M.Tech Programme

Electrical Engineering- Electrical Machines

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 1001	Advanced Mathematics and Optimization	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 1001	Power Electronic Circuits	3	3	3	40	60	100	Do
ECC 1003	Dynamics of Linear Systems	3	3	3	40	60	100	Do
EPC 1003	Power Quality	3	3	3	40	60	100	Do
EMC 1002	Modeling of Electrical Machines	3	3	3	40	60	100	Do
EMC 1003	Synchronous Generators	3	3	3	40	60	100	Do
EMC 1101	Power Electronics & Machines Lab	1	2	-	100	-	100	No End Sem Examinations
EMC 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	
EMC 2001	Electric Drives	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 2002	Special Electrical Machines	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
EMC 2101	Electrical Drives Lab	1	2	-	100		100	No End Sem Examinations
EMC 2102	Seminar	2	2	-	100		100	do
EMC 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

EME2001	Field Theory
EPE2005	Engineering Optimization
EPE2003	Distributed Generation

Stream Elective II

EME2002	PWM Converters and Applications
EPE2002	FACTS and Custom Power Devices
EPC2002	Power System Dynamics and 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
EMC 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

EME3001	Dynamics of Power Converters
EME3002	Design of Power Electronic Systems
EME3003	Advanced Topics in Power Electronics and Drives

Stream Elective IV

EPE3003	EHV AC & DC Transmission System
EPE3004	Static VAR Controllers and Harmonic Filtering
ECE3004	Advanced Instrumentation

SEMESTER IV

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

EMA1001 ADVANCED MATHEMATICS AND OPTIMIZATION 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 objective

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

Learning outcomes

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

Module I (Linear Algebra) (Definitions, theorems without proofs and problems**)**

Vector Spaces and sub spaces ,Null spaces ,Column spaces and Linear transformations , Dimensions of a vector space , Rank and Nullity, Innerproduct spaces, Norm and orthogonality- Gram -schemidt process. Matrix factorization-QR factorization, Singular value decomposition and least square problems.

Module II

Dual simplex method, Integer programming: Cutting plane method, Branch and bound method, Zero – One Programming, Unconstrained non-linear programming: Powel's method, Hooke-Jeeves method.

Module III

Constrained non-linear programming: Kuhn-Tucker conditions, Convex programming problem, Quadratic programming, gradient of a function, steepest descent method, conjugate gradient method, Dynamic Programming: Minimal path problems.

References

1. David C. Lay, '*Linear Algebra'*, Pearson Edn., 4th Edn., 2012
2. Richard Bronson, Gabriel B. Costa, '*Linear Algebra - An Introduction'*, Elsevier-Academic Press, 2nd Edn.
3. Otto Bretsher, '*Linear Algebra with Application'* - Pearson Education., 4th edn.
4. R. Hariprakash and B. Durga Prasad, *Operations Research* , Scitech. 1st edn., 2010
5. Handy A. Taha, *Operations Research an Introduction*, PHI, 9th Edn., 2011
6. B. S. Goel and S. K. Mittal, *Operations Research*, Pragathi Prakashan, 25th Edn., 2009.
7. K. V. Mittal and C. Mohan, '*Optimization Methods in Operations Research and System Analysis'*, 3rd Edn., New Age International Publishers.
8. Singiresu S Rao, *Engineering Optimization Theory and Practice*, 3rd Edn, New Age International Publishers.

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.

EMC1001 POWER ELECTRONIC CIRCUITS 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 familiarize Power Electronic circuits.

Learning Outcome

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

1. Choose a suitable power semiconductor device for a specific application
2. Design experiments to characterize power devices
3. Develop ideal and nonideal model of power devices for analysis and simulation
4. Analyse and evaluate various power electronic converter topologies including AC-AC converters, DC-DC converters and inverters.
5. Design and develop power converter topologies.
6. Design control schemes for Power converters including PWM schemes

Module I

Power Electronic Elements: The ideal switch, Characteristics of ideal switches, two-quadrant and four-quadrant switches- Switching constraints in power electronic circuits-Practical switches: Static and dynamic characteristics of Power Diodes, MOSFETs, IGBTs and GTOs-implementations of different configurations of switches using semiconductor devices.
Losses in practical switches: Models of diode, MOSFET and IGBTs for evaluating conduction and switching losses.

Module II

AC voltage controllers: Analysis of single-phase ac voltage controller with R and RL load, Performance parameters, Sequential control of single-phase ac voltage controllers.
DC-DC converters: Buck, boost, buck-boost and Ćuk Topologies-Representation with ideal switches, Steady state analysis in continuous conduction mode using inductor volt-sec balance - current and voltage ripples. Design relations for inductor and capacitors. Discontinuous Conduction Mode operation of basic buck and boost converter. Isolated DC-DC converters: Steady-state analysis of flyback, forward, push-pull and bridge topologies.

