limitations-Typical circuits.	6	15%
2	Boot-strap power supply technique for high-side Gate drives: IR 2110 family of Gate drive ICs. Power circuit design: Selection of power devices, losses, thermal design, paralleling of MOSFETs. Considerations in Gate drive design for paralleled MOSFETs.	9	15%
	First Internal Exam		
3	Passive elements in Power electronics: Inductors: types of inductor and transformer assembly, cores : amorphous, ferrite and iron cores : magnetic characteristics and selection based on loss performance and size, relative merits/demerits. Capacitors: types of capacitors used in PE, selection of capacitors, dc link capacitors in inverters and rectifiers, filter capacitors in dc-dc and inverter circuits,- Equivalent Series Resistance and Equivalent Series Inductance of capacitors and their effects in converter operation- Resistors: Power resistors, use in snubbers. Resistors for special purpose: HV resistors and current shunts.	9	15%
4	Magnetics design: Design based on area-product approach, inductors, transformers. Sensors: Design of current transformers for Power Electronics Applications, Resistive shunts, Hall-effect based current sensors, Typical design based on hall-effect sensors, auxilliary scaling and signal	6	15%

	conditioning circuits.		
	Second Internal Exam		
5	Design of protection elements, thermal protection, thermal sensor based protection, short-circuit and over-current protection in IGBTs (de-saturation protection in gate drives). Snubbers and Snubber design for typical applications (in flyback /forward converters) (RCD snubbers) Design of filters - input and output filters - selection of components - typical filter design for single phase and three phase inverters - LC filter - corner frequency selection - harmonic filtering performance - Constraints in the design.	6	20%
6	System integration issues: Parasitics and noise in Power Electronics: parasitics and their effects and tackling parasitics, leakage inductance and bus-bar inductance, Power circuit assembly, techniques in bus-bar design for medium and high power converters to minimise dc-bus loop inductance - idea of ground loops and their effects in converter operation. Creepage-requirements in power converter hardware	6	20%
	End Semester Exam		

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

Course Objectives

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

Syllabus

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

Expected Outcome

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

References

1. N G Hingorani and L Gyugyi, "Understanding FACTS", IEEE Press, 2000
2. T J E Miller, "Reactive Power Control in Power Systems", John Wiley, 1982
3. J Arriliga and N R Watson, "Computer modeling of Electrical Power Systems", Wiley, 2001
4. K R Padiyar, "FACTS Controllers in Power Transmission and Distribution", New Age International Publishers, 2007
5. Y.H. Song and A.T. Johns, "Flexible ac Transmission Systems (FACTS)", IEE Press, 1999
6. Ned Mohan et. al "Power Electronics", John Wiley and Sons.

COURSE PLAN

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

	Comparison between SVC and STATCOM- Applications Switching converter type Series Compensators-(SSSC)- Principle of operation, configuration and control	3	
VI	Unified Power Flow Controller: Circuit Arrangement, Operation and control of UPFC- Basic principle of P and Q control- independent real and reactive power flow control- Applications	4	20
	Introduction to interline power flow controller. Modeling and simulation of FACTS controllers	3	
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE6116	Sliding Mode Control	3-0-0	3	2015

Course Objectives

1. To familiarize the students with the methodology for the design and implementation of sliding mode controllers for any uncertain plant.
2. To design higher order sliding mode controllers and observers.

Syllabus

Introduction to variable structure systems; Mathematical background; existence conditions of sliding mode; concept of a manifold; sliding surface; sliding mode motion and sliding mode control; Method of equivalent control Chattering Problem; Approaches of sliding hyper plane design; Discrete-time sliding mode control; Multi-rate output feedback; Discrete-time sliding mode control based on multi-rate output feedback techniques; Sliding mode observers; Introduction to Higher Order Sliding Mode (HOSM) control and observation; Twisting controller; Super Twisting controller; Lyapunov based sliding mode control; Super twisting based observers and differentiators

Expected Outcome

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

1. Design robust nonlinear sliding mode controllers for any uncertain plant.
2. Design higher order sliding mode controllers and observers .

