M.Tech Programme

Electrical Engineering- Power Control & Drives

Curriculum and Scheme of Examinations

SEMESTER I

Code No.	Name of Subject	Credits	Hrs / week	End Sem Exam (hours)	Marks			Remarks
					Internal Continuous Assessment	End Semester Exam	Total	
EMA 1002	Applied Mathematics	3	3	3	40	60	100	Of the 40 marks of internal assessment, 25 marks for tests and 15 marks for assignments. End sem exam is conducted by the University
EDC 1001	Power Coverters and Analysis	3	3	3	40	60	100	Do
EIC 1002	Advanced Signal Processing	3	3	3	40	60	100	Do
EMC 1002	Modeling of Electrical Machines	3	3	3	40	60	100	Do
EDC 1002	Applications of Power Electronics in Power Systems	3	3	3	40	60	100	Do
ECC 1003	Dynamics of Linear Systems	3	3	3	40	60	100	Do
EDC 1101	Power Electronics Lab	1	2	-	100	-	100	No End Sem Examinations
EDC 1102	Seminar	2	2	-	100	-	100	Do
	TOTAL	21	22		440	360	800	7 Hours of Departmental assistance work

SEMESTER II

Code No.	Name of Subject	Credits	Hrs / week	End Sem Exam (hours)	Marks			Remarks
					Internal Continuous Assessment	End Semester Exam	Total	
EDC 2001	Design Principles in Power Converters	3	3	3	40	60	100	Of the 40 marks of internal assessment, 25 marks for tests and 15 marks for assignments. End sem exam is conducted by the University
EMC 2001	Electric Drives	3	3	3	40	60	100	Do
**	Stream Elective I	3	3	3	40	60	100	Do
**	Stream Elective II	3	3	3	40	60	100	Do
**	Department Elective	3	3	3	40	60	100	Do
ECC 2000	Research Methodology	2	2	3	40	60	100	End Sem Exam is conducted by the Individual Institutions
EDC 2101	Drives & Simulation Lab	1	2	-	100		100	No End Sem Examinations
EDC 2102	Seminar	2	2	-	100		100	do
EDC 2103	Thesis - Preliminary - Part I	2	2	-	100		100	do
	TOTAL	22	23	---	540	360	900	6 Hours of Departmental assistance work

Stream Elective I

EDE2001	Power Quality Assessment and Improvement
EDE2002	Finite Element Methods of Electrical Machines
EDE2003	Power Electronics for Renewable Energy Systems
EDE2004	Digital Simulation of Power Electronic Systems

Stream Elective II

EDE2005	Power System Planning Operation & Control
EDE2006	Microcontroller Applications in Power Electronics
EDE2007	Optimization Techniques for Power Control

List of Department Electives

ECD2001	Industrial Data Networks
ECD2002	Process Control and Industrial Automation
ECD2003	Soft Computing Techniques
ECD2004	Embedded Systems and Real-time Applications
ECD2005	Biomedical Instrumentation
EPD2001	New and Renewable Source of Energy
EPD2002	SCADA System and Application
EMD2001	Electric and Hybrid Vehicles
EDD2001	Power Electronics System Design using ICs
EDD2002	Energy auditing conservation and Management
EDD2003	Advanced Power System Analysis
EDD2004	Industrial Automation Tools
EID2001	Advanced Microprocessors and Microcontrollers
EID2002	Modern Power Converter
EID2003	Power Plant Instrumentation
EID2004	Advanced Control System Design
EID2005	Multivariable Control Theory

SEMESTER III

Code No.	Name of Subject	Credit	Hrs / week	End Sem Exam (hours)	Marks			Remarks
					Continuous Assessment	End Semester Exam	Total	
**	Stream Elective III	3	3	3	40	60	100	End Sem Exam is conducted by the Individual Institutions
**	Stream Elective IV	3	3	3	40	60	100	Do
**	Non- Dept. (Interdisciplinary) Elective	3	3	3	40	60	100	Do
EDC 3101	Thesis – Preliminary – Part II	5	14	-	200		200	No End Sem Examinations
	TOTAL	14	23		320	180	500	6 Hours of Departmental assistance work

Stream Elective III

EDE3001	Reactive Power Management in Power systems
EDE3002	Instrumentation for Power Electronics and Power Systems
EDE3003	Digital Controllers in Power Electronics
EDE3004	Power System Protection

Stream Elective IV

EDE3005	Control of Advanced Electrical Machines
EDE3006	Switched Mode Power Converters
EDE3007	FACTS and Custom Power Devices
EDE3008	Embedded Systems & FPGA based Systems Design

SEMESTER IV

Code No	Subject Name	Credits	Hrs/ week	Marks				
				Continuous Assessment		University Exam		Total
				Guide	Evaluation Committee	Thesis Evaluation	Viva Voce	
EDC 4101	Thesis	12	21	150	150	200	100	600
	TOTAL	**12**	**21**	**150**	**150**	**200**	**100**	8 Hours of Departmental assistance work

EDC1001 POWER CONVERTERS AND ANALYSIS 3-0-0-3

Pre-requisites: Basic Course in Power Electronics

Structure of the Course

Lecture	: 3 hrs/week	Credits: 3
Internal Continuous Assessment	: 40 Marks	
End Semester Examination	: 60 Marks	

Course Objectives

1. To give in depth knowledge of the various power electronics circuits,
2. Analyze the behaviour of the Power Electronic circuits.

Learning Outcomes

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

1. Analyze the circuits and select them for the suitable applications.
2. Understand the problems associated with the Power Electronic circuits.

Module 1

Uncontrolled rectifiers – Single phase and three phase – Analysis with R and RL loads, Analysis with capacitive filter – Line current Distortion, Total Harmonic Distortion, Displacement Power Factor, Power Factor, Line voltage distortion – effect of source inductance.
Controlled Rectifiers – Single phase and Three phase – fully controlled and semi controlled- Analysis with RL, RLE loads – Performance, Voltage conversion ratio, Effect of source impedance – power factor – Inversion mode of operation

Module 2

DC-DC Converters: Steady state analysis and design of DC to DC converters. Buck, Boost, Buck-Boost, and Ćuk converters. Control methods of DC to DC converters- duty ratio control. Principles of volt-seconds balance in inductor for analysis of DC-DC converter topologies. Voltage conversion ratios of different topologies .Current ripple and voltage ripple calculations.
Isolated dc-dc converter topologies: fly-back and forward converters, Push-pull and bridge topologies. Steady state analysis – Voltage conversion ratios. Use in Switched Mode Power Supplies-Characteristics of SMPS – Requirements of isolation and protection.

Module 3

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 - Resonant inverters – series and parallel, concept of multi level inverters.

References

1. Daniel W. Hart, *Introduction to Power Electronics*, Prentice Hall, 1997
2. L. Umanand , *Power Electronics: Essentials and Applications*, Wiley, 2009
3. Rashid M.H., *Power Electronics Circuits, Devices and Applications*, 2nd edition, Prentice Hall India, New Delhi, 1995.
4. Ned Mohan, Undeland, Robbins, *Power Electronics: Converters, Applications and Design*, 3rd ed., John Wiley, 2003
5. Cyril W. Lander, *Power Electronics*, Third Edition, McGraw-Hill, 1993
6. G. K. Dubey, S. R. Doradla, R. M. K Sinha, *Thyristorised Power Controllers*, New Age International Publications, reprint: 2005
7. William Shepherd, Li Zhang, *Power Converter Circuits*, Marcel Dekker, 2004
8. Joseph Vithayathil, *Power Electronics: Principles and Applications*, McGraw-Hill, 1994

Structure of the Question paper

For the end semester examination, the question paper will consist of 60 % Design problems and 40 % Theory. There will be three questions from each module out of which two questions are to be answered by the students.

EIC1002 ADVANCED SIGNAL PROCESSING

Structure of the course

Lecture	: 3 hrs/week	Credits: 3
Internal Continuous Assessment	: 40 Marks	
End Semester Examination	: 60 Marks	

Course Objective

To learn about DSP techniques.

Learning Outcomes

Upon successful completion of this course, students will be able to apply signal processing strategies.

Module I

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

Module II

Digital Filter Design Techniques-Introduction – Design of IIR Digital Filters from Analog Filters –Analog –Digital Transformation –Properties of FIR Digital Filters –Design of FIR Filters Using Windows –A Comparison of IIR and FIR Digital Filters. Finite Register Length Effects-Introduction -Effects of coefficient on Quantization –Quantization in Sampling -Analog Signals - Finite Register Length effects in realizations of Digital Filters – discrete Fourier Transform Computations

Module III

Time frequency analysis, the need for time frequency analysis, Time frequency distribution, Short time Fourier Transform, Wigner distribution. Multirate digital signal processing: Basic multirate operation (up sampling, down sampling), Efficient structures for decimation and interpolation, Decimation and interpolation with polyphase filters, Noninteger sampling rate conversion , Efficient multirate filtering Applications, 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 – Instruction and programming –Simple programs.

References

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

Structure of the Question paper

For the end semester examination, the question paper will consist of three questions from each module out of which two questions are to be answered by the students

EMC 1002 MODELING OF ELECTRICAL MACHINES 3-0-0-3

Structure of the course

Lecture	: 3 hrs/week	Credits: 3
Internal Assessment	: 40 Marks.	
End semester Examination	: 60 Marks	

Course Objective

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

Learning Outcome

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

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

Module I

Unified approach to the analysis of electrical machine performance - per unit system - basic two pole model of rotating machines- Primitive machine -special properties assigned to rotor windings - transformer and rotational voltages in the armature voltage and torque equations resistance, inductance and torque matrix. Transformations - passive linear transformation in machines- invariance of power - transformation from three phase to two phase and from rotating axes to stationary axes-Park's transformation

Module II

DC Machines: Application of generalized theory to separately excited, shunt, series and compound machines. Steady state and transient analysis, transfer functions. Sudden short circuit of separately excited generator, sudden application of inertia load to separately excited dc motor.
Synchronous Machines: synchronous machine reactance and time constants-Primitive machine model of synchronous machine with damper windings on both axes. Balanced steady state analysis-power angle curves. Transient analysis- sudden three phase short circuit at generator terminals - armature currents and torque. - Transient power angle curve

Module III

Induction Machines: Primitive machine representation- Steady state operation-Equivalent circuit- Double cage rotor representation - Equivalent circuit -Single phase induction motor- Voltage and Torque equations.

References

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

Structure of the question paper

For the end semester examination, the question paper contains three questions from each module out of which two questions are to be answered by the student.

EDC1002 APPLICATIONS OF POWER ELECTRONICS IN POWER SYSTEMS 3-0-0-3

Prerequisite: Basic course in Power Systems and Power Electronics

Structure of the Course

Lecture	: 3 hrs/week	Credits: 3
Internal Continuous Assessment	: 40 Marks	
End Semester Examination	: 60 Marks	

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 familiarise the problems related to power quality

Learning Outcomes

Upon successful completion of this course, students will be

1. Implementation of FACTS devices
2. Solve issues related to power quality

Module I

Steady state and dynamic problems in AC systems. Flexible AC transmission systems (FACTS). Principles of series and shunt compensation. Description of static VAR compensators (SVC), Thyristor Controlled series compensators (TCSC), Static phase shifters (SPS), Static condenser (STATCON), Static synchronous series compensator (SSSC) and Unified power flow controller (UPFC). Modelling and Analysis of FACTS controllers. Control strategies to improve system stability

Module II

Power Quality problems in distribution systems, harmonics, harmonics creating loads, modelling, harmonic propagation, Series and parallel resonances, harmonic power flow, Mitigation of harmonics, filters, passive filters, Active filters, shunt, series hybrid filters, voltage sags & swells, voltage flicker. Mitigation of power quality problems using power electronic conditioners. IEEE standard 1159-2009.

Module III

Need for HVDC, AC vs. DC: Comparative advantages. Converters and their characteristics. Control of the converters (CC and CEA). Parallel and series operation of converters. Distributed Generation - Resurgence of DG - DG Technologies, Interface to the Utility System. Local and Remote Techniques for Islanding Detection in Distributed Generators. Distributed Generation and Islanding – Study on Converter Modelling of PV Grid Connected Systems under Islanding Phenomena. Performance of Micro turbine Generation System in Grid Connected and Islanding Modes of Operation.