Module III

Switched Mode Inverters: Topologies of single-phase half-bridge, full-bridge and three-phase bridge Voltage Source Inverters-Representation using ideal switches- stepped wave and PWM operation-Sine-Triangle PWM-Selective Harmonic Elimination--Space Vector PWM-Evaluation of dwell times.
Principles of Current-Controlled VSI- Hysteresis control and PWM current control.
Current Source Inverters: Analysis of capacitor commutated single phase CSI feeding resistive and pure-inductor loads.

References

1. Ned Mohan, *et al.*, *Power Electronics: Converters, Design and Applications*, Wiley
2. V. Ramanarayanan, *Course Notes on Switched Mode Power Converters*, Dept. of Electrical Engineering, IISc, Bangalore
3. G. K. Dubey, *et al.*, *Thyristorised Power Controllers*, New Age International Publishers
4. John Vithayathil, Power *Electronics: Principles and Application*, Tata McGraw-Hill
5. Bin Wu, *High Power Converters and AC Drives*, IEEE Press, Wiley Interscience, 2006.
6. L. Umanand, *Power Electronics: Essentials and Applications*, Wiley, 2009

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, 8^{th} Edition, 1998
5. Gene K. Franklin & J. David Powell, *Feedback Control of Dynamic Systems*, Addison -Wesley, 3^{rd} 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.

EPC1003 **POWER QUALITY** **3-0-0-3**

Structure of the course

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

Course Objective

Objective of the course is to discuss various power quality issues and different methods to control them

Learning Outcomes

Upon successful completion of this course, students will be able to identify the power quality problems, causes and suggest suitable mitigating techniques.

Module I

Understanding Power Quality - Power quality issues in distribution systems - Sources and Effects of power quality problems, Power quality monitoring: Need for power quality monitoring, types of power quality disturbances - Voltage sag (or dip), Transients, short duration voltage variation, Long duration voltage variation, voltage imbalance, waveform distortion, and voltage flicker- methods of characterization- Power Quality Costs Evaluation - Causes and effects of power quality disturbances.

Module II

Harmonics -mechanism of harmonic generation-harmonic indices (THD, TIF, DIN, C - message weights). standards and recommended practices - Harmonic sources - SMPS, Three phase power converters, arcing devices, saturable devices, fluorescent lamps- Harmonic Analysis - Fourier series and coefficients, the Fourier transforms, discrete Fourier transform, fast Fourier transform, Window function- Effects of Power System harmonics on Power System equipment and loads

Module III

Harmonic elimination - Design philosophy of filters to reduce harmonic distortion - Power conditioners ,passive filter, active filter - shunt , series, hybrid filters, Computation of harmonic flows- Voltage regulation- devices for voltage regulation-capacitors for voltage regulation. Dynamic Voltage Restorers for sag, swell and flicker problems

Electromagnetic Interference (EMI -introduction -Frequency Classification - Electrical fields - Magnetic Fields - EMI Terminology - Power frequency fields - High frequency Interference - EMI susceptibility - EMI mitigation -Cable shielding- Health concerns of EMI

References

1. R. C. Durgan, M. F. Me Granaghen, H. W. Beaty, *'Electrical Power System Quality'*, McGraw-Hill
2. Jose Arillaga, Neville R. Watson, *'Power System Harmonics',* Wiley, 1997
3. C. Sankaran, *'Power Quality',* CRC Press, 2002
4. G. T. Heydt, *'Power Quality'*, Stars in circle publication, Indiana, 1991
5. Math H. Bollen, *'Understanding Power Quality Problems'*
6. *Power Quality Handbook*
7. J. B. Dixit & Amit Yadav, *'Electrical Power Quality'*
8. Recent literature

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.

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.

EMC1003 SYNCHRONOUS GENERATORS 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

Equip the Students with a thorough understanding of Synchronous Generators and stability analysis

Learning Outcome

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

1. To understand the performance of synchronous generators in power system.
2. To understand the dynamics of synchronous generators in transient situations.

Module I

Review of the basic principles of working , construction, different types, Working as a motor and generator, no load and load operation- starting performance of salient pole and cylindrical rotor synchronous machines- Performance of alternator connected to infinite bus bar.

Synchronous generator in power systems: Excitation systems- classification, components- voltage regulator, Exciter, Stabilizer.

Compensation of excitation systems- Instability problem of exciter- solution to the instability of exciter, need of the Power System Stabilizer (PSS)

Module II

Stability Studies: Transient stability study- Transient analysis- sudden three phase short circuit at generator terminals- armature currents and torque. Sub- transient time constant, Transient time constant. Determination of reactance and time constants from short circuit oscillogram - Transient power angle curve- Hunting performance of motion of rotor- linearised analysis for small oscillations.

Basic Dynamics of Synchronous Generators in transient situations : factors affecting transient stability.-Multi machine system- interactions between generators, two machines inter connected with external buses.

Module III

Synchronous Machine Dynamics- Classification of stability problems- Angle stability- The swing equation- Normalised swing equation- The power angle equation- Synchronous machine power coefficients- transient power. Angle characteristics- Transient power curve and dynamics- Response to a step change in mechanical power (P_m)- Linear analysis of swing equation- Equal area criterion of Stability (Non-linear analysis of swing equation)- Numerical Integration methods to solve power system stability problems.