References

1. C. Edwards and S. K. Spurgeon, Sliding mode control: Theory and applications. Taylor and Francis; 1998.
2. V. I. Utkin, Sliding Modes in Control Optimization. New York: Springer-Verlag; 1992.
3. J. Y. Hung, W. Gao and J. C. Hung, "Variable structure control: A survey;" IEEE Transactions on Automatic Control; vol. 40; 1993.
4. Y. W. WeibingGao and A. Homaifa, "Discrete-time variable structure control systems;" IEEE Transactions on Ind. Electronics; vol. 42; no. 2; pp. 117–122; 1995.
5. B. Bandyopadhyay and S. Janardhanan, Discrete-time Sliding Mode Control: A Multi-rate Output Feedback Approach. Lecture Notes in Control and Information Sciences; Berlin: Springer-Verlag; 2005; no. 323.
6. K. Abidi, J. X. Xu, and Y. Xinghuo, "On the discrete-time integral sliding-mode control;" IEEE Transactions on Automatic Control; vol. 52; no. 4; pp. 709–715; 2007

COURSE PLAN

Module	Contents	Hours Allotted	% of Marks in End-Semester Examination
I	Introduction to variable structure systems; definition of variable structure and sliding mode; examples of dynamic systems with sliding modes. Mathematical background: differential equations with discontinuous right-hand sides; solutions in Filippov sense ; existence conditions of sliding mode; concept of a manifold; sliding surface; sliding mode motion and sliding mode control.	6	15%
II	Regular form Approach-Pole placement and LQR method. Properties of sliding mode motion. Reaching laws; methods of equivalent control Chattering Problem. Approaches of sliding hyper plane design	9	15%
FIRST INTERNAL EXAM			
III	Discrete-time sliding mode control: definitions; design methods; reaching laws for discrete-time sliding mode control; Switching and non-switching based discrete-time sliding mode control.	9	15%
IV	Discrete-time sliding mode control based on Multi-rate Output Feedback techniques. Terminal Sliding mode control; Integral Sliding mode control - Design of sliding surface and control law development	6	15%
SECOND INTERNAL EXAM			
V	Sliding mode observers - Need of sliding mode observers; Design of sliding mode observers; design examples.	6	20%
VI	Introduction to Higher Order Sliding Mode (HOSM) control and observation. Twisting controller. Super Twisting controller. Lyapunov based sliding mode control. Super twisting based observers and differentiators. Applications of Sliding mode controllers.	6	20%
END SEMESTER EXAM			

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

Course Objectives

The purpose of this course is:-

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

Syllabus

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

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

Industrialization, Globalization and Environment; Global environmental issues; Waste land reclamation, Resource degradation, carbon credits and Carbon trading – Carbon footprint;

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

Expected Outcome

The student will be able to

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

References

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

Delhi, 2004.

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

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

Course No	Course Name	L-T-P	Credits	Year of Introduction
01EE6318	Finite Element Methods of Electrical Machines	3-0-0	3	2015

Course Objectives

1.To understand the basic electromagnetic field equations and the problem formulation for CAD applications.

2.To become familiar with Finite Element Method as applicable for Electrical Engineering.

3.To apply Finite Element Method for the design of different Electrical apparatus.

Syllabus

Need for Field Analysis based design- Recent Trends Mathematical Formulation of Field Problems- Development of Torque/Force- Electromagnetic Field Equations - Magnetic Vector/Scalar Potential - Electrical Vector/Scalar Potential- Inductances - Maxwell Equations - Laplace and Poissons Equations- Philosophy of FEM- Differential/Integral Equations - Finite Difference Method - Finite Element Method- boundary conditions- Elements of CAD Systems - Preprocessing - Modeling - meshing - Material Properties - Boundary Conditions - Setting up Solutions- The electric field-finite element analysis

Expected Outcome:

