## M.Tech Programme
### Electrical Engineering- Control Systems
### Curriculum and Scheme of Examinations

**SEMESTER I**

<table>
<thead>
<tr>
<th>Code No.</th>
<th>Name of Subject</th>
<th>Credits</th>
<th>Hrs / week</th>
<th>End Sem Exam (Hours)</th>
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<td>EMC 1001</td>
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**TOTAL** 21 22 440 360 800 7 Hours of Departmental assistance work

Of the 40 marks of internal assessment 25 marks for tests and 15 marks for assignments. End sem exam is conducted by the University.
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<th>Code No.</th>
<th>Name of Subject</th>
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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
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<td>ECD2002</td>
<td>Process Control and Industrial Automation</td>
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<td>ECD2003</td>
<td>Soft Computing Techniques</td>
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<tr>
<td>ECD2004</td>
<td>Embedded Systems and Real-time Applications</td>
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<tr>
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<td>New and Renewable Source of Energy</td>
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<td>EDD2001</td>
<td>Power Electronics System Design using ICs</td>
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<td>EDD2002</td>
<td>Energy auditing conservation and Management</td>
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<th>Code No.</th>
<th>Name of Subject</th>
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<td>EME3001</td>
<td>Dynamics of Power Converters</td>
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<tr>
<td>ECE3001</td>
<td>Robust Control</td>
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<td>ECE3004</td>
<td>Advanced Instrumentation</td>
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### Stream Elective IV

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<tr>
<td>ECE3002</td>
<td>System Identification and Parameter Estimation</td>
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<tr>
<td>ECE3003</td>
<td>Multi Variable Control Systems</td>
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<td>ECE3005</td>
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Structure of the course
Lecture : 3 hrs/week
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.

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

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

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

Credits: 3

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


Module II


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

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

Module III
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
2. V. Ramanarayanan, Course Notes on Switched Mode Power Converters, Dept. of Electrical Engineering, IISc, Bangalore

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.
Structure of the course

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

Credits: 3

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

References


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.
Structure of the course

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

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


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.
Structure of the Course

Lecture : 3 hrs/week  
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


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

References

Structure of the Question paper
There will be three questions from each module, out of which students have to answer any two.
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
Structure of the course
Lecture : 3 hrs/week
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

Module II

Module III
References

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

Module II
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


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.
Structure of the course
Lecture : 3 hrs/week
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


Concepts of relative degree, Lie algebra, Lie bracket.


Module II


Module III

References


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

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

Module II

Module III
References


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.
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

References

Structure of the Question paper
There will be three questions from each module, out of which students have to answer any two.
Structure of the course

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

Credits: 3

Course Objective

The improvement in converters and development of new drive control strategies such as field oriented (vector) control of AC drives, sliding mode control, energy saving strategies etc 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

Module-II

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

References
2. R. Krishnan, ‘Electric Motor Drives: Modelling, Analysis and Control’

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.
Structure of the course

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 on stability and implementation
3. Develop ability to design a stable adaptive system subject to modelling errors and to meets the performance objectives
4. Design a model reference adaptive control system considering matched structured uncertainties.
5. 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


Module II

Module III

References
4. Petros A. Ioannou, Jing, ‘*Robust Adaptive Control*’, Prentice-Hall, 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.
Structure of the course
Lecture : 3 hrs/week  
Internal Assessment : 40 Marks  
End semester Examination : 60 Marks 
Credits: 3

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.

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.
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

2. Bin Wu, ‘High Power Converters and AC Drives’
5. Werner Leonhard, ‘Control of Electrical Drives’, 3rd Ed., Springer

Technical Papers

Thesis/Reports


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.
Structure of the course
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 ≤3).
2. To develop dynamic model of a robot (DOF ≤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 ≤3)- examples, Inverse kinematics problem, Inverse kinematics of robots (DOF ≤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 ≤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


References


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

Credits: 3

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


Module II


Module III

References


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.
Structure of the course

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


Module III

References

1. George Stephanopoulos, "Chemical Process Control", Prentice-Hall of India
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.
Structure of the course
Lecture : 3 hrs/week
Internal Assessment : 40 Marks
End semester Examination : 60 Marks
Credits: 3

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


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.
Structure of the course

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

Credits: 3

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, watchdog 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

References

8. Yeralan S., Ahluwalia A. 'Programming and Interfacing the 8051 Microcontroller', Addison - Wesley, 1995

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

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

Module III
References
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.
Structure of the course
Lecture : 3 hrs/week  
Internal Assessment : 40 Marks  
End semester Examination : 60 Marks  
Credits: 3

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 biofuels; 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


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.
Structure of the course
Lecture : 3 hrs/week
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

References

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.
Structure of the course

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 or 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.


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.

References


(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.
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


Module III

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


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.
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

Module III
References

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.
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

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

Module III

References


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. $H_2/H_\infty$ Theory- Solution for design using $H_2/H_\infty$ - 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

5. Stuart A. Boyer: *SCADA-Supervisory Control and Data Acquisition*, Instrument Society of America Publications, USA, 1999

Structure of the Question Paper

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

References


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


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
Structure of the course
Lecture: 3hrs/week Credit: 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

Module II

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
3. B. Singh, Microprocessor control and instrumentation of electrical power systems, University of Bradford, 1987

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.
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

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

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.
Structure of the course

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

Credits: 3

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

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.
Structure of the course

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

Credits: 2

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

References

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 systems.
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 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
13. Stepper Motor control Using Microprocessor 85AD.
15. Speed and position control using DC servomotor.
17. Nonlinear Relay Control System.
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
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
Structure of the course

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

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.
Structure of the course

Lecture : 3 hrs/week  
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


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

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- $H_\infty$ optimization techniques-state space formulation $H_\infty$ control problem and solution - selection of weighting functions – general $H_\infty$ Control algorithm - $H_\infty$ filter-generalized $H_\infty$ regulator, Basic concepts of $H_\infty$ and $\mu$ – synthesis controllers

References


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

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


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.
Structure of the course

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

Credits: 3

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


Module II

Module III


References

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.
Structure of the course

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**


**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.
Structure of the course
Lecture : 3 hrs/week
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

Module II

Module III
References


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 earmarked for publication in Journal/Conference)] TOTAL – 300 Marks