M.Tech Programme

Electrical Engineering- Control Systems

Curriculum and Scheme of Examinations

SEMESTER I

Code No.	Name of Subject	Credits	Hrs / week	End Sem Exam (Hours)	Marks			Remarks
					Internal Continuous Assessment	End Semester Exam	Total	
EMA 1002	Applied Mathematics	3	3	3	40	60	100	Of the 40 marks of internal assessment 25 marks for tests and 15mark for assignments. End sem exam is conducted by the University
ECC 1001	Optimization Techniques	3	3	3	40	60	100	Do
EMC 1001	Power Electronic Circuits	3	3	3	40	60	100	Do
ECC 1002	Digital Control Systems	3	3	3	40	60	100	Do
ECC 1003	Dynamics of Linear Systems	3	3	3	40	60	100	Do
EGC 1002	Introduction to Flight	3	3	3	40	60	100	Do
ECC 1101	Advanced Control Lab I	1	2	-	100	-	100	No End Sem Examinations
ECC 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	
ECC 2001	Optimal Control Theory	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
ECC 2002	Non Linear Control Systems	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
ECC 2101	Advanced Control Lab II	1	2	-	100		100	No End Sem Examinations
ECC 2102	Seminar	2	2	-	100		100	do
ECC 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

ECE2002	Sliding Mode Control Theory
ECE2003	Stochastic Control
EGE 2001	Flight Dynamics and Control

Stream Elective II

EMC2001	Electric Drives
ECE2001	Adaptive Control
EME2002	PWM Converters and Applications
ECE2004	Robotics

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
ECC 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
ECE3001	Robust Control
ECE3004	Advanced Instrumentation

Stream Elective IV

ECE3002	System Identification and Parameter Estimation
ECE3003	Multi Variable Control Systems
ECE3005	Estimation Theory

SEMESTER IV

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

EMA1002 APPLIED MATHEMATICS 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

Modern engineering problems are complex and varied and require a variety of mathematical tools to solve them. This course is designed to introduce to students some of the basic tools in higher mathematics which are essential for higher studies and research in engineering.

Learning outcomes

Upon successful completion of this course, students will be familiar with some of the basic tools in higher mathematics which are essential for higher studies and research in engineering.

Review

Random Process, auto-correlation, stationarily power spectrum, Poisson process

Module I

Vector Spaces: Vector space, subspace, linear independence, basis and dimension (Definitions, theorems without proof and problems), linear transformations, Rank and nullity, Inner product, Norm of a vector, orthogonal vectors, Gram Schmidt Orthogonalization process. Matrix factorizations - LU Factorization, QR factorization, Singular value decomposition.

Module II

Calculus of Variations: Basic problems of calculus of variations, other forms of Euler's equation, problems, problems of the minimum surface of revolution, minimum energy problem, Brachistochrone problem, Isoperimetric problem.
Integral Equations: Formation of Volterra - Fredholm integral equations, solution of integral of 2^{nd} kind by transform methods, convolution type, method of successive approximation and iterative method.
Boundary Value Problem: Solution of partial differential equations using Laplace Transform Method.

Module III

Special processes: Gaussian processes, Discrete time Markov chains, Chapman- Kolmogorov Equations, classification of states, Steady State Probabilities, continuous - time Markov chain: State occupancy times, transition rates, Steady State Probabilities, Global balance equations, Application to Birth - death process and Queuing models (M/M/1 and M/M/c models with infinite capacity).

References

1. David C. Lay, *Linear Algebra*, Pearson, 4th ed., 2012.
2. Serge Lang, *Introduction to Linear Algebra,* Springer, 2nd ed.
3. G. F. Simmons, *Differential Equation with historical notes*, 2nd ed.
4. B. S. Grewal, *Higher Engineering Mathematics*, Khanna Publishers, 40th ed.
5. Sankara Rao, *Introduction to Partial Differential Equations*, PHI, 3rd ed., 2011.
6. Alberto Leon-Garcia, *Probability and Random Processes for Electrical Engineering*, Pearson, 2nd ed., 2009
7. S. M. Ross, *Introduction to Probability Models*, Elsevier, 10th ed., 2009.
8. Sundarapandian, *Probability Statistics and Queuing Theory*, PHI, 2009.
9. T. Veerarajan, *Probability and Random Process*, Tata McGraw-Hill, 3rd ed., 2011

Structure of the question paper

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

ECC1001 OPTIMIZATION TECHNIQUES 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. 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.

Learning Outcomes

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

1. Formulate engineering design problems as mathematical optimization problems
2. Categorize the given problem as linear/ nonlinear, constrained/ unconstrained etc.
3. Choose appropriate solution method for the given optimization problem
4. Understand how optimization methods can be used to solve engineering problems of relevance to industries/ research.
5. Model real-world situations using game theory and analyze the situations using game theoretic concepts.

Module I

Classification of optimization problems and applications - Basic concepts of design vectors, design constraints, constraint surface and objective function surfaces. Formulation and solution of linear programming problem - Simplex Method, Two phase simplex method, Duality theory, Dual Simplex method. Sensitivity analysis to linear programming problem-changes in constants of constraints, changes in cost coefficients-changes in the coefficients of constraints, addition of new variables and addition of new constraints. Introduction to Integer Programming methods - Branch and bound method-Gomory's cutting plane method for integer and mixed integer programming.

Module II

Nonlinear programming- Properties of single and multivariable functions. Classical optimization techniques-Optimality criteria, Lagrange Multipliers, Unconstrained optimization technique-direct search methods- Random search methods, univariate method, Hooke and Jeeves Method, Powell’s Method-Steepest Descent (Cauchy) Method, Conjugate Gradient Method.

Gradient based methods-Newton's method- Conjugate Gradient Methods-Fletcher-Reeves - Quasi - Newton Methods-DFP method. Constrained optimality criteria-KKT Conditions-interpretation of KKT Conditions. Method of feasible directions-GRG method, Quadratic Programming-Wolfe’s method.

Module III

Dynamic programming-basic concepts-multistage decision problems-computation procedure-applications in linear and non-linear optimization. Preview of cooperative and non-cooperative game: prisoner's dilemma, Two person zero sum game: Matrix game, Introduction to Nash equilibrium, Mixed strategy equilibrium in two person zero sum game, Two person nonzero sum game, bimatrix game - explanation of Nash equilibrium, Linear programming and game theory, Reaction curves, Cournot’s competition, Extensive form game: single act and multiact game, normal form game, Dynamic game, backward induction, subgame perfect equilibrium.