References

1. Roger C. Ducan, McGranaghan, Santose Beaty, *Electrical Power Systems Quality*, McGraw-Hill, New York, 2nd edition, 2002.
2. Hingorani N. G. & L. Gyugyi, *Understanding Facts Concepts and Technology of Flexible AC Transmission Systems*, Standard Publishers Distributors, 2001
3. G. T. Heydt, *Power Quality*, Stars in a Circle Publications, Indiana, 1991.
4. T. J. E. Miller, *Static Reactive Power Compensation*, John Wiley & Sons, New York, 1982.
5. K. R. Padiyar, *HVDC Power Transmission Systems*, Wiley eastern Ltd. 1990.
6. Loi Lei Lai, Tze Fun Chan, *Distributed Generation: Induction and Permanent Magnet Generators*, IEEE Press, John Wiley & Sons Ltd., England 2007
7. E. J. Womack, *MHD Power Generation Engineering Aspects*, Chapman and Hall Publication, 2002.
8. D. N. Gaonkar, '*Distributed Generation'*, e-book

Structure of the question paper

For the end semester examination, the question paper contains three questions from each module out of which two questions are to be answered by the student.

ECC1003 DYNAMICS OF LINEAR SYSTEMS 3-0-0-3

Structure of the course

Credits: 3

Lecture : 3 hrs/week
Internal Assessment : 40 Marks
End semester Examination : 60 Marks

Course Objectives

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

Learning Outcomes

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

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

Module I

Design of feedback control systems- Approaches to system design-compensators-performance measures - cascade compensation networks-phase lead and lag compensator design using both Root locus and Bode plots-systems using integration networks, systems with pre-filter, PID controllers-effect of proportional, integral and derivative gains on system performance, PID tuning , integral windup and solutions.

Module II

State Space Analysis and Design- Analysis of stabilization by pole cancellation - Canonical realizations - Parallel and cascade realizations - reachability and constructability - stabilizability - controllability - observability -grammians. Linear state variable feedback for SISO systems, Analysis of stabilization by output feedback-modal controllability-formulae for feedback gain -significance of controllable Canonic form-Ackermann's formula- feedback gains in terms of Eigen values - Mayne-Murdoch formula - Transfer function approach - state feedback and zeros of the transfer function - non controllable realizations and stabilizability -controllable and uncontrollable modes - regulator problems - non zero set points - constant input disturbances and integral feedback.

Module III

Observers: Asymptotic observers for state measurement-open loop observer-closed loop observer-formulae for observer gain - implementation of the observer - full order and reduced order observers - separation principle - combined observer -controller – optimality criterion for choosing observer poles - direct transfer function design procedures - Design using polynomial equations - Direct analysis of the Diophantine equation.
MIMO systems: Introduction, controllability, observability, different companion forms.

References

1. Thomas Kailath, *Linear System*, Prentice Hall Inc., Eaglewood Cliffs, NJ, 1998
2. Benjamin C. Kuo, *Control Systems*, Tata McGraw-Hill, 2002
3. M. Gopal, *Control Systems-Principles and Design*, Tata McGraw-Hill
4. Richard C. Dorf & Robert H. Bishop, *Modern Control Systems*, Addison Wesley, 8th Edition, 1998
5. Gene K. Franklin & J. David Powell, *Feedback Control of Dynamic Systems*, Addison -Wesley, 3rd Edition
6. Friedland B., *Control System Design: An Introduction to State Space Methods*, McGraw-Hill, NY 1986
7. M. R. Chidambaram and S. Ganapathy, *An Introduction to the Control of Dynamic Systems*, Sehgal Educational Publishers, 1979
8. C.T. Chen, *Linear System Theory and Design*, Oxford University Press, New York, 1999

Structure of the question paper

For the end semester examination, the question paper consists of at least 60% design problems and derivations. The question paper contains three questions from each module out of which two questions are to be answered by the student.

EDC1101 POWER ELECTRONICS LAB 0-0-2-1

Structure of the course

Lecture	: 2 hrs/week	Credits: 1
Internal Assessment	: 100 Marks.	
End semester Examination	: Nil	

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

Learning Outcomes

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

Experiments

1. Single phase, three phase Semi converters and Full converters
   a) R load
   b) RL load
   c) RLE (motor) load
2. DC-DC Choppers using self communicating Devices.
3. Single phase and three phase inverters using IGBTs
4. AC-AC voltage regulators
   a) Lamp load
   b) Motor load

2. Practical converter design considerations - Snubber design, gate and base drive circuits.
3. Generation of sine-PWM using analog circuits
4. Gate drive circuits for MOSFETs , IGBTs, Transient performance
5. MATLAB simulations on some of the above experiments

EDC1102 SEMINAR

Structure of the Course

Seminar	: 2 hrs/week	Credits : 2
Internal Continuous Assessment	: 100 Marks	

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

Marks:	Seminar Report Evaluation	: 50
	Seminar Presentation	: 50

EDC2001 DESIGN PRINCIPLES IN POWER CONVERTERS 3-0-0-3

Prerequisites: Basic Course in Power Electronics

Structure of the Course

Lecture	: 3 hrs/week	Credits: 3
Internal Continuous Assessment	: 40 Marks	
End Semester Examination	: 60 Marks	

Course Objectives

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

Learning Outcomes

Upon successful completion of this course, students will be able

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

Module I

Power circuit design, selection of power devices, losses, advanced thermal design, Typical examples based on dc-dc converters and bridge inverters.

Magnetics design based on area-product approach, inductors, transformers, design of current transformers.

Passive elements in Power electronics: Inductors : types of inductor and transformer assembly, cores : amorphous, ferrite iron and powdered iron cores : magnetic characteristics and loss performance and size, relative merits/demerits.

Capacitors: types of capacitors used in PE, selection of capacitors, dc link capacitors in inverters and rectifiers, filter capacitors in dc-dc and inverter circuits, Equivalent Series Resistance (ESR) and Equivalent Series Inductance (ESL) in capacitors.

Module II

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.

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 (limitations and scope of each method).

Module III

Design of protection elements, thermal protection, thermal sensor based protection, short-circuit and over-current protection in IGBTs using de-saturation schemes -Design of filters - input and output filters - selection of components - typical filter design for single phase and three phase inverters - LC filter - corner frequency selection - harmonic filtering performance - Constraints in the design.
Basics of EMI/EMC issues: conductive and radiated EMI- basic solutions. System integration.

References

1. V. Ramanarayanan, "*Switch Mode Power Conversion*," e-book, Department of Electrical Engineering, Indian Institute of Science, Bangalore.
2. L. Umanand, "*Power Electronics: Essentials & Applications*," New Delhi, Wiley India Pvt. Ltd.
3. Ned Mohan, Undeland, Robbins, '*Power Electronics: Converters, Applications and Design'*, 3rd edn., John Wiley, 2003
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

Structure of the question paper

For the end semester examination, the question paper contains three questions from each module out of which two questions are to be answered by the student.

EMC2001 **ELECTRIC DRIVES** **3-0-0-3**

Structure of the course

Lecture	: 3 hrs/week	Credits: 3
Internal Assessment	: 40 Marks	
End semester Examination	: 60 Marks	

Course Objective

The improvement in converters and development of new drive control strategies such as field oriented (vector) control of A C drives, sliding mode control, energy saving strategies etc provided an opportunity to bring about another revolution in drive technology and performance

Learning Outcomes

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

1. Select a suitable drive for a 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 explore and do research in advanced topics in electric drives.

Module I

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 – 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

Module-II

Induction Motor Drives: Steady state equivalent circuit of 3-phase Induction motor-- Stator voltage control – constant v/f speed control with VSI -v/f control with slip compensation– Slip-power recovery schemes –sub-synchronous and super-synchronous speed operation (Static Kramer and Static Scherbius drives).

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**.**

Module-III

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—Vector control of Permanent Magnet Brushless DC Motors.

Speed Control of Trapezoidal EMF machines (Brushless DC motors)- Basic principles and Control schemes.

References

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

Structure of the question paper

For the end semester examination, the question paper contains three questions from each module out of which two questions are to be answered by the student.

EDE 2001 POWER QUALITY ASSESSMENT AND IMPROVEMENT 3-0-0-3

Prerequisite: Basic course in Power Systems

Structure of the Course

Lecture	: 3 hrs/week	Credits: 3
Internal Continuous Assessment	: 40 Marks	
End Semester Examination	: 60 Marks	

Course Objectives

To study principles and algorithms of digital relaying for protection of power systems.

Learning Outcomes

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

1. Understand various communication architectures and protocols in an embedded system
2. Understand capabilities of Embedded C and execute basic programs using it
3. Understand, Analyse RTOS features and apply them for real time applications

Module I

Power Quality: Need for power quality- general classes of power quality problems- transients- long duration voltage variations- short duration voltage variations- voltage imbalance- waveform distortions- voltage fluctuations- power acceptability curves

Sources of power quality issues: Poor load power factor- loads containing harmonics- notching in loads- unbalanced loads- disturbance in supply voltage.

Introduction to power quality standards and power quality monitoring- IEEE 1159-2009

Module II

Measurement and analysis of power quality indices: RMS voltage and current- distortion factors- distortion power- power factor- crest factors-telephone interference factor

Harmonic studies: Electric circuit analysis and power assessment under non sinusoidal conditions- symmetrical components- harmonic propagation studies in large network-Fourier analysis-FFT analysis- wavelet transforms.

Module III

Power Quality Solutions: Passive filters-reactive power compensation- shunt, series and hybrid active filters- instantaneous reactive power theory (IRPT) algorithm- Synchronous Detection (SD) algorithm- DC bus voltage algorithm- Synchronous Reference Frame (SRF) algorithm- AI based control algorithm-custom power devices

References

1. R.C. Dugan , '*Electrical Power Systems Quality'*, 2nd edition, McGraw-Hill Companies
2. Arindam Ghosh "*Power Quality Enhancement Using Custom Power Devices*", Kluwer Academic Publishers, 2002
3. G. T. Heydt, '*Electric Power Quality'*, Stars in a Circle Publications, 1994(2nd edition)
4. Barry W Kennedy, '*Power Quality Primer'*, The McGraw Hill Companies, 2000
5. A.J. Arrillaga , '*Power System Harmonics'*, Wiley, 2nd edn., 2003
6. Math J. Bollen, "*Understanding Power Quality Problems-Voltage Sags and Interruptions*", John Wiley & Sons Ltd., 2001
7. Enrique Acha and Manuel Madrigal, "*Power Systems Harmonics-Computer Modelling and Analysis*", John Wiley & Sons Ltd., 2001
8. George J. Wakileh, "*Power Systems Harmonics-Fundamentals, Analysis and Filter Design*", Springer-Verlag, New York ,2001
9. J. Arillaga, N. R. Watson, S. Chen, "*Power System Quality Assessment*", John Wiley &Sons, England, 2000.
10. Derek A. Paice, '*Power Electronic Converter Harmonics: Multipulse Methods for Clean Power'*, Wiley-IEEE Press, 1999.

Structure of the Question Paper

For the end semester examination, the question paper consists of three questions from each module, out of which two are to be answered by the students.

EDE2002 FINITE ELEMENT METHODS OF ELECTRICAL MACHINES 3-0-0-3

Structure of the Course

Lecture	: 3 hrs/ Week	Credits: 3
Internal Continuous Assessment	: 40 Marks	
End Semester Examination	: 60 Marks	

Course Objective

1. To introduce the basics of Computer Aided Design technology for the design of Electrical Machines
2. To give a basic idea of the finite elements methods as applicable to electrical engineering
3. To apply for analyzing the performance of electrical machines.

Learning Outcomes

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

1. Learn the importance of computer aided design method.
2. Understand the basic electromagnetic field equations and the problem formulation for CAD applications.
3. Become familiar with Finite Element Method as applicable for Electrical Engineering.
4. Know the organization of a typical CAD package.
5. Apply Finite Element Method for the design of different Electrical apparatus

Module I

*Introduction***:** Conventional Design Procedures – Limitations – Need For Field Analysis Based Design – History Of Development And Applications – Recent Trends.
Mathematical Formulation Of Field Problems : Review – Development Of Torque/Force – Electromagnetic Field Equations – Magnetic Vector/Scalar Potential – Electrical Vector/Scalar – Potential – Stored Energy In Field Problems – Inductances - Maxwell Equations – Laplace And Poisons Equations – Energy Functional – Principle Of Energy Conversion.

Module II

Philosophy Of FEM : Mathematical Models – Differential/Integral Equations –Finite Difference Method – Finite Element Method – Energy Minimization – Variational Method – 2d Field Problems – Discretization – Shape Function – Stiffness Matrix – 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 – Solution Techniques .

