KERALA TECHNOLOGICAL UNIVERSITY

Master of Technology

Curriculum, Syllabus and Course Plan

Cluster	:	*01*
Branch	:	*Electrical and Electronics Engineering*
Stream	:	*Power Control and Drives*
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 Systems	3-1-0	40	60	3	4
C	01EE6301	Modelling of Electrical Machines	3-1-0	40	60	3	4
D	01EE6501	Power Converter Circuits	3-0-0	40	60	3	3
E	01EE6503	Advanced Signal Processing	3-0-0	40	60	3	3
	01EE6999	Research Methodology	0-2-0	100			2
	01EE6591	Seminar I	0-0-2	50			2
	01EE6593	Power Electronics Lab	0-0-2	50			1
		TOTAL	**15-4-4**	**400**	**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	01EE6502	Design Principles of power converters	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
	01EE6592	Mini Project	0-0-4	100			2
	01EE6594	Drives & Simulation Lab	0-0-2	50			1
		TOTAL	**15-1-6**	**350**	**300**	**-**	**19**

TOTAL CONTACT HOURS : 22
TOTAL CREDITS : 19

Elective I

01EE6112 Process Control & Industrial Automation

01EE6412 New and Renewable Sources of Energy

01EE6512 Applications of Power Electronics in Power Systems

01EE6514 Embedded Systems and Real time Applications

Elective II

01EE6418 Flexible AC Transmission Systems

01EE6516 Microcontroller Applications in Power Electronics

01EE6518 Power Electronics for Renewable Energy Systems

01EE6522 Digital Simulation of Power Electronic Systems

Elective III

01EE6126 Soft Computing Techniques

01EE6524 Modern Power Converters

01EE6318 Finite Element Methods for Electrical Machines

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
	01EE7591	Seminar II	0-0-2	50			2
	01EE7593	Project (Phase I)	0-0-12	100			6
		TOTAL	**6-0-14**	**230**	**120**	**-**	**14**

TOTAL CONTACT HOURS : 20
TOTAL CREDITS : 14

Elective IV

01EE7113 Advanced Instrumentation
01EE7511 Digital controllers in Power Electronics
01EE7513 Power System Protection
01EE7411 EHVAC and DC Transmission

Elective V

01EE7515 Switched Mode Power Converters
01EE7121 Biomedical Instrumentation
01EE7315 Hybrid Electric Vehicles

SEMESTER 4

Examination Slot	Course Number	Name	L-T-P	Internal Marks	End Semester Examination		Credit
					Marks	Duration (hours)	
	01EE7594	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

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
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 voltageand 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 separatelyexcited generator, sudden application of inertia load to separately excited dc motor-Synchronous Machines- synchronous machine reactance and time constants-Primitive machine modelof 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 andTorque 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 polemodel of rotating machines- Primitive machine -special properties assigned to rotor windings -transformer and rotational voltages in the armature voltage and torque equationsresistance, inductanceand 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'stransformation-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 compoundmachines. 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 modelof 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 – armaturecurrents 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
01EE6501	Power Converter Circuits	**3-0-0**	**3**	**2015**

Course Objectives

1. To develop a deep knowledge of Power semiconductor devices and their applications
2. To analyse and design AC/DC & DC/AC converters
3. To analyse and design DC/DC converters
4. To develop skills to use power electronic circuits in energy conversion systems

Syllabus

Power electronic switches; Switching constraints; Charecteristics;Losses; Switch model; Uncontrolled Rectifier; Single Phase; Three Phase; Filters; Line Current Distortion; Total Harmonic Distortion; Displacement Power Factor; Power Factor; Effect of source impedance; Controlled Rectifier; single phase; Three phase; Semiconverter; Inversion mode; Dc –Dc converter; Buck Converter; Boost converter; Buck- Boost converter; Cuk Converter; Volt- Sec balance; Switched Mode Power Converter; Isolation & Protection; Flyback converter; Forward Converter; Push – Pull converter; Half Bridge converter; Full Bridge converter; Voltage Source Inverters; Single Phase; Three Phase; PWM Techniques; Harmonic Elimination; Current Source Inverter; Multilevel Inverter

Expected Outcome

After successful completion of the course, students will be able to

1. Analyse and design various types of power converters.
2. Apply power electronics circuits in power convert to improve the performance and efficiency

References

1. Rashid M.H., *Power Electronics Circuits, Devices and Applications*, 3rdedition, Prentice Hall India, New Delhi,2004.
2. Ned Mohan, Undeland, Robbins, *Power Electronics: Converters, Applications and Design*, 3rd ed., John Wiley, 2003
3. L. Umanand , *Power Electronics: Essentials and Applications*, Wiley, 2009
4. Daniel W. Hart, *Introduction to Power Electronics*, Prentice Hall, 1997
5. William Shepherd, Li Zhang, *Power Converter Circuits*, Marcel Dekker, 2004
6. G. K. Dubey, S. R. Doradla, R. M. K Sinha, *Thyristorised Power Controllers*, New Age International Publications, reprint: 2005
7. Joseph Vithayathil, *Power Electronics: Principles and Applications*, McGraw-Hill, 1994
8. 6. Nptel.ac.in/downloads/108105066/

COURSE PLAN

Module	Contents	Hours Allotted	% of Marks in End-Semester Examination
I	Power Electronic Elements: The ideal switch, Characteristics of ideal switches, two-quadrant and four-quadrant switches Switching constraints in power electronic circuits. Losses in practical switches: Models of MOSFET and IGBTs for evaluating conduction and switching losses.	6	12
II	Uncontrolled rectifiers : Single phase and three phase - Analysis with R and RL loads, Analysis with capacitive filter Fourier Analysis of repetitive waveforms, Line current Distortion, Total Harmonic Distortion, Displacement Power Factor, Power Factor, Line voltage distortion	7	16
FIRST INTERNAL EXAM			
III	Controlled Rectifiers : Single phase , Three phase - fully controlled and semi controlled- Analysis with R, RL, RLE loads Performance, Voltage conversion ratio, Total Harmonic Distortion, Displacement Power Factor, Effect of source impedance, Inversion mode of operation	8	16
IV	DC-DC Converters: Steady state analysis and design of DC to DC converters. Buck, Boost, Buck Boost. Control methods of DC to DC converters- duty ratio control, Voltage conversion ratios of different topologies, Current ripple and voltage ripple calculations.	8	16
SECOND INTERNAL EXAM			
V	Isolated dc-dc converter topologies: Fly-back and forward converters, Push-pull and bridge topologies, Steady state analysis - Voltage conversion ratios. Block diagram of Switched Mode Power Supply - Requirements of isolation and protection.	6	20
VI	Inverters: Performance analysis of voltage source inverter, PWM Techniques-Analysis of single pulse, multiple pulse modulation and sinusoidal pulse modulation, various harmonic elimination techniques. Current source inverters, Concept of multi level inverters.	7	20
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE6503	Advanced Signal Processing	3-0-0	3	2015

Course Objectives

1. The course will prepare the students to understand the concept of discrete time system & its properties.
2. The course will make the students to understand the use of z transform for discrete time LTI systems.
3. The course will impart the knowledge to students about the Discrete Fourier Transform (DFT) and Fast Fourier Transform (FFT).
4. The course develops the students to know the designing of the FIR and IIR filters.
5. The course develops the students to understand multirate signal processing & different applications of DSP.