References

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

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.

EMC1101 POWER ELECTRONICS AND MACHINES LAB 0-0-2-1

Structure of the course

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

Course Objective

1. To familiarize various power electronics devices and use them to do experiments.
2. To design various power electronic circuits.

Learning Outcomes

1. To understand concepts and principles involved in power electronics.
2. To train the students to perform experimental work for project/thesis.

Power Electronics

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

Machines

1. Modelling of dc and ac machines using computer simulation packages.
2. Modelling of drive systems.
3. Determination of Subtransient and Transient Reactance of Synchronous machine.
4. Performance testing of Induction Generator.

In addition to the above, the Department can offer a few experiments in the **Electrical Machines Laboratory** and newly developed experiments in the **Power Electronics Laboratory**

Minimum of 10 experiments are to be conducted

EMC1102 **SEMINAR**

Structure of the Course Credits: 2

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

The student is expected to present a seminar in one of the current topics in Electrical Machines' 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:

Report Evaluation	: 50
Presentation	: 50

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 –subsynchronous and supersynchronous 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.

EMC2002 SPECIAL ELECTRICAL MACHINES 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

This paper gives an over view of some of the special machines for control and industrial applications.

Learning Outcomes

Upon successful completion of this course, students will be able to know the construction and principle of operation of certain special machines like switched reluctance motor, stepped motor and brushless machines.

Module I

Reluctance Motors: Principle of Operation-Conventional and special types of rotor construction analysis and equivalent circuit-phasor diagram-circular loci of current and voltage components maximum pf-power expression-pull-in characteristics-factors affecting pulling in-applications
Switched Reluctance Motors: Principle of Operation-structure-inductance profile-Torque production-static and dynamic-Energy conversion loops-partition of energy and effects of saturation-control-Torque/speed characteristics-Rotor position sensing methods-different types comparison

Module II

Stepper Motors: different types-construction-theory of operation-monofilar and bifilar windings modes of excitation-static and dynamic characteristics-no of teeth-steps per revolution and no of poles-single phase stepping motors.
Linear Motors: different types-end effect -goodness factor-equivalent circuit of LIM - applications-linear reluctance motor-linear synchronous motors.

Module III

Brushless Machines: Brushless DC motors-construction, types, torque generation, principle of operation, motor characteristics-torque equation, position sensing, drive circuits-power circuits-variable speed operation.
Permanent Magnet Synchronous Machine: Construction-principle of operation, performance characteristics-advantages-applications.

Reference

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

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.

EME2001 FIELD THEORY 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

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

Learning Outcomes

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

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

Module I

Time varying fields and electromagnetic waves - Solution of Maxwell's equations for charge free unbounded region - Uniform waves - Uniform plane waves - Characteristics - Wave impedance and propagation constant - Wave propagation in good dielectrics, conductors - Depth of penetration - Surface impedance of good conductor to sinusoidal currents - Polarization - Elliptic, Linear and Circular polarization.

Waves at boundary between two media - Wave incident normally on boundary between perfect dielectrics - Wave incident obliquely on boundary between perfect dielectrics - Wave polarized perpendicular to the plane of incidence - Parallel polarization - Wave incident normally on perfect conductor - Oblique incidence - Brewster angle. Snell’s Law.

Module II

Poynting Vector - Poynting Vector for a plane wave in a dielectric - Flow of direct current in cylindrical resistor - Co-axial cables - Instantaneous. Average and Complex Poynting vector.

Guided waves - Essential conditions -Transverse electric waves - Transverse magnetic waves - Characteristics - TEM waves - Velocities of Propagation - TEM waves in co-axial cables and two wire transmission line - Attenuation factor for TE, TM and TEM waves.

Module III

Propagation characteristics of Radio waves - Electro-magnetic wave spectrum – Transmission path from transmitter to receiver - Ionosphere - Ionospheric investigation - Virtual height and critical frequency - Maximum usable frequency.

Eddy current problems - Calculation of Eddy current loss - Effect of saturation Flux plotting - Two Dimensional field plotting methods - Method of images - Multiple images - Image of point charge in conducting sphere - Graphical method of field mapping - experimental methods.

References

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

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.

EPE2005 ENGINEERING OPTIMIZATION 3-0-0-3

Structure of the course

Lecture : 3hrs/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 solve optimisation problems in engineering very effectively.

Course Objectives

1. Provide the students with basic mathematical concepts of optimization
2. Provide the students with modelling skills necessary to describe and formulate optimization problems
3. Provide the students with the skills necessary to solve and interpret optimization problems in engineering.

