# BIRLA INSTITUTE OF TECHNOLOGY- MESRA, RANCHI

**REVISED COURSE STRUCTURE - Effective from academic session 2021-22**

**Based on CBCS & OBE Model**

**M.Tech (Control System)**

| SEMESTER / Session of Study (Recomended) | Course Level | Category of Course | Course Code | Courses | Mode of delivery & credits *L-Lecture; T-Tutorial;P-Practicals* | | | Total Credits *C- Credits* |
|---|---|---|---|---|---|---|---|---|
| | | | | | L *(Periods/week )* | T *(Periods/week)* | P *(Periods/week)* | C |
| | THEORY | | | | | | | |
| FIRST / Monsoon | Fifth | Programme Core (PC) | EE501 | Advanced Digital Signal Processing | 3 | 0 | 0 | 3 |
| | | | EE503 | Modern Control Theory | 3 | 0 | 0 | 3 |
| | | | EE505 | System Identification and Adaptive Control | 3 | 0 | 0 | 3 |
| | | | EE601 | Process Measurement and Control | 3 | 0 | 0 | 3 |
| | | Programme Elective (PE) | | PE 1 | 3 | 0 | 0 | 3 |
| | | LABORATORIES | | | | | | |
| | Fifth | Programme Core (PC) | EE502 | Advanced Digital Signal Processing Laboratory | 0 | 0 | 4 | 2 |
| | | | EE552 | Control System Design Laboratory | 0 | 0 | 4 | 2 |
| | | TOTAL | | | | | | 19 |
| SECOND/ Spring | Fifth | Programme Core (PC) | EE551 | Optimal Control Theory | 3 | 0 | 0 | 3 |
| | | | EE553 | Nonlinear Control System | 3 | 0 | 0 | 3 |
| | | | EE555 | Statistical Control Theory | 3 | 0 | 0 | 3 |
| | | Programme Elective (PE) | | PE II | 3 | 0 | 0 | 3 |
| | | | | PE III | 3 | 0 | 0 | 3 |
| | | LABORATORIES | | | | | | |
| | | | | | | | | |
| | Fifth | Programme Core (PC) | EE504 | AI based Advanced Control System Laboratory | 0 | 0 | 4 | 2 |
| | | | EE554 | Power Electronics and Drives Laboratory | 0 | 0 | 4 | 2 |
| | | TOTAL | | | | | | 19 |
| THIRD / Monsoon | Sixth | Programme Core (PC) | EE600 | Thesis (Part I) | | | | 8 |
| | | Open Elective (OE) | | OE I / MOOC | 3 | 0 | 0 | 3 |
| | | | | OE II / MOOC | 3 | 0 | 0 | 3 |
| | | TOTAL | | | | | | 14 |
| FOURTH/ Spring | Sixth | (PC) | EE650 | Thesis (Part II) | | | | 16 |
| | | TOTAL | | | | | | 16 |
| GRAND TOTAL FOR M.TECH PROGRAMME (38 + 30) | | | | | | | | 68 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Programme Elective - I** | | | | | | | |
| 5 | EE511 | Optimization in Engineering Design | | 3 | 0 | 0 | 3 |
| | EE515 | Control System Design | | 3 | 0 | 0 | 3 |
| | EE513 | Robotics and Automation | | 3 | 0 | 0 | 3 |
| | EE517 | Image Processing and Computer Vision | | 3 | 0 | 0 | 3 |
| **Programme Elective - II** | | | | | | | |
| 5 | EE575 | Robust Control | EE575 Modern Control Theory | 3 | 0 | 0 | 3 |
| | EE573 | Embedded System and Application | | 3 | 0 | 0 | 3 |
| | EE571 | Soft Computing Techniques in | | 3 | 0 | 0 | 3 |
| | | Engineering | | 3 | 0 | 0 | 3 |
| | EE577 | Control of Electric Drives | | 3 | 0 | 0 | 3 |
| | EE565 | Power System Operation and Control | | 3 | 0 | 0 | 3 |
| **Programme Elective - III** | | | | | | | |
| 6 | EE611 | Physiological Control System | | 3 | 0 | 0 | 3 |
| | EE605 | Micro- grid Operation and | | 3 | 0 | 0 | 3 |

## LIST OF OPEN ELECTIVES (PG)

| **Level of Study** | **Course** | **Courses** | **Pre-requisites** | **Mode of delivery & credits** *L-Lecture; T-Tutorial;P- Practicals* | | | **Total Credits** *C- Credits* |
|---|---|---|---|---|---|---|---|
| | | | | **L** ***(Periods/ week )*** | **T** ***(Periods/*** | **P** ***(Periods/*** | **C** |
| **5** | EE585 | Hybrid Electric Vehicle | NIL | 3 | 0 | 0 | 3 |
| | EE587 | Electromechenical Energy Conversion | NIL | 3 | 0 | 0 | 3 |
| | EE589 | Power Semiconductor Devices | NIL | 3 | 0 | 0 | 3 |
| | EE595 | Smart Grid | NIL | 3 | 0 | 0 | 3 |
| | EE597 | Reliability Engineering | NIL | 3 | 0 | 0 | 3 |
| **6** | EE601 | Process Measurement and Control | NIL | 3 | 0 | 0 | 3 |