Module III

CAD Packages And Design Applications : Elements Of CAD Systems – Preprocessing – Modelling – Meshing – Material Properties – Boundary Conditions – Setting Up Solutions – Post Processing.
Design Applications: Electric And Magnetic Fields In Co-Axial Cable – Voltage Stress in Insulators – Capacitance calculation - Design of Solenoid Actuator – Inductance and force calculation – Torque calculation in Switched Reluctance Motor.

References

1. S. J. Salon, '*Finite Element Analysis of Electrical Machines'*, Kluwer Academic Publishers, London, 1995.
2. Nicola Bianchi, '*Electrical Machine Analysis using Finite Elements'*, CRC Taylor& Francis, 2005.
1. Joao Pedro, A. Bastos and Nelson Sadowski, '*Electromagnetic Modelling by Finite Element Methods'*, Marcell Dekker Inc., 2003
2. Peter P. Silvester , Ronald L Ferrari. '*Finite Elements For Electrical Engineers'* , Cambridge University Press, 1983
3. S.R.H.Hoole, '*Computer Aided Analysis and Design of Electromagnetic Devices'*, Elsevier, New York, 1989.
4. D.A.Lowther and P.P Silvester, '*Computer Aided Design in Magnetics'*, Springer Verlag, New York, 1986.
5. Krishna Moorthy C. S., *An Introduction To Computer Aided Electromagnetic Analysis*, Vector Field Finite Element Analysis.
6. User Manuals of MAGNET, MAXWELL & ANSYS Softwares.

Structure of the Question Paper

For the end semester examination, the question paper consists of three questions from each module, out of which two are to be answered by the students.

EDE2003 POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS 3-0-0-3

Structure of the Course

Lecture	: 3 hrs/week	Credits: 3
Internal Continuous Assessment	: 40 Marks	
End Semester Examination	: 60 Marks	

Course Objectives

1. To study the various renewable energy options.
2. To conduct qualitative study of power converters

Learning Outcomes

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

1. Understand technology behind green energy harnessing
2. Understand power electronic application to renewable
3. Undertake projects based on grid interconnected green power system.

Module I

Introduction: Environmental aspects of electric energy conversion: impacts of renewable energy generation on environment (cost-GHG Emission) - Qualitative study of different renewable energy resources: Solar, wind, ocean, Biomass, Fuel cell, Hydrogen energy systems and hybrid renewable energy systems.

Electrical machines for Renewable Energy conversion**:** Review of reference theory fundamentals-principle of operation and analysis: IG, PMSG, SCIG and DFIG.

Module II

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.

Wind: three phase AC voltage controllers- AC-DC-AC converters: uncontrolled rectifiers, PWM Inverters, Grid Interactive Inverters - matrix converters.

Module III

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-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).

References

1. Rashid .M. H, *Power Electronics Handbook*, Academic press, 2nd edn., 2001.
2. Rai. G.D, *Non-conventional Energy Sources*, Khanna publishers, 1993.
3. Rai. G.D, *Solar Energy Utilization*, Khanna Publishers, 1993.
4. Gary, L. Johnson, *Wind Energy System*, Prentice Hall Inc, 1995.
5. B.H. Khan, *Non-conventional Energy Resources*, Tata McGraw-Hill Publishing Company, New Delhi.
6. Leon Freris, David Infield, *Renewable Energy in Power Systems*, John Wiley & Sons., 2008

Structure of the Question Paper

For the end semester examination, the question paper consists of three questions from each module, out of which two are to be answered by the students.

EDE 2004 DIGITAL SIMULATION OF POWER ELECTRONIC SYSTEMS 3-0-0-3

Pre-requisites: Basic Course in Power Electronics.

Structure of the Course

Lecture: 3 hrs/week Credits: 3
Internal Continuous Assessment: 40 Marks
End Semester Examination : 60 Marks

Course Objectives

1. To give in depth knowledge of the various power electronics circuits,
2. Analyze the behaviour of the Power Electronic circuits.

Learning Outcomes

After completing the course, the student should be able to:

1. Analyze the circuits and select them for the suitable applications.
2. Understand the problems associated with the Power Electronic circuits.

Module I

Principles of Modelling Power semi conductor Devices-Macro Models versus Micro models-Thyristor models-Semiconductor Device modelled as Resistance, resistance –Inductance and Inductance –Resistance-Capacitance combination- 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.

Module II

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, simulation of basic electric drives, stability aspects.
Dynamic modelling and simulation of DC-DC converters using MATLAB-Simulation of
State Space Models. Modelling and simulation of inverters using MATLAB.

Module III

Circuit analysis Software Micro Sim Pspice 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.
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.

References

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

Structure of the Question Paper

For the end semester examination, the question paper consists of three questions from each module, out of which two are to be answered by the students.

EDE2005 POWER SYSTEM PLANNING, OPERATION & CONTROL 3-0-0-3

Structure of the Course

Lecture	: 3 hrs/week	Credits: 3
Internal Continuous Assessment	: 40 Marks	
End Semester Examination	: 60 Marks	

Course Objectives

1. To get an in depth knowledge in planning and operation
2. Analyze the behaviour of the Power Electronic circuits.

Learning Outcomes

Upon successful completion of this course, students will be able to:
1. Analyze the circuits and select them for the suitable applications.
2. Understand the problems associated with the Power Electronic circuits.

Module I

Objectives of planning – Long and short term planning .Load forecasting – characteristics of loads – methodology of forecasting – energy forecasting – peak demand forecasting – total forecasting – annual and monthly peak demand forecasting.
Characteristics of power generation units: Characteristics of steam units, variation in steam unit characteristics, cogeneration. Plants, hydro electric units.

Module II

Economic dispatch of thermal units: Economic dispatch problem, thermal dispatching with network losses considered, Penalty factors, lambda iteration method, gradient method, Newtons method.
Dynamic programming, base point and participation factors. Economic dispatch vs. Unit commitment, constraints in unit commitment. Introduction to optimal power Flow, solution of optimal power flow by gradient method.
Hydro thermal co-ordination: Introduction to long range and short range hydro scheduling, types of short range. Scheduling problem, scheduling energy. The short term hydro-thermal scheduling
Problems and its solution by lambda-gamma iteration method and gradient method.

Module III

Generation control: Generator, prime mover, governor, tie line and load models, load frequency Control, load frequency and economic dispatch control, automatic voltage control, Load frequency control with generation rate constraints, decentralized control.
Interchange of power and energy: Economy interchange between inter connected utilities, inter utility economy. Energy evaluation, capacity interchange, diversity interchange, energy banking, Emergency power interchange, power pools, transmission effects and issues.

References

1. Allen J. Wood, Bruce F. Woollenberg, *Power Generation Operation and Control*, John Wiley & Sons, 2nd Edition 1996.
2. D. P. Kothari and J. S. Dhillon, *Power System Optimization*, Prentice-Hall of India, Pvt. Ltd., New Delhi, 2006
3. L. K Kirchmayer, *Economic Operation of Power Systems*, John Willey & Sons, NY, 99^{th} Edn., 2009.
4. D. P. Kothari, I. J. Nagrath, *Modern Power System Analysis*, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 3^{rd} edn. 2006.
5. Sullivan R. L., *Power System Planning*, McGraw-Hill Inc., US, 1987.

Structure of the Question Paper

For the end semester examination, the question paper consists of three questions from each module, out of which two are to be answered by the students.

EDE2006 MICROCONTROLLER APPLICATIONS IN POWER ELECTRONICS 3-0-0-3

Structure of the Course

Lecture	: 3 hrs/week	Credits: 3
Internal Continuous Assessment	: 40 Marks	
End Semester Examination	: 60 Marks	

Course Objectives

1. To understand how embedded devices can be used in the field of power electronics
2. To familiarize the operation of microcontrollers.

Learning Outcomes

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

1. Analyze different family of microcontroller
2. Implement microcontroller in various control schemes.

Module 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, Assembly language, addressing modes-instruction set – interrupt structure – high speed inputs, expansion methods – bus control- memory timing – external RAM and ROM expansion – PWM control- A/D interface.

Software blocks and applications**:** Application of 8051 controller to generate gating signal for converters and inverters.

Module II

Microcontrollers in Closed Loop Control Schemes: Importance of measurement and sensing in closed loop control, Measurement of voltage, current, speed, power and power factor using microprocessors, Per-unit representation of variables in digital domain, data representation in fixed point and floating point form, round-off errors- Implementation of P, PI and PID controllers using microprocessors.

Module III

Microcontroller Based Firing Scheme For Converters: Firing schemes for single phase and three phase rectifiers-3-phase AC choppers, Firing at variable frequency environments, Firing scheme for DC choppers, voltage and current commutation. Inverters, types of pulse width modulation techniques, their implementation. Using microcontrollers, application of these firing schemes to the control of DC drive, induction motors, synchronous motors and other special machines, Application in Electrical Traction.

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.

References

1. Kenheth J. Hintz and Daniel Tabak, ‘*Microcontrollers: Architecture, Implementation and Programming*’, McGraw Hill, USA, 1992
2. John B. Peatman, ‘*Design with Microcontrollers’*, McGraw-Hill International Ltd, 1997
3. *8-bit Embedded Controllers*, Intel Corporation, 1990
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.

Structure of the Question Paper

For the end semester examination, the question paper consists of three questions from each module, out of which two are to be answered by the students.

EDE2007 OPTIMIZATION TECHNIQUES FOR POWER CONTROL 3-0-0-3

Structure of the Course

Lecture	: 3 hrs/week	Credits: 3
Internal Continuous Assessment	: 40 Marks	
End Semester Examination	: 60 Marks	

Prerequisites: Knowledge in matrix algebra and differential calculus

Course Objectives

1. Introduce methods of optimization to engineering students.
2. Maintain a balance between theory, numerical computation, and problem setup for solution by optimization software, and applications to engineering systems.
3. Be capable of determining which models are appropriate to use in practical situations.

Learning Outcomes

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

1. Master basic process, implementation and analysis of master genetic algorithm
2. Master the basic process implementation, analysis and applications of single-objective optimization algorithm
3. Grasp the focus on solutions for multi-objective optimization algorithm with constraints based on evolutionary strategies
4. Master the basic process implementation, analysis and applications of multi-objective optimization algorithm

Module I

Classification of optimization problems and applications-Basic concepts of design vectors-design constraints-constraint surface and objective function surfaces-formulation and solution of linear programming problem-Karmarker's method-simplex method-two phase simplex method-duality theory, Duel simplex method-sensitivity analysis to linear programming problem-changes in constants of constraints-changes in cost coefficients-changes in the coefficients of constraints-addition of new variables and addition of new constraints

Module II

Introduction to Integer Programming methods

Branch and bound method-Gomory's cutting plane method for integer and mixed integer programming- integer polynomial programming –sequential linear discrete programming and non linear programming-Nonlinear programming –Properties of single and multivariable functions-Optimality criteria-Direct search methods-Gradient based methods-Newton's method-conjugate Gradient methods-Quasi-Newton Methods-DFP methods-Broyden-Fletcher-Golfarb-Shanno method

Module III

Constrained optimality criteria-Lagrange multipliers-KKT Conditions-interpretation of KKT conditions, Second order optimality Conditions-Linearization methods for constrained problems-method of feasible directions-GRG methods-Quadratic approximation methods for constrained problems-variable metric methods for constrained optimization- Quadratic Programming-Dynamic Programming-Stochastic linear programming- Stochastic non linear programming- Stochastic separable programming-multi objective optimization methods

Basic concepts of Genetic algorithm based optimization

References

1. G. V. Reklaitis, A. Ravindran, K. M. Rajsdell, *Enginee*ring *Optimization: Methods and Applications*, John Wiley & Sons
2. Singiresu S. Rao, *Engineering Optimization Theory and Practices*, 4th edition, Wiley and Sons, 2009.
3. Ravindran, Don T. Philips, Jamer J. Solberg, *Operations Research: Principles and Practice*, Wiley and Sons
4. P. G. Gill, W. Murray and M. H. Wright, *Practical Optimization*, Academic Press 1981.
5. G. V. Reklaitis, A. Ravindran & K. M. Rajsdell, *Engineering Optimization: Methods and Applications*, John Wiley & Sons.
6. Fredrick S. Hiller and G. J. Liberman, *Introduction to Operations Research*, McGraw-Hill Inc. 1995
7. Kalyanmay Deb, 'Optimization for Engineering Design-Algorithms and Examples', Prentice Hall India, 8th edition, 2005.
8. Ashok D. Belegundu, Tirupathi R. Chandrapatla, *'Optimization Concepts and Applications in Engineering*, Pearson Education, Delhi, 2002

Structure of the Question Paper

For the end semester examination, the question paper consists of three questions from each module, out of which two are to be answered by the students.