Syllabus

Discrete time Signals and systems–Stability and Causality –LTI systems and properties–Z Transform –Properties –Inverse Z-transform. Discrete Fourier Series –Properties Fourier series – Discrete time sequences – Discrete Fourier Transform (DFT), Fast Fourier Transform (FFT)-properties of discrete Fourier Transform –Linear Convolution – Decimation –in- Time and Decimation in- Frequency –FFT Algorithms. Classification of filter design - Design of IIR filters – Bilinear transformation technique – Impulse invariance method – Step invariance method.FIR filter design – Fourier series method - Window function technique - A Comparison of IIR and FIR Digital Filters. Finite Word Length Effects, Effects of coefficient on Quantization –Quantization in Sampling, discrete Fourier Transform Computations. Time frequency analysis, the need for time frequency analysis, Time frequency distribution, Short time Fourier Transform, Wigner distribution. Multirate digital signal processing: Basic multi-rate operation (up sampling, down sampling), Efficient structures for decimation and interpolation, Applications – Phase shifters – Interfacing of digital systems with different sampling rates - Sub band coding- Oversampled A/D and D/A converter. Introduction to Digital Signal Processors-Commercial DSP devices – TMS C240 processor and ADSP 2181 processor –Architecture – Addressing modes – Program control – Instructions

Expected Outcome

1. Differentiate between different types of signal and systems.
2. Evaluate the discrete Fourier transform (DFT) and Fast Fourier transform (FFT) of a sequence.
3. Compute the z-transform and inverse z transform of a sequence, and identify its region of convergence.

4. Represent and design the FIR and IIR filter
5. Understand the application of DSP and multi-rate signal processing

References

1. Emmanuel C. Ifeachor, Barrie W. Jervis, *Digital Signal Processing: A Practical Approach*, Pearson Education India Series, New Delhi, 2nd Edition, 2004.
2. Sanjit K. Mitra, *Digital Signals Processing: A Computer Based Approach*, Tata McGraw-Hill Publishing Company Limited, 2nd Edition, 2004.
3. John G. Proakis and Manolakis. D.G, '*Digital Signal Processing: Principles Algorithms andApplications*', Prentice Hall of India, New Delhi, 2004.
4. Alan Oppenheim V., Ronald W. Schafer, 'Digital Signal Processing', Prentice Hall of India Private Limited, New Delhi, 1989.
5. Oppenheim V. and Ronald W. Schafer, 'Discrete Time Signal Processing', Prentice Hall of India Private Limited., New Delhi, 2001.
6. Leon Cohen, 'Time Frequency Analysis', Prentice Hall, 1995.
7. P. P. Vaidyanathan, 'Multirate systems and Filter Banks', Prentice Hall, 1993.
8. Avatar Singh and Srinivasan S., 'Digital Signal Processing: Implementation using DSP. Microprocessors with Examples from TMS 320C54XX', Thompson Brooks/Cole, 2004.
9. Nptel.ac.in/courses/117101001/

COURSE PLAN

Module	Contents	Hours Allotted	% of Marks in End-Semester Examination
I	Discrete time signals & Systems: Review of DTS, stability & causality, frequency domain representation, LTI systems and properties. Z transform-properties-system characterization in Z-domain, Inverse Z-transform	7	14
II	Representation of Periodic Sequences: Discrete Fourier Series, Properties Discrete time sequences, Discrete Fourier Transform (DFT),properties, linear convolution , Fast Fourier Transform (FFT),Decimation in time and frequency algorithm	7	16
	FIRST INTERNAL EXAM		
III	Classification of filter design: Design of IIR filters, Bilinear transformation technique, Impulse invariance method, Step invariance method. FIR filter design, Fourier series method, Window function technique	7	14
IV	Comparison and Effects: A Comparison of IIR and FIR Digital Filters. , Finite Word Length Effects, Effects of coefficient on Quantization, Quantization in Sampling Discrete Fourier Transform Computations.	6	16
	SECOND INTERNAL EXAM		

V	Time frequency analysis & Multi rate signal processing: The need for time frequency analysis, Time frequency distribution, Short time Fourier Transform, Wigner distribution. Mathematical description of sampling rate conversion - Interpolation and Decimation, Decimation by an integer factor - Interpolation by an integer factor, Sampling rate conversion by a rational factor, Filter implementation for sampling rate conversion- direct form FIR structures, Polyphase filter structures.	8	20
VI	Application & Processors: Phase shifters – Interfacing of digital systems with different sampling rates - Sub band coding- Oversampled A/D and D/A converter, Commercial DSP devices, TMS C240 processor and ADSP 2181 processor, Architecture Addressing modes, Program control, Instructions.	7	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,	5	

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

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE6591	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
01EE6593	Power Electronics Lab	**0-0-2**	**1**	**2015**

Course Objectives

1. Conduct experiments in hardware to test and verify design of power converters.
2. Use computer simulation software MATLAB/SIMULINK to test and verify design of power converters.
3. Document test results and develop engineering communications using reports.

Experiments

1. DC-DC Choppers using self-commutating Devices.
   a) Buck Converter
   b) Boost converter
2. AC-AC voltage regulators
   a) Lamp load
   b) Motor load
3. Practical converter design considerations - gate and base drive circuits
4. Generation of sine-PWM using analog circuits
5. Push pull inverter.
6. MATLAB simulations of Single phase, three phase uncontrolled converter, Semi converters and Full converters
   a) R load
   b) RL load
   c) RLE (motor) load
7. Matlab simulation of DC-DC regulator

Expected Outcome

1. To understand the basic principle of drive circuits
2. To analyze and design an AC/DC rectifier circuit.
3. To analyze and design DC/DC converter circuits.
4. To analyze and design DC/AC inverter circuits.
5. Get exposure to simulation tools using MATLAB/SIMULINK software

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 – Design of current controller and speed controller –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 – Gain of the modulator and converter	8	15%
	First Internal Exam		
3	Induction Motor Drives: Steady state equivalent circuit of 3-phase Induction motor-- Stator voltage contol – constant v/f speed control with VSI -v/f control with slip compensation– Slip-power recovery schemes –subsynchronous and supersynchronous 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-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
01EE6502	Design Principles of Power Converters	**3-0-0**	**3**	**2015**

Course Objectives

1. To know how to design various components in a circuit
2. Analyze the safety precautions needed while using various power devices.

Syllabus

Thermal Design of Power modules; Magnetics design based on area-product approach; Techniques in bus-bar design for medium and high power converters to minimise dc-bus loop inductance; Idea of ground loops; Gate drive circuit design; Popular gate drive circuits for MOSFETs, SCRs, BJTs and IGBTs; Thermal protection de-saturation schemes; Basics of EMI/EMC issues

Expected Outcome

1. Design the various components in a circuit.
2. Understand the safety requirements in using power devices.

References

1. L. Umanand, "*Power Electronics: Essentials & Applications*," New Delhi, Wiley India Pvt. Ltd.,2009

2. Ned Mohan, Undeland, Robbins, '*Power Electronics: Converters, Applications and Design*', 3rdedn., John Wiley, 2003

3. Ramanarayanan, "*Switch Mode Power Conversion*," e-book, Department of Electrical Engineering, Indian Institute of Science, Bangalore.