| BIRLA INSTITUTE OF TECHNOLOGY- MESRA, RANCHI DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Level** | **Course Code** | **Courses** | **Prerequisites courses with** | **Mode of delivery & credits L-Lecture; T-Tutorial;P-** | | | **Total Credits C-** |
| | | | | **L** | **T** | **P** | C |
| **Programme Elective - I** | | | | | | | |
| 5 | EE511 | Optimization in Engineering Design | | 3 | 0 | 0 | 3 |
| | EE515 | Control System Design | | 3 | 0 | 0 | 3 |
| | EE513 | Robotics and Automation | | 3 | 0 | 0 | 3 |
| | EE517 | Image Processing and Computer Vision | | 3 | 0 | 0 | 3 |
| **Programme Elective - II** | | | | | | | |
| 5 | EE571 | Soft Computing Techniques in Electrical | | 3 | 0 | 0 | 3 |
| | EE575 | Robust Control | | 3 | 0 | 0 | 3 |
| | EE577 | Control of Electric Drives | | 3 | 0 | 0 | 3 |
| | EE565 | Power System Operation and Control | | | | | |
| | EE573 | Embedded System and Applications | | 3 | 0 | 0 | 3 |
| **Programme Elective - III** | | | | | | | |
| 6 | EE611 | Physiological Control System | | 3 | 0 | 0 | 3 |
| | EE605 | Micro- grid Operation and Control | | 3 | 0 | 0 | 3 |

| BIRLA INSTITUTE OF TECHNOLOGY- MESRA, RANCHI DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Level of Study** | **Course Code** | **Courses** | **Pre-requisites** | **Mode of delivery & credits** | | | **Total Credits** |
| | | | | **L** | **T** | **P** | **C** |
| 5 | EE585 | Hybrid Electric Vehicle | NIL | 3 | 0 | 0 | 3 |
| | EE587 | Electromechenical Energy Conversion | NIL | 3 | 0 | 0 | 3 |
| | EE589 | Power Semiconductor Devices | NIL | 3 | 0 | 0 | 3 |
| | EE595 | Smart Grid | NIL | 3 | 0 | 0 | 3 |
| | EE597 | Reliability Engineering | NIL | 3 | 0 | 0 | 3 |
| **6** | EE601 | Process Measurement and Control | NIL | 3 | 0 | 0 | 3 |

# Department of Electrical and ElectronicsEngineering

**Birla Institute of Technology, Mesra, Ranchi - 835215 (India)**

## Institute Vision

To become a Globally Recognized Academic Institution in consonance with the social, economic and ecological environment, striving continuously for excellence in education, research and technological service to the National needs.

## Institute Mission

To educate students at Undergraduate, Postgraduate, Doctoral, and Post-Doctoral levels to perform challenging engineering and managerial jobs in industry.

- To provide excellent research and development facilities to take up Ph.D. programmes and research projects.
- To develop effective teaching and learning skills and state of art research potential of the faculty.
- To build national capabilities in technology, education and research in emerging areas.
- To provide excellent technological services to satisfy the requirements of the industry and overall academic needs of society.

## Department Vision

To become an internationally recognized centre of excellence in academics, research and technological services in the area of Electrical and Electronics Engineering and related inter-disciplinary fields.

## Department Mission

- Imparting strong fundamental concepts to students and motivate them to find innovative solutions to engineering problems independently.
- Developing engineers with managerial attributes capable of applying appropriate technology with responsibility.
- Creation of congenial atmosphere and ample research facilities for undertaking quality research to achieve national and international recognition by faculty and students.
- To strive for internationally recognized publication of research papers, books and to obtain patent and copyrights.
- To provide excellent technological services to industry for the benefit of society.

## Programme Educational Objectives (PEOs) –Control System

**PEO1:** To acquire in-depth knowledge of complex Electrical Engineering problems especially in Control Systems to impart ability to discriminate, evaluate, analyze critically and synthesize knowledge pertaining to state of art and innovative research.

**PEO2:** To solve complex control system problems with commensurate research methodologies as well as modern tools to evaluate a broad spectrum of feasible optimal solutions keeping in view socio- cultural and environmental factors.

**PEO3:** To posses wisdom regarding group dynamics to efficaciously utilize opportunities for positive contribution to collaborative multidisciplinary engineering research and rational analysis to manage projects economically.

**PEO4:** To communicate with engineering community and society at large adhering to relevant safety regulations as well as quality standards.

**PEO5:** To inculcate the ability for life-long learning to acquire professional and intellectual integrity, ethics of scholarship and to reflect on individual action for corrective measures to prepare for leading edge position in industry, academia and research institutes.

# Graduate Attributes (GAs)

**GA1: Scholarship of Knowledge**

Acquire in-depth knowledge of specific discipline or professional area, including wider and global perspective, with an ability to discriminate, evaluate, analyse and synthesise existing and new knowledge, and integration of the same for enhancement of knowledge.

**GA2: Critical Thinking**

Analyse complex engineering problems critically, apply independent judgement for synthesising information to make intellectual and/or creative advances for conducting research in a wider theoretical, practical and policy context.

**GA3: Problem Solving**

Think laterally and originally, conceptualise and solve engineering problems, evaluate a wide range of potential solutions for those problems and arrive at feasible, optimal solutions after considering public health and safety, cultural, societal and environmental factors in the core areas of expertise.

**GA4: Research Skill**

Extract information pertinent to unfamiliar problems through literature survey and experiments, apply appropriate research methodologies, techniques and tools, design, conduct experiments, analyse and interpret data, demonstrate higher order skill and view things in a broader perspective, contribute individually/in group(s) to the development of scientific/technological knowledge in one or more domains of engineering.

**GA5: Usage of modern tools**

Create, select, learn and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling, to complex engineering activities with an understanding of the limitations.

**GA6: Collaborative and Multidisciplinary work**

Possess knowledge and understanding of group dynamics, recognise opportunities and contribute positively to collaborative-multidisciplinary scientific research, demonstrate a capacity for self-management and teamwork, decision-making based on open-mindedness, objectivity and rational analysis in order to achieve common goals and further the learning of themselves as well as others.

**GA7: Project Management and Finance**

Demonstrate knowledge and understanding of engineering and management principles and apply the same to one ‘s own work, as a member and leader in a team, manage projects efficiently in respective disciplines and multidisciplinary environments after consideration of economical and financial factors.