Module I

Review of linear and non-linear programming
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.
Piecewise linear approximation of a non-linear function, multi objective optimization-weighted and constrained methods, multilevel optimization

Module II

Genetic algorithm: Basic concept , encoding , fitness function, Reproduction ,Basic genetic programming concepts, differences between GA and Traditional optimization methods, Applications, Variants of GA-Simulated Annealing, Particle Swarm optimization

Module III

Theory of Games : Characteristics-Two Persons Zero sum Games- Maximin, Minimax principle - Saddle points- Games without Saddle Points
Reliability- Basic concepts-conditional failure rate function-failure time distributions-certain life models – reliability of a system in terms of the reliability of its components- series systems- parallel systems

References

1. G. V. Reklaitis, A. Ravindran & K. M. Rajsdell, *'Engineering Optimization, Methods and Applications'*, John Wiley & Sons.
2. Singiresu S. Rao, John, *'Engineering Optimization Theory and Practice'*, 3rd Edition, Wiley and Sons, 1998
3. A. Ravindran, Don T. Philips and Jamer J. Solberg, *'Operations Research - Principles and Practice', John* Wiley & Sons.
4. P. G. Gill, W Murray and M. H. Wright, *'Practical Optimization'*, Academic Press, 1981.
5. Fredrick S. Hiller and G J Liberman, *'Introduction to Operations Research'*, McGraw-Hill Inc., l995.
6. Ashok D. Belegundu, Tirupathi R. Chandrapatla, *'Optimization Concepts and Applications in Engineering'*, Pearson Education, Delhi, 2002.
7. G Owen, Game Theory
8. Hans Peters, *Game Theory: A Multilevel Approach*
9. Davis E. Goldberg , Genetic *Algorithms: Search, Optimization and Machine Learning*, Addison Wesley

Knowledge in matrix algebra and differential calculus.

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.

EPE 2003 DISTRIBUTED GENERATION 3-0-0-3

Structure of the course

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

Course Description

This course focuses on the new renewable energy based electric energy generation technologies and their integration into the power grid. The principles of new energy based distributed generation technologies: solar, wind, and fuel cells. Interconnection of distributed generation sources to power distribution grid. Economic aspects of distributed generation.

Course Objectives

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

Learning Outcomes

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

1. Choose the right renewable energy source and storage method
2. Design various interconnecting options of DG with the grid and its control
3. Address the problems of islanding, reactive power management and harmonics in a DG systems and its economic aspects

Module I

Distributed Generation Definition, Distributed generation advantages, challenges and needs. Non conventional and renewable energy sources-Wind Power- wind turbine and rotor types, wind speed – power curve, power coefficient, tip speed ratio, wind energy distribution, environmental impact. Photovoltaic and Thermo-solar power –Solar cell technology, Photovoltaic power characteristics and Thermo-solar power generation. Biomass Power, Fuel cells types, types of Tidal power generation schemes, mini and micro hydro power schemes, and Micro turbines for DG, bulb and tubular turbines. Energy Storage for use with Distributed Generation-Battery Storage, Capacitor Storage, ultra capacitors and Mechanical Storage: Flywheels, Pumped and Compressed Fluids.

Module II

Grid Interconnection Options, Pros and Cons of DG – Grid Interconnection, Standards of interconnection. Recent trends in power electronic DG interconnection. General power electronic DG interconnection topologies for various sources and control. Control of DG inverters, current control and DC voltage control for stand alone and grid parallel operations. Protection of the converter, Control of grid interactive power converters, phase locked loops ,synchronization and phase locking techniques, current control, DC bus control during grid faults, converter faults during grid parallel and stand alone operation.

Module III

Intentional and unintentional islanding of distribution systems. Passive and active detection of unintentional islands, non detection zones. Reactive power support using DG. Power quality improvement using DG, Power quality issues in DG environment.
Economic aspects of DG- Generation cost, investment, tariffs analysis. Hybrid energy systems.

References

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

In addition to readings from the textbook, the course will use selected papers and articles from professional magazines and industry internet sources as reference materials.

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.

EME2002 **PWM CONVERTERS AND APPLICATIONS** **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 equip the students with knowledge of PWM technique that has emerged from recent research and various topologies of multi-level converters and application of PWM converters

Learning Outcomes

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

1. Represent complex power converters using simple switch elements and analyse their steady state behaviour.
2. Create simulation models of advanced PWM converters including multilevel converters.
3. Design and implement modulation/control strategies such as sine-triangle PWM, Space Vector PWM and hysteresis control.
4. Develop control strategies for PWM converters with applications to drives, active front-end rectifier and shunt active filters.
5. Analyse and develop selective harmonic elimination strategies for converters.
6. Implement space vector modulation for CSI.

Module-I

Use of Single-Pole-Double-Throw Single-Pole-Multi-Throw switches to describe Converter Topologies: Basic switch constraints-Implementation of various switch schemes using available power semiconductor devices.

Topologies of Inverters and Rectifiers--relation between Pole voltages, Line voltages and Line-to-load neutral voltages in multi-phase two-level inverters-Basic modulation methods--duty ratio--sine-triangle modulation--implementation of unipolar and bipolar modulation--three-phase inverters- Harmonic performance of Unipolar and Bipolar modulation schemes in single phase and three phase inverters-linear modulation and overmodulation

Module-II

Space vector PWM - conventional sequence- 30 degree and 60 degree bus clamped PWM--relation between sine-triangle and space vector PWM--dc bus utilisation of SPWM and SVPWM. Overmodulation in SVPWM-Overmodulation zones.