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. Luen Berger, *Linear and Nonlinear Programming*.
4. A Ravindran, Don T Philips and Jamer J Solberg, “*Operations Research-Principles and Practice*”, John Wiley & Sons.
5. P. G. Gill, W. Murray and M. H. Wright, “*Practical Optimization*”, Academic Press, 1981.
6. Fredrick S. Hiller and G. J. Liberman, “*Introduction to Operations Research*”, McGraw-Hill Inc, l995.
7. Ashok D. Belegundu, Tirupathi R. Chandrapatla, “*Optimization Concepts and Applications in Engineering*”, Pearson Education, Delhi, 2002.
8. T. Basar, G. J. Olsder, “*Dynamic Non-cooperative Game*”.
9. G. Owen, Hans Peters, “*Game Theory: A Multilevel Approach*”.

Structure of the question paper

For the end semester examination, the question paper consists of at least 60% problems and derivations. 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.

ECC1002 DIGITAL CONTROL SYSTEMS 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 introduce the concepts of digital control.
2. To analyse the stability using different methods.
3. To design compensators using classical methods.
4. To impart in-depth knowledge in state space design of digital controllers and observers.
5. To analyse the system performance with controller and estimator in closed loop.

Learning Outcomes

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

1. Analyse a given discrete-time system and assess its performance.
2. Design a suitable digital controller for a given system to meet the specifications.
3. Design a digital controller and observer for a given system and evaluate its performance.

Module I

Analysis in Z-domain: Review of Z Transforms, Pulse Transfer Function and sample and hold, effect of damping, mapping between the s plane and the z plane, stability analysis of closed loop systems in the z- plane, Jury's test, Schur Cohn test, Bilinear Transformation, Routh-Hurwitz method in w-plane. Discrete equivalents: Discrete equivalents via numerical integration-pole-zero matching-hold equivalents.

Module II

Digital Controller Design for SISO systems: Design based on root locus method in the z-plane, design based on frequency response method design of lag compensator, lead compensator , lag lead compensator, design of PID Controller based on frequency response method- Direct Design-method of Ragazzini. Design using State Space approach, pulse transfer function matrix, discretization of continuous time state space equations, Controllability, Observability, Control Law Design, decoupling by state variable feedback, effect of sampling period.

Module III

Estimator/Observer Design: Full order observers - reduced order observers, Regulator Design, Separation Principle - case with reference input. MIMO systems: Introduction to MIMO systems, Design Concept - Case Studies.

References

1. Gene F. Franklin, J. David Powell, Michael Workman, “*Digital Control of Dynamic Systems*”, Pearson, Asia.
2. J. R. Liegh, "*Applied Digital Control*", Rinchart & Winston Inc., New Delhi.
3. Frank L. Lewis, "*Applied Optimal Control & Estimation*", Prentice-Hall, Englewood Cliffs NJ, 1992.
4. Benjamin C Kuo, “*Digital Control Systems*”, 2nd Edition, Saunders College Publishing, Philadelphia, 1992.
5. K. Ogata, “*Discrete-Time Control Systems*”, Pearson Education, Asia.
6. C. L. Philips, H. T. Nagle, “*Digital Control Systems*", Prentice-Hall, Englewood Cliffs, New Jersey, 1995.
7. R. G. Jacquot, “*Modern Digital Control Systems*”, Marcel Decker, New York, 1995.
8. M. Gopal, “*Digital Control and State Variable Methods*”, Tata McGraw-Hill, 1997.

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.

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

Structure of the course

Credits: 3

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

Course Objectives

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

Learning Outcomes

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

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

Module I

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

Module II

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

Module III

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

References

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

Structure of the question paper

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

EGC1002 INTRODUCTION TO FLIGHT 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

To induct fundamental concepts of aerodynamics, aircraft performance, stability and control.

Learning Outcomes

Upon successful completion of this course, students will have knowledge of standard atmosphere, basic aerodynamics and aerodynamic shapes, general idea of airplane performance, stability and control.

Module I

Aerodynamics- standard atmosphere-definition of altitude-layers of atmosphere-isothermal and gradient layers-calculation of pressure, density, temperature in stratosphere and troposphere- stability of atmosphere-lapse rate-pressure, density and temperature altitudes.

Aerodynamic flow- types of flow -inviscid and viscous flows-incompressible and compressible flows- subsonic, transonic-supersonic and hypersonic flow regimes-boundary layer- laminar and turbulent flow-vorticity-circulation- pressure and shear stress distribution -downwash and induced drag- wash-in wash-out, Reynolds number-dimensional analysis-Buckingham PI theorem-aerodynamic forces and moments- aerodynamic heating - -dynamic pressure-pressure coefficient-isentropic flow.

Module II

Airfoils- air foil nomenclature- symmetric and cambered airfoils- pressure distribution over airfoil -elliptical lift distribution- Generation of lift-lifting surfaces-wings-wing geometry-aspect ratio – chord line-angle of attack-aerodynamic forces- lift, drag and moment coefficients-variation with angle of attack- aerodynamic center- Center of pressure-stalling of airfoils-characteristics of ideal airfoil - lift curve -drag curve-lift/drag ratio curve- swept wings-super critical airfoils.

Mach number, critical Mach number, drag divergence Mach number-Mach angle-Mach number independence, compressibility- flow similarity-wind tunnels-open ,closed and variable density tunnels- NACA airfoils- modern low speed airfoils -critical shock stall- drag polar.

Module III

Control surfaces-elevator-aileron-rudder-canard--tail plane-loads on tail plane -dihedral angle, dihedral effect- flaps and slots- spoilers.

Aircraft Stability and control-Static stability, dynamic stability, horizontal and vertical stabilisers, moments on the airplane, criteria for longitudinal static stability.

Anatomy of aerospace vehicles-Aircrafts-Helicopters-Launch Vehicles-Missiles-Unmanned Aerial Vehicles and Spacecrafts.