ECD2001 INDUSTRIAL DATA NETWORKS 3-0-0-3

Structure of the course

Credits: 3

Lecture : 3 hrs/week
Internal Assessment : 40 Marks
End semester Examination : 60 Marks

Course objectives

1. To understand the basics of data networks and internetworking
2. To have adequate knowledge in various communication protocols
3. To study the industrial data networks

Learning Outcomes

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

1. Explain and analyse the principles and functionalities of various industrial Communication Protocols
2. Implement and analyse industrial Ethernet and wireless communication modules

Module I

Data Network Fundamentals: Network hierarchy and switching – Open System Interconnection model of ISO– Data link control protocol: - HDLC – Media access protocol – Command/response – Token passing – CSMA/CD, TCP/IP, Bridges – Routers – Gateways –Standard ETHERNET and ARCNET configuration special requirement for networks used for control.

Module II

Hart, Fieldbus, Modbus and Profibus PA/DP/FMS and FF: Introduction- Evolution of signal standard – HART communication protocol – Communication modes - HART networks - HART commands - HART applications. Fieldbus: Introduction - General Fieldbus architecture - Basic requirements of Field bus standard - Fieldbus topology - Interoperability - Interchangeability - Introduction to OLE for process control (OPC). MODBUS protocol structure - function codes - troubleshooting Profibus: Introduction - profibus protocol stack – profibus communication model - communication objects - system operation - troubleshooting - review of foundation field bus.

Module III

Industrial Ethernet and Wireless Communication: Industrial Ethernet: Introduction - 10Mbps Ethernet, 100Mbps Ethernet. Radio and wireless communication: Introduction - components of radio link - the radio spectrum and frequency allocation - radio modems.

References

1. Steve Mackay, Edwin Wrijut, Deon Reynders, John Park, '*Practical Industrial Data Networks Design, Installation and Troubleshooting*', Newnes publication, Elsevier, First edition, 2004.
2. William Buchanan '*Computer Busses'*, CRC Press, 2000.
3. Andrew S. Tanenbaum, '*Modern Operating Systems*', Prentice Hall India, 2003
4. Theodore S. Rappaport, '*Wireless Communication: Principles & Practice,* 2nd Edition, 2001, Prentice Hall of India
5. Willam Stallings, ' *Wireless Communication & Networks*' 2nd Edition, 2005, Prentice Hall of India

Structure of the Question Paper

For the end semester examination, the question paper consists of three questions from each module, out of which two are to be answered by the students.

Industrial Relevance of the Course

There is a serious shortage of industrial data communications and industrial IT engineers, technologists and technicians in the world. Only recently these new technologies have become a key component of modern plants, factories and offices. Businesses throughout the world comment on the difficulty in finding experienced industrial data communications and industrial IT experts, despite paying outstanding salaries. The interface from the traditional SCADA system to the web and SQL databases has also created a new need for expertise in these areas. Specialists in these areas are few and far between. The aim of this course is to provide students with core skills in working with industrial data Communications and industrial IT systems and to take advantage of the growing need by industry.

ECD 2002 PROCESS CONTROL & INDUSTRIAL AUTOMATION 3-0-0-3

Structure of the course

Credits: 3

Lecture : 3 hrs/week
Internal Assessment : 40 Marks
End semester Examination : 60 Marks

Course objectives

1. To provide an insight into process control.
2. To provide knowledge on the role of PID controllers in an industrial background.
3. To give an overview of the different control structures used in process control.
4. To give an in depth knowledge on industrial automation-SCADA and PLC.

Learning Outcomes

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

1. Model a process control system and analyse its performance.
2. Design and tune PID controllers for a system.
3. Recognise the need of each type of control structure used in industry.
4. Write simple ladder programs for simple industrial automation –case study.

Module I

Introduction to process dynamics: Physical examples of first order process-first order systems in series-dynamic behaviour of first and second order systems - Control valves and transmission lines, the dynamics and control of heat exchangers. Level control, flow control, dynamics, Stability and control of chemical reactors, Control modes: on-off, P, PL PD, PID, Controller tuning-Zeigler Nichols self tuning methods.

Module II

Advanced control techniques: Feed forward control, Cascade control. Ratio control. Adaptive control, Override control, Control of nonlinear process. Control of process with delay. Hierarchical control, Internal mode control, Model predictive control. Statistical process control. Digital controllers Effects of sampling-implementation of PID controller-stability and tuning-digital feed forward control.

Module III

Industrial Automation: SCADA Systems, SCADA Architecture: Monolithic, Distributed and Networked. Programmable logic controllers, combinational and sequential logic controllers - System integration with PLCs and computers - PLC application in Industry - distributed control system - PC based control - Programming On /Off Inputs to produce On/Off outputs, Relation of Digital Gate Logic to contact /Coil Logic, PLC programming using Ladder Diagrams from Process control Descriptions, Introduction to IEC 61511/61508 and the safety lifecycle.

References

1. George Stephanopoulos, "*Chemical Process Control*", Prentice-Hall of India
2. Donald R. Coughnour, *'Process System Analysis and Control*'', McGraw-Hill, 1991
3. D. E. Seborg, T. F. Edger, *'Process Dynamics and Control'*, John Wiley, 1998
4. Enrique Mandado, Jorge Marcos, Serafin A Perrez, *'Programmable Logic Devices and Logic Controllers'*, Prentice-Hall, 1996
5. Dobrivoje Popovic, Vijay P. Bhatkar, Marcel Dekker, *'Distributed Computer Control for Industrial Automation*'', INC, 1990
6. G. Liptak, *'Handbook of Process Control*, 1996
7. Ronald A. Reis, '*Programmable logic Controllers Principles and Applications*', Prentice-Hall of India
8. *Pocket Guide on Industrial Automation for Engineers and Technicians*, Srinivas Medida, IDC Technologies

Structure of the Question Paper

For the end semester examination, the question paper consists of three questions from each module, out of which two are to be answered by the students.

ECD2003 SOFT COMPUTING TECHNIQUES 3-0-0-3

Structure of the course

Lecture	: 3 hrs/week	Credits: 3
Internal Assessment	: 40 Marks	
End semester Examination	: 60 Marks	

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.

Learning Outcomes

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

1. Design a complete feedback system based on ANN or Fuzzy control.
2. Identify systems using soft computing techniques.
3. Use genetic algorithm to find optimal solution to a given problem.
4. Design systems by judiciously choosing hybrid techniques.

Module I

Neural network: 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).

Learning process : Supervised and unsupervised learning - Error-correction learning - Hebbian learning – Boltzmann learning - Single layer and multilayer perceptrons - 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.

Module II

Fuzzy sets: Fuzzy set operations - Properties - Membership functions , Fuzzy to crisp conversion, fuzzification and defuzzification methods , applications in engineering problems.

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.

Module III

Genetic Algorithm: Introduction - basic concepts, application.

Hybrid Systems: Adaptive Neuro-fuzzy Inference System (ANFIS), Neuro-Genetic, Fuzzy-Genetic systems. Ant colony optimization, Particle swarm optimization (PSO). Case Studies.

References

1. J. M. Zurada, '*Introduction to Artificial Neural* Systems', Jaico Publishers, 1992.
2. Simon Haykins, '*Neural Networks - A Comprehensive Foundation, Mcmillan College*', Proc., Con., Inc., New York. 1994.
3. D. Driankov. H. Hellendorn, M. Reinfrank, '*Fuzzy Control - An Introduction, Narora Publishing House*', New Delhi, 1993.
4. H. J. Zimmermann, '*Fuzzy Set Theory and its Applications*', 111 Edition, Kluwer 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. Suran Goonatilake, Sukhdev Khebbal (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.

Structure of the Question Paper

For the end semester examination, the question paper consists three questions from each module, out of which two are to be answered by the students.

ECD2004 EMBEDDED SYSTEMS AND REAL TIME APPLICATIONS 3-0-0-3

Structure of the course

Lecture	: 3 hrs/week	Credits: 3
Internal Assessment	: 40 Marks	
End semester Examination	: 60 Marks	

Course objectives

1. To equip students for the development of an Embedded System for Control/ Guidance/ Power/Electrical Machines applications.
2. To make students capable of developing their own embedded controller for their applications

Learning outcomes

Upon successful completion of this course, students will be able to design and develop suitable embedded controller for any physical system and implement it in real-time.

Module I

Introduction to Embedded Systems: Embedded system definition, features. Current trends and Challenges, Real-time Systems. Hard and Soft, Predictable and Deterministic kernel, Scheduler. 8051-8 bit Microcontroller: Architecture, CPU Block Diagram, Memory management, Interrupts peripheral and addressing modes. ALP & Embedded C programming for 8051 based system-timer, watch dog timer, Analog & digital interfacing, serial communication. Introduction to TI MSP430 microcontrollers. Architecture, Programming and Case study/Project with popular 8/16/32 bit microcontrollers such as 8051, MSP 430, PIC or AVR.

Module II

High Performance RISC Architecture : ARM Processor Fundamentals, ARM Cortex M3 Architecture, ARM Instruction Set, Thumb Instructions, memory mapping, Registers, and programming model. Optimizing ARM assembly code. Exceptions & Interrupt handling. Introduction to open source development boards with ARM Cortex processors, such as Beagle Board, Panda board & leopard boards. Programming & porting of different OS to open source development boards.

Module III

Real time Operating System: Basic Concepts, Round robin, Round robin with interrupts, Function queue scheduling architecture, semaphores, Mutex, Mail box, memory management, Priority inversion, thread Synchronisation. Review of C-Programming, RTOS Linux & RTLinux Internals, Programming in Linux & RTLinux Configuring & Compiling RTLinux.

References

1. Raj Kamal, "*Embedded Systems*", Tata McGraw-Hill, 2003
2. Shultz T. W., "C and the 8051: Programming for Multitasking", Prentice-Hall, 1993
3. Mazidi, "*The 8051 Microcontrollers & Embedded Systems*", Pearson Education Asia.
4. B. Kanta Rao, "*Embedded Systems*", PHI, 2011
5. Barnett, R. H, "*The 8051 family of Microcontroller*, Prentice Hall, 1995.
6. Ayala K. J., *The 8051 Microcontroller: Architecture, Programming and Applications*, West Publishing, 1991,
7. Stewart J. W., Regents, *The 8051 Microcontroller: Hardware, Software and Interfacing*, , Prentice Hall, 1993
8. Yeralan S., Ahluwalia A. *'Programming and Interfacing the 8051 Microcontroller'*, Addison - Wesley, 1995
9. Andrew Dominic, Chris, *ARM System Developers Guide*, MK Publishers

Structure of the Question Paper

For the end semester examination, the question paper consists of three questions from each module, out of which two are to be answered by the students.

ECD2005 BIOMEDICAL INSTRUMENTATION 3-0-0-3

Structure of the course

Lecture	: 3 hrs/week	Credits: 3
Internal Assessment	: 40 Marks	
End semester Examination	: 60 Marks	

Course objectives

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

Learning outcome

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

Module 1

Introduction to the physiology of cardiac, nervous, muscular and respiratory systems. Transducers and Electrodes. Different types of transducers and their selection for biomedical applications, Electrode theory. Different types of electrodes, reference electrodes, hydrogen, calomel, Ag-AgCl, pH electrode, selection criteria of electrodes.

Module II

Measurement of electrical activities in muscles and brain. Electromyography, Electroencephalograph and their interpretation. Cardiovascular measurement. The cardio vascular system, Measurement of blood pressure, sphygmomanometer, blood flow, cardiac output and cardiac rate. Electrocardiography, echo- cardiography, ballisto-cardiography, plethysmography, magnetic and ultrasonic measurement of blood flow.

Module III

Therapeutic Equipment Cardiac pace-makers, defibrillators, machine, diathermy.
Respiratory System Measurement: Respiratory mechanism, measurement of gas volume, flow rate, carbon dioxide and oxygen concentration in inhaled air, respiration controller.
Instrumentation for clinical laboratory - Measurement of pH value of blood, ESR measurements, oxygen and carbon concentration in blood, GSR measurement X-ray and Radio isotopic instrumentation, diagnostic X-ray, CAT, medical use of isotopes. Ultrasonography, MRI.