**GA8: Communication**

Communicate with the engineering community, and with society at large, regarding complex engineering activities confidently and effectively, such as, being able to comprehend and write effective reports and design documentation by adhering to appropriate standards, make effective presentations, and give and receive clear instructions.

**GA9: Life-long Learning**

Recognise the need for and have the preparation and ability to engage in life-long learning independently, with a high level of enthusiasm and commitment to improve knowledge and competence continuously.

**GA10: Ethical Practices and Social Responsibility**

Acquire professional and intellectual integrity, professional code of conduct, ethics of research and scholarship, consideration of the impact of research outcomes on professional practices and an understanding of responsibility to contribute to the community for sustainable development of society.

**GA11: Independent and Reflective Learning**

Observe and examine critically the outcomes of one ‘s actions and make corrective measures subsequently and learn from mistakes without depending on external feedback.

**PROGRAM OUTCOMES (POs) for M.Tech (CONTROL SYSTEM)**

**PO1:** An ability to independently carry out research /investigation and development work to solve practical problems.

**PO2**: An ability to write and present a substantial technical report/document.

**PO3:** Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in B. Tech program in Electrical Engineering / Electrical and Electronics Engineering

**PO4: Ability to model and analyze responses of complex systems under various conditions with appropriate techniques for the purpose of control for different multidisciplinary engineering fields.**

**PO5: An ability to design complex systems in advanced areas of control engineering by applying their expertise acquired through usage of modern tools.**

**PO6: An ability to demonstrate managerial and practical skills through laboratory experiments**.

# COURSE INFORMATION SHEET

**Course code: EE501**
**Course title: ADVANCED DIGITAL SIGNAL PROCESSING**
**Pre-requisite(s):** Basics of signals and systems, transform methods, Filter theory.
**Credits: L:3,T:0,P:0**
**Class schedule per week: 3**
**Class: M. Tech**
**Semester / Level: I / 5**
**Branch: EEE**
**Name of Teacher:**
**Course Objectives:** This course enables the students to:

| | |
|---|---|
| A. | Enumeratethe basic concepts of signals and systems, frequency response of discrete-time systems using various techniques like Z-transform**,** Hilbert transform**,** DFT, FFT; |
| B. | Apply digital IIR and FIR filters applying different techniques and finally construct using different realisation structures. |
| C. | Illustration of the concept of Decimation and Interpolation, Sampling rate conversion by a rational factor, Multi stage implementation of sampling rate conversion. |
| D. | Development of adaptive filter and its application. adaptive linear combiner (ALC), Signal processing applications in the area of speech and image, Adaptive signal processing applications to biomedical engineering. |
| E. | Apply DSP processor in processing of 1D and 2D signals. |

**Course Outcomes**

After the completion of this course, students will be able to:

| | |
|---|---|
| CO1 | State sampling theorem and reproduce a discrete-time signal from an analogsignal; frequency response of discrete-time systems by applying Z-transform**,** understand the basic of Hilbert transform, DFT, FFT algorithms, STFT for spectral analysis. |
| CO2 | Apply FIR filters using filter approximation theory, frequency transformation techniques, window techniques and finally construct different realisation structures.Realization of IIR filters. |
| CO3 | Illustrate the concept of Decimation and Interpolation, Multi stage implementation of sampling rate conversion. |
| CO4 | Development of adaptive filter and its in the area of speech and image, Adaptive signal processing applications to biomedical engineering. |
| CO5 | Construct (structure) and recommend environment-friendly filter for real- time applications.DesignFIR and IIR filters used as electronic filter, digital filter, mechanical filter, distributed element filter, waveguide filter, crystal filter, optical filter, acoustic filter, etc. Application of DSP processor. |

# Syllabus

**Module 1: Introduction:**

Overview of discrete time signal and systems, ADC and DAC conversion, Time domainanalysis of discrete-time linear time invariant systems, Analysis and characterization of LTI systems using Z-transform,Frequency domain analysis of signals using DFT and FFT algorithm. Hilbert transform, Spectral analysis using DFT, Short term DFT. [8]

**Module 2: Filter function approximation, IIR and FIR filter design and implementation:**

Review of approximation of ideal analog filter response. Buttorworth, Chebyshev type I & II, Digital filter structures: Direct form I & II, Cascade, Parallel and ladder realization. IIR filter designs based on impulse invariant and Bilinear transformation. Characteristic of FIR, Symmetric and antisymmetric FIR filters, design of linear phase FIR filters using windows and frequency sampling methods, comparison of FIR and IIR filters. [8]

**Module 3: Multirate signal processing:**

Decimation: Time domain characterization, frequency domain characterization, Interpolation, Sampling rate conversion by a rational factor, Multi stage implementation of sampling rate conversion. [8]

**Module 4: Adaptive Filter:**

Introduction to adaptive filter, adaptive linear combiner (ALC), Signal processing applications in the area of speech and image, Adaptive signal processing applications to biomedical engineering. [8]

**Module 5: DSP Processor and applications**

Introduction to DSP processor, Types of architectures, DSP support tools, code composer studio, compiler, assembler and linker, Introduction TMS320 C6x architecture, functional units, fetch and execute packets, pipe lining, registers, linear and circular addressing modes. Convolution, DFT,FFT implementation using DSP processor. [8]

**Text Books:**

1. John G. Proakis, Dimitris G. Mamalakis, Digital Signal Processing, Principles, Algorithms and Applications
2. Alan V. Oppenheim Ronald W. Schafer, Digital Signal Processing, PHI, India.

**Reference Book**:

1. Antonious, Digital Filter Design, Mc-Graw-Hill International Editions.
2. S. Salivahanan C Gnanapriya, Digital Signal Processing, Tata McGraw Hill Education Private Limited.
3. A.NagoorKani, Digital Signal Processing, McGraw Hill Education Private Limited.

**COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE**

**DIRECT ASSESSMENT**

| Assessment Tool | % Contribution during CO Assessment |
|---|---|
| Quizzes (3) | 3x10 = 30 |
| Seminar | 10 |
| Assignment | 10 |
| Semester EndExamination | 50 |

**INDIRECT ASSESSMENT –**

1. Students' Feedback on Course Outcome

**MAPPING OF COURSE OUTCOMES ONTO PROGRAM OUTCOMES**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | 2 | 1 | 1 | 1 | 1 | 1 |
| **CO2** | 1 | 1 | 3 | 1 | 1 | 1 |
| **CO3** | 1 | 1 | 2 | 3 | 2 | 1 |
| **CO4** | 1 | 1 | 1 | 3 | 3 | 3 |
| **CO5** | 1 | 2 | 3 | 3 | 3 | 3 |

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low)   2: Moderate (Medium)   3: Substantial (High)

**Gaps in the syllabus (to meet Industry/Profession requirements):**
1. Visualize different signal processing techniques in real time.
2. Application of real time implementation of digital filter

**POs met through Gaps in the Syllabus:**

**Topics beyond syllabus/Advanced topics/Design:**

**POs met through Topics beyond syllabus/Advanced topics/Design:**

**Course Delivery Methods**

| CD | Course Delivery methods |
|---|---|
| CD1 | Lecture by use of boards/LCD projectors |
| CD2 | Tutorials/Assignments |
| CD3 | Seminars |
| CD4 | Industrial visits/in-plant training |
| CD5 | Self- learning such as use of NPTEL materials and internets |
| CD6 | Simulation |

**MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD**

| **Mapping Between COs and Course Delivery (CD) methods** | |
|---|---|
| **Course Outcome** | **Course Delivery Method** |
| CO1 | CD1, CD2, CD3,CD5 |
| CO2 | CD1, CD2, CD3,CD5 |
| CO3 | CD1, CD2, CD3,CD5 |
| CO4 | CD1, CD2, CD3, CD5 |
| CO5 | CD1, CD2, CD3,CD5 |

**Course code: EE503**
**Course title: Modern Control Theory**
**Pre-requisite(s): Knowledge on basic control theory.**

| **Credits:** | L: | T: | P: |
|---|---|---|---|
| | 3 | 0 | 0 |

**Class schedule per week: 3**
**Class: M. Tech**
**Semester / Level: I / 5**
**Branch: EEE**
**Name of Teacher:**

**Course Objectives: This** course enables the students to:

| | |
|---|---|
| A. | grasp the concepts of state variables, state diagrams, controllability, observability |
| B. | extend comprehensive knowledge of mathematical modeling of various physical systems |
| C. | apply skill of transformations and decompositions for controllability and observability tests |
| D. | enhance skills with application of different control strategy for designing a control problem |
| E. | design controller and observer for any type of linear plants |

**Course Outcomes**

After the completion of this course, students will be able to:

| | |
|---|---|
| **CO1** | comprehend the building blocks to obtain mathematical model multidisciplinary engineering systems for the purpose of control in input-output or transfer function form |
| **CO2** | apply skill of transformations and decompositions to satisfy design requirements |
| **CO3** | analyze time-domain responses |
| **CO4** | design of controller and observer in a feedback control system with expertise |
| **CO5** | aspire to take active role in developing state-of-the-art electrical and allied system solutions and indulge in life-long learning. |

## Syllabus

**Module 1: Modelling**

Background and Preview, Modelling, Highlights of Classical Control Theory; Block diagram, Transfer functions, State Variables and State Space description of dynamic systems, State diagrams, Differential equations to state diagrams, State diagrams to Transfer function, State diagrams to state and output equations, State equations from system's linear graph. [8]

**Module 2: Mathematical basis for transformations and decompositions**

Fundamentals of Matrix Algebra, Vectors and Linear Spaces, Simultaneous Linear Equations, Eigen values and Eigenvectors, Functions of Square Matrices, Similarity Transformations, CCF, OCF, DCF and JCF forms, Decomposition of Transfer Functions, The Caley-Hamilton Theorem and its applications [8]

**Module 3: Stability Analysis**

Analysis of Continuous and Discrete-Time Linear State Equations, Local linearization of nonlinear models, State Transition Matrix, Significance, Properties and Evaluation of STM, Stability analysis using direct method of Lyapunov. [8]

**Module 4: Controllability and Observability concepts**

Controllability and Observability concept for linear Systems, Relationship among Controllability, Observability and Transfer Functions, Invariant theorems on Controllability and Observability. [8]

**Module 5: Design of Linear Feedback Control Systems**

Design of Linear Feedback Control Systems, pole placement design through state feedback, Design of servo systems, State observers, Design of Regulator Systems with observers, Design of control systems with Observers, Quadratic Optimal Regulator Systems [8]

**TEXTBOOKS:**

1. Modern Control Theory by Brogan, Pearson, 3rd edition. (**T1)**
2. Systems and Control by Zak, 1st edition, Oxford University Press. **(T2)**
3. Modern Control System Theory by M. Gopal, New Age International(P) Ltd., 2nd edition.(**T3**)
4. Automatic Control Systems by F. Golnaraghi and B.C.Kuo, Wiley Student Edition, 9th edition.(**T4**)
5. Modern Control Engineering by K. Ogata, Pearson, 5th edition (**T5)**

**REFERENCE BOOKS:**

1. Digital Control & State Variable Methods – M. Gopal, Tata McGraw Hill Education. (**R1**)
2. Linear Systems by Thomas Kailath, Prentice-Hall Inc.,1980. (**R2**)

**COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE**

**DIRECT ASSESSMENT**

| Assessment Tool | % Contribution during CO Assessment |
|---|---|
| Quizzes (3) | 3x10 = 30 |
| Seminar | 10 |
| Assignment | 10 |
| Semester End Examination | 50 |