References

1. John D. Anderson Jr., '*Introduction to Flight*' McGraw-Hill International, Fifth Edition,2005
2. John D. Anderson Jr., *'Fundamentals of Aerodynamics'*, McGraw-Hill International, Fourth Edition, 2007.
3. A. C. Kermode, *'Mechanics of Flight'*, Pearson Education, Tenth Edition, 2005.
4. Bernard Etkin, '*Dynamics of flight Stability and Control*', John Wiley and Sons Inc. Third Edition, 1996.
5. E. L. Houghton and N. B. Carruthers, *'Aerodynamics for Engineering Students'*, Arnold Publishers, Third Edition, 1986.
6. Thomas R. Yechout, *'Introduction to Aircraft Flight Mechanics'*, AIAA Education Series, 2003
7. Richard S. Shevell, *'Fundamentals of Flight'*, Pearson Education Inc., Second Edition, 2004.
8. Louis V. Schmidt, *'Introduction to Aircraft Flight Dynamics'*, AIAA Education Series, 1997
9. Current Literature.

Structure of the Question paper

There will be three questions from each module, out of which students have to answer any two.

ECC1101 ADVANCED CONTROL LAB-I 0-0-2-1

Structure of the course

Practical : 2 hrs/week Credits: 1

Internal Assessment : 100 Marks

End semester Examination : Nil

Course Objectives

1. Design, simulate and evaluate control systems.
2. Design and fine tuning of PID controller and familiarise the roles of P, I and D in feedback control.
3. Design and analysis of control systems using MATLAB/SIMULINK.

Learning Outcomes

1. Acquire ability to critically analyse different dynamic systems and choose a suitable controller.
2. Get exposure to aspects of control systems design.
3. Get exposure to simulation tools using MATLAB/SIMULINK and LABVIEW softwares.

List of Experiments

1. Familiarization of MATLAB commands.
2. Analysis and design of systems using MATLAB and SIMULINK.
    - 2.1. Satellite control system
    - 2.2. Torsional mechanical system
3. Compensator design based on time domain and frequency domain approaches.
    - 3.1. Lag compensator
    - 3.2. Lead compensator
    - 3.3. Lag lead compensator
4. Design and Realization of compensator for a given system.
5. Design and realization of state feedback control for a given order system.
6. Design and realization of full order observer for a given order system.
7. Design and realization of a closed loop reduced observer for a given system to implement a state feedback controller.

ECC1102 SEMINAR

Structure of the Course

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

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

Marks:

Report Evaluation	: 50
Presentation	: 50

ECC2001 OPTIMAL CONTROL THEORY 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 design suitable performance measure to meet the specification requirements.
2. To analyse the physical system and design the controller by optimizing the suitable performance criteria by satisfying the constraints over the state and inputs.
3. To apply the design algorithms to various physical systems.
4. Provides a solid foundation on functions, functionals, various norms, etc.

Learning Outcomes

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

1. Formulate the optimal controller design problem.
2. Apply constrained optimization to various physical systems.
3. Implement optimal control algorithms to track the response of the system through a predefined trajectory

Module I

Optimal control problems- mathematical models-selection of performance measures, constraints- classification of problem constraints-problem formulation-examples.
Dynamic Programming- Optimal control law-principle of optimality - Application to decision making-routing problem-Hamilton Jacobi Bellman equation- Standard Regulator Problem: Solution of finite time regulator Problem – Discrete Linear Regulator Problem – Infinite time Regulator Problem – Stability.

Module II

Calculus of Variations: basic concepts - variation of a functional - extremals – fundamental theorem in calculus of variation - Euler equation - Piecewise smooth extremals – constrained extrema – Hamiltonian - necessary condition for optimal control.

Module III

Pontryagin's Minimum Principle: Minimum time problem, Minimum Control Effort problem, Minimum Fuel problem, Minimum Energy problem, Singular intervals, Effects of Singular Intervals, Numerical Examples.

References

1. Donald E. Kirk, *Optimal Control Theory - An Introduction*, Prentice-Hall Inc. Englewood Cliffs, New Jersey, 1970.
2. Brian D. O. Anderson, John B. Moore, *Optimal Control-Linear Quadratic Methods*, Prentice-Hall Inc., New Delhi, 1991.
3. Athans M. and P. L. Falb, *Optimal control- An Introduction to the Theory and its Applications*, McGraw Hill Inc., New York, 1966.
4. Sage A. P., *Optimum Systems Control*, Prentice-Hall Inc., Englewood Cliffs, New Jersey, 1968.
5. D. S. Naidu, *Optimal Control Systems*, CRC Press, New York Washington D. C., 2003.

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.

ECC2002 NONLINEAR CONTROL SYSTEMS 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 study the essentials of Nonlinear control.
2. To extend the analysis techniques for classical control theory to nonlinear system.
3. To analyse the physical system with inherent non-linearity for stability and performance.
4. To provide the necessary methods for designing controllers for Non-linear systems.

Learning Outcomes

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

1. Gain insight into the complexity of nonlinear systems.
2. Apply methods of characterizing and understanding the behaviour of systems that can be described by nonlinear ordinary differential equations.
3. Use tools including graphical and analytical for analysis of nonlinear control systems.
4. Use a complete treatment of design concepts for linearization via feedback.
5. Demonstrate an ability to interact and communicate effectively with peers.

Module I

Describing function analysis: Fundamentals-Describing Function of saturation, dead-zone, on-off non-linearity, backlash, Hysteresis-Describing Function Analysis of Non-linear Systems, Dual Input Describing Function (DIDF)-Existence of Limit Cycles.
Phase plane analysis: Concept of Phase Portraits-Singular Points Characterization – Analysis of Non-linear Systems Using Phase Plane Technique – Classification of Equilibrium Points - Stable & Unstable – Limit Cycle Analysis- Existence – Stability.

Module II

Concept of stability: Definition of Stability - Stability in the Sense of Lyapunov, Analysis of Instability, Absolute Stability, Zero- Input and BIBO Stability, Second method of Lyapunov-Stability theory for Continuous and Discrete Time Systems - Aizermanns and Kalman's conjecture - Construction of Lyapunov function for non linear systems - Methods of Aizerman-Zubov - Variable Gradient Method.
Absolute Stability:- Lure’s Problem - Kalman- Yakubovich-Popov Lemma - Circle Criterion Popov's stability Criterion - Popov's Hyper Stability Theorem.

Module III

Non-linear control system design: Design via Linearization - Stabilization - Regulation via Integral Control – Gain Scheduling Feedback Linearization - Stabilization - tracking - Regulation via Integral Control - Cascade Designs-Back Stepping Design.