Upon successful completion of this course, students will be able to apply Finite Element Method for analyzing the performance of electrical machines. They will become familiar withthe organization of a typical CAD package and problem formulation for different applications

Textbooks:

1. SJ.Salon, Kluwer , ^Finite Element Analysis of Electrical Machines', Academic Pub;ishers, London
2. Krishna Moorthy C. S., An Introduction to Computer Aided Electromagnetic Analysis,Vector Field Finite Element Analysis *

References:

1. Peter Silvester. Ronald L Ferrari. "Finite Elements for Electrical Engineers', Cambridge University Press.
2. S. Ratnajeevan H. Hoole , 'Computer Aided analysis and design of electromagnetics devices' Elsevier, Newyork.
3. D.A.Lowther and P.P.Silvester , 'Computer Aided design in Magnetics\ Springer Verlag, Newyork

COURSE PLAN			
Module	**Contents**	**Hours**	**End semester exam % marks**
1	Introduction: Conventional design Procedures - Limitations - Need for Field Analysis based design - History of development and Applications - Recent Trends Mathematical Formulation of Field Problems: Review- Development of Torque/Force	7	15%
2	Electromagnetic Field Equations - Magnetic Vector/Scalar Potential - Electrical Vector/Scalar Potential - Stored Energy in Field Problems - Inductances - Maxwell Equations - Laplace and Poissons Equations - Energy Functional	8	15%
	First Internal Exam		
3	- Principle of Energy Conversion Philosophy of FEM: Mathematical Models - Differential/Integral Equations - Finite Difference Method - Finite Element Method - Energy Minimization - Variational Method - 2d Field problems - Discretization - Shape Functions - Stiffness Matrix	8	20%
4	Rayleigh Ritz and Galerkin Approach to finite Elements - Normal gradient boundary conditions- Forced and natural boundary conditions-a typical current flow problem - Galerkin Method for poison equation -A numerical example	7	20%
	Second Internal Exam		
5	Solution Techniques CAD Packages and Design Applications: Elements of CAD Systems - Preprocessing - Modeling - meshing - Material Properties - Boundary Conditions - Setting up Solutions	6	15%
6	Electric and Magnetic Fields in a co-axial cable - The magnetic field - The electric field-finite element analysis - Case study of machines.	6	15%
	End Semester Exam		

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

Course Objectives

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

Syllabus

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

Expected Outcome

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

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

References

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. GautamShroff, Enterprise Cloud Computing Technology Architecture Applications [ISBN: 978-0521137355]

COURSE PLAN

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

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

Course Objectives

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

Syllabus

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

Expected Outcome

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

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

REFERENCES

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

COURSE PLAN

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

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE6392	Mini Project	0-0-4	2	2015

Course Objectives

To make students

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

Approach

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

Expected Outcome

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

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

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE6394	Electrical Drives Lab	0-0-2	1	2015

Course Objectives

1. To study the closed loop control of DC motor and AC motor drives
2. To study software like LABVIEW and MAXWELL.
3. To study testing of Lightning arrestors and Insulators.

Expected Outcomes

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

1. To analyse the machine performance from modelling and simulation .
2. To design machines and electrical system using MAXWELL and LABVIEW.
3. To test Lightning arrestors and Insulators

LIST OF EXPERIMENTS

1. Control of DC motor(Simulation using MATLAB/SIMULINK)
2. Control of Induction motor (Vector control using MATLAB/SIMULINK)
3. Voltage and Current monitoring using LABVIEW
4. Control Experiments using LABVIEW
5. Design Experiments using MAXWELL
6. Control of SRM
7. Impulse Test on Lightning arrestors
8. Power frequency test on Insulators

SEMESTER – III

Syllabus and Course Plan

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE7311	Field Theory	3-0-0	3	2015

Course Objectives:

This presents a unified macroscopic theory of electromagnetic waves in accordance with the principle of special relativity from the point of view of the form in invariance of Maxwell's equations and the constitutive relations. The topic includes the fundamental equations and boundary conditions, time harmonic fields, waves through space and media, reflection, transmission, guidance and resonance of electromagnetic waves, antenna theory and the various methods of flux plotting