**INDIRECT ASSESSMENT –**

1. Students' Feedback on Course Outcome

**MAPPING OF COURSE OUTCOMES ONTO PROGRAM OUTCOMES**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | 2 | 2 | 1 | 3 | 2 | 3 |
| **CO2** | 3 | 2 | 1 | 2 | 2 | 2 |
| **CO3** | 3 | 3 | 2 | 3 | 2 | 2 |
| **CO4** | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO5** | 3 | 3 | 3 | 3 | 3 | 3 |

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

**Gaps in the syllabus (to meet Industry/Profession requirements):**
**1. Industry related control applications can be undertaken**

**POs met through Gaps in the Syllabus: PO5,PO6**

**Topics beyond syllabus/Advanced topics/Design:**
**1. Digital control**
**2. Nonlinear control technologies**
**3. Process Measurement and control**

**POs met through Topics beyond syllabus/Advanced topics/Design:**
**PO5, PO6**
**Course Delivery Methods**

| CD | Course Delivery methods |
|---|---|
| CD1 | Lecture by use of boards/LCD projectors |
| CD2 | Tutorials/Assignments |
| CD3 | Seminars |
| CD4 | Industrial visits/in-plant training |
| CD5 | Self- learning such as use of NPTEL materials and internets |

| | |
|---|---|
| CD6 | Simulation |

## MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

| **Mapping Between COs and Course Delivery (CD) methods** | |
|---|---|
| **Course Outcome** | **Course Delivery Method** |
| CO1 | CD1, CD2, CD3,CD5 |
| CO2 | CD1, CD2, CD3,CD5 |
| CO3 | CD1, CD2, CD3,CD5 |
| CO4 | CD1, CD2, CD3, CD5 |
| CO5 | CD1, CD2, CD3,CD5 |

**Course code: EE505**
**Course title: System Identification and Adaptive Control**
**Pre-requisite(s):** Fundamentals of signal and system, Digital signal processing,
**Credits:** L T P
3 0 0
**Class schedule per week: 3**
**Class: M.Tech.**
**Semester / Level: I/05**
**Branch: Electrical Engineering**
**Name of Teacher:**

**Course Objectives:**

This course enables the students to:

| | |
|---|---|
| A. | illustrate the process of system identification and interpret data based identification techniques. |
| B. | understand the concepts of time invariant systems identification, and apply it to specific real time numerical problems. |
| C. | illustrate and summarize the techniques of adaptive control. |
| D. | derive necessary and sufficient conditions for Input/Output, Lyapunov (Direct and Indirect) stability. |
| E. | develop adaptive laws for On-line Parameter Estimation and derive schemes and procedures for Direct Model Reference Adaptive Control. |

**Course Outcomes:**

At the end of the course, a student should be able to:

| | |
|---|---|
| CO1 | enumerate the process of system identification and apply the data based identification techniquesto identify transfer functions of unknown plant models. |
| CO2 | apply the static and dynamic system identification techniques to identify the estimated states for the unknown or perturbed time invariant plant models. |
| CO3 | state and interpret the concepts of adaptive control and determine Input/output and Lyapunov stability of a LTI feedback system |
| CO4 | apply various techniques or laws of adaptation for online parameter estimation and reproduce the results and write effective reports suitable for quality journal and conference publications. |
| CO5 | design adaptive observers and model reference adaptive control for SISO and MIMO plants and simultaneouslyrecognize the need to learn, to engage and to adapt in a world of constantly changing technology and play role of team leader or supporter of team. |

## SYLLABUS

**Module 1:**
**Introduction to System Identification:** Data based identification (System Response Methods, Frequency Response Methods, Correlation Methods). **8L**

**Module 2:**
**Time Invariant Systems Identification:** Static Systems Identification, Dynamic Systems Identification. **8L**

**Module 3:**
Introduction to Adaptive Control: Models for Dynamic Systems, Stability.**8L**

**Module 4:**
**On-line Parameter Estimation:** Fundamentals of random signals, Spectral estimation, Optimum (Wiener and Kalman) linear estimation, Extended Kalman filter, Particle filter, Parameter Identifiers and Adaptive Observers.**8L**

**Module 5:**
**Model Reference Adaptive Control (MRAC):** Simple Direct MRAC Schemes, MRC for SISO Plants, Direct MRAC with Unnormalized Adaptive Laws, Direct MRAC with Normalized Adaptive Laws. **8L**

**Books recommended:**

**Text Books:**
1. Systems Identification: An Introduction – Karel J. Keesman, Springer, 2011.
2. Robust Adaptive Control - Petros A. Ioannou and Jing Sun, 1996.
3. Optimization, Estimation and Control - A.E. Bryson & Y.C. Ho
4. Applied Optimal Estimation - A. Gelb, NIT Press, Cambridge
5. Optimal Estimation, Identification and Control - RCK Lee, NIT Press, Combridge, Massachusetts, 1964.
6. Stochastic Optimal Linear Estimation and Control - J.S. Meditch, McGraw Hill, N.Y., 1969.

**Course Evaluation:**
Individual assignment, Theory (Quiz and End semester) examinations

**Gaps in the syllabus (to meet Industry/Profession requirements):**
Design of real-time industrial projects.
POs met through Gaps in the Syllabus:**PO5 & PO6**

**Topics beyond syllabus/Advanced topics/Design:**
Advanced topic in adaptive signal processing, Artificial Intelligence Techniques.