References

1. Hassan K. Khalil, “*Nonlinear Systems*”, McMillan Publishing Company, NJ, 2004.
2. John E. Gibson, “*Nonlinear Automatic Control*”, McGraw-Hill, New York.
3. Jean-Jacques E. Slotine and Weiping Li, “*Applied Nonlinear Control*”, Prentice-Hall, NJ, 1991.
4. M. Vidyasagar, “*Nonlinear Systems Analysis*”, Prentice-Hall, India, 1991,
5. Shankar Sastry, “*Nonlinear System Analysis, Stability and Control*”, Springer, 1999.
6. Alberto Isidori, “*Nonlinear Control Systems: An Introduction*”, Springer-Verlag, 1985.

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.

ECE2002 SLIDING MODE CONTROL THEORY 3-0-0-3

Structure of the course

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

Prerequisites: Linear and Non-linear Control Theory

Course Objectives

1. To familiarize the students with the methodology for the design and implementation of sliding mode controllers.
2. Design of high performance control systems.

Learning Outcomes

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

1. Design robust nonlinear sliding mode controller for any uncertain plant.
2. Define finite time higher order sliding mode controllers and observers.
3. Familiarize with modern control strategies.

Module I

Review of Systems Theory-Basic concepts, Vector Spaces, linear dependence, basis, subspaces. Linear transformation, Similarity transformation, Eigen values, Eigen vectors. Linear systems, Controllability and Observability, State feedback, Output feedback, Observers. Stability of dynamical systems – Lyapunov Stability, Quadratic Stability, Finite time Stability.

Concepts of relative degree, Lie algebra, Lie bracket.

Variable Structure and Sliding mode control – Motivation, Variable Structure Systems, Differential equations with discontinuous right hand side, Filippov solution. Concept of a manifold, Sliding surface, sliding mode motion and sliding mode control. Properties of sliding mode motion. Reaching laws, Approaches of sliding surface design.

Module II

Discrete-time Sliding mode control- Introduction to discrete sliding mode. Switching and non switching based DSMC. Multi-rate Output Feedback. DSMC based on Multirate Output Feedback techniques. Terminal Sliding mode control- Motivation. Design of sliding surface and control law development. Non singular terminal sliding mode. Integral Sliding mode control- motivation. Design principles.

Module III

Sliding mode observers - Need of sliding mode observers, First order sliding mode observers. Introduction to Higher order sliding mode control and observation- motivation of HOSMC and definition. 2-sliding controllers. Twisting controller. Super Twisting controller. Lyapunov based sliding mode control. Super twisting based observers and differentiators. Applications of Sliding mode controllers.

References

1. Utkin, '*Control Systems of Variable Structure*', New York, Wiley, 1976.
2. S. I. Zinober (Edited by), *'Deterministic Control of Uncertain Systems'*, British Library Cataloguing in Publication Data, Peter Peregrinus Ltd., 1990.
3. Drazenovic, "*The invariance conditions in variable structure systems", Automatica*, Vol. 5. pp. 287-295, 1969.
4. K. K. D. Young, "Design of Variable Structure Model Following Control Systems", *IEEE Transactions on Automatic Control*, Vol. 23, pp 1079-1085, 1978.
5. A. S. I. Zinobar, O.M.E. EI-Ghezawi and S.A. Billings, "Multivariable variable structure adaptive model following control systems", *Proc. IEE*. Vol. 129, no. l, pp 6-12, 1982.
6. J. J. Slotine and S.S. Sastry, "Tracking control of non-linear systems using sliding surfaces with application to robot manipulators", *International Journal of Control*, 1983, Vol. 38, No.2, pp 465-492.
7. Vadim I. Utkin, "Variable Structure Systems with Sliding Mode", *IEEE Transactions on Automatic Control*, April 1977, pp. 212-222.
8. K. K. D. Young, "A Variable Structure Model Following Control Design for Robotic Applications", *IEEE Transactions on Automatic Control*, Vol. 23, pp. 1079-1085.

Structure of the Question Paper

For the end semester examination, the question paper consists of at least 60% design problems. There will be three questions from each module out of which two questions are to be answered by the students.

ECE2003 STOCHASTIC CONTROL 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 design suitable performance measure to meet the specification requirements.
2. To analyse the physical system and design the structure of controller by optimizing the suitable performance criteria.
3. To apply the design algorithms to various physical systems with stochastic parameters.
4. Provides a solid foundation on modelling and analysis of system with stochastic parameter.

Learning Outcomes

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

1. Analyse the stability and performance of the systems with stochastic parameters.
2. Identify suitable estimation algorithm for stochastic systems.
3. Formulate and design suitable control structure of stochastic system model.
4. Implement optimal control algorithms to achieve specified performance for systems with stochastic parameters.

Module I

Introduction: Random Variables – Probability Distribution Function – Probability Density Function – Functions of Random Variables – Expectations and Moments of Random Variables – Conditional Expectations and Conditional Probabilities – Corelation – Auto Co-relation - Concept of Special Stochastic Processes – Covariance Function – Spectral Density.

Module II

Stochastic State Models: Discrete Time Systems – Solution of Stochastic Difference Equations – Continuous Time Systems - Stochastic Integrals – Linear Stochastic Differential Equations – ITO Differentiation Rule – Modelling of Physical Process by Stochastic Differential Equations.

Module III

Analysis of Dynamical Systems with Stochastic Inputs: Discrete Time Systems – Spectral Factorization of Discrete Time Processes – Analysis of Continuous Time Systems with Stochastic Input – Spectral Factorization of Continuous Time Process.

References

1. Jason L. Speyer and Walter H. Chung, "*Stochastic Process, Estimation and Control*," Siam Philadelphia, 2008.
2. Karl J. Åström, "*Introduction to Stochastic Control Theory*," Academic Press, New York and London, 1970.
3. Kaddour Najim, Enso Ikonen and Ait-Kadi Daoud, "*Stochastic Processes Estimation, Optimization & Analysis*," Kogan Page Science, London and Sterling, 2004.
4. Birkhäuser, "*Stochastic Switching System: Analysis and Design*," Library of Congress Cataloguing-in-Publication Data, United States of America, 2006.

Structure of the Question Paper

For the end semester examination, the question paper consists of at least 60% design problems. There will be three questions from each module out of which two questions are to be answered by the students.