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

Prerequisite: Basic knowledge in electronic instrumentation

Structure of the Question Paper

For the end semester examination, the question paper consists of three questions from each module, out of which two are to be answered by the students.

EPD 2001 NEW AND RENEWABLE SOURCES OF ENERGY 3-0-0-3

Structure of the course

Lecture	: 3 hrs/week	Credits: 3
Internal Assessment	: 40 Marks	
End semester Examination	: 60 Marks	

Learning Outcomes

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

Course Objective

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

Module 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; solar thermal applications - 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.

Module II

Energy from oceans-Wave energy generation - potential and kinetic energy from waves; wave energy conversion devices; advantages and disadvantages of wave energy- Tidal energy - basic principles; tidal power generation systems; estimation of energy and power; advantages and limitations of tidal power generation- Ocean thermal energy conversion (OTEC); methods of ocean thermal electric power generation Wind energy - basic principles of wind energy conversion; design of windmills; wind data and energy estimation; site selection considerations.

Module III

Classification of small hydro power (SHP) stations; description of basic civil works design considerations; turbines and generators for SHP; advantages and limitations. Biomass and bio-fuels; energy plantation; biogas generation; types of biogas plants; applications of biogas; energy from wastes
Geothermal energy- Origin and nature of geothermal energy; classification of geothermal resources; schematic of geothermal power plants; operational and environmental problems
New energy sources (only brief treatment expected)-Fuel cell: hydrogen energy; alcohol energy; nuclear fusion: cold fusion; power from satellite stations

References

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

Structure of the question paper

For the end semester examination, the question paper contains three questions from each module out of which two questions are to be answered by the student.

EPD 2002 SCADA SYSTEMS AND APPLICATIONS

Structure of the course

Lecture	: 3 hrs/week	Credits: 3
Internal Assessment	: 40 Marks	
End semester Examination	: 60 Marks	

Course Objective

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

Learning Outcomes

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

Module I

Introduction to SCADA Data acquisition systems - Evolution of SCADA, Communication technologies-. Monitoring and supervisory functions- SCADA applications in Utility Automation, Industries- SCADA System Components: Schemes- Remote Terminal Unit (RTU), Intelligent Electronic Devices (IED),Programmable Logic Controller (PLC), Communication Network, SCADA Server, SCADA/HMI Systems

Module II

SCADA Architecture: Various SCADA architectures, advantages and disadvantages of each system - single unified standard architecture -IEC 61850-SCADA Communication:Various industrial communication technologies -wired and wireless methods and fibre optics-Open standard communication protocols

Module3

SCADA Applications: Utility applications- Transmission and Distribution sector -operations, monitoring, analysis and improvement. Industries - oil, gas and water. Case studies, Implementation. Simulation Exercises

References

1. Stuart A Boyer. *SCADA-Supervisory Control and Data Acquisition*', Instrument Society of America Publications. USA. 1999.
2. Gordan Clarke, Deon RzynAzvs, *Practical Modern SCADA Protocols:* DNP3, 60870J and Related Systems', Newnes Publications, Oxford, UK,2004

Structure of the question paper

For the end semester examination, the question paper contains three questions from each module out of which two questions are to be answered by the student.

EMD2001 ELECTRIC AND HYBRID VEHICLES 3-0-0-3

Structure of the course

Credits: 3

Lecture	: 3 hrs/week
Internal Assessment	: 40 Marks
End semester Examination	: 60 Marks

Course Objective

To present a comprehensive overview of Electric and Hybrid Electric Vehicle.

Learning Outcomes

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

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

Module I

Introduction to Hybrid Electric Vehicles: History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies.

Conventional Vehicles: Basics of vehicle performance, vehicle power source characterization, transmission characteristics, mathematical models to describe vehicle performance.

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.

Module II

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.

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.

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,

Module III

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.
Case Studies: Design of a Hybrid Electric Vehicle (HEV), Design of a Battery Electric Vehicle (BEV).

References

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

(The course syllabus is as presented in NPTEL, IIT-M. The online resources in the NPTEL library may be utilised for this course).

Structure of the question paper

For the end semester examination, the question paper contains three questions from each module out of which two questions are to be answered by the student.

EDD2001 POWER ELECTRONICS SYSTEM DESIGN USING ICs 3-0-0-3

Structure of the Course

Lecture	: 3 hrs/week	Credits: 3
Internal Continuous Assessment	: 40 Marks	
End Semester Examination	: 60 Marks	

Course Objectives

1. To learn about specialized IC's and its applications
2. To understand PLL design and its applications
3. To study basics of PLCs

Learning Outcomes

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

1. Understand analog and digital system design concepts
2. Learn the specifications and applications of PWM control ICs.
3. Learn about self-biased techniques used in power supplies
4. Obtain information about different special purpose ICs and their applications

Module I

Introduction: Measurement Techniques for Voltages, Current, Power, power factor in Power Electronic circuits, other recording and analysis of waveforms, sensing of speed.
Phase – Locked Loops (PLL) & Applications: PLL Design using ICs, 555 Timer & its applications, Analog to Digital converter using ICs, Digital to Analog converters using ICs, implementation of different gating circuits.

Module II

Switching Regulator Control Circuits: Introduction, Isolation Techniques of switching regulator systems, PWM Systems, Some commercially available PWM control ICs and their applications: TL 494 PWM Control IC, UC 1840 Programmable off line PWM controller, UC 1524 PWM control IC, UC 1846 current mode control IC, UC 1852 Resonant mode power supply controller.
Switching Power Supply Ancillary, Supervisory & Peripheral circuits and components: Introduction, Optocouplers, self-Biased techniques used in primary side of reference power supplies, Soft/Start in switching power supplies, Current limit circuits, Over voltage protection, AC line loss detection.

Module III

Programmable Logic Controllers (PLC): Basic configuration of a PLC, Programming and PLC, Program Modification, Power Converter control using PLCs.

References

1. G. K. Dubey, S. R. Doradla, A. Johsi, and R. M. K. Sinha, *Thyristorised Power Controllers*, New Age International, 1st Edition, 2004.
2. George Chryssis, *High Frequency Switching Power Supplies*, McGraw-Hill, 2nd Edition,
3. Unitrode application notes: http://www.smps.us/Unitrode.html

Structure of the Question Paper

For the end semester examination, the question paper consists of three questions from each module, out of which two are to be answered by the students

EDD2002 ENERGY AUDITING CONSERVATION AND MANAGEMENT 3-0-0-3

Structure of the Course

Lecture	: 3 hrs/week	Credits: 3
Internal Continuous Assessment	: 40 Marks	
End Semester Examination	: 60 Marks	

Course Objective

Understanding, analysis and application of electrical energy management measurement and accounting techniques, consumption patterns, conservation methods.

Learning Outcomes

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

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

Module I

Energy Auditing and Economics: System approach and End use approach to efficient use of Electricity; Electricity tariff types; Energy auditing-Types and objectives-audit instruments –ECO assessment and Economic methods-cash flow model, time value of money, evaluation of proposals, pay-back method, average rate of return method, internal rate of return method, present value method, profitability index, life cycle costing approach, investment decision and uncertainty, consideration of income taxes, depreciation and inflation in investment analysis- specific energy analysis-Minimum energy paths- consumption models- Case study.

Module II

Reactive Power Management and Lighting: Reactive Power management –Capacitor Sizing-Degree of Compensation-Capacitor losses-Location-Placement-Maintenance-Case study. Economics of power factor improvement. Peak Demand controls- Methodologies –Types of Industrial Loads-Optimal Load scheduling-Case study. Lightning-Energy efficient light sources-Energy Conservation in Lighting schemes. Electronic Ballast-Power quality issues-Luminaries-Case study.

Module III

Cogeneration and conservation in industries: Cogeneration-Types and Schemes-Optimal operation of cogeneration plants- Case study. Electric loads of Air conditioning and Refrigeration –Energy conservation measures-Cool storage- Types- Optimal operation-Case study .Electric water heating-Geysers-Solar Water Heaters-Power Consumption in Compressors, Energy conservation measures-Electrolytic Process-Computer Control-Software –EMS.

References

1. Giovanni Petrecca, *Industrial Energy Management: Principles and Application*, The Kluwer International Series-207, 1999
2. Anthony J. Pansini, Kenneth D. Smalling, *Guide to Electric Load Management*, Pennwell Pub.,1998
3. Howard E. Jordan, *Energy-Efficient Electric Motors and their Applications*, Pleneum Pub Corp. 2nd edition, 1994
4. Turner, Wayne C., *Energy Management Handbook*, Lilburn, The Fairmont Press, 2001.
5. Albert Thumann, *Handbook of Energy Audits*, Fairmont Press 5th Edition, 1998
6. IEEE Bronze Book, *Recommended Practice for Energy Conservation and Cost effective Planning in Industrial Facilities* ,IEEE Inc ,USA
7. Albert Thumann P.W, *Plant Engineers and Managers Guide to Energy Conservation*, 7th Edition, TWI Press Inc. Terre Haute.
8. Donald R. W., *Energy Efficiency Manual*, Energy Institute Press
9. Partab H., *Art and Science of Utilization of Electrical Energy*, Dhanpat Rai & Sons , New Delhi
10. Tripathy S. C., *Electrical Energy Utilization and Conservation*, Tata McGraw-Hill
11. NESCAP- *Guide Book on Promotion of Sustainable Energy Consumption*

Structure of the Question Paper

For the end semester examination, the question paper consists of three questions from each module, out of which two are to be answered by the students

EDD 2003 ADVANCED POWER SYSTEM ANALYSIS 3-0-0-3

Prerequisites: Basic Course in Power System Engineering

Structure of the Course

Lecture	: 3 hrs/week	Credits: 3
Internal Continuous Assessment	: 40 Marks	
End Semester Examination	: 60 Marks	

Course Objectives

1. At the end of the course students will be able to perform analysis power network systems.
2. Should be able to analyze faults and load flows
3. Can develop programming skills for coding load flows and its applications like OPF.
4. Ability to understand concepts for solving multi phase systems.

Learning Outcomes

Upon successful completion of this course, students will be able to use various algorithms for solving a real time power system network.

Module I

Basics of graph theory-incidence matrices-Primitive network- Building algorithm for formation of bus impedance matrix (Z_{BUS})--Modification of Z_{BUS} due to changes in the primitive network with and without mutual coupling. Review of Y_{BUS} formation-Modification of Z_{BUS} and Y_{BUS} for change of reference.

Network fault Calculations: Review of sequence transformations and impedance diagrams- Fault calculations using Z_{BUS}, Analysis of balanced and unbalanced three phase faults –Short circuit faults – open circuit faults.

Module II

Network modelling – Conditioning of Y Matrix – Load Flow basics- Newton Raphson method– Fast decoupled Load flow –Three phase load flow.

Review of HVDC systems- DC power flow – Single phase and three phase

Need for AC-DC systems- AC-DC load flow – DC system model – Unified and Sequential Solution Techniques.

Module III

Review of economic dispatch**:** strategy for two generator system – generalized strategies – effect of transmission losses. Combined economic and emission dispatch- Reactive power dispatch-Formulation of optimal power flow (OPF) – various equality and inequality constraints -solution by Gradient method – Newton's method – Security constrained OPF- Sensitivity factors - Continuation Power flow method.

References

1. G. W. Stagg and El-Abiad, *Computer Methods in Power System Analysis*, McGraw-Hill, 1968.
2. Arrillaga J., and Arnold C.P., ‘*Computer Analysis of Power Systems’*, John Wiley and Sons, New York, 1997
3. Allen J. Wood and Bruce F. Woollenberg, *‘Power Generation Operation and Control’*, John Wiley & Sons, 2nd Edition 1996.
4. D.P. Kothari, J.S. Dhillon, ‘*Power System Optimization’*, Prentice-Hall India Pvt. Ltd., New Delhi, 2006
5. Grainger J. J., Stevenson W. D., ‘*Power System Analysis’*, Tata McGraw-Hill, New Delhi, 2003
6. Nagrath, D. P. Kothari, "*Modern Power System Analysis*", Tata McGraw-Hill, 1980
7. Pai M.A., ‘*Computer Techniques in Power System Analysis’*, 2nd edition, Tata McGraw-Hill, New Delhi, 2006.
8. Ajjarapu V., Christy C., “*The Continuation Power Flow: A Tool for Voltage Stability Analysis*”, IEEE Transactions on Power Systems, Vol. 7(1), pp 416-423.