POs met through Topics beyond syllabus/Advanced topics/Design: **PO5 & PO6**

## Course Delivery Methods

| | |
|---|---|
| CD1 | Lecture by use of boards/LCD projectors/OHP projectors |
| CD2 | Assignments/Seminars |
| CD3 | Laboratory experiments/teaching aids |
| CD4 | Industrial/guest lectures |
| CD5 | Industrial visits/in-plant training |
| CD6 | Self- learning such as use of NPTEL materials and internets |
| CD7 | Simulation |

**MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | 3 | 1 | 1 | 3 | 1 | 1 |
| **CO2** | 2 | 1 | 1 | 2 | 1 | 1 |
| **CO3** | 2 | 1 | 2 | 2 | 1 | 2 |
| **CO4** | 2 | 2 | 2 | 3 | 3 | 3 |
| **CO5** | 2 | 3 | 3 | 1 | 1 | 3 |

**< 34% = 1, 34-66% = 2, > 66% = 3**

**MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD**

| Course Outcomes | Course Delivery Method |
|---|---|
| CO1 | CD1,CD6 |
| CO2 | CD1, CD6,CD7 |
| CO3 | CD1, CD2, CD3,CD6,CD7 |
| CO4 | CD1, CD3,CD6,CD7 |
| CO5 | CD1,CD2,CD3,CD4,CD5,CD7 |

**Course code: EE601**
**Course title: Process Measurement and Control**
**Pre-requisite(s): Instrumentation and Measurement**
**Co- requisite(s): control system**
**Credits: L:3 T:0 P:0**
**Class schedule per week: 03**
**Class: Mtech**
**Semester / Level: 0X**
**Branch: control/ EEE**
**Name of Teacher:**

## Course Objectives

This course enables the students:

| | |
|---|---|
| A. | Expose students to the advanced control methods used in industries and research. |
| B. | Understand various process model |
| C. | Understand process control |
| D. | Control system analysis and design |
| E | Understand various process model |

## Course Outcomes

After the completion of this course, students will be:

| | |
|---|---|
| CO1 | controller tuning |
| CO2 | type of controller that can be used for specific problems in industry |
| CO3 | design of controllers for interacting multivariable systems |
| CO4 | design of digital control systems |
| CO5 | Understanding of production line |

## Syllabus

**Module 1 Fundamentals of Process:** Control Elements of process control loop, Process Characteristics and their significance. Process gain, Process reaction curve, process time constant, step analysis method, finding time constant, dead time. [8L]

**Module 2 Feedback Controller Tuning**: Types of Controllers, Tuning methods, Selection of controller for specific application, Controller settings- evaluation criteria – 1/4th decay ratio, IEA, ISE, ITAE - determination of optimum settings for mathematically described process using time response and frequency response. [8L]

**Module 3 Stability Analysis and Performance of Feedback Control systems**: Concept of stability, Stability analysis of linear and linearised systems, principles, Bode Method, Controller tuning based on stability Control Performance via closed loop frequency Response, Control system factors influencing control Performance. [8L]

**Module 4 Control strategies**: Multi loop process control systems, Feedback-feed forward control,adaptive control, Smith predictor, internal model control. Cascade Control, Ratio Control, Selective Control, and Split-range Control with industrial applications. [8L]

**Module 5 Analysis of Multivariable Systems Process Interaction:** Effects of Interaction, Block representation and transfer function matrix interaction, relative gain array, resiliency, Morari resiliency index, Niederlinsky index Multivariable Control Singular Value Analysis, Selection of manipulated and Controlled Variables, Tuning of multiloop PID control systems, Decoupling and Multivariable control Strategies. [8L]

**Text books:**

1. "Process Control", F. G. Shinskey, McGraw Hill Book Company
2. "Process, Modeling, Simulation and Control for Chemical Engineers", W. L. Luyben, McGraw Hill.
3. D.R. Coughanour, 'Process Systems analysis and Control', McGraw-Hill, 2nd Edition, 1991.

**COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE**

**DIRECT ASSESSMENT**

| Assessment Tool | % Contribution during CO Assessment |
|---|---|
| Quizzes (3) | 3x10 = 30 |
| Seminar | 10 |
| Assignment | 10 |
| Semester EndExamination | 50 |

**INDIRECT ASSESSMENT –**

**1.** Students' Feedback on Course Outcome

**MAPPING OF COURSE OUTCOMES ONTO PROGRAM OUTCOMES**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | 2 | 2 | 2 | 2 | 3 | 3 |
| **CO2** | 1 | 3 | 3 | 3 | 3 | 3 |
| **CO3** | 3 | 2 | 2 | 2 | 2 | 3 |
| **CO4** | 3 | 3 | 2 | 3 | 3 | 3 |
| **CO5** | 2 | 2 | 3 | 2 | 3 | 3 |

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low)   2: Moderate (Medium)   3: Substantial (High)

**Gaps in the syllabus (to meet Industry/Profession requirements):**
**1. Production related concept can be undertaken**

**POs met through Gaps in the Syllabus:**
**PO5,PO6**

**Topics beyond syllabus/Advanced topics/Design:**
**1. AI system**
**2. fluid mechanics**
**3. Industrial instrumentation and measurement**

**Course Delivery Methods**

| CD | Course Delivery methods |
|---|---|
| CD1 | Lecture by use of boards/LCD projectors |
| CD2 | Tutorials/Assignments |
| CD3 | Seminars |
| CD4 | Industrial visits/in-plant training |
| CD5 | Self- learning such as use of NPTEL materials and internets |
| CD6 | Simulation |

## MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

| **Mapping Between COs and Course Delivery (CD) methods** | |
|---|---|
| **Course Outcome** | **Course Delivery Method** |
| CO1 | CD1, CD2, CD3,CD5 |
| CO2 | CD1, CD2, CD3,CD5 |
| CO3 | CD1, CD2, CD3,CD5 |
| CO4 | CD1, CD2, CD3, CD5 |
| CO5 | CD1, CD2, CD3,CD5 |