EGE2001 FLIGHT DYNAMICS AND CONTROL 3-0-0-3

Structure of the Course

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

Course Objectives

To give insight into the dynamics, performance and control of aircrafts.

Learning Outcomes

Upon successful completion of this course, students will be able to develop the point mass model of aircrafts, understand their dynamics and analyse their performances and stability issues.

Module I

Brief history of aviation, Aircraft Performance Drag Polar, Drag polar of vehicles from low speed to hypersonic speed. Equation of motion of aircraft-level, unaccelerated flight, thrust available and maximum velocity, power required for level unaccelerated flight, thrust available and maximum velocity, power available and maximum velocity, altitude effects on power required and available.

Module II

Rate of climb, gliding flight, time to climb, range and endurance, take-off performance, landing performance, turning flight and V-n diagram-wing loading -load factor-absolute and service ceilings- numerical problems.

Module III

Aircraft Stability and Control - Longitudinal and lateral dynamics- stability and control-modes of motion: short period-phugoid-spiral divergence-dutch roll-stability derivatives-roll coupling-. Aircraft transfer functions, control surface actuator - longitudinal autopilots- displacement autopilot, pitch autopilot - block diagrams-root locus-flight path stabilization- acceleration control systems -lateral autopilots-yaw and roll autopilots - attitude control systems - stability augmentation-state observers - optimal control - instrument landing systems - numerical problems and simulations.

References

1. John D. Anderson Jr., '*Introduction to Flight'*, McGraw-Hill International, Fifth Edition, 2005.
2. John D. Anderson Jr., ‘*Aircraft Performance and Design'*, McGraw-Hill International, 1999.
3. Thomas R. Yechout, ‘*Introduction to Aircraft Flight Mechanics’*, AIAA Education Series, 2003.
4. A. C. Kermode, ‘*Mechanics of Flight’*, Pearson Education, Tenth Edition, 2005.
5. John H. Blakelock, ‘*Automatic Control of Aircraft and Missiles’* Second Edition, Wiley-Inter Science Publication, John Wiley and Sons, Inc., 1991.
6. Bernard Etkin, ‘*Dynamics of Flight Stability and Control’*, John Wiley and Sons Inc., Third edition, 1996.
7. Robert C. Nelson, ‘Flight *Stability and Automatic Control’*, WCB McGraw-Hill, Second
   Edition, 1998.
8. Louis V. Schmidt, ‘*Introduction to Aircraft Flight Dynamics’* AIAA Education Series, 1997
9. E. L. Houghton and N. B. Carruthers, ‘*Aerodynamics for Engineering Students’*, Arnold Publishers, Third Edition, 1986.
10. Nguyen X. Vinh, ‘*Flight Mechanics of High Performance Aircraft’*, Cambridge University
    Press, 1993.
11. Current Literature.

Structure of the Question paper

There will be three questions from each module, out of which students have to answer any two.

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:

6. Select a suitable drive for a particular application
7. Analyse the steady state operation and dynamic behaviour of DC and AC drive systems.
8. Design and implement basic algorithms for speed control for DC and AC motors in all four quadrants.
9. 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.

ECE2001 ADAPTIVE CONTROL 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. Develop a conceptual basis for robust adaptive control.
2. To provide knowledge on adaptive control, with a basic understanding
3. on stability and implementation
4. Develop ability to design a stable adaptive system subject to modelling errors and to meets the performance objectives
5. Design a model reference adaptive control system considering matched structured uncertainties.
6. To apply the design algorithms to various physical systems.

Learning Outcomes

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

1. Formulate the adaptive controller design problem.
2. Identify suitable control algorithm for a given system with uncertain parameter.
3. Apply design algorithms to various physical systems whose parameter changes during operation.
4. Implement adaptive control algorithms to track the response of the system with errors in systems parameters.

Module I

Introduction: Adaptive Control, effects of process variation, Adaptive schemes, Adaptive Control problem, Applications.
Real -Time Parameter Estimation: Introduction - Least Squares and Regression Models - Estimating - Parameters in Dynamical Systems - Experimental Conditions - Simulation of Recursive Estimation
Model Reference Adaptive Systems: Introduction - MIT Rule - Determination of the Adaptation Gain - Lyapunov Theory - Design of MRAS Using Lyapunov Theory - Bounded - Input -Bounded - Output Stability - Applications to Adaptive control - Output Feedback.

Module II

Self-Tuning Regulators: Introduction - Adaptive PID Controller Design - Pole Placement Design - Indirect Self-tuning Regulators - Continuous Time Self-tuners - Direct Self-tuning Regulators - Disturbances with Known Characteristics - Relations between MRAS and STR.
Adaptive Predictive Control: Stochastic and Predictive Self-Tuning Regulators – Introduction -Design of Minimum-Variance and Moving-Average controllers - Stochastic Self-Tuning Regulators - Unification of Direct Self-tuning Regulators - Linear Quadratic STR.

Module III

Robust Adaptive Laws: Introduction - Plant Uncertainties and Robust Control. Instability - Phenomena in Adaptive Systems - Modifications for Robustness - Simple Examples - Robust Adaptive Laws - Summary of Robust Adaptive Laws.

Gain Scheduling: Introduction - Principle - Design of Gain-Scheduling controllers - Nonlinear Transformations - Applications of Gain Scheduling.

References

1. Karl Johan Astrom and Bjom Wittenmark, *Adaptive Control'*, Addison Wesley, 2003
2. Shankar Sastry, '*Adaptive Control'*, PHI (Eastern Economy Edition), 1989
3. Karl Johan Astrom, '*Adaptive Control'*, Pearson Education, 2001
4. Petros A. loannou, Jing, '*Robust Adaptive Control'*, Prentice-Hall, 1995
5. Eykhoff P., '*System Identification: Parameter and State Estimation'*, 1974
6. Ljung, '*System Identification Theory for the User'*, Prentice-Hall, 1987

Structure of the Question Paper

For the end semester examination, the question paper consists of at least 60% design problems. There will be three questions from each module out of which two questions are to be answered by the students.

EME2002 PWM CONVERTERS AND 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 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.