Synchronised and non-synchronised PWM-Multilevel Converters: Topologies. Neutral Point Clamped and Flying Capacitor Topologies. Cascaded Multilevel Inverters-Multilevel Converters Modulation - Carrier based approach-Conventional Space Vector Modulation for 3-level inverters.

Module-III

Applications of PWM converters--Active front end rectifier--vector control of front-end rectifier-Control of Shunt active filter - PWM converters in AC drives-Current Control in inverters: Current controlled PWM VSI -Hysteresis Control - fixed band and variable band hysteresis.

Selective Harmonic Elimination-Derivation of simultaneous transcendental equations for elimination of harmonics- PWM Current Source Inverters--Current Space Vectors- Space Vector Modulation of CSI-Application of CSI in high-power drives-Fundamental principles of Hybrid schemes with CSI and VSI.

References

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

Technical Papers

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

Thesis/Reports

1. A.R.Beig, "Application of three level voltage source inverters to voltage fed and current fed high power induction motor drives" *-Ph.D. Thesis of Electrical Engineering*, IISc, Bangalore, April 2004.
2. G. Narayanan, "Synchronised Pulse-width Modulation Strategies based on Space Vector Approach for Induction Motor Drives"*-Ph.D. Thesis of Electrical Engineering*, IISc, Bangalore, August 1999.
3. Debmalya Banerjee, "Load Commutated Current Source Inverter fed Induction Motor drive with sinusoidal voltage and current," - *PhD. Thesis of Electrical Engineering*, IISc, Bangalore, June 2008.

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.

EPE2002 FACTS AND CUSTOM POWER 3-0-0-3

Structure of the course

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

Course Objective

Advances in Power electronics Industry led to rapid development of Power Electronics controllers for fast real and reactive power control and to introduce these advancements.

Learning Outcomes

Upon successful completion of this course, students will be able to select suitable FACTS device for the enhancement of power transfer capability and to control the power flow in an efficient manner.

Module I

Power flow in Power Systems-Benefits of FACTS Transmission line compensation- Uncompensated line -shunt compensation - Series compensation -Phase angle control. Reactive power compensation – shunt and series compensation principles – reactive compensation at transmission and distribution level – Static vs. Passive VAR Compensators – Converters for Static Compensation

Module II

Static shunt Compensator - Objectives of shunt compensations, Methods of controllable VAR generation - Variable impedance type VAR Generators -TCR, TSR, TSC, FC-TCR Principle of operation, configuration and control, Switching converter type VAR generators- Principle of operation, configuration and control, SVC and STATCOM, Comparison between SVC and STATCOM - Applications

Module III

Static Series compensator - Objectives of series compensations, Variable impedance type series compensators - GCSC. TCSC, TSSC - Principle of operation, configuration and control. Application of TCSC for mitigation of SSR. Switching converter type Series Compensators (SSSC)- Principle of operation, configuration and control. Static Voltage and Phase Angle Regulators (TCVR &TCPAR): Objectives of Voltage and Phase angle regulators, Thyristor controlled Voltage And Phase angle Regulators

Unified Power Flow Controller: Circuit Arrangement, Operation and control of UPFC- Basic principle of P and Q control- independent real and reactive power flow control- Applications - Introduction to interline power flow controller. Modelling and simulation of FACTS controllers

References

1. T. J. E. Miller, *'Reactive Power Control in Power Systems'*, John Wiley, 1982
2. J. Arriliga and N. R. Watson, *'Computer Modelling of Electrical Power Systems'*, Wiley, 2001
3. N.G. Hingorani and L. Gyugyi, *'Understanding FACTS'*, IEEE Press, 2000
4. K. R. Padiyar, '*FACTS Controllers in Power Transmission and Distribution'*, New Age International Publishers, 2007
5. Y.H. Song and A.T. Johns, *'Flexible ac Transmission Systems (FACTS)'*, IEE Press, 1999
6. Ned Mohan et al., '*Power Electronics*', John Wiley and Sons.
7. Dr. Ashok S. & K. S. Suresh Kumar, *'FACTS Controllers and Application'* Course Book for STTP 2003
8. Current Literature

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.

EPC2002 POWER SYSTEM DYNAMICS AND CONTROL 3-0-0-3

Structure of the course

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

Course Objective

To introduce various types of small signal stability problems that will encounter in power systems and also to introduce means to overcome them

Learning Outcomes

Upon successful completion of this course, students will be able to identify the small signal and stability problems, analyse them and to design power system stabilizers which can improve small signal stability in a power system.