Structure of the Question Paper

For the end semester examination, the question paper consists of three questions from each module, out of which two are to be answered by the students

EDD2004 INDUSTRIAL AUTOMATION TOOLS 3-0-0-3

Prerequisite: Basic knowledge in electrical engineering, Control Systems.

Structure of the Course

Lecture	: 3 hrs/week	Credits: 3
Internal Continuous Assessment	: 40 Marks	
End Semester Examination	: 60 Marks	

Course Objectives

1. To introduce students to the use of PLCs in industry and to provide skills with modern PLC programming tools.
2. To acquire basic knowledge about multi-input multi-output (MIMO) systems.
3. To acquire extensive basic and advanced knowledge about various aspects of PLC, SCADA, DCS and Real Time Systems.

Learning Outcomes

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

1. Understand the operation of a PLC (Programmable Logic Controller) and its use in industry.
2. Hardwire a PLC and apply ladder logic programming to perform simple automation tasks.
3. Understand and apply common industrial analogue and digital input/output modules.
4. Demonstrate an understanding of field bus systems and SCADA at an introductory level.

Module I

Multivariable control- Basic expressions for MIMO systems- Singular values- Stability norms- Calculation of system norms- Robustness- Robust stability.
H_2/H_∞ Theory- Solution for design using H_2/H_∞ - Case studies. Interaction and decoupling- Relative gain analysis- Effects of interaction- Response to disturbances- Decoupling- Introduction to batch process control.
PLC Basics: PLC system, I/O modules and interfacing, CPU processor, programming equipment, programming formats, construction of PLC ladder diagrams, devices connected to I/O modules. PLC Programming: Input instructions, outputs, operational procedures, programming examples using contacts and coils, Drill press operation.

Module II

Digital logic gates, programming in the Boolean algebra system, conversion examples. Ladder diagrams for process control: Ladder diagrams and sequence listings, ladder diagram construction and flow chart for spray process system.
Large Scale Control Systems - SCADA: Introduction, SCADA Architecture, Different Communication Protocols, Common System Components, Supervision and Control, HMI, RTU and Supervisory Stations, Trends in SCADA, Security Issues

Module III

Distributed Control Systems (DCS): Introduction, DCS Architecture, Local Control (LCU) architecture, LCU languages, LCU - Process interfacing issues, communication facilities, configuration of DCS, displays, and redundancy concept - case studies in DCS.
Real time systems- Real time specifications and design techniques- Real time kernels- Inter task communication and synchronization- Real time memory management- Supervisory control- direct digital control- Distributed control- PC based automation.

References

1. Shinskey F.G., *Process Control Systems: Application, Design and Tuning*, McGraw Hill International Edition, Singapore, 1988.
2. Belanger P.R., *Control Engineering: A Modern Approach*, Saunders College Publishing, USA, 1995.
3. Dorf R. C. and Bishop R. T., *Modern Control Systems*, Addison Wesley Longman Inc., 1999
4. Laplante P.A., *Real Time Systems: An Engineer's Handbook*, Prentice Hall of India Pvt. Ltd., New Delhi, 2002.
5. Stuart A. Boyer: *SCADA-Supervisory Control and Data Acquisition*, Instrument Society of America Publications,USA,1999
6. Efim Rosenwasser, Bernhard P. Lampe, *Multivariable Computer-Controlled Systems*: *A Transfer Function Approach*, Springer, 2006
7. John W. Webb, Ronald A. Reiss, *Programmable Logic Controllers: Principle and Applications*, Fifth Edition, PHI
8. R. Hackworth and F.D Hackworth Jr., *Programmable Logic Controllers: Programming Method and Applications*, Pearson, 2004.

Structure of the Question Paper

For the end semester examination, the question paper consists of three questions from each module, out of which two are to be answered by the students.

EID2001 ADVANCED MICROPROCESSORS AND MICROCONTROLLERS

Structure of the course

Lecture	: 3hrs/week	Credits: 3
Internal Continuous Assessment	: 40 Marks	
End Semester Examination	: 60 Marks	

Course Objective

To provide experience to design digital and analog hardware interface for microcontroller based systems. To provide in depth knowledge of higher bit processors

Learning Outcomes

Upon successful completion of this course, students will be able to use microprocessors and microcontrollers for different applications.

Module I

Internal architecture of 8086 CPU, instruction set and programming, assembly language programming on IBM PC, ROM bios and DOS utilities. 8086 basic system concepts, signals, instruction queue, MIN mode and MAX mode, bus cycle, memory interface, read and write bus cycles, timing parameters.

Module II

Input/output interface of 8086, I/O data transfer, I/O bus cycle. Interrupt interface of 8086, types of interrupts, interrupt processing. DMA transfer, interfacing and refreshing DRAM, 8086 based multiprocessing system, 8087 math coprocessor. Typical 8086 based system configuration, keyboard interface, CRT controller, floppy disk controller

Module III

Introduction to higher bit processors, 80286, 80386, 80486, Pentium. A typical 16 bit Microcontroller with RISC architecture and Integrated A-D converter e.g. PIC 18Cxxx family: Advantages of Harvard Architecture, instruction pipeline, analog input, PWM output, serial I/O, timers, in-circuit and self programmability. Instruction set. Typical application. Development tools.

References

1. Ray A. K., Bhurchandi K. M., *Advanced Microprocessor and Peripherals, Architecture, Programming and Interfacing*, TMH, 2006
2. Hall D.V., *Microprocessor & Interfacing – Programming & Hardware – 8086, 80286, 80386, 80486*', TMH, 1992
3. Rajasree Y., *Advanced Microprocessor*, New Age International Publishers, 2008
4. Brey B. B. '*The Intel Microprocessor 8086/8088, Pentium , Pentium Processor*, PHI, 2008
5. Ayala K. J., *The 8086 Microprocessor*, Thomson Delmar Learning, 2004.
6. Cady F. M., *Microcontrollers & Microcomputers Principles of Software &Hardware Engineering*, Oxford University Press, 1997
7. Tabak D., *Advanced Microprocessors*,TMH, 1996
8. Deshmukh, *Microcontrollers : Theory and Application*, TMH, 2005

Structure of the Question paper

For the end semester examination, the question paper will consist of three questions from each module out of which two questions are to be answered by the students

EID2002 MODERN POWER CONVERTER

Structure of the course

Lecture	: 3hrs/week	Credits: 3
Internal Continuous Assessment	: 40 Marks	
End Semester Examination	: 60 Marks	

Course Objective

To equip students with various advanced topics in power electronics

Learning Outcomes

Upon successful completion of this course, students will be able to understand working of power converters and design converters for industrial applications

Module 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.

Module 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-Push pull converter transistor-Limitation of the Push Pull circuit-circuit variation of the push pull converter-the half bridge and full bridge DC-DC converters. High frequency inductor design and transformer design considerations, magnetic core, current transformers.

Module III

Control of switched mode DC power supplies: Voltage feed forward PWM control, current mode control, digital pulse width modulation control, isolation techniques of switching regulator systems: soft start in switching power supply designs, current limit circuits, over voltage protection circuit. 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. Power conditioners and Uninterruptible Power Supplies, Types of UPS-Redundant and Non Redundant UPS.

References

1. Mohan, Undeland, Robbins, *Power Electronics: Converters, Application and Design*, John Wiley & Sons, 1989
2. A.I. Pressman, *Switching Mode Power Supply Design*, Tata McGraw-Hill, 1992
3. M. H. Rashid, *Power Electronics*, PHI, 2004
4. Michel, D., *DC-DC Switching Regulator Analysis*, Newness, 2000
5. Lee, Y., *Computer Aided Analysis and Design of Switch Mode Power Supply*, 1993
6. Staff, VPEC, *Power Device & their Application*, 2000

Structure of the Question paper

For the end semester examination, the question paper will consist of three questions from each module out of which two questions are to be answered by the students

EID2003 POWER PLANT INSTRUMENTATION

Structure of the course

Lecture: 3hrs/week Credits: 3
Internal Continuous Assessment: 40 Marks
End Semester Examination: 60 Marks

Course Objective

To equip students with various advanced topics in Power System Instrumentation

Learning Outcomes

Upon successful completion of this course, students will be acquainted to advanced instrumentation techniques employed in power plants.

Module I

General scope of instrumentation in power systems. Electrical instruments and meters. Telemetry. Data transmission channels-pilots, PLCC, Microwave links. Interference effect. Automatic meter reading and billing.

Module II

Simulators. SCADA and operating systems. Data loggers and data display system. Remote control instrumentation. Disturbance recorders. Area and Central Control station instrumentation.

Module III

Frontiers of future power system instrumentation including microprocessor based systems. Application of digital computers for data processing and on-line system control.

References

1. Central Power Research Institute (India),*Power System Instrumentation: National Workshop: Papers*, 1991
2. B.G Liptak, '*Instrumentation in Process Industries'*, CRC, 2010
3. B. Singh, Microprocessor control and instrumentation of electrical power systems, University of Bradford, 1987
4. Bonneville Power Administration, *SCADA: Remote Control For a Power System*, 1995

Structure of the Question paper

For the end semester examination, the question paper will consist of three questions from each module out of which two questions are to be answered by the students

EID2004 ADVANCED CONTROL SYSTEM DESIGN

Structure of the course

Lecture	: 3hrs/week	Credits: 3
Internal Continuous Assessment	: 40 Marks	
End Semester Examination	: 60 Marks	

Course Objective

To understand about the basics of optimal control. To introduce about the current research in optimization for robust control.

Learning Outcomes

Upon successful completion of this course, students will be able to implement control techniques optimally.

Module I

Describing system and evaluating its performance: problem formulation - state variable representation of the system-performance measure-the carrier landing of a jet aircraft-dynamic programming

Module II

Linear quadratic optimal control: formulation of the optimal control problem- quadratic integrals and matrix differential equations-optimum gain matrix –steady state solution-disturbances and reference input: exogenous variables general performance integral –weighting of performance at terminal time, concepts of MIMO system.

Module III

Linear quadratic Gaussian problem : Kalman identity-selection of the optimal LQ performance index-LQR with loop shaping techniques-linear quadratic Gaussian problem-kalman state estimator -property of the LQG based controller-reduced order LQG control law design- advances in control system design-concept of robust control- H infinity design techniques

References

1. Bernad Friedland, *Control System Design*, McGraw-Hill, 2012.
2. Ching-Fang-Lin , *Advanced Control System Design*, Prentice Hall, 1994.
3. Krick D. E., *Optimal Control Theory*, Dover Publications, 2004.

Structure of the Question paper

For the end semester examination, the question paper will consist of three questions from each module out of which two questions are to be answered by the students.

EID2005 **MULTIVARIABLE CONTROL THEORY**

Structure of the course

Lecture : 3hrs /week Credits: 3
Internal Assessment : 40 Marks.
End semester Examination : 60 Marks.

Course objectives

1. To introduce the concepts of linear and nonlinear multivariable systems.
2. To impart an in-depth knowledge on the different representations of MIMO systems.
3. To provide the difference between linear single and multivariable systems using time and frequency domain techniques and their design.
4. To provide an insight into nonlinear MIMO systems.

Learning Outcomes

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

1. Use different representations for MIMO systems.
2. Analyse given linear and non linear multivariable systems and assess its performance using frequency and time domain techniques.
3. Design linear MIMO systems.

Module I

Linear Multivariable Control Systems: Canonical representations and stability analysis of linear MIMO systems, General linear square MIMO systems ,Transfer matrices of general MIMO systems , MIMO system zeros and poles, Spectral representation of transfer matrices: characteristic transfer functions and canonical basis, Representation of the open-loop and closed MIMO system via the similarity transformation and dyads, Stability analysis of general MIMO systems, Singular value decomposition of transfer matrices, Uniform MIMO systems, Characteristic transfer functions and canonical representations of uniform MIMO systems, Stability analysis of uniform MIMO systems, Normal MIMO systems, Canonical representations of normal MIMO systems.
Circulant MIMO systems, Anticirculant MIMO systems, Characteristic transfer functions of complex circulant and anticirculant systems, Multivariable root loci , Root loci of general MIMO systems, Root loci of uniform systems , Root loci of circulant and anticirculant systems.