**Course code: EE502**
**Course title: Advanced Digital Signal Processing Laboratory**
**Pre-requisite(s): Basics of signals and systems, Transform methods.**
**Credits: 2 L T P**
**0 0 4**
**Class schedule per week: 4 Class: M.Tech.**
**Semester / Level: I/05**
**Branch: Electrical Engineering**
**Name of Teacher:**

**Course Objectives:**

**This course enables the students to:**

| | |
|---|---|
| A. | enumerate the basic concepts of signals and systems and their interconnections in a simple and easy-to-understand manner through different mathematical operations like folding, shifting, scaling, convolutions, etc. using MATLAB; also gain Knowledge of TMS kit, digital image filter; |
| B. | construct different realization structures; |
| C. | determine transfer function and predict frequency response of discrete-time systems by applying various techniques like Z-transform, DFT and FFT using MATLAB; |
| D. | evaluate cost of filters in terms of memory space complexity, algorithm complexity and economic values; |
| E. | design and compose digital IIR and FIR filters using filter approximation theory, for optimal cost. |

**Course Outcomes:**

At the end of the course, a student should be able to:

| | |
|---|---|
| CO1 | convert analog signal into digital signals and vice-versa, generation of different signals and basic knowledge of TMS kit; |
| CO2 | compute frequency response of the systems using frequency transformation technique, DFT, DIF-FFT or DIT-FFT algorithm, window techniques and visualization using MATLAB; |
| CO3 | design FIR and IIR filters; |
| CO4 | evaluate performance of filter with time variant signals; |
| CO5 | recommend environment-friendly filter for different real- time applications such as optical filter design, acoustic filter design etc. |

## List of Experiments

Overview of discrete time signal and systems, ADC and DAC conversion, Time domain analysis of discrete-time linear time invariant systems, Analysis and characterization of LTI systems using Z-transform,Frequency domain analysis of signals using DFT and FFT algorithm. Hilbert transform, Spectral analysis using DFT, Short term DFT.

**Module 2: Filter function approximation, IIR and FIR filter design and implementation:**

Review of approximation of ideal analog filter response. Buttorworth, Chebyshev type I & II, Digital filter structures: Direct form I & II, Cascade, Parallel and ladder realization. IIR filter designs based on impulse invariant and Bilinear transformation.Characteristic of FIR, Symmetric and antisymmetric FIR filters, design of linear phase FIR filters using windows and frequency sampling methods, comparison of FIR and IIR filters.

**Module 3: Multirate signal processing:**

Decimation: Time domain characterization, frequency domain characterization, Interpolation, Sampling rate conversion by a rational factor, Multi stage implementation of sampling rate conversion.

**Module 4: Adaptive Filter:**

Introduction to adaptive filter, adaptive linear combiner (ALC), Signal processing applications in the area of speech and image, Adaptive signal processing applications to biomedical engineering.

**Module 5: DSP Processor and applications**

Introduction to DSP processor, Types of architectures, DSP support tools, code composer studio, compiler, assembler and linker, Introduction TMS320 C6x architecture, functional units, fetch and execute packets, pipe lining, registers, linear and circular addressing modes. Convolution, DFT, FFT implementation using DSP processor.

**1. Name: -** ADC and DAC conversion considering sampling theorem and aliasing effect.

**Aim: -**Generation and representation of different types of signal, Implementation of Analog to digital and digital to analog conversion suitably considering sampling theorem and aliasing effect.

**2. Name:-**Linear convolution,Cross-correlation, Auto-correlation of two sequences.

**Aim:**Analysis of interaction of digital signal with digital system using **l**inear convolution of two sequences. Perform Linear convolution of two sequence using circular matrix method.

3.**Name:-** Discrete Fourier transform and Inverse- Discrete Fourier transform
**Aim:**Frequency domain analysis of signals using DFT and IDFT algorithms.

4.**Name**: DFT by DIT-FFT and DIF-FFT method.
**Aim:**Frequency analysis of discrete signal by applying DIT-FFT and DIF-FFT algorithm.

5.**Name:**IIR filter realization.
**Aim:**Design and implementation ofIIR filter using Direct form I and Direct form-II structure.

6.**Name:**FIR filter realization.
**Aim:**Design and implementation FIR filter using Direct form I and Direct form-II structure.

7.**Name:** Familiarization with TMS-320C6713 DSP starter Kit, convolution of two sequence applying TMS-320C6713 DSP starter Kit.
**Aim:**Implementation of interaction of digital signal and system applying TMS- 320C6713 DSP starter Kit.

8. **Name:**DFT and IDFT using TMS-320C6713 DSP starter Kit.
**Aim:** To perform frequency analysis using DFT and IDFT by applying TMS-320C6713 DSP starter Kit.

9. **Name: A**daptive filter design and implementation in speech processing.
**Aim:** To remove noise from a 1D biomedical and speech signal by applying adaptive linear combiner (ALC).

10.**Name**: Fundamentals on image processing.Noise suppression from digital image.

**Aim:** To change the intensity of specific part of given gray scale image. To write a program to remove Salt &pepper type noise from a given gray scale image using mean and median filters.

11. **Name:**Noise suppression from digital image using adaptive filter.
**Aim:**Write a program to remove Gaussian noise from given image by applying adaptive filter/ Artificial neural network.

**Books Recommended:**

1. Digital signal processing and applications with C6713 and C6416 DSK by RulphChassaing, wiley publication.
2. Real-Time digital signal processing based on the TMS320C6000 by Nasser Kehtarnavaz, ELSEVIER publication
3. DSP applications using C and the TMS320c6x DSK by RulphChassaing, Wiley Publication.

**Reference Books**:

1. Antonious,Digital Filter Design,Mc-Graw-Hill International Editions.
2. WavelateTransform,S.Rao.
3. WavelateAnalysis:"The scalable structure of Information"Springer2008–Howard L.Resinkoff,RaymondO.Wells

**Course Evaluation:**

Group project evaluation, Progressive and End semester evaluations

**Gaps in the syllabus (to meet Industry/Profession requirements) :**

1. Visualize different signal processing techniques in real time.
2. Application of real time implementation of digital filter.