Module I

Concept of Power system stability-Types of stability-Classical model of single machine connected to infinite bus and a multi machine system-mathematical modelling of power system elements for stability studies-Synchronous machines. Excitation systems and Prime mover controllers-Transmission lines-Loads-HVDC and FACTS devices

Module II

Small Signal Analysis-Fundamental concepts of Stability of Dynamic Systems: State Space representation-Linearization-Eigen properties of state matrix-Small Signal Stability of Single Machine Infinite Bus(SMlB) System-Heffron-Phillips constants-Effects on Excitation system -Block diagram representation with exciter and AVR-Power System Stabiliser (PSS): State matrix including PSS-Small Signal Stability of Multi Machine Systems-Special Techniques for analysis of very large systems: Analysis of Essentially Spontaneous Oscillations in Power Systems(AESOPS) algorithms-Modified Arnoldi Method(MAM), Characteristics of Small Signal Stability Problems: local problems and global problems-Small Signal Stability Enhancement: Using Power System Stabilisers-Supplementary control of Static VAR Compensators-Supplementary Control of HVDC transmission links-Inter area oscillations

Module III

Sub-synchronous Resonance (SSR)-Turbine-Generator torsional Characteristics-Torsional interaction with Power System Controls-Sub synchronous resonance-Impact of network switching disturbances-Torsional interaction between closely coupled units-Hydro generator torsional characteristics

References:

1. Anderson and Fourd, *'Power System Control and Stability*, Galgotia Publications, 1981
2. K . R . Padiyar, *'Power System Dynamics'*, 2nd Edition, B. S. Publishers, 2003
3. P. Kundur, *'Power system Stability and Control',* McGraw-Hill Inc., 1994
4. P. W. Sauer & M. A. Pai, *'Power System Dynamics and Stability,* Pearson, 2003
5. Olle I. Elgerd, *'Electric Energy Systems Theory an Introduction'*, 2nd Edition, McGraw-Hill, 1983
6. E. W. Kimbark, *'Power System Stability',* Wiley & IEEE Press, 1995
7. Yao-nan-Yu, *'Electric Power Systems Dynamics',* Academic Press, 1983

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.

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

Credits: 3

Lecture : 3 hrs/week
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.

EMC2101 ELECTRICAL DRIVES 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. To simulate various motors using MATLAB/SIMULINK.
2. To perform monitoring and control experiments using LABVIEW.
3. To conduct test on lightning arresters and insulators.

Learning Outcomes

Acquire capacity to organise experiments/simulations for project and thesis works.

Experiments

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

In addition to the above, the Department can offer a few newly developed experiments in the Electrical Machines Laboratories, Power Systems Laboratories, Drives Lab, etc.

Minimum of 10 experiments are to be conducted

EMC2102 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 - 50 marks
Seminar Presentation - 50 marks

EMC2103 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

EME3001 DYNAMICS OF POWER CONVERTERS 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 equip the students with the dynamic aspect of different converters and their analysis

Learning Outcomes

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

1. Develop dynamic models of switched power converters using state space averaging and circuit averaging techniques.
2. Develop converter transfer functions.
3. Design closed loop controllers for DC-DC power converters.
4. Design and implement current mode control for DC-DC converters.

Module I

Fundamentals of Steady state converter modelling and analysis, Steady-state equivalent circuits, losses and efficiency. Inclusion of semiconductor conduction losses in converter model.
Small-signal AC modelling- Averaging of inductor/capacitor waveforms- perturbation and linearisation.
State-Space Averaging-Circuit Averaging and averaged switch modelling- Canonical Circuit Model-Manipulation of dc-dc converters' circuit model into Canonical Form-Modelling the pulse width modulator

Module II

Converter Transfer Functions:-Review of frequency response analysis techniques- Bode plots – Converter transfer functions-graphical construction. Measurement of ac transfer functions and impedances.
Controller Design: Effect of negative feedback on the network transfer functions-loop transfer function-Controller design specifications- PD, PI and PID compensators - applications to the basic dc-dc topologies - Practical methods to measure loop gains: Voltage and current injection

Module III

Converters in Discontinuous Conduction Mode: AC and DC equivalent circuit modelling of the discontinuous conduction mode-Generalised Switch Averaging-small-signal ac modelling of the dcm switch network-
Current-Mode Control: Average Current-mode Control, Peak Current-mode control-first order models-accurate models for current-mode control-application to basic dc-dc converter topologies-Subharmonic oscillation for $d > 0.5$; Slope compensation- Discontinuous conduction mode in current-mode control.

References

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

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.

EME3002 DESIGN OF POWER ELECTRONIC 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 Objective

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

Learning Outcomes

Upon successful completion of this course, students will be able to design entire power electronics systems including power circuit, protection and sensing, auxiliary devices (inductors, filters) etc.

Module I

Designing with Power Semiconductors: Gate Drive requirements of SCRs, BJTs, MOSFETs and IGBTs. Precautions- Typical gate drive circuits using discrete components and Integrated Circuits-High-side switch driving using isolated gate drives : Pulse transformers and Opto-isolator based circuits and limitations-Typical circuits. Boot-strap power supply technique for high-side Gate drives: IR 2110 family of Gate drive ICs.
Power circuit design: Selection of power devices, losses, thermal design, paralleling of MOSFETs. Considerations in Gate drive design for paralleled MOSFETs.