Module II

Performance and design of linear MIMO systems: Generalized frequency response characteristics and accuracy of linear, MIMO systems under sinusoidal inputs, Frequency characteristics of general MIMO systems, Frequency characteristics and oscillation index of normal MIMO systems, Frequency characteristics and oscillation index of uniform MIMO systems, Dynamical accuracy of MIMO systems under slowly changing deterministic signals, Matrices of error coefficients of general MIMO systems.
Dynamical accuracy of circulant, anticirculant and uniform MIMO systems, Accuracy of MIMO systems with rigid cross-connections , Statistical accuracy of linear MIMO systems, Accuracy of general MIMO systems under stationary stochastic signals, Statistical accuracy of normal MIMO systems ,Statistical accuracy of uniform MIMO systems, Formulae for mean square outputs of characteristic systems , Design of linear MIMO systems

Module III

Nonlinear Multivariable Control System: Study of one-frequency self-oscillation in nonlinear harmonically linearized MIMO systems, Mathematical foundations of the harmonic linearization method for one-frequency periodical processes in nonlinear MIMO systems, One-frequency limit cycles in general MIMO systems, Necessary conditions for the existence and investigation of the limit cycle in harmonically linearized MIMO systems, Stability of the limit cycle in MIMO systems, Limit cycles in uniform MIMO systems, Necessary conditions for the existence and investigation of limit cycles in uniform MIMO systems, Analysis of the stability of limit cycles in uniform systems.
Limit cycles in circulant and anticirculant MIMO systems, Necessary conditions for the existence and investigation of limit cycles in circulant and anticirculant systems, Limit cycles in uniform circulant and anticirculant systems.

References

1. Oleg N. Gasparyan, *Linear and Nonlinear Multivariable Feedback Control: A Classical Approach*, John Wiley & Sons Ltd.,2008.
2. Sigurd Skogestad, Ian Postlethwaite, *Multivariable Feedback Control - Analysis and Design*, John Wiley & Sons Ltd., 2nd Edition, 2005.

Structure of the Question Paper

For the end semester examination, there will be three questions from each module out of which two questions are to be answered by the students.

ECC2000 RESEARCH METHODOLOGY 2-0-0-2

Structure of the course

Credits: 2

Lecture	: 2 hrs/week
Internal Assessment	: 40 Marks
End semester Examination	: 60 Marks

Course Objective

1. To formulate a viable research question
2. To distinguish probabilistic from deterministic explanations
3. To analyze the benefits and drawbacks of different methodologies
4. To understand how to prepare and execute a feasible research project

Learning Outcomes

Upon successful completion of this course, students will be able to understand research concepts in terms of identifying the research problem, collecting relevant data pertaining to the problem, to carry out the research and writing research papers/thesis/dissertation.

Module I

Introduction to Research Methodology - Objectives and types of research: Motivation towards research - Research methods *vs.* Methodology. Type of research: Descriptive *vs.* Analytical, Applied *vs.* Fundamental, Quantitative *vs.* Qualitative, and Conceptual *vs.* Empirical.

Research Formulation - Defining and formulating the research problem -Selecting the problem - Necessity of defining the problem - Importance of literature review in defining a problem. Literature review: Primary and secondary sources - reviews, treatise, monographs, patents. Web as a source: searching the web. Critical literature review - Identifying gap areas from literature review - Development of working hypothesis. (15 Hours)

Module II

Research design and methods: Research design - Basic Principles- Need for research design — Features of a good design. Important concepts relating to research design: Observation and Facts, Laws and Theories, Prediction and explanation, Induction, Deduction. Development of Models and research plans: Exploration, Description, Diagnosis, Experimentation and sample designs. Data Collection and analysis: Execution of the research - Observation and Collection of data - Methods of data collection - Sampling Methods- Data Processing and Analysis strategies - Data Analysis with Statistical Packages - Hypothesis-Testing -Generalization and Interpretation. (15 Hours)

Module III

Reporting and thesis writing - Structure and components of scientific reports -Types of report - Technical reports and thesis - Significance - Different steps in the preparation, Layout, structure and Language of typical reports, Illustrations and tables, Bibliography, referencing and footnotes. Presentation; Oral presentation - Planning - Preparation -Practice - Making presentation - Use of audio-visual aids - Importance of effective communication.

Application of results of research outcome: Environmental impacts –Professional ethics - Ethical issues -ethical committees. Commercialization of the work - Copy right - royalty - Intellectual property rights and patent law - Trade Related aspects of Intellectual Property Rights - Reproduction of published material - Plagiarism - Citation and acknowledgement - Reproducibility and accountability.

References

1. C. R. Kothari, *Research Methodology*, Sultan Chand & Sons, New Delhi,1990
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 of India, New Delhi, 2012.

EDC2101 DRIVES & SIMULATION LAB 0-0-2-1

(FIELD COMPUTATION)

Structure of the course

Practical : 2 hrs/week Credits: 1

Internal Assessment : 100 Marks

End semester Examination : Nil

Course Objectives

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

Learning Outcomes

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 and ANSYS MAXWELL software

List of Experiments

1. Chopper Fed DC Drive

2. DSP controlled AC drive

3. Performance study of Stator Voltage Controlled Induction Motor Drive

7. Harmonic Analysis of Converter Fed Drive

8. IGBT Based Three Phase PWM Inverter

9. IGBT Based Three Phase SVPWM Inverter

10. Simulation of Power Electronic Systems using PSpice

11. Modeling and Simulation of Electric Drives using MATLAB

12. Simulation of closed loop control of converter fed DC motor drive.

8. Simulation of closed loop control of chopper fed DC motor drive.

9. Simulation of VSI fed three phase induction motor drive.

10. Simulation of three phase synchronous motor and drive.

11. Field Computation using MAXWELL software package

EDC2102 SEMINAR

Structure of the Course

Duration	: 2 hrs/week	Credits : 2
Continuous Assessment	: 100 Marks	

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

Distribution of marks

Seminar Report Evaluation	- 40 marks
Seminar Presentation	- 60 marks

EDC2103 THESIS PRELIMINARY: PART-I

Structure of the Course

Thesis	: 2 hrs/week	Credits : 2
Internal Continuous Assessment	: 100 Marks	

For the Thesis-Preliminary part I the student is expected to start the preliminary background studies towards the Thesis by conducting a literature survey in the relevant field. He/she should broadly identify the area of the Thesis work, familiarize with the design and analysis tools required for the Thesis work and plan the experimental platform, if any, required for Thesis work. The student will submit a detailed report of these activities at the end of the semester.

Distribution of marks

Internal assessment of work by the Guide	: 50 marks
Internal evaluation by the Committee	: 50 Marks

EDE3001 REACTIVE POWER MANAGEMENT IN POWER SYSTEM 3-0-0-3

Prerequisite*:* Basic course in Power Systems, Power Quality

Structure of the Course

Lecture	: 3 hrs/week	Credits: 3
Internal Continuous Assessment	: 40 Marks	
End Semester Examination	: 60 Marks	

Course Objectives

1. To study the reactive power management in power systems.
2. To analyze the effect of harmonics on electrical equipments.

Learning Outcomes

Upon successful completion of this course, students will be able to understand the importance of reactive power and the methods to control reactive power

Module I

Theory of Load Compensation**:** Introduction- Requirement for compensation objectives in load compensation, the ideal compensator specifications of a load compensator , Power factor correction and voltage regulations in single phase system, phase balancing and p. f. correction of unsymmetrical loads, compensation in term of symmetrical components , expression for the compensating susceptances in terms of phase line currents.

Module II

Reactive Power Control: fundamental requirement in AC Power transmission, Fundamental transmission line equation, surge impedance and natural loading, voltage and current profiles of uncompensated radial and symmetrical line on open circuit, uncompensated line under load, effect of line length, load power and p.f on voltage and reactive power, passive and active compensators, uniformly distributed fixed compensation, passive shunt compensation, control of open circuit voltage by shunt reactance, required reactance of shunt reactors, multiple shunt reactors along the line, voltage control by means of switch shunt compensation, midpoint shunt reactor or capacitor, expression for midpoint voltage, series compensation , objectives and practical limitation , symmetrical line with midpoint series capacitor and shunt reactor, power transfer characteristics and maximum transmissible power for a general case, fundamental concepts of compensation by sectioning.

Module III

Dynamic performance of transmission systems with reactive power compensation: The dynamics of electrical Power Systems, need for adjustable reactive compensation, four characteristics time period.

Principles of Static Compensation: Principle of operation of thyristor controlled reactor, thyristors switch capacitor, saturated reactor compensator.

Series Capacitors: Introduction, protective gear, reinsertion schemes varistor protective gear. Synchronous Condenser : Introduction, Power system Voltage control, Emergency reactive power supply, starting methods, starting motor, reduced voltage starting, static starting.

Harmonics: Sources, effects of harmonics on electrical equipment. Reactive power management, utility objectives and utility practices, transmission Reactive Power Co-Ordination benefits**.**

References

1. T. J. E. Miller, *Reactive Power Control in Electrical Systems*, John Wiley publications.
2. Leon Freris, David Infield, *Renewable Energy in Power Systems*, John Wiley & Sons, 2008
3. D. M. Tagare, *Reactive Power Management*, Tata McGraw-Hill, 1st Reprint, 2007.

Structure of the Question paper

For the end semester examination, the question paper will consist of three questions from each module out of which two questions are to be answered by the students.

EDE 3002 INSTRUMENTATION FOR POWER ELECTRONICS AND POWER SYSTEMS 3-0-0-3

Structure of the Course

Lecture	: 3 hrs/week	Credits: 3
Internal Continuous Assessment	: 40 Marks	
End Semester Examination	: 60 Marks	

Course Objectives

1. To impart knowledge about the principle, construction and characteristics of transducers and telemetry systems.
2. To provide the knowledge about data acquisition system

Learning Outcomes

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

1. Cognize different schemes for converting physical quantities into electrical equivalents
2. Understand of typical sensor configurations employed in power electronic circuits
3. In-depth knowledge of sampled data systems specifically in control applications.

Module I

Transducers: Classification of Transducers including analog and digital transducers, Selection of Transducers, Static and Dynamic response of transducer System.

Measurement of length & thickness, linear Displacement, Angular Displacement, force, weight, torque, Moisture, Level, Flow, pH & Thermal Conductivity, Measurement of Frequency, Proportional, Geigermuller & Scintillation Counters.

Module II

Sensor Design for Power Electronics: current sensor circuits, Resistive shunts, Hall-effect based current sensors, Typical design based on hall-effect sensors, auxiliary scaling and signal conditioning circuits using op-amps. [7]

Telemetry: Basic Principles, Proximity & remote Action Telemetry systems, Multiplexing; Time Division and frequency division. Various types of Display Device, Digital Voltmeters, Dual Slope DVMS, Digital encoders, Analog and Digital encoders, Analog and Digital Data Acquisition System, A/D Converter.

Module III

Fibre Optic Technology for data transmission, Supervisory Control and Data Acquisition Systems (SCADA), Q-meter. Electrical noise in control signals, its remedial measures.

References

1. W. D. Cooper & A. D. Helfrick, '*Modern Electronic Instrumentation and Measurement Techniques*', Prentice Hall; Rev Sub edition, 1989.
2. B. C. Nakra, K. K. Chaudhary, *Instrumentation Measurement Analysis*, Tata McGraw-Hill, 2nd edn. 2009.
3. Hermann, K. P. Neubert, '*Instrument Transducers: Introduction to Their Performance and Design*', Oxford University Press, 2nd edn. 1975.
4. P. H. Mansfield, '*Electrical Transducers for Industrial Measurement'*, Butterworth, 1973.
5. Walt Boyes, *Instrumentation Reference Book*, Butterworth, 4th edn., 2010
6. C. Rangan, G. Sarma, V.S.V. Mani, '*Instrumentation: Devices and Systems'*, Tata McGraw Hill, 2008.
7. P, A. Borden, G. M. Thynell, '*Principles and Methods of Telemetering'*, Reinhold Pub. Corp, University of Michigan, 2007
8. Ned Mohan, Undeland, Robbins, '*Power Electronics: Converters, Applications and Design'*, 3rd edn., John Wiley, 2003

Structure of the Question Paper

For the end semester examination, the question paper consists of three questions from each module, out of which two are to be answered by the students

EDE 3003 DIGITAL CONTROLLERS IN POWER ELECTRONICS 3-0-0-3

Structure of the Course

Lecture	: 3 hrs/week	Credits: 3
Internal Continuous Assessment	: 40 Marks	
End Semester Examination	: 60 Marks	

Course Objectives

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

Learning Outcomes

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

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

Module 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, 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.