**POs met through Gaps in the Syllabus:PO5& PO6**

**Topics beyond syllabus/Advanced topics/Design:**

Adaptive signal processing, Image processing.

**POs met through Topics beyond syllabus/Advanced topics/Design:** PO5 & PO6

**Course Outcome (CO) Attainment Assessment tools & Evaluation procedure**

**Direct Assessment**

| Assessment Tool | % Contribution during CO Assessment |
|---|---|
| Continuous Internal Assessment | 50 |
| Semester End Examination | 50 |

| Continuous Internal Assessment | % Distribution |
|---|---|
| 3 quizzes | 30 (3×10) |
| Assignment(s) | 10 |
| Seminar before a committee | 10 |

| Assessment Components | CO1 | CO2 | CO3 | CO4 | CO5 |
|---|---|---|---|---|---|
| Continuous Internal Assessment | | | | | |
| Semester End Examination | | | | | |

**Indirect Assessment**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

**Course Delivery Methods**

| | |
|---|---|
| CD1 | Lecture by use of boards/LCD projectors/OHP projectors |
| CD2 | Assignments/Seminars |
| CD3 | Laboratory experiments/teaching aids |
| CD4 | Industrial/guest lectures |
| CD5 | Industrial visits/in-plant training |
| CD6 | Self- learning such as use of NPTEL materials and internets |
| CD7 | Simulation |

**MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | 3 | 2 | 1 | - | - | - |
| **CO2** | 3 | 2 | 1 | 2 | - | 1 |
| **CO3** | 3 | 1 | 2 | 3 | - | 1 |
| **CO4** | 2 | 2 | 2 | 3 | 2 | 2 |
| **CO5** | 2 | 2 | 3 | 1 | 3 | 3 |

**< 34% = 1, 34-66% = 2, > 66% = 3**

**MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD**

| Course Outcomes | Course Delivery Method |
|---|---|
| CO1 | CD1,CD6 |
| CO2 | CD1, CD6,CD7 |
| CO3 | CD1, CD2, CD3,CD6,CD7 |
| CO4 | CD1, CD3,CD6,CD7 |
| CO5 | CD1,CD2,CD3,CD4,CD5,CD7 |

**Course code: EE504**
**Course title: Adaptive Control System Lab**
**Pre-requisite(s):** Introduction to System theory, Control theory, Control system design
**Co- requisite(s):**
**Credits: 2** L:0 T:0 P:4
**Class schedule per week: 04**
**Class: M.Tech.**
**Semester / Level: I/05**
**Branch: Electrical Engineering**
**Name of Teacher:**

**Course Objectives:**

This course enables the students to:

| | |
|---|---|
| 1. | To describe the basic components and various specifications of system |
| 2. | To explain and interpret the performance of different controllers |
| 3. | To analyse various techniques in time domain and frequency domain to ensure stability of a system. |
| 4. | To simulate and test them on systems like Inverted Pendulum, Twin Rotor MIMO system (TRMS) and Magnetic Levitation System |
| 5. | To determine the response of different types of systems using real time workshop in Matlab and appraise their use in real life. |

**Course Outcomes:**

At the end of the course, a student should be able to:

| | |
|---|---|
| CO1 | examine performance characteristics of basic components of a system and describe various specifications used for a system |
| CO2 | explain and interpret the performance characteristics of different sensors, DC motor, ON/OFF and PLC/PID Controllers |
| CO3 | analyse the effect of addition of poles and zeros in time domain and frequency domain |
| CO4 | appraise various techniques and analyse stability of a given system |
| CO5 | simulate and test the techniques on Inverted Pendulum, Twin Rotor MIMO system (TRMS) and Magnetic Levitation System |

**Lab Experiments:**

1. To study and implementation of ON-OFF temperature controller.
2. To obtain the step response of first and second order RLC series circuit and determine the value of R and L for a given value of C through time response specification.
3. To obtain Bode plot of the given circuit through experimentation and in term determine the transfer function through by calculations and simulate the same system in Matlab.
4. To obtain the Nyquist plot of the given transfer function and determine the gain margin, phase margin, gain crossover frequency, phase crossover frequency. Comment on the stability.
5. To obtain the characteristics of synchros.
6. To obtain the characteristics of Linear Variable Differential Transformer (LVDT).
7. Study the effect of addition of poles and zeros and correlate the time and frequency domain behavior using MATLAB sisotool for a given system.
8. To study the characteristics of different sensors and transducers.
9. To design a PID controller for a DC motor using Z-N method and verify it in MATLAB.
10. Pole placement design of Inverted pendulum
11. PLC / PID controller based Pressure control using Process trainer kit
12. Study the operation of Twin rotor MIMO system
13. Study the operation of Magnetic Levitation system

**Books recommended:**

Text Books:

1. B.C. Kuo, "Automatic Control System", 7th Edition PHI. (T1)
2. M. Gopal, "Control Systems Principles & Design", 2nd Edition, TMH. (T2)
3. J.G. Truxal, "Automatic Feedback Control System", McGraw Hill, New York. (T3)
4. K. Ogata, "Discrete Time Control Systems", 2nd Edition, Pearson Education. (T4)

Reference Books:

1. Norman Nise, "Control System Engineering", 4th Edition. (R1)

## COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

## DIRECT ASSESSMENT

| Assessment Tool | | % Contribution during CO Assessment |
|---|---|---|
| Progressive Evaluation | Day to Day Performance | 30 |
| | Quiz | 10 |
| | Viva | 20 |
| End Sem Examination Marks | Lab Performance | 30 |
| | Quiz | 10