Module II

Passive elements in Power electronics: Inductors : types of inductor and transformer assembly, cores : amorphous, ferrite and iron cores : magnetic characteristics and selection based on loss performance and size, relative merits/demerits.
Capacitors: types of capacitors used in PE, selection of capacitors, dc link capacitors in inverters and rectifiers, filter capacitors in dc-dc and inverter circuits,- Equivalent Series Resistance and Equivalent Series Inductance of capacitors and their effects in converter operation-Resistors: Power resistors, use in snubbers. Resistors for special purpose: HV resistors and current shunts.
Magnetics design: Design based on area-product approach, inductors, transformers.
Sensors: Design of current transformers for Power Electronics Applications, Resistive shunts, Hall-effect based current sensors, typical design based on hall-effect sensors, auxiliary scaling and signal conditioning circuits.

Module III

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

References

1. V. Ramanarayanan, '*Switch Mode Power Conversion*,' e-book, Department of Electrical Engineering, IISc, Bangalore. Available at: *http://www.ee.iisc.ernet.in/new/people/faculty/vram* (For Thermal Design, Magnetics design, Reactive elements, Drive circuits, etc).
2. L. Umanand, "*Power Electronics: Essentials & Applications*," New Delhi, Wiley India Pvt. Ltd.
3. Ned Mohan et al., '*Power Electronics: Converters, Design and Applications*', John Wiley and sons, (Power circuit design, assembly, parasitics, current sensors, etc
4. Robert Erickson and Dragan Maksimovic, '*Fundamentals of Power Electronics*,' Springer India
5. Daniel W. Hart, "*Power Electronics*", Tata McGraw-Hill
6. International Rectifiers Application Notes. AN 936, AN 937, AN 941, AN 944, AN 978, AN 1084, AN1092
7. Data sheets EPCOS, ALCON etc., for capacitors, ferrite cores etc. (Available on http://www.epcos.com, and http://www.alconelectronics.com)

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.

EME3003 ADVANCED TOPICS IN POWER ELECTRONICS AND DRIVES 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 introduce special and advanced topics in power electronic and drives such as utility front converters-soft-switching converters sensorless vector control and high power drives

Learning Outcomes

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

1. Analyse and develop control strategies for high power factor rectifiers, soft switching converters.
2. Develop advanced schemes for induction motor and PMSM, BLDC drives
3. Develop control schemes for active filters (Direct Torque Control)

Module I

High power factor rectifiers: Properties of ideal rectifiers-realisation of near-ideal rectifier for single phase and three-phase ac input- Modelling losses and efficiency in continuous conduction mode (CCM) low harmonic rectifier – Controller schemes for high power factor rectifiers – average current control, current mode control, hysteritic control and nonlinear carrier control – Control system modelling.

Module II

Resonant and soft switching converters: Sinusoidal analysis of resonant converters-modelling-Series resonant and parallel resonant converters – zero voltage and zero current switching in resonant converters- Quasi resonant converters: ZVS, ZCS switch cells- AC modelling of quasi resonant converters – Zero voltage transition converters

Module III

Advanced Topics in Drives: Sensorless vector control of Induction Motors, PMSM and synchronous motor-Motor modelling-Control of Doubly fed Induction machines-High power drives – CSI fed Induction motor drives-control of high power synchronous motor drives-Switched reluctance motor drives- BLDC motor control - Active filter control – Shunt Active filter (vector control)

References

Technical papers and current literature.

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.

EPE 3003 EHV AC&DC TRANSMISSION SYSTEM 3-0-0-3

Structure of the course

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

Course Objective

To enable the students gain a fair knowledge on the concepts and technology of EHV-AC & DC transmission systems

Learning Outcomes

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

Module I

EHV AC transmission-configuration-features-intermediate substations-applications- interconnected AC networks-HVDC system-classification-configuration-equipment in HVDC substations-Power flow in AC and HVDC lines-EHV AC vs. HVDC-economic comparison-HVDC power flow- power conversion principle-power loss in DC system-steady state U_d/I_d characteristics

Converter circuits-single phase and three phase circuits-analysis of bridge converter-with and without overlap-grid control - control characteristics-constant minimum ignition angle control-constant current control-extinction angle control

Harmonics-characteristics of harmonics-means of reducing harmonics-telephone interference-filters-single frequency and double frequency-tuned filters-DC harmonic filter

Module II

Reactive power requirements in HVDC substations-effect of delay angle and extinction angle-short circuit ratio in planning of HVDC

DC line oscillations and line dampers-over voltage protection-DC lightning arresters-DC circuit breakers -basic concepts types & characteristics

Earth electrode-location and configuration-earth return-materials of anode-sea electrode –shore electrode-troubles by earth currents and remedial measures

Module III

EHV AC Transmission-Components of transmission system-voltage gradients of conductor-single and bundled conductor

Corona & corona losses in EHVAC and HVDC-critical surface gradient-Peeks law-critical disruptive voltage and critical electric stress for visual corona-Insulation requirements of EHV AC and DC transmission lines - Electrostatic field of EHV lines-biological effects-live wire maintenance-insulation coordination-insulation for power frequency-voltage-switching over voltage-lightning performance-calculation of line & ground parameters

References

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

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.