Module II

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

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

Module III

8051 microcontroller-typical applications-DC motor speed control, speed measurement, Temperature control, stepper motor control, PID control

References

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

Structure of the Question Paper

For the end semester examination, the question paper consists of three questions from each module, out of which two are to be answered by the students

EDE 3004 POWER SYSTEM PROTECTION 3-0-0-3

Structure of the Course

Lecture	: 3 hrs/week	Credits: 3
Internal Continuous Assessment	: 40 Marks	
End Semester Examination	: 60 Marks	

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

Learning Outcomes

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

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.

Module 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, Bus Protection, Performance of current and voltage protection,
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.

Module II

Transmission line relaying algorithms: Introduction, sources of error, relaying as parameter estimation, Symmetrical component distance relay, Protection of series compensated lines
Protection of transformers, Machines and buses: Power transformer algorithms, digital protection of generators and motors.

Module III

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.
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.

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

Structure of the Question paper

For the end semester examination, the question paper will consist of three questions from each module out of which two questions are to be answered by the students.

EDE 3005 CONTROL OF ADVANCED ELECTRICAL MACHINES 3-0-0-3

Pre-requisite*:* Basic principles of Electrical Machines, Microprocessor systems, Control systems

Structure of the Course

Lecture	: 3 hrs/week	Credits: 3
Internal Continuous Assessment	: 40 Marks	
End Semester Examination	: 60 Marks	

Course Objective

1. The objective of this course is to emphasize on the importance of DC machines in Industrial appliances.
2. Learn the basic operation of stepper motors and switched-reluctance motor drives
3. Provide deeper understanding of the closed loop control of electric drives

Learning Outcomes

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

1. Analyze electrical machines both static and dynamic equivalent circuits.
2. Compare the machine performance for difference industrial applications.

Module I

Stepper Motors - Constructional features, principle of operation, modes of excitation, single phase stepping motors, torque production in variable Reluctance (VR) stepping motor, Dynamic characteristics, Drive systems and circuit for open loop control, Closed loop control of stepping motor, microprocessor based controller.

Module II

Switched Reluctance Motors - Constructional features, principle of operation. Torque equation, Power controllers, Characteristics and control. Microprocessor based controller .Sensor less control. Synchronous Reluctance Motors-Constructional features: axial and radial air gap Motors. Operating principle, reluctance torque – Phasor diagram, motor characteristics.

Module II

Permanent Magnet Brushless DC Motors - Commutation in DC motors, Difference between mechanical and electronic commutators, Hall sensors, Optical sensors, Multiphase Brushless motor, Square wave permanent magnet brushless motor drives, Torque and EMF equation, Torque-speed characteristics, Controllers-Microprocessor based controller. Sensorless control.

References

1. Kenjo T., Sugawara A, *Stepping Motors and their Microprocessor Control*, Clarendon Press, Oxford, 1994
2. Miller T. J. E., *Switched Reluctance Motor and Their Control*, Clarendon Press, Oxford, 1993.
3. Miller T. J. E., *Brushless Permanent Magnet and Reluctance Motor Drives*, Clarendon Press, Oxford, 1989.
4. B K Bose, Modern Power Electronics & AC drives, Pearson, 2002.

Structure of the Question paper

For the end semester examination, the question paper will consist of three questions from each module out of which two questions are to be answered by the students.

EDE 3006 SWITCHED MODE POWER CONVERTERS 3-0-0-3

Pre-requisite: Review of Buck, Boost, Buck-Boost topologies, Push-pull and Forward converters, Half and Full Bridge Converters, Fly back Converters

Structure of the Course

Lecture	: 3 hrs/week	Credits: 3
Internal Continuous Assessment	: 40 Marks	
End Semester Examination	: 60 Marks	

Course Objective

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

Learning Outcomes

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

1. Knowledge of different control modes of SMPS
2. Practical modelling guidelines for non-ideal converter design
3. Through understanding of resonant converter characteristics

Module I

Voltage Mode Control of SMPS - Loop gain and Stability Considerations - Shaping the Error Amplifier gain versus frequency characteristics - Error amplifier Transfer function – Tran conductance Error amplifiers.
Current Mode Control of SMPS – Current Mode Control Advantages- Current Mode versus Voltage Mode Control of SMPS – Current Mode Deficiencies - Slope Compensation.

Module II

Modelling of SMPS - Basic AC modelling Approach -– Modelling of non ideal fly back converter - 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

Module III

Introduction to Resonant Converters – Classification of Resonant Converters – Basic Resonant circuit concepts – load resonant converters – resonant switch converters – Zero voltage switching, clamped voltage topologies – resonant DC Link inverters with zero voltage switching – High frequency link integral half cycle 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

Structure of the Question paper

For the end semester examination, the question paper will consist of three questions from each module out of which two questions are to be answered by the students.

EDE 3007 FACTS AND CUSTOM POWER DEVICES 3-0-0-3

Structure of the Course

Lecture	: 3 hrs/week	Credits: 3
Internal Continuous Assessment	: 40 Marks	
End Semester Examination	: 60 Marks	

Course Objectives

1. To understand operation, control and application of different FACTS devices and custom power devices.
2. To understand the power quality issues related to distribution system Learn about voltage stability and reactive power control in power systems.

Learning Outcomes

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

1. Perform fundamental computation and modelling of power system control and stability.
2. Analyze dynamic behaviour of power control systems subject to various disturbances from the aggregated behaviour of the many dynamic devices.

Module I

FACTS and preliminaries: FACTS concept and general system considerations - power flow in AC system - definitions on FACTS - basic types of FACTS controllers.

Converters for Static Compensation - Three phase converters and standard modulation strategies (Programmed Harmonic Elimination and SPWM) - GTO Inverters - Multi-Pulse Converters and Interface Magnetics

Transformer Connections for 12, 24 and 48 pulse operation - Multi-Level Inverters of Diode Clamped Type and Flying Capacitor Type and suitable modulation strategies (includes SVM) - Multi-level inverters of Cascade Type and their modulation - Current Control of Inverters.

Module II

Static Shunt and Series Compensators: Static Shunt Compensators - SVC and STATCOM - Compensator Control - Comparison between SVC and STATCOM - STATCOM for transient and dynamic stability enhancement.

Static Series Compensation -TCSC and SSSC - operation and control - external system control for series compensators - SSR and its damping - static voltage and phase angle regulators - TCVR and TCPAR - operation and control.

Module III

Power Quality and introduction to custom power devices: Power Quality issues related to distribution systems – custom power devices – Distribution STATCOM – Dynamic Voltage restorer.

UPFC and IPFC: The Unified Power Flow Controller - operation, comparison with other FACTS devices - control of P and Q - dynamic performance - Special Purpose FACTS Controllers - Interline Power Flow Controller - operation and control.

Unified Power Quality Conditioner – Application of D-STATCOM, DVR and UPQC for improving power quality in distribution systems.

References

1. N. G. Hingorani & L. Gyugyi, *Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems*, IEEE Press, 2000.
2. T. J. E Miller, *Reactive Power Control in Electric Systems*, John Wiley & Sons.
3. Ned Mohan et.al, *Power Electronics*, John Wiley and Sons.
4. Ashok S. & K. S. Suresh Kumar "*FACTS Controllers and Applications*" course book for STTP, 2003.
5. K. R. Padiyar, *FACTS Controllers in Power Transmission and Distribution*, New Age International, First Edition.

Structure of the Question paper

For the end semester examination, the question paper will consist of three questions from each module out of which two questions are to be answered by the students.

EDE3008 EMBEDDED SYSTEMS & FPGA BASED SYSTEMS DESIGN 3-0-0-3

Pre-requisites: Basic knowledge in microprocessors and assembly language programming

Structure of the Course

Lecture	: 3 hrs/week	Credits: 3
Internal Continuous Assessment	: 40 Marks	
End Semester Examination	: 60 Marks	

Course Objectives

1. The ability to identify the configuration of hardware and software for an embedded system.
2. Should be able to use Embedded C for real time applications
3. Ability to apply RTOS concepts for solving multi task applications
4. Should understand the construction of FPGA

Learning Outcomes

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

1. Understand various communication architectures and protocols in an embedded system
2. Understand capabilities of Embedded C and execute basic programs using it
3. Understand, Analyze RTOS features and apply them for real time applications
4. Understand the configuration and programming of Field programmable gate array

Module I

Definition and classification-Overview of processors and hardware units in an embedded system-Software embedded into the system-Exemplary embedded systems –I/O devices- Synchronous, Iso-synchronous and Asynchronous communications from serial devices-UART and HDLC-Parallel port devices-Timer and Counting devices-I2C,USB,CAN and advanced I/O serial high speed buses-ISA,PCI,PCI-X and advanced buses. Programming in Assembly language vs. High Level Language-C Program Elements, Macros and functions -Use of Pointers - NULL Pointers - Function Pointers – Function Queues and Interrupt Service Routines Queues – Concepts of EMBEDDED PROGRAMMING in C++ - Objected Oriented Programming – Embedded Programming in C++, ‘C’ Program compilers – Cross compiler – Optimization of memory codes.

Module II

RTOS Task scheduling models - Handling of task scheduling and latency and deadlines as performance metrics – Co-operative Round Robin Scheduling – Cyclic Scheduling with Time Slicing (Rate Monotonics Co-operative Scheduling) – Preemptive Scheduling Model strategy by a Scheduler – Critical Section Service by a Preemptive Scheduler – Fixed (Static) Real time scheduling of tasks – inter process communication and synchronization– Shared data problem – Use of Semaphore(s) – Priority Inversion Problem and Deadlock Situations – Inter Process Communications using Signals – Semaphore Flag or Mutex as Resource key – Message Queues – Mailboxes – Pipes

Module III

Overview of FPGA architectures and technologies: FPGA Architectural options, granularity of function and wiring resources, coarse vs. fine grained, vendor specific issues (emphasis on Xilinx and Altera), Logic block architecture: FPGA logic cells, timing models, power dissipation I/O block architecture: Input and Output cell characteristics, clock input, Timing, Power dissipation. Programmable interconnect - Partitioning and Placement, Routing resources, delays

References

1. Rajkamal, '*Embedded Systems: Architecture: Programming and Design'*, Tata McGraw Hill Education, 2nd edn, 2009
2. Frank Vahid, Tony Givargis, *Embedded Systems Design: A Unified Hardware-Software Introduction*', John Wiley, 2002
3. David Simon, '*An Embedded Software Primer'*, Pearson Education Asia, 1999
4. Wayne Wolf, '*FPGA-Based System Design'*, Pearson Education Limited, 2009
5. M. J. S. Smith, '*Application Specific Integrated Circuits'*, Pearson, 2000

Structure of the Question paper

For the end semester examination, the question paper will consist of three questions from each module out of which two questions are to be answered by the students.

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EDC3101 THESIS PRELIMINARY: PART II

Structure of the Course

Thesis	: 14 hrs/week	Credits: 5
Internal Continuous Assessment	: 200 Marks	

The Thesis Preliminary Part - II is an extension of Thesis Preliminary Part - I. Thesis Preliminary Part II comprises preliminary thesis work, two seminars and submission of Thesis - Preliminary report. The first seminar would highlight the topic, objectives and methodology and the second seminar will be a presentation of the work they have completed till the third semester and the scope of the work which is to be accomplished in the fourth semester, mentioning the expected results.

Distribution of marks

Internal assessment of work by the Guide : 100 Marks

Internal evaluation by the Committee : 100 marks

EDC4101 THESIS

Structure of the Course

Thesis	: 21 hrs/week	Credits: 12
Internal Continuous Assessment	: 300 Marks	
End Semester Examination	: 300 Marks	

The student has to continue the thesis work done in second and third semesters. There would be an interim presentation at the first half of the semester to evaluate the progress of the work and at the end of the semester there would be a pre-Submission seminar before the Evaluation committee for assessing the quality and quantum of work. This would be the qualifying exercise for the students for getting approval from the Department Committee for the submission of Thesis. At least once technical paper is to be prepared for possible publication in Journals/Conferences. The final evaluation of the Thesis would be conducted by the board of examiners constituted by the University including the guide and the external examiner.

Distribution of marks

Internal evaluation of the Thesis work by the Guide : 150 Marks

Internal evaluation of the Thesis by the Evaluation Committee : 150 Marks

Final evaluation of the Thesis Work by the Internal and External Examiners:

[Evaluation of Thesis: 200 marks *+ Viva Voce: 100 marks (**5% of the marks is earmarked for publication in Journal/Conference*)] TOTAL – 300 Marks