Syllabus

Time varying fields and electromagnetic waves , Wave impedance and propagation constant, wave propagation in good dielectrics, conductors, depth of penetration, surface impedance of good conductor to sinusoidal currents, Polarization, waves at boundary between two media, wave incident normally on boundary between perfect dielectrics, wave incident obliquely on boundary between perfect dielectrics, wave polarized perpendicular to the plane of incidence, Parallel polarization, wave incident normally on perfect conductor, Oblique incidence, Brewster angle. Snell's Law, poynting Vector, Poynting Vector for a plane wave in a dielectric, average and Complex Poynting vector, Guided waves essential conditions, Transverse electric waves, Transverse magnetic waves, characteristics, TEM waves, Velocities of Propagation. Propagation characteristics of Radio waves, Electro-magnetic wave spectrum, Transmission path from transmitter to receiver, Ionosphere, Ionospheric investigation, Eddy current problems, Flux plotting, method of images.

Expected Outcomes

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

1. Know the principles of techniques in electromagnetic theory
2. Apply the physics principles learnt in this class in their research future career
3. Apply the knowledge of electricity and magnetism in public affairs

References

1. V. V. Sarwate, '*Electromagnetic Field and Waves*', Wiley Eastern, Second Edition
2. William H. Hayt Jr., 'E*ngineering Electromagnetics*', Tata McGraw-Hill, Fifth Edition
3. Kraus Fleiseh, 'Electromagnetics with application', McGraw-Hill international, Fifth Edition
4. E. C. Jordan, ' *Electromagnetic Waves and Radiating Systems*'
5. P. V. Gupta '*Electromagnetic Field*'

COURSE PLAN

Module	Contents	Hours	End semester exam % marks
1	Time varying fields and electromagnetic waves - Solution of Maxwell's equations for charge free unbounded region - Uniform waves - Uniform plane waves - Characteristics - Wave impedance and propagation constant - Wave propagation in good dielectrics, conductors - Depth of penetration - Surface impedance of good conductor to sinusoidal currents - Polarization - Elliptic, Linear and Circular polarization.	8	20%
2	Waves at boundary between two media - Wave incident normally on boundary between perfect dielectrics - Wave incident obliquely on boundary between perfect dielectrics - Wave polarized perpendicular to the plane of incidence - Parallel polarization - Wave incident normally on perfect conductor - Oblique incidence - Brewster angle. Snell's Law.	8	15%
	First Internal Exam		
3	Poynting Vector - Poynting Vector for a plane wave in a dielectric - Flow of direct current in cylindrical resistor - Co-axial cables - Instantaneous. Average and Complex Poynting vector - propagation in good conductors - skin effect.	6	15%
4	Guided waves - Essential conditions -Transverse electric waves - Transverse magnetic waves - Characteristics - TEM waves - Velocities of Propagation - TEM waves in co-axial cables and two wire transmission line - Attenuation factor for TE, TM and TEM waves.	7	15%
	Second Internal Exam		
5	Propagation characteristics of Radio waves - Electro-magnetic wave spectrum – Transmission path from transmitter to receiver - Ionosphere - Ionospheric investigation - Virtual height and critical frequency - Maximum usable frequency.	6	15%
6	Eddy current problems - Calculation of Eddy current loss -Effect of saturation Flux plotting - Two Dimensional field plotting methods - Method of images - Multiple images – Image of point charge in conducting sphere – Graphical method of field mapping - experimental methods.	7	20%
	End Semester Exam		

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Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE7313	Dynamics of Power Converters	3-0-0	3	2015

Course Objectives

To equip the students with the dynamic aspect of different converters and their analysis