ECE2004 ROBOTICS 3-0-0-3

Structure of the course

Credits: 3

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

Prerequisite: Thorough understanding of Matrix and Vector algebra

Course objectives

1. To familiarize students with robot classifications and configurations.
2. To acquaint the students with Forward Kinematics and Inverse Kinematics, Trajectory planning, dynamic modelling, control and applications of robots.
3. To acquaint the students with mobile robot locomotion and kinematics, environment perception, localization, mapping and navigation of mobile robots.

Learning Outcomes

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

1. To obtain kinematic model of a robot (DOF $\leq$3).
2. To develop dynamic model of a robot (DOF $\leq$3).
3. To design a linear / nonlinear controller for a robot.
4. To identify the various types of sensors and recognize common uses.
5. To choose a sensor for a robot depending on the application.
6. To design a simple mobile robot for accomplishing a task autonomously.

Module I

Introduction to Robotics , classification, specifications, Work envelopes of different robots, notations , Co-ordinate frames, Rotations, Translations, Homogeneous coordinates, Direct kinematics, The arm equation, Kinematic analysis of robots (DOF $\leq$3)- examples, Inverse kinematics problem, Inverse kinematics of robots (DOF $\leq$3)- examples, Basic study of other robots up to 6 DOF, Workspace analysis, Pick and place operation, Tool configuration Jacobian and manipulator Jacobian matrix. Trajectory planning - Joint space and Cartesian space techniques.

Module II

Manipulator Dynamics-Dynamic models of robots using Lagrange's Equation (DOF $\leq$2), State space model of the robot and the linearized model. The control problem- Linear control Schemes, Single axis PID control, PD gravity control, Nonlinear control Schemes-Computed torque control, Variable Structure control, Force and Impedance control, co-ordinated control.
Robot Vision - Image representation, template matching, edge and corner detection, shape analysis, segmentation, perspective transformations, camera calibration.
Robot applications-material handling applications, Machine loading and unloading, spot welding, arc welding, spray painting and technical specifications of the robot used for these applications.

Module III

Autonomous mobile robots- Locomotion- legged mobile robots –Leg configurations and stability, examples of legged automation, wheeled mobile robots- wheeled locomotion the design space and case studies, mobile robot kinematics- kinematic models and constraints, representing robot position, forward kinematic models, wheel kinematic constraints, robot kinematic constraints, Examples: robot kinematic models and constraints, perception- sensors for mobile robots, Sensor classification , Characterizing sensor performance, Wheel/motor sensors, Heading sensors, Accelerometers, IMU, Ground-based beacons, Active ranging, Motion/speed sensors, Vision-based sensors, Basics of mobile robot localization and navigation.

References

1. Robert J. Schilling, "*Fundamentals of Robotics-Analysis and Control*", Pearson Education, Asia.
2. R. K. Mittal and J. Nagrath, "*Robotics and Control*", Tata McGraw-Hill Education.
3. R. Siegwart, I. Nourbakhsh, D. Scaramuzza, "*Introduction to Autonomous Robots*", Intelligent Robotics and Autonomous Agents series, The MIT Press, Massachusetts Institute of Technology, Cambridge, Massachusetts.
4. Ashitava Ghosal, "*Robotics-Fundamental Concepts and Analysis*", Oxford university press.
5. Janakiraman P. A., "*Robotics and Image Processing*", Tata McGraw Hill. New Delhi, 1995
6. S. R. Deb, "*Robotics Technology and Flexible Automation*", Tata McGraw Hill, New Delhi
7. Peter Corke, "*Robotics, Vision and Control – Fundamental Algorithms in MATLAB*", Springer Tracts in Advanced Robotics, volume 73.
8. Lorenzo Sciavicco & Bruno Siciliano, "*Modeling and Control of Robot Manipulator*", The McGraw Hill Companies

Structure of the Question Paper

For the end semester examination, the question paper consists of at least 60% design problems. There will be three questions from each module out of which two questions are to be answered by the students.

ECD2001 INDUSTRIAL DATA NETWORKS 3-0-0-3

Structure of the course

Credits: 3

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

Course objectives

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

Learning Outcomes

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

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

Module I

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

Module II

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

Module III

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

References

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

Structure of the Question Paper

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

Industrial Relevance of the Course

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

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

Structure of the course

Credits: 3

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

Course objectives

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

Learning Outcomes

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

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

Module I

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

Module II

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

Module III

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

References

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

Structure of the Question Paper

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

ECD2003 SOFT COMPUTING TECHNIQUES 3-0-0-3

Structure of the course

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

Course objectives

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

Learning Outcomes

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

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

Module I

Neural network: Biological foundations - ANN models - Types of activation function - Introduction to Network architectures -Multi Layer Feed Forward Network (MLFFN) - Radial Basis Function Network (RBFN) - Recurring Neural Network (RNN).

Learning process : Supervised and unsupervised learning - Error-correction learning - Hebbian learning – Boltzmann learning - Single layer and multilayer perceptrons - Least mean square algorithm – Back propagation algorithm - Applications in pattern recognition and other engineering problems Case studies - Identification and control of linear and nonlinear systems.

Module II

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

Fuzzy control systems: Introduction - simple fuzzy logic controllers with examples - Special forms of fuzzy logic models, classical fuzzy control problems , inverted pendulum, image processing , home heating system, Adaptive fuzzy systems.

Module III

Genetic Algorithm: Introduction - basic concepts, application.

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

References

1. J. M. Zurada, '*Introduction to Artificial Neural* Systems', Jaico Publishers, 1992.
2. Simon Haykins, '*Neural Networks - A Comprehensive Foundation, Mcmillan College*', Proc., Con., Inc., New York. 1994.
3. D. Driankov. H. Hellendorn, M. Reinfrank, '*Fuzzy Control - An Introduction, Narora Publishing House*', New Delhi, 1993.
4. H. J. Zimmermann, '*Fuzzy Set Theory and its Applications*', 111 Edition, Kluwer Academic Publishers, London.
5. G. J. Klir, Boyuan, '*Fuzzy Sets and Fuzzy Logic*', Prentice Hall of India (P) Ltd, 1997.
6. Stamatios V Kartalopoulos, '*Understanding Neural Networks And Fuzzy Logic Basic Concepts And Applications*', Prentice Hall of India (P) Ltd, New Delhi, 2000.
7. Timothy J. Ross, '*Fuzzy Logic With Engineering Applications*', McGraw Hill, New York.
8. Suran Goonatilake, Sukhdev Khebbal (Eds.), '*Intelligent Hybrid Systems*', John Wiley & Sons, New York, 1995.
9. Vose Michael D., '*Simple Genetic Algorithm - Foundations and Theory*', Prentice Hall of India.
10. Rajasekaran & Pai, '*Neural Networks, Fuzzy Logic, and Genetic Algorithms: Synthesis and Applications*', Prentice-Hall of India, 2007.
11. J. S. Roger Jang, C. T. Sun and E. Mizutani, '*Neuro Fuzzy and Soft Computing*', Prentice Hall Inc., New Jersey, 1997.