EPE 3004 STATIC VAR CONTROLLERS & HARMONIC FILTERING 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 familiarize the different control schemes for Static VAR Compensators to mitigate power quality problems in Power System

Learning Outcomes

Upon successful completion of this course, students will be able to design controllers for FACTS device for different application and to develop power system conditioner.

Module I

Fundamentals of Load Compensation, Steady-State Reactive Power Control in Electric Transmission Systems, Reactive Power Compensation and Dynamic Performance of Transmission Systems.

Converters for Static Compensation, Single Phase and Three Phase Converters and Standard Modulation Strategies (Programmed Harmonic Elimination and SPWM). GTO Inverters, Multi-Pulse Converters and Interface Magnetics Multi-Level Inverters of Diode Clamped Type and Flying Capacitor Type and suitable modulation strategies. Multi-level inverters of Cascade Type and their modulation . Current Control of Inverters.

Module II

Static Reactive Power Compensators and their control. Shunt Compensators, SVCs of Thyristor Switched and Thyristor Controlled types and their control, STATCOMs and their control, Series Compensators of Thyristor Switched and Controlled Type and their Control, SSSC and its Control, Sub-Synchronous Resonance and damping, Use of STATCOMs and SSSCs for Transient and Dynamic Stability Improvement in Power Systems

Module III

Passive Harmonic Filtering . Single Phase Shunt Current Injection Type Filter and its Control, Three Phase Three-wire Shunt Active Filtering and their control using p-q theory and d-q modelling . Three-phase four-wire shunt active filters . Hybrid Filtering using Shunt Active Filters . Series Active Filtering in Harmonic Cancellation Mode . Series Active Filtering in Harmonic Isolation Mode. Dynamic Voltage Restorer and its control. Power Quality Conditioner

References

1. T. J. E. Miller, '*Reactive Power Control in Electric Systems*', John Wiley & Sons, 1982.
2. N. G. Hingorani & L. Gyugyi, *Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems*, IEEE Press, 2000.
3. Ned Mohan et.al, '*Power Electronics'* John Wiley and Sons, 2006

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.

ECE3004 **ADVANCED INSTRUMENTATION** **3-0-0-3**

Structure of the course

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

Course objective

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

Learning Outcome

Upon completion of the course, the student will be able to

1. Identify the performance of different measurement systems and apply it for different control systems.
2. Students will also get a good idea of the virtual instrumentation which is an emerging technology.

Module I

Generalized performance characteristics of instruments - Static characteristics, static calibration, memory, precision and bias, dynamic characteristics, development of mathematical model of various measurement systems. Classification of instruments based on their order. General concept of transfer function (with special reference to measuring systems) Dynamic response and frequency response studies of zero order, first order and second order instruments. Response of a general form of instrument to a periodic input. Response of a general form of instrument to a transient input. Requirement of instrument transfer function to ensure accurate measurement.

Module II

Plant level automation- process and instrumentation diagrams- Performance modelling — role of performance modelling- performance measures. Petrinet models- introduction to petrinets- basic definitions and analytical techniques, Smart Sensors, Wireless sensors and Wireless Sensor network protocol.

Module III

Virtual instrumentation – Definition, flexibility – Block diagram and architecture of virtual instruments – Virtual instruments versus traditional instruments – Review of software in virtual instrumentation - VI programming techniques , sub VI, loops and charts ,arrays, clusters and graphs, case and sequence structures, formula nodes, string and file input / output.

References

1. B. D. Doeblin, *Measurement Systems -Application and Design*, McGraw-Hill New York.
2. John P. Bentley, *'Principles of Measurement System'*, Pearson Education.
3. J. W. Dally, W. F. Reley and K. G. McConnel, *'Instrumentation for Engineering measurements*, Second edition, John Wiley & Sons Inc., New York, 1993.
4. Curtis D. Johnson, '*Process Control Instrumentation Technology'*, Prentice Hall of India Private Ltd., New Delhi.
5. Dale E. Soberg, Thomson F. Edgar, '*Process Dynamics and Control'*, Second Edition, Wiley.
6. K. B. Klaasen, *'Electronic Measurements and Instrumentation'*, Cambridge University Press.
7. Waltenegus Dargie & Christian Poella Bauer, "*Fundamentals of Wireless Sensor networks*", Wiley Series.
8. Jun Zheng & Abbas Jamalipour, *Wireless Sensor Networks - A Networking Perspective*, Wiley.

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.

EMC3101 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

EMC4101 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 ear marked for publication in Journal/Conference*)] TOTAL – 300 Marks