Syllabus

Fundamentals of Steady state converter modelling and analysis-Steady-state equivalent circuits-losses and efficiency- Inclusion of semiconductor conduction losses in converter model-Small-signal AC modelling- Averaging of inductor/capacitor waveforms- perturbation and linearization-State-Space Averaging-Circuit Averaging and averaged switch modelling-Canonical Circuit Model- Manipulation of dc-dc converters' circuit model into Canonical Form-Modelling the pulse width modulator-Converter Transfer Functions:-Review of frequency response analysis techniques -Converter transfer functions-graphical construction. Measurement of ac transfer functions and impedances-Controller Design-Effect of negative feedback on the network transfer functions-loop transfer function-Controller design specifications- applications to the basic dc-dc topologies - Practical methods to measure loop gains-Converters in Discontinuous Conduction Mode-AC and DC equivalent circuit modelling of the discontinuous conduction mode-Generalised Switch Averaging-small-signal ac modelling of the dcm switch network- Current-Mode Control-Average Current-mode Control-Peak Current-mode control-first order models accurate models for current-mode control-application to basic dc-dc converter topologies-Sub harmonic oscillation for d> 0.5; Slope compensation-Discontinuous conduction mode in current-mode control.

Course Outcome:

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

1.Develop dynamic models of switched power converters using state space averaging and circuit averaging techniques.

2.Develop converter transfer functions.

3.Design closed loop controllers for DC-DC power converters.

4.Design and implement current mode control for DC-DC converters.

REFERENCES:

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

COURSE PLAN

Module	Course description	Hours	End semester exam % marks
1	Fundamentals of Steady state converter modelling and analysis, Steady-state equivalent circuits, lossesand efficiency. Inclusion of semiconductor conduction losses in converter model.	6	15%
2	Small-signal AC modelling- Averaging of inductor/capacitor waveforms- perturbation andlinearisation.State-Space Averaging-Circuit Averaging and averaged switch modelling- Canonical Circuit Model-Manipulation of dc-dc converters' circuit model into Canonical Form-Modelling the pulse widthmodulator	9	20%
	First Internal Exam		
3	Converter Transfer Functions:-Review of frequency response analysis techniques- Bode plots –Converter transfer functions-graphical construction. Measurement of ac transfer functions andimpedances.	6	15%
4	Controller Design: Effect of negative feedback on the network transfer functions-loop transferfunction-Controller design specifications- PD, PI and PID compensators - applications to the basic dcdctopologies - Practical methods to measure loop gains: Voltage and current injection.	6	15%
	Second Internal Exam		
5	Converters in Discontinuous Conduction Mode: AC and DC equivalent circuit modelling of thediscontinuous conduction mode-Generalised Switch Averaging-small-signal ac modelling of the dcmswitch network-	6	15%
6	Current-Mode Control: Average Current-mode Control, Peak Current-mode control-first order modelaccuratemodels for current-mode control-application to basic dc-dc converter topologies-Subharmonic oscillation for d> 0.5; Slope compensation- Discontinuous conduction mode in current mode control.	9	20%
	End Semester Exam		

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

Course Objectives

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

Syllabus

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

EHV AC Transmission; Corona; Insulation requirements of EHV AC and DC transmission lines ; insulation coordination; switching over voltage.

Expected Outcome

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

References

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

COURSE PLAN

Module	Contents	Hours Allotted	% of Marks in End-Semester Examination
I	EHV AC transmission-configuration-features-intermediate substations-applications- interconnected AC networks-HVDC system-classification-configuration-equipment in HVDC substations-	3	15
	Power flow in AC and HVDC lines-EHV AC vs. HVDC-economic comparison-HVDC power flow- power conversion principle-power loss in DC system-steady state U_d/I_d characteristics	4	
II	Converter circuits-single phase and three phase circuits-analysis of bridge converter-with and without overlap-grid control - control characteristics-constant minimum ignition angle control-constant current control-extinction angle control	6	15
FIRST INTERNAL EXAM			
III	Harmonics-characteristics of harmonics-means of reducing harmonics-telephone interference-filters-single frequency and double frequency-tuned filters-DC harmonic filter	3	15
	Reactive power requirements in HVDC substations-effect of delay angle and extinction angle-short circuit ratio in planning of HVDC	4	
IV	DC line oscillations and line dampers - Over voltage protection-DC lightning arresters-DC circuit breakers -basic concepts types & characteristics	4	15
	Earth electrode-location and configuration-earth return-materials of anode-sea electrode –shore electrode-troubles by earth currents and remedial measures	4	
SECOND INTERNAL EXAM			
V	EHV AC Transmission-Components of transmission system-voltage gradients of conductor-single and bundled	4	20

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

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

Course Objectives:

To present a comprehensive overview of Electric and Hybrid Electric Vehicle

Syllabus

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

Expected Outcome:

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

1. Choose a suitable drive scheme for developing an electric hybrid vehicle depending on resources
2. Design and develop basic schemes of electric vehicles and hybrid electric vehicles.
3. Choose proper energy storage systems for vehicle applications
4. Identify various communication protocols and technologies used in vehicle networks.

References

1. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003

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

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

COURSE PLAN

Module	Course description	Hours	End semester exam % marks
1	Introduction to Hybrid Electric Vehicles: History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies. Conventional Vehicles: Basics of vehicle performance, vehicle power source characterization, transmission characteristics, mathematical models to describe vehicle performance.	7	15%
2	Hybrid Electric Drive-trains: Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis. Electric Drive-trains: Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis.	8	15%
	First Internal Exam		
3	Electric Propulsion unit: Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, drive system efficiency	8	15%
4	Energy Storage: Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Super Capacitor based energy storage and its analysis, Flywheel based energy storage and its analysis, Hybridization of different energy storage devices.	7	15%
	Second Internal Exam		
5	Sizing the drive system: Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology, Case Studies: Design of a Hybrid Electric Vehicle (HEV), Design of a Battery Electric Vehicle (BEV).	6	20%
6	Communications, supporting subsystems: In vehicle networks- CAN, Energy Management Strategies: Introduction to energy management strategies used in hybrid and electric vehicles,	6	20%

	classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy management strategies.		
	End Semester Exam		

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

Course Objectives

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

Syllabus

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

Expected Outcome

Upon successful completion of this course, students will be able to:
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 Examination
I	Introduction to SCADA systems: • Evolution of SCADA • Fundamental Principle of Modern SCADA Systems, Monitoring and supervisory functions • Application area of SCADA Consideration and benefits of SCADA system	6	15
II	SCADA System Components: • Remote Terminal Unit-(RTU), Intelligent Electronic Devices (IED) • PLC: Block diagram, programming languages, Ladder diagram, Functional block diagram, Applications, Interfacing of PLC with SCADA. • Communication Network • SCADA Server, SCADA/HMI Systems	8	15
FIRST INTERNAL EXAM			
III	SCADA Architecture: • Various SCADA architectures, advantages and disadvantages of each system • Single unified standard architecture, IEC 61850 SCADA / HMI Systems	6	15

IV	SCADA Communication: • Various industrial communication technologies -wired and wireless methods and fiber optics Open standard communication protocols	6	15
SECOND INTERNAL EXAM			
V	Operation and control of interconnected power system • Automatic substation control, SCADA configuration • Energy management system • System operating states System security, state estimation	8	20
VI	SCADA Applications: • Utility applications Transmission and Distribution sector operations, monitoring, analysis and improvement. • Industries - oil, gas and water. • Case studies: • Implementation. Simulation Exercises	6	20
END SEMESTER EXAM			

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

Course Objectives

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

Syllabus

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

Expected Outcome

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

References

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

COURSE PLAN

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

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE7391	Seminar II	0-0-2	2	2015

Course Objectives

To make students

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

Approach

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

Expected Outcome

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

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

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE7393	Project (Phase 1)	0-0-12	6	2015

Course Objectives

To make students

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

Approach

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

Expected Outcome

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

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

SEMESTER – IV

Syllabus and Course Plan

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE7394	Project (Phase 2)	0-0-23	12	2015

Course Objectives

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

Approach

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

Expected Outcome

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

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