Structure of the Question Paper

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

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

Structure of the course

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

Course objectives

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

Learning outcomes

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

Module I

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

Module II

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

Module III

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

References

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

Structure of the Question Paper

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

ECD2005 BIOMEDICAL INSTRUMENTATION 3-0-0-3

Structure of the course

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. 2^{nd} edition, 1994
4. Turner, Wayne C., *Energy Management Handbook*, Lilburn, The Fairmont Press, 2001.
5. Albert Thumann, *Handbook of Energy Audits*, Fairmont Press 5^{th} 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*, 7^{th} 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.

ECC2101 ADVANCED CONTROL LAB-II 0-0-2-1

Structure of the course

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

Course Objectives

1. Design and implementation of control sytems.
2. Design and implementation of PID controller and familiarise the role of P, I and D in feedback control.
3. Practice of control system design in inverted pendulum system which is widely used as a benchmark for testing control algorithms.
4. Implementation of real time controller for dynamic systems like temperature control systems, speed control system servomotors in digital and and analog mode.

Learning Outcomes

1. Get exposure to practical aspects of control systems design.
2. Equip the students to perform system identification (make measurements of a system and determine the transfer function).
3. Acquire an ability to critically analyse different dynamic systems and choose a suitable controller (using multi-loop controller, PID controller).
4. Equip the students to apply the concepts of linear and non-linear theory to the design of dynamic systems.

List of Experiments

12. Real Time Liquid Level control Using P, PI and PID Controllers.
13. Stepper Motor control Using Microprocessor 85AD.
14. Zeigler Nichols Tuning of P, PI and PID controller for Temperature Control System.
15. Speed and position control using DC servo motor.
16. Digital control of speed and position using DC servomotor.
17. Nonlinear Relay Control System.
18. Implementation of digital controller using microprocessor.
19. Design and realization of compensators for a real time system.
20. Realization of system using discrete components.
21. Study of position control system using Quanser module
22. Design of a controller for an inverted pendulum system.
23. Controller design of twin rotor mimo.
24. Design of a tracking controller for a mobile robot.
25. Controller design for a real time system (temperature control or a motor) using microcontroller/ DSP processor/ PC
    a. Acquire input sensor data using data acquisition system.
    b. Process the data.
    c. Implement a simple controller using the processor.
    d. Output the control signals to the actuator.

ECC2102 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

ECC2103 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

1. Robert Erickson and Dragan Maksimovic, '*Fundamentals of Power Electronics*', Springer India
2. 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.

ECE 3001 ROBUST CONTROL 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 the students with the basic knowledge of robust control of linear dynamic systems
2. To identify the sources of uncertainties and also able to model the different uncertainties
3. To enable to analyze the sensitivity analysis of feedback control systems
4. To enable the students to check robust stability and robust performance using different approaches
5. To equip the students to design H- infinity control problems

Learning Outcomes

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

1. Identify different uncertainties and to model the uncertainties
2. Apply different approaches for checking the robust stability and robust performance
3. Design robust controllers for physical systems and compare the performance of the system with other controllers

Module I

Modelling of parametric Uncertain systems and sensitivity Analysis: Definition of robust control-classification of robust control-elements of robust control theory-modelling-design objectives and specifications – classification of uncertainties- additive and multiplicative perturbations –plant - controller configuration- shaping the loop gain. Modeling systems with parameter uncertainty- general concepts - generalization of several control concepts to parametric uncertain systems.
Sensitivity Analysis: Single degree of freedom design structure for SISO and MIMO systems- design of SISO feedback systems for disturbance rejection - design of SISO feedback systems for noise rejection - design of SISO feedback systems with unmodelled dynamics – combining uncertainties for the design of scalar feedback systems.

Module II

Robust Stability Analysis: Boundary crossing theorem-stability-Gamma stability boundaries-Gamma stability radius-Schur stability test-Hurwitz stability test, Well-posedness, internal stability, parameterization approach, co-prime factorization of plant, co-prime factorization of controller-state space realization, strong stabilization -problem formulation-model matching problem-trade-offs for multivariable plants-design limitations due to right half plane zeros-plant uncertainty and robustness, robust stability-robustness under perturbations, small gain theorem, stability margins-1-2 stability, 1-infinity and 1-1 stability margins, robust stabilizing controllers-stabilizing P controllers-stabilizing PI controllers -

stabilizing PID controllers, Kharitonov approach for stability – preliminary theorems – Kharitonov theorem - control design using Kharitonov theorem.

Module III

Robust Control Design: LQG methodology-separation principle-Algebraic Riccati Equation-solution of LQG problem-robustness properties of the LQG solution- H_∞ optimization techniques-state space formulation H_∞ control problem and solution - selection of weighting functions – general H_∞ Control algorithm - H_∞ filter-generalized H_∞ regulator, *Basic concepts of* H_∞ *and* μ *– synthesis controllers*

References

1. S. P. Bhattacharya, L. H. Keel, H. Chapellat '*Robust Control: The Parametric Approach*', Prentice-Hall, 1995
2. P. C. Chandrasekharan, *Robust Control of Linear Dynamical Systems*, Academic Press, 1996
3. Michael Green, David J. N. Limebeer, *Linear Robust Control*, Prentice-Hall, 1995
4. Kemin Zhou, *Essentials of Robust Control*, Prentice-Hall, 1998
5. Sigurd Skogestad, Ian Postewaite, *Mutivariable Feedback Design,* Second Edition, John Wiley, 2005
6. Pierre R. Belanger, *Control Engineering: A Modern Approach*, Saunders College Publishing, 1995

Structure of the Question Paper

For the end semester examination, the question paper consists of at least 60% design problems. There will be three questions from each module out of which two questions are to be answered by the students.