4. AN-936, "*Do's and Don'ts of using MOS gated transistors*", International Rectifiers

5. AN-944, "*Use Gate Charge to Design the Gate Drive Circuit for Power MOSFETs and IGBTs*",International Rectifiers

COURSE PLAN

Module	Contents	Hours Allotted	% of Marks in End-Semester Examination

I	Power circuit design, selection of power devices, losses, advanced thermal design, Typical examples based on dc-dc converters and bridge inverters.	8	16
II	Magnetics design based on area-product approach, inductors, transformers.	6	14
FIRST INTERNAL EXAM			
III	Parasitics and noise in PE: 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.	8	16
IV	Gate drive circuit design - precautions - popular gate drive circuits for MOSFETs, SCRs, BJTs and IGBTs. Gate drive ICs : Typical design using IC IR 2110, isolation, and techniques of isolation opto-isolater based gate drive design, pulse transformer based design	6	14
SECOND INTERNAL EXAM			
V	Design of protection elements, thermal protection, thermal sensor based protection, short-circuit and over-current protection in IGBTs using de-saturation schemes	8	20
VI	Basics of EMI/EMC issues: conductive and radiated EMI- basic solutions. System integration.	6	20
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE6112	Process Control & Industrial Automation	**3-0-0**	**3**	**2015**

Course Objectives

1. To understand physical process control problems
2. To provide knowledge on the industrial application of PID controllers
3. To analyse different control structures used in process control
4. To understand the field of industrial automation

Syllabus

Introduction to process dynamics; process control dynamics; different control modes and tuning; Advanced process control techniques for both linear and nonlinear systems; Control using hierarchical; MPC and Internal mode architectures; Statistical process control; Digital controllers; Implementation of PID. Introduction to SCADA; PLC; Interfacing of PLC; Industrial application of PLC; Distributed control systems; Digital gate logic; PLC Ladder logic; Introduction to IEC 61511/61508

Expected Outcome

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

1. Model a process control system and understand its dynamics
2. Able to recommend different control architectures needed in the industry
3. Design and tune PID controllers for a given system.
4. Hands on training on latest industrial automation tools such as SCADA, PLC..

References

1. Luyben W., 'Process Modelling, Simulation and Control for Chemical Engineers,' Mc-Graw Hill, 2/e.
2. Donald R. Coughanowr , 'Process Systems Analysis And Control, ' Mc-Graw hill, 3/e.
3. G. Liptak, 'Handbook of Process Control,' 1996
4. George Stephanopoulos, 'Chemical Process Control,' Prentice Hall of India.
5. Enrique Mandado, Jorge Marcos, Serrafin A Perrez, 'Programmable Logic Devices and Logic Controllers,' Prentice Hall, 1996.

COURSE PLAN

Module	Contents	Hours Allotted	% of Marks in End-Semester Examination
I	Introduction to process dynamics- Physical examples of first order process, first order systems in series, dynamic behavior of first and second order systems, Control valves and transmission lines, dynamics and control of heat exchangers.	5	15%
II	Process control dynamics- level control, flow control, stability and control of chemical reactors, different control modes and tuning- ON/OFF, P, PI, PD, PID. Ziegler Nichols self tuning methods.	7	15%
FIRST INTERNAL EXAM			
III	Advanced process control techniques for both linear and nonlinear systems- Feed forward control, cascade control, ratio control, adaptive control, override control, control of nonlinear process with delay, Hierarchical control, internal mode control.	9	15%
IV	MPC, Statistical process control. Digital controllers, effect of sampling, Implementation of PID-stability and tuning, digital feed forward control	7	15%
SECOND INTERNAL EXAM			
V	Introduction to SCADA- SCADA Systems, SCADA Architecture; monolithic, distributed and network, PLC-combinational and sequential logic controllers, system integration with PLCs and computers, application in industry. Distributed control systems-PC based control	7	20%
VI	Programming ON/OFF inputs to produce ON/OFF outputs, Relation of digital gate logic to contact/coil logic, Digital gate logic, PLC Ladder logic, Introduction to IEC 61511/61508 and the safety cycle.	7	20%
END SEMESTER EXAM			

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

Course Objectives

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

Syllabus

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

Expected Outcome

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

References

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

COURSE PLAN

Module	Contents	Hours Allotted	% of Marks in End-Semester Examination

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

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE6512	Applications of Power Electronics in Power Systems	**3-0-0**	**3**	**2015**

Course Objectives

1. To provide an extended knowledge of power electronic devices in power system
2. To understand the concept of FACTS devices
3. To familiarize the problems related to power quality
4. To develop skills to use power electronic devices in Distributed Generation

Syllabus

Flexible AC transmission systems (FACTS). Modeling and Analysis of various FACTS controllers. Steady state and dynamic problems in AC systems. Power Quality problems in distribution systems, harmonics, Series and parallel resonances, harmonic power flow, Filters, Power Quality Problems. Power electronic conditioners. Harmonic Analyzer. Need for HVDC, AC vs. DC: Comparative advantages. Converters and their characteristics. Control of the converters. Parallel and series operation of converters. Grid Interactive Inverters-Study on Modeling of Converters, Protection against islanding and reverse power flow in grid interactive systems. IEEE standards 929-2000 for power transfer from inverter to grid. Case study of PV Grid Connected Systems under Islanding Phenomena. Distributed Generation - Resurgence of DG - DG Technologies, Interface to the Utility System. Local and Remote Techniques for Islanding Detection in Distributed Generator

Expected Outcome

After successful completion of this course, students will be able to implement FACTS devices to solve issues related to power quality. They will be able to model converters for custom power devices in Distributed Generation

References

1. Hingorani N. G. & L. Gyugyi, *Understanding Facts Concepts and Technology of Flexible ACTransmission Systems*, Standard Publishers Distributors, 2001
2. Roger C. Ducan, McGranaghan, SantoseBeaty, *Electrical Power Systems Quality*, McGraw-Hill, New York, 2nd edition, 2002.
3. K. R. Padiyar, *HVDC Power Transmission Systems*, Wiley eastern Ltd. 2008.
4. Loi Lei Lai, Tze Fun Chan, *Distributed Generation: Induction and Permanent Magnet Generators*, IEEE Press, John Wiley & Sons Ltd., 2008
5. Gregory W. Massey - *Essentials of Distributed Generation Systems* Jones and Bartllet Publishers 2011.
6. By Suleiman M. Sharkh, Mohammad A. Abu-Sara, Georgios I. Orfanoudakis, Babar Hussain, *Power Electronic Converters for Microgrids*, John Wiely 2014
7. Angelo Baggini, *Handbook of Power Quality (Google eBook)*, John Wiley & Sons, 2008
8. http://www.pserc.wisc.edu/documents/general_information/presentations/presentations_by_pserc_university_members/power-electronics/
9. http://nptel.ac.in/courses/Webcourse-contents/IIT-KANPUR/power-system/ui/.html

10. http://nptel.ac.in/courses/108101038/2

COURSE PLAN

Module	Contents	Hours Allotted	% of Marks in End-Semester Examination
I	Flexible AC transmission systems (FACTS). Principles of series and Shunt compensation. Description of static VAR compensators (SVC), Static Condensor(STATCOM)	6	14
II	Thyristor Controlled series compensators (TCSC), Static synchronous series compensator (SSSC) and Unified power flow controller (UPFC). Modeling and Analysis of FACTS controllers.	8	16
	FIRST INTERNAL EXAM		
III	Power Quality problems in distribution systems, Electromagnetic Interference (EMI), Conducted EMI, harmonics, harmonics creating loads, modeling, harmonic propagation, and harmonic power flow. Series and parallel resonances, Mitigation of harmonics, filters, passive filters, Active filters, shunt, series hybrid filters, voltage sags & swells, voltage flicker.	7	16
IV	Mitigation of power quality problems using power electronic conditioners. Harmonic Analyzer-Functional Block Diagram. Need for HVDC, AC vs. DC: Comparative advantages. Converters and their characteristics. Control of the converters. Parallel and series operation of converters.	7	14
	SECOND INTERNAL EXAM		
V	Grid Interactive Inverters- Study on Modeling of Converters, Protection against islanding and reverse power flow in grid interactive systems. IEEE standards 929-2000 for power transfer from inverter to grid. Study on converter, Modeling of PV Grid Connected Systems under Islanding Phenomena.	7	20
VI	Distributed Generation - Interface to the Utility System. Local and Remote Techniques for Islanding Detection in Distributed Generators. Optimal allocation of Distributed Generators.	7	20
	END SEMESTER EXAM		