Prerequisite: First level course in control systems

ECE3004 ADVANCED INSTRUMENTATION 3-0-0-3

Structure of the course

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

Course 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.

ECE 3002 SYSTEM IDENTIFICATION AND PARAMETER ESTIMATION 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 design suitable performance measure to meet the specification requirements.
2. To analyse the physical system and design the structure of system model by optimizing the suitable performance criteria by satisfying the constraints over the system parameter.
3. To apply the design algorithms to various physical systems with unknown system parameters.
4. Provides a solid foundation on modelling and analysis of system with stochastic parameter.

Learning Outcomes

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

1. Identify suitable estimation algorithm for implementation.
2. Formulate and design suitable structure of system model.
3. Apply iterative estimation algorithms to model various physical systems.
4. Implement optimal control algorithms to track the response of the system with unknown system parameters.

Module I

Principles of Modelling and Transfer function identification: System Identification and Stochastic Modeling- Structure and parameter estimation. Properties of estimates - validation of models-impulse Response. Step Response - Frequency response- transfer function from these - disturbances and transfer function

State Space Models: Distributed parameter models- model structures, identifiability of model structures - signal spectra - single realization and ergodicity - multivariable systems - Transfer function from frequency response. Fourier Analysis and Spectral analysis - Estimating Disturbance Spectrum - Correlation Identification - Practical Implementation - Pseudo random binary signals - maximum length sequences - generation using hardware - random number generation on digital computer.

Module II

Parameter Estimation Methods: Guiding principles behind parameter estimation methods. Minimizing prediction errors. Linear regression and least squares methods. Statistical framework for parameter estimation. Maximum likelihood estimation. Correlating prediction errors with past data. Instrumental variable method, consistency and identifiability, Recursive methods . RLS Algorithm, Recursive IV Method- Recursive Prediction Error Method, recursive pseudo-linear regressions. Choice of updating step.

Module III

Experiment Design and Choice of Identification Criterion: Optimal Input design. Persistently exciting condition. Optimal input design for higher order black box models. Choice of sampling interval and pre-sampling filters. Choices of Identification criterion. Choice of norm, variance, optimal instruments.

References

1. Lennart Ljung, *System Identification Theory for the User*, Prentice Hall Information Systems Science Series, 1987.
2. Sinha N. K., Kuztsas, '*System Identification and Modeling of Systems'*, 1983.
3. Harold W. Sorensen, *'Parameter Estimation*', Marcel Dekker Inc, New York, 1980.
4. Daniel Graupe, *Identification of Systems*,Van Nostrand.
5. Tohru Katayama, '*Subspace Methods for System Identification'*, Springer-Verlag London Limited, 2005.

Structure of the Question Paper

For the end semester examination, the question paper consists of at least 60% design problems. There will be three questions from each module out of which two questions are to be answered by the students.

ECE3003 MULTI VARIABLE CONTROL 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 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 and Ian Postlethwaite, *Multivariable Feedback Control, Analysis and Design*, John Wiley & Sons Ltd., Second Edition.

Structure of the Question Paper

For the end semester examination, the question paper consists of at least 60% design problems. There will be three questions from each module out of which two questions are to be answered by the students.

ECE3005 **ESTIMATION THEORY** **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 train the students to implement state feedback controller by estimating the state of the system.
2. Able to apply the estimation algorithms to estimate unknown quantities from the available measured signals.
3. Provides a solid foundation on Matrix algebra, Probability and Statistics

Learning Outcomes

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

1. Select suitable estimation for implementation.
2. Apply estimation algorithms to estimate signals and parameters of the system.
3. Implement optimal estimation algorithms to estimate signals from noisy data for linear as well as nonlinear systems.

Module I

Elements of Probability and Random Process: Sample Spaces and Events - Axioms of Probability - Conditional Probability - Continuous Probability - Probability Functions - Bayes' Formula- Random Variables-Expectation - Variance - Covariance - White and Colored Noises- Correlated Noise. Least Square Estimation: Estimation of Constant. Weighted Least Square Estimation, Recursive Least Square Estimation.

Module II

Wiener filtering - Propagation of States and Co-Variance - Continuous Time and Discrete Time Systems. Kalman Filter: Discrete-time Kalman Filter- Properties- Propagation of Covariance – Sequential Kalman Filtering - Information Filtering – Square root Filtering - Correlated Process and Measurement Noise - Colored Process and Measurement Noise-Steady State Filtering.

Module III

Continuous Time Kalman Filter: Discrete time and Continuous time White Noise – Solution through Riccati Equation – Generalization of Continuous -time Filter – Steady State Filter. Optimal Smoothing: Fixed-point Smoothing- Fixed-lag Smoothing – Fixed-interval Smoothing.
Nonlinear Kalman Filter: Linearized Kalman Filter – Extended Kalman Filter – Higher Order Approaches – Parameter Estimation.

References

1. Dan Simon, "*Optimal State Estimation Kalman, H_∞, and Nonlinear Approaches*," Wiley Interscience, John Wiley & Sons, Inc., Publication, 2006.
2. Athanasios Papoulis and S. Unnikrishna Pillai, "*Probability, Random Variables and Stochastic Process*," Tata McGraw-Hill Publishing Company Limited, New Delhi, India, 2002.
3. Sheldon M. Ross, "*Introduction to Probability and Statistics for Engineers and Scientists*," 3rd ed., Academic Press, Delhi, India, 2005.
4. Jerry M. Mendel, "*Lessons in Estimation Theory for Signal Processing, Communications and Control*," Prentice Hall PTR, Englewood Cliffs, New Jersey, USA, 1995.
5. Paul Zarchan and Howard Musof, "*Fundamentals of Kalman Filtering: A Practical Approach*," AIAA Inc., Alexander Bell Drive, Reston, Vergenia, 2000.
6. Robert Grover Brown and Patrick Y. C. Hwang, "*Introduction to Random Signals and Applied Kalman Filtering*," 3rd ed., John Wiley & Sons Inc., Canada, 1997.
7. Alexander D. Poularikas and Zayed M. Ramadan, "*Adaptive Filtering Primer with MATLAB,*" CRC Press, Taylor & Francis, Boca Raton, London, 2006.

Structure of the Question Paper

For the end semester examination, the question paper consists of at least 60% design problems. There will be three questions from each module out of which two questions are to be answered by the students.

ECC3101 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

ECC4101 **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