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE6514	Embedded Systems and Real time Applications	**3-0-0**	**3**	**2015**

Course Objectives

1. To develop a deep knowledge of the architecture and working of different types of embedded processors available for real time applications.
2. To assess the different kinds of real time operating systems in practice.
3. To identify various open source development boards.
4. To design an embedded controller application.

Syllabus

Embedded systems: current trends and challenges; features; Hard and soft real time systems;8051 microcontroller architecture, CPU block diagram, memory management, addressing modes, ALP and C programming of 8051 timers, interrupts, serial communication and analog/digital interfacing; Introduction to MSP 430 microcontroller.ARM processor: fundamentals, Instruction set, thumb instructions, memory, registers, Cortex M3 architecture. Introduction to Beagle Board, Panda Board, Leopard Board; Programming and porting of OS to open source development boards. Real time operating system: Round robin, Round robin with interrupts, Semaphores, mutex. Priority inversion, RTOSLinux, RTLinux configuring and compiling

Expected Outcome

After the successful completion of this course, students will be able to evaluate the different open source development boards used for real time projects. They will be able to analyze the different concepts of real time operating system and program accordingly

References

1. Muhammed Ali Mazidi, "The 8051 Microcontroller and Embedded Systems Using Assembly and C", 2nd Edition, Pearson India.
2. David E Simon,"An Embedded Software Primer",Pearson Addison Wesley.
3. Raj Kamal, "Embedded Systems: Architecture, Programming and Design", Second Edition, Tata McGraw Hill Education Pvt Ltd.
4. http://www.arm.com/products/processors/classic/arm11/index.php
5. Andrew Dominic, Chris, "Arm system developers guide", MK publishers.
6. nptel.ac.in/downloads/subject Id=108102045.

Shibu K V," Introduction to Embedded Systems", Tata McGraw Hill Education Pvt Ltd, 2009 edition

COURSE PLAN

Module	Contents	Hours Allotted	% of Marks in End-Semester Examination
I	Embedded Systems: Definition and characteristics, Recent trends and challenges, Design issues, Hard and soft real time real time systems, 8051 microcontroller architecture, memory management, Addressing modes, Assembly language programming of timers, serial communication, interrupts.	7	14
II	Embedded C programming of 8051 timers, serial communication, interrupts, interfacing keyboard, stepper motor, analog/digital and LCD.TI MSP 430 microcontroller: Architecture and programming. Case study of 8/16/32 bit microcontroller(8051,PIC/MSP 430,AVR)	7	16
FIRST INTERNAL EXAM			
III	ARM processor: Fundamentals, Cortex M3 architecture, Instruction set, Thumb Instructions, memory mapping, Registers. Optimizing ARM assembly code.	6	14
IV	Introduction to open source development board with ARM cortex processors: Beagle board –programming and porting OS. Panda Board-programming and porting OS. Leopard Board – programming and porting OS.	6	16
SECOND INTERNAL EXAM			
V	Real time operating system: Concepts, Round robin, round robin with interrupts, Function queue scheduling architecture, Semaphores, mutex, mailbox. Memory management, priority inversion, thread synchronisation	8	20
VI	Review of C programming, RTOS Linux and RT Linux kernels. Programming in Linux, RT Linux configuring & compiling RT Linux.	8	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 seriescompensators - GCSC. TCSC, TSSC - Principle of operation, configuration and control.Application of TCSC for mitigation of SSR	4	
IV	Static Voltage and Phase AngleRegulators (TCVR &TCPAR): Objectives of Voltage and Phase angle regulators	4	15
	Thyristorcontrolled 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-ApplicationsSwitching converter type Series Compensators-(SSSC)- Principle of operation, configuration and control	3	
VI	UnifiedPowerFlow 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
01EE6516	Microcontroller Applications in Power Electronics	**3-0-0**	**3**	**2015**

Course Objectives

1. The course will prepare the students to explain the need of microcontrollers.
2. The course will make the students to understand the utility of 8051 microcontroller for better controlling of Electrical circuits.
3. The course will impart the knowledge to students about the measurement of electrical and non electrical quantities using processor.
4. The course develops the students to know the architecture and operation of 8051 microcontroller.
5. The course develops the students to understand how embedded devices can be used in the field of power electronics.

Syllabus

Comparison between microprocessor and microcontroller, overview on 8051, 8096 and PIC series microcontrollers. 8051 architecture- CPU structure-register file, Assembly language, addressing modes-instruction set –interrupt structure – timers/counters, serial communication, Memory organization-external RAM and ROM expansion – A/D interface. Application of 8051 controller to generate gating signal (PWM) for converters and inverters. Microprocessor based applications:Importance of measurement and sensing in closed loop control, Signal conditioning using comparators, Clippers, Clampers, Precision Rectifier and Zero crossing Detector. Measurement of voltage, current, speed, power and power factor using microprocessors, Measurement of non-electrical quantities like Strain, Temperature, Speed and Torque. Per-unit representation of variables in digital domain, data representation in fixed point and floating point form, - Implementation of P, PI and PID controllers using microprocessors. Microcontroller Based Firing Scheme For Converters: Applications of MCS-51 Microcontrollers- Square Wave Generation- Rectangular Waves- Pulse Generation- Pulse Width Modulation- Staircase Ramp Generation- Sine Wave Generation- Pulse Width Measurement- Frequency Counter. Digital pulse width modulation techniques and its comparison with the analog type. Using microcontrollers, application of the firing schemes to the control of DC drive, induction motors, synchronous motors and other special machines. Typical applications in the control of power electronic converters for power supplies and electric motor drives: Stepper motor control, DC motor control, AC motor control.

Expected Outcome

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

1. Analyze different family of microcontrollers.
2. Write assembly language program for 8051 microcontroller to achieve solution to given task.
3. Learn functioning of Signal conditioning using specific circuits/ transducers and to measure electrical or non-electrical quantities using processor.

4. Describe Architecture and operation of 8051 microcontroller.
5. Implement microcontroller in various control schemes.

References

1. Kenheth J. Hintz and Daniel Tabak, '*Microcontrollers: Architecture, Implementation and Programming*', McGraw Hill, USA, 1992
2. The 8051 Microprocessor Architecture, Programming and Applications: Ayala, Kenneth J.
3. John B. Peatman, '*Design with Microcontrollers*', McGraw-Hill International Ltd, 1997.
4. John B. Peatman, *Design with PIC Microcontrollers*, Pearson Education Inc., India, 2005
5. Douglas V. Hall, *Microprocessors and Interfacing: Programming and Hardware*, Tata McGraw-Hill, Eleventh edition, 2003.
6. Micro controllers-Theory and Applications by Ajay V Deshmukh, McGraw Hills.
7. Micro processors and Microcontrollers by Prof. C R Sarma.
8. Nptel.ac.in/electronics & communication engineering/microcontroller applications

COURSE PLAN

Module	Contents	Hours Allotted	% of Marks in End-Semester Examination
I	Evolution of microcontrollers: Comparison between microprocessor and microcontroller, microcontroller development systems; overview on 8051, 8096 and PIC series microcontrollers. 8051 architecture- CPU structure-register file, special function registers, registers and pin description. Assembly language, addressing modes-instruction set.	7	16
II	Interrupts & Timers/Counters: Interrupt structure – timers/counters. Serial data input/output. Internal RAM & ROM, interfacing with external memory. ADC & DAC interfacing with the controller. PWM signal generation using timer/counter	7	14
	FIRST INTERNAL EXAM		
III	Microprocessor based applications: Importance of measurement and sensing in closed loop control. Signal conditioning using comparators, Clippers, Clampers, Precision Rectifier and Zero crossing Detector. Measurement of voltage, current, speed, power and power factor using microprocessors.	6	16

IV	Microprocessor based control: Measurement of non-electrical quantities like Strain, Temperature, Speed and Torque. Per-unit representation of variables in digital domain, data representation in fixed point and floating point form. Implementation of P, PI and PID controllers using microprocessors	6	14
SECOND INTERNAL EXAM			
V	Applications of MCS-51 Microcontrollers: Square Wave Generation- Rectangular Waves- Pulse Generation- Pulse Width Modulation- Staircase Ramp Generation- Sine Wave Generation. Pulse Width Measurement- Frequency Counter. Digital pulse width modulation techniques and its comparison with the analog type.	8	20
VI	Microcontroller Based Firing Scheme For Converters: Using microcontrollers, application of the firing schemes to the control of DC drive, induction motors, synchronous motors and other special machines. Typical applications in the control of power electronic converters for power supplies and electric motor drives: Stepper motor control, DC motor control, AC motor control.	8	20
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE6518	Power Electronics for Renewable Energy Systems	**3-0-0**	**3**	**2015**

Course Objectives

1. To study the various renewable energy options.
2. To conduct qualitative study of power converters
3. To design a solar PV system

Syllabus

Environmental aspects of electric energy conversion; impacts of renewable energy generation on environment ; Electrical machines for Renewable Energy conversion ;Qualitative study of different renewable energy ; Solar: Block diagram; Power converters ; selection of inverter; battery sizing; array sizing; Wind; AC-DC-AC converters; PWM Inverters, Grid Interactive Inverters; matrix converters; Hybrid Renewable Energy systems; Analysis of Wind and PV systems; Stand alone operation wind energy conversion systems and solar system; Grid connection Issues ;Grid integrated WECS; Grid Integrated solar system; studies of Wind-PV-Maximum Power Point Tracking

Expected Outcome

1. To understand the technology behind green energy harnessing & power electronic applications.
2. Undertake projects based on grid interconnected green power systems.

References

1. C.S.Solanki, ", Solar Photovoltaics: Fundamentals Technologies And Applications", Prentice-Hall Of India Pvt. Limited, 2009
2. Joshua Earnest, Tore Wizelius, Wind Power Plants And Project Development, PHI Learning, 2011
3. Rashid M.H., *Power Electronics Circuits, Devices and Applications*, 3rd edition, Prentice Hall
   a. India, New Delhi,2004.
4. Rai. G.D, Non-conventional Energy Sources, Khanna publishers, 2011.
5. Rai. G.D, Solar Energy Utilization, Khanna Publishers, 1995.
6. Gary, L. Johnson, Wind Energy System, Prentice Hall Inc, 1995.
7. Leon Freris, David Infield, Renewable Energy in Power Systems, John Wiley &Sons., 2008
8. http://freevideolectures.com/Course/2342/Energy-Resources-and-Technology

COURSE PLAN

Module	Contents	Hours Allotted	% of Marks in End-Semester Examination
I	Environmental aspects of electric energy conversion: impacts of renewable energy generation on environment (cost-GHG Emission) - Electrical machines for Renewable Energy conversion: Review of reference theory fundamentals principle of operation and analysis: IG, PMSG, SCIG and DFIG.	8	16
II	Qualitative study of different renewable energy resources: Solar, wind, ocean, Biomass, Fuel cell, Hydrogen energy systems and hybrid renewable energy systems.	6	14
FIRST INTERNAL EXAM			
III	Power converters - Solar: Block diagram of solar photo voltaic system -Principle of operation: line commutated converters (inversion-mode) - Boost and buck-boost converters- selection of inverter, battery sizing, array sizing.	8	16
IV	Wind: three phase AC voltage controllers- AC-DC-AC converters: uncontrolled rectifiers, PWM Inverters, Grid Interactive Inverters - matrix converters.	7	14
SECOND INTERNAL EXAM			
V	Hybrid Renewable Energy systems- Need for Hybrid Systems- Analysis of Wind and PV systems- Stand alone operation of fixed and variable speed wind energy conversion systems and solar system	6	20
VI	Grid connection Issues -Grid integrated PMSG and SCIG Based WECS- Grid Integrated solar system Range and type of Hybrid systems- Case studies of Wind-PV-Maximum Power Point Tracking (MPPT).	7	20
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE6522	Digital Simulation of Power Electronic Systems	**3-0-0**	**3**	**2015**

Course Objectives

1. To develop in depth knowledge of the modelling of various power semiconductor devices
2. To analyze on different approaches to modelling of power electronics systems
3. To apply software tools for analysis of Power electronic systems

Syllabus

Principles of Modelling Power semi conductor Devices; Modelling of Diode, Thyristor TRIAC, IGBT and Power Transistors; Modelling of Control circuits for power electronics switches; Computer Formulation of equations for Power Electronic Systems; AC equivalent circuit modelling; Modelling of electrical Machines; Modelling and simulation of DC-DC converters, Rectifiers, Power factor correction schemes and Choppers; Circuit analysis Software Micro SimPspice A/D; Analog behaviour Modelling

Expected Outcome

After successful completion of the course, students will be able to analyze the circuits and select them for the suitable applications. They will acquire skills to determine the problems associated with the modelling of Power Electronic circuits. They will be able to apply software tools for the analysis of power electronic systems

References

1. Robert W. Erickson, Fundamentals of Power Electronics', Chapman & Hall, 2nd. Edn.,1997 Marcel Dekker, Inc
2. Micro SimPSpice A/D and Basics+: Circuit Analysis Software, User's Guide Micro Sim Corporation
3. Jai P. Agarwal, Power Electronic Systems-Theory and Design, Pearson- 2001
4. Micro Sim Schematics: Schematic Capture User's Guide Micro Sim Corporation.

Simulink Reference Manual, Math works, USA.

5. Randall Shaffer, Fundamentals of Power Electronics with MATLAB, Firewall Media, India, 2007

COURSE PLAN

Module	Contents	Hours Allotted	% of Marks in End-Semester Examination
I	Principles of Modelling Power semi conductor Devices, Macro Models versus Micro models, Modelling of diode in simulation. Diode with R, R-L, R-C and R-L-C load with ac supply. Thyristor models-Semiconductor Device modelled as Resistance, resistance –Inductance and Inductance–Resistance-Capacitance combination, Modelling of TRIAC, IGBT and Power Transistors in simulation	7	16
II	Modelling of Control circuits for power electronics switches. Computer Formulation of equations for Power Electronic Systems. Review of Graph Theory as applied to Electrical Networks Systematic method of formulating state equations-computer solution of state equations. Explicit integration method-implicit integration method.	6	14
FIRST INTERNAL EXAM			
III	AC equivalent circuit modelling, Basic AC modelling approach-State space averaging circuit, Averaging and averaged switch modelling, Modelling the PWM, Modelling of electrical Machines-induction, DC and synchronous machines	7	16
IV	Modelling and simulation of DC-DC converters using MATLAB - Simulation of State Space Models, Simulation of single phase and three phase uncontrolled and controlled (SCR) rectifiers, converters with self commutated devices using MATLAB. Simulation of power factor correction schemes using MATLAB, Simulation of chopper fed dc motor using MATLAB	6	14
SECOND INTERNAL EXAM			
V	Circuit analysis Software Micro SimPspice A/D, Simulation overview-creating and preparing a circuit for simulation, Simulating a Circuit with Pspice A/D- displaying simulation results-Pspice A/D analysis, Simple multi run analysis-Statistical analysis-Simulation examples of Power Electronic systems.	8	20
VI	Micro Sim PSPICE A/D –Preparing a schematic for simulation –creating symbols-creating models-Analog behaviour Modelling –Setting up and Running analyses-viewing results-examples of power electronic systems.	8	20
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 – Boltzmenlearning - Single layer and multilayerperceptrons - Least mean square algorithm – Back propagation algorithm - Applications in pattern recognition and other engineering problems Casestudies - Identification and control of linear and nonlinear systems.	9	15
FIRST INTERNAL EXAM			
III	Fuzzy sets: Fuzzy set operations - Properties - Membership functions, Fuzzy to crisp conversion, fuzzification and defuzzification methods, applications in engineering problems.	9	15
IV	Fuzzy control systems: Introduction - simple fuzzy logic controllers with examples - Special forms of fuzzy logic models, classical fuzzy control problems, inverted pendulum, image processing, home heating system, Adaptive fuzzy systems.	6	15
SECOND INTERNAL EXAM			
V	Genetic Algorithm: Introduction - basic concepts of Genetic Algorithm, applications.	6	20
VI	Hybrid Systems: Adaptive Neuro fuzzy Inference System (ANF1S), Neuro –Genetic, Fuzzy-Genetic systems.	6	20
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE6524	Modern Power Converters	**3-0-0**	**3**	**2015**

Course Objectives

1. To analyse and design Switched mode power converters
2. To analyse the Control of switched mode DC power supplies
3. To explain the Electromagnetic interferences in power supplies.

Syllabus

Switched mode power converters; Buck Converter; Boost converter; Buck- Boost converter; Cuk Converter; Isolation & Protection; DC-DC converter with isolation; Flyback converter; Forward Converter; Push – Pull converter; Half Bridge converter; Full Bridge converter; Series and parallel resonant inverters; Zero current and Zero voltage switching resonant converters; Control of switched mode DC power supplies Single Phase; Monolithic PWM control circuit; Electromagnetic and radio frequency interference; AC power supplies, classification; Resonant AC power supplies; Introduction power line disturbances. .

Expected Outcome

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

1. Evaluate the working of various power converters
2. Design the converters for industrial applications.

References

1. Rashid M.H., Power Electronics Circuits, Devices and Applications, 4th edition, Prentice Hall India, New Delhi, 2013.
2. Ned Mohan, Undeland, Robbins, Power Electronics: Converters, Applications and Design, 3rd ed., John Wiley, 2008
3. L. Umanand , Power Electronics: Essentials and Applications, Wiley, 2009
4. Joseph Vithayathil, Power Electronics: Principles and Applications, McGraw-Hill, 1994
5. A.I. Pressman, Switching Mode Power Supply Design, Tata McGraw-Hill, 1992
6. Michel, D., DC-DC Switching Regulator Analysis, Newness, 2000
7. Lee, Y., Computer Aided Analysis and Design of Switch Mode Power Supply, 1993
8. Staff, VPEC, Power Device & their Application, 2000

COURSE PLAN

Module	Contents	Hours Allotted	% of Marks in End-Semester Examination
I	Introduction to switched mode power converters, Generalized comparison between switched mode and linear DC regulators, Operation and steady state performance of Buck, Boost, Buck-Boost and Cuk Converters: Continuous conduction mode, discontinuous conduction mode and boundary between continuous and discontinuous mode of operation, output voltage ripple calculation, effect of parasitic elements.	7	16
II	DC-DC converter with isolation: Fly back converters- other fly back converter topologies, forward converter, the forward converter switching transistor- Variation of the basic forward converter. Push pull converter transistor-Limitation of the Push Pull circuit-circuit variation of the push pull converter-the half bridge and full bridge DC-DC converters	7	14
FIRST INTERNAL EXAM			
III	Resonant Pulse Converters, Series and parallel resonant inverters - zero current and Zero voltage switching resonant converters, frequency response. Two quadrant zero voltage switching resonant converters	7	16
IV	Control of switched mode DC power supplies: Voltage feed forward PWM control, current mode control, digital pulse widthmodulation control, isolation techniques of switching regulator systems: soft start in switching power supply designs, current limit circuits, over voltage protection circuit.	6	14
SECOND INTERNAL EXAM			
V	A typical monolithic PWM control circuit and their application: TL 494. Power factor control in DC-DC converters. Electromagnetic and radio frequency interference, conducted and radiated noise, EMI suppression, EMI reduction at source, EMI filters, EMI screening, EMI measurements and specifications.	7	20
VI	AC power supplies, classification switched mode ac power supplies Resonant AC power supplies, bidirectional ac power supplies, multistage conversions, control circuits and applications. Introduction power line disturbances, power conditioners, uninterruptible Power supplies – applications.	8	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

References

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 *
3. Peter Silvester. Ronald L Ferrari. "Finite Elements for Electrical Engineers', Cambridge University Press.
4. S. Ratnajeevan H. Hoole , 'Computer Aided analysis and design of electromagnetics devices' Elsevier, Newyork.
5. 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	**I**ntroduction: 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
01EE6592	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
01EE6594	Drives & Simulation Lab	**0-0-2**	**1**	**2015**

Course Objectives

1. To provide hands on experience on the equipment for converters, inverters, choppers and closed loop control for electrical drives.
2. Conduct experiments in hardware to study the principles of modern control techniques for DC and AC drives.
3. Computer simulation of power electronics and motor Drives.

Experiments

1. Simulation of Power Electronic Systems using PSpice
   a) Single phase uncontrolled half wave & Full wave rectifier
   b) Single phase half wave & Full wave controlled rectifier
2. Simulation of Electric Drives using MATLAB
   a) Single phase semiconverter Fed separately excited DC motor
   b) Single phase Full converter Fed separately excited DC motor
   c) Chopper control Fed separately excited DC motor
   d) Three Phase Converter fed separately excited DC motor
   e) Closed Loop Control of three Phase Converter fed separately excited DC motor
3. Study of three phase parallel inverter.
4. Open loop control of DC drive.
5. Open loop control of AC drive.
6. Jones chopper.
7. SCR parallel inverter.

Expected Outcome

1. To perform design calculations for drive and power supply applications.
2. Analyze operation of power converters and inverters.
3. Get exposure to simulation tools using MATLAB/SIMULINK & PSPICE

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE7113	Advanced Instrumentation	**3-0-0**	**3**	**2015**

Course Objectives

To impart principles of different measurement systems and methods of modern instrumentation.

Syllabus

Generalized performance characteristics of instruments, General concept of transfer function, Dynamic response and frequency response studies, Response of a general form of instrument, Plant level automation, Petrinet models, Sensors, Virtual instrumentation, VI programming techniques.

Expected Outcome

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

1 By the end of the course the student will be able to identify the performance of different measurement systems and apply it for different control systems.

2 Students will also get a good idea of the virtual instrumentation which is an emerging technology.

References

1. B. D. Doeblin, 'Measurement systems -Application and Design, McGraw Hill New York.
2. John P. Bentley, 'Principles of Measurement System', Pearson Education.
3. J. W. Dally, W. F. Reley and K. G. Mc Connel, 'Instrumentation for Engineering measurements 2/e, John Wiley & sons Inc, New York, 1993.
4. Curtis D. Johnson, 'Process Control Instrumentation Technology', Prentice Hall of India Private Limited, New Delhi.
5. Dale E. Soberg, Thomson F Edgar, 'Process Dynamics and Control', 2/e, Wiley.
6. K. B. Klaasen, 'Electronic Measurement. And Instrumentation', Cambridge University Press.
7. WaltenegusDargie& Christian Poella Bauer, "Fundamentals of Wireless Sensor networks": Wiley Series.
8. Jun Zheng & Abbas Jamalipour, Wireless sensor Networks, A Networking perspective, Wiley.

COURSE PLAN

Module	Contents	Hours Allotted	% of Marks in End-Semester Examination

I	Generalized performance characteristics of instruments - Static characteristics, static calibration, memory, precision and bias, dynamic characteristics, development of mathematical model of various measurement systems. Classification of instruments based on their order.	6	15
II	General concept of transfer function (with special reference to measuring systems) Dynamic response and frequency response studies of zero order, first order and second order instruments. Response of a general form of instrument to a periodic input. Response of a general form of instrument to a transient input. Requirement of instrument transfer function to ensure accurate measurement.	9	15
FIRST INTERNAL EXAM			
III	Plant level automation- process and instrumentation diagrams- Performance modeling — role of performance modeling- performance measures.	9	15
IV	Petrinet models- introduction to petrinets - basic definitions and analytical techniques, Smart Sensors, Wireless sensors and Wireless Sensor network protocol	6	15
SECOND INTERNAL EXAM			
V	Virtual instrumentation – Definition, flexibility – Block diagram and architecture of virtual instruments – Virtual instruments versus traditional instruments	6	20
VI	Review of software in virtual instrumentation - VI programming techniques, sub VI, loops and charts, arrays, clusters and graphs, case and sequence structures, formula nodes, string and file input / output	6	20
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE7511	Digital controllers in Power Electronics	**3-0-0**	**3**	**2015**

Course Objectives

1. To understand the architecture and peripherals of DSP
2. To know the different applications of 8051 microcontroller

Syllabus

C2xx DSP core and code generation, Assembly Programming using C2xx DSP ,instruction Set, Software Tools, Types of Physical Memory, memory addressing modes, Assembly Programming using C2xx DSP ,instruction Set, Software Tools, Pin multiplexing (MUX) and general Purpose I/O overview, ADC overview, Operation of the ADC in the DSP, Overview of the event Manager, Event Manager, Interrupts, Introduction to Field Programmable gate Arrays-CPLD Vs FPGA-types of FPGA, Xilinx XC3000 series, configurable logic Blocks (CLB), Input/output block-Programmable interconnect Point(PIP)- Xilinx 4000 series-HDL programming-overview of Spartan 3E and Virtex II pro FPGA boards –case study, 8051 microcontroller-typical applications-DC motor speed control, speed measurement, Temperature control, stepper motor control, PID control

Expected Outcome

1. Exposure to the internal architecture and peripherals of Digital signal processors
2. Comparison between programmable devices & DSPs
3. Using Microcontrollers in different control applications

References

1. Hamid A. Toliyat, Steven G. Campbell: 'DSP based Electromechanical Motion Control' Press New York 2004
2. Sen M. Kuo, Woon Seng Gan, 'Digital Signal Processors: Architecture, Implementation and Applications', Pearson, 2005.
3. XC3000 series data sheets(Version 3.1) Xilinx Inc., USA 1998
4. XC4000 series data sheets(Version 1.6) Xilinx Inc., USA 1999
5. Wayne Wolf, 'FPGA based system Design' Prentice Hall 2004
6. Phil Lapsley, Bler, Sholam, E.A. Lee, '*DSP Processor Fundamentals*', IEE Press, 1997

COURSE PLAN

Module	Contents	Hours Allotted	% of Marks in End-Semester Examination
I	Introduction to the C2xx DSP core and code generation:- The components of C2xx DSP core, Mapping external devices to the C2xx DSP core, peripherals and Peripheral Interface, System configuration registers, Memory:-Types of Physical Memory, memory addressing modes	6	14
II	Assembly Programming using C2xx DSP, instruction Set, Software Tools. Pin multiplexing (MUX) and general Purpose I/O overview, Multiplexing and general Purpose I/O Control registers, Introduction to Interrupts, Interrupt Hierarchy, Interrupt control registers, Initializing and servicing Interrupts in software	6	16
FIRST INTERNAL EXAM			
III	ADC overview:-Operation of the ADC in the DSP, Overview of the event Manager, Event Manager, Interrupts:- General purpose (GP) timers, compare units Capture units and Quadrature enclosed Pulse(QEP) circuitry, General Event Manager Information	8	16
IV	Introduction to Field Programmable gate Arrays-CPLD Vs FPGA-types of FPGA, Xilinx XC3000 series, configurable logic Blocks (CLB), Input/output block-Programmable interconnect Point(PIP)-Xilinx 4000 series	8	14
SECOND INTERNAL EXAM			
V	HDL programming-overview of Spartan 3E and Virtex II pro FPGA boards –case study PID control	6	20
VI	8051 microcontroller-typical applications-DC motor speed control, speed measurement, Temperature control, stepper motor control	8	20
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE7513	Power System Protection	**3-0-0**	**3**	**2015**

Course Objectives

1. To study principles and algorithms for protection of power systems.
2. To study design of protection schemes
3. To apply the principles of power system protection in setting protective relays.
4. To analyze the operations of relays for various faults in the system

Syllabus

Introduction to computer relaying; Review of relaying practices; Review of mathematical basis for protective relaying algorithms; Transmission line relaying algorithms; Protection of transformers, Machines and buses; Power transformer algorithms; digital protection of generators and motors; Hardware organization; System relaying and control; Development in new relaying principles; recent developments in relaying.

Expected Outcome

1. Understand the digital methods to protect power system.
2. Carry out quantitative analysis of the performance of typical protection systems.
3. Explore new relaying techniques and recent developments in relaying schemes

References

1. *Computer Relaying for Power Systems,* Arun G. Phadke and James S Thorp, John Wiley & Sons Inc, New York.
2. Ravindra P. Singh, '*Digital Power System Protection*', Prentice-Hall of India Pvt. Ltd., New Delhi, 2007.
3. T. Johns, S. K. Salman, '*Digital Protection for Power Systems*', Peter Peregrinus Ltd., 1995

COURSE PLAN

Module	Contents	Hours Allotted	% of Marks in End-Semester Examination
I	Introduction to computer relaying: Development and historical background, expected relay architecture, A-D converters, Anti –aliasing Filters, substation computer hierarchy. Review of relaying practices: functions of a protective system, Protection of transmission lines, Transformers, Reactors and generator Protection,	6	14

	Bus Protection, Performance of current and voltage protection		
II	Review of mathematical basis for protective relaying algorithms: Fourier series, Orthogonal expansions, Fourier transforms, Discrete Fourier transforms, Introduction to probability and random processes, Kalman Filtering..	8	16
FIRST INTERNAL EXAM			
III	Transmission line relaying algorithms: Introduction, sources of error, relaying as parameter estimation, Symmetrical component distance relay, Protection of series compensated lines	6	16
IV	Protection of transformers, Machines and buses: Power transformer algorithms, digital protection of generators and motors.	6	14
SECOND INTERNAL EXAM			
V	Hardware organization: Computers for relaying, substation environment, Industry environmental standards, counter measures against EMI, Redundancy and Back up. System relaying and control: Measurement of frequency and phase, sampling clock synchronization, Application of phase measurements to static and dynamic state estimation, system monitoring.	8	20
VI	Development in new relaying principles: Travelling waves in single phase and three phase lines travelling waves due to faults, directional wave relay, Travelling wave distance relay, Differential Relaying with phasors, travelling wave differential relays, adaptive relaying fault location algorithms, recent developments in relaying.	8	20
END SEMESTER EXAM			

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

Course Objectives

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

Syllabus

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

Expected Outcome

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

References

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

COURSE PLAN

Module	Contents	Hours Allotted	% of Marks in End-Semester Examination
I	EHV AC transmission-configuration-features-intermediate substations-applications- interconnected AC networks-HVDC system-classification-configuration-equipment in HVDC substations-	3	15
	Power flow in AC and HVDC lines-EHV AC vs. HVDC-economic comparison-HVDC power flow- power conversion principle-power loss in DC system-steady state U_d/I_d characteristics	4	

II	Converter circuits-single phase and three phase circuits-analysis of bridge converter-with and without overlap-grid control - control characteristics-constant minimum ignition angle control-constant current control-extinction angle control	6	15
FIRST INTERNAL EXAM			
III	Harmonics-characteristics of harmonics-means of reducing harmonics-telephone interference-filters-single frequency and double frequency-tuned filters-DC harmonic filter	3	15
	Reactive power requirements in HVDC substations-effect of delay angle and extinction angle-short circuit ratio in planning of HVDC	4	
IV	DC line oscillations and line dampers - Over voltage protection-DC lightning arresters-DC circuit breakers -basic concepts types & characteristics	4	15
	Earth electrode-location and configuration-earth return-materials of anode-sea electrode –shore electrode-troubles by earth currents and remedial measures	4	
SECOND INTERNAL EXAM			
V	EHV AC Transmission-Components of transmission system-voltage gradients of conductor-single and bundled conductor	4	20
	Corona & corona losses in EHVAC and HVDC-critical surface gradient-Peeks law-critical disruptive voltage and critical electric stress for visual corona	3	
VI	Insulation requirements of EHV AC and DC transmission lines - Electrostatic field of EHV lines-biological effects-live wire maintenance	4	20
	insulation coordination-insulation for power frequency-voltage-switching, over voltage-lightning performance	3	
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE7515	Switched Mode Power Converters	**3-0-0**	**3**	**2015**

Course Objectives

1. To acquaint the students with working, analysis of different types of converters.
2. To understand the modeling of SMPS
3. To understand resonant converters and its type.

Syllabus

Voltage Mode Control of SMPS; Current Mode Control of SMPS ; Current Mode versus Voltage Mode Control of SMPS ; Modelling of SMPS ; Basic AC modelling Approach; Basic state space averaged modeling ; State space averaging of non ideal buck boost converter; Modelling of pulse width modulator; Classification of Resonant Converters ; Resonant Converter topologies; Zero voltage switching, clamped voltage topologies;

Expected Outcome

After successful completion of the course, students will be able to:
1. Understand different control modes of SMPS
2. Model Practical non-ideal converters
3. Understand the characteristics of resonant converter

References

1. Ned Mohan, *Power Electronics*, John Wiley & Sons
2. Abraham I Pressman , Switching Power Supply Design, McGraw-Hill Publishing Company
3. R. W. Erickson , *Fundamental of Power Electronics*, Chapman & Hall Publishers

COURSE PLAN

Module	Contents	Hours Allotted	% of Marks in End-Semester Examination
I	Voltage Mode Control of SMPS - Loop gain and Stability Considerations - Shaping the Error Amplifier gain versus frequency characteristics - Error	6	14

	amplifier Transfer function – Tran conductance Error amplifiers		
II	Current Mode Control of SMPS – Current Mode Control Advantages- Current Mode versus Voltage Mode Control of SMPS – Current Mode Deficiencies - Slope Compensation.	8	16
FIRST INTERNAL EXAM			
III	Modelling of SMPS - Basic AC modelling Approach -– Modelling of non ideal fly back converter	6	14
IV	State Space Averaging – basic state space averaged model – State space averaging of non ideal buck boost converter - Circuit averaging and averaged switch modelling – Modelling of pulse width modulator	8	16
SECOND INTERNAL EXAM			
V	Introduction to Resonant Converters – Classification of Resonant Converters – Basic Resonant circuit concepts – load resonant converters – resonant switch converters	6	20
VI	Zero voltage switching, clamped voltage topologies – resonant DC Link inverters with zero voltage switching – High frequency link integral half cycle converter	8	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	Electrode theory, Different types of electrodes, reference electrodes, hydrogen, calomel, Ag-AgCl, pH electrode, selection criteria of electrodes.	6	15
FIRST INTERNAL EXAM			
III	Measurement of electrical activities in heart, brain and muscles - Electrocardiography - EEG machine, Disease diagnosis from ECG, Computer aided electro cardiographs- Applications of ECG. Electroencephalogram and their interpretation. EEG machine applications, Rapid eye movement- Electromyography, EMG machines, Conduction velocity in a nerve fiber. Important applications of EMG.	9	15
IV	Electromagnetic and ultrasonic measurement of blood flow, various methods, Therapeutic Equipment - Cardiac pace-makers, Types of pace-makers, Defibrillators, Types of defibrillators, Electrodes used in defibrillators, diathermy machines, Microwave and short wave diathermy machines.	9	15
SECOND INTERNAL EXAM			
V	Introduction to Biomedical signal processing, Methods of signal processing – Digital and analogue. Introduction to Biomedical image processing- Analysis of x-rays, CT and MRI images – Basic methods.	6	20
VI	Instrumentation for clinical laboratory - Measurement of pH value of blood, ESR, and GSR measurement, modern imaging modalities - X-ray machines, Diagnostic x-rays - Computed Tomography – Ultrasonography - Magnetic resonance imaging - Nuclear medicine - Radio isotopic instrumentation - Medical uses of isotopes – Applications of robotics in medical field- Cyber knife.	6	20
END SEMESTER EXAM			

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

Course Objectives:

To present a comprehensive overview of Electric and Hybrid Electric Vehicle

Syllabus

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

Expected Outcome:

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

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

References

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

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

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

COURSE PLAN

Module	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),	6	20%

	Design of a Battery Electric Vehicle (BEV).		
6	Communications, supporting subsystems: In vehicle networks- CAN, Energy Management Strategies: Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy management strategies.	6	20%
	End Semester Exam		

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE7591	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
01EE7593	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.

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01EE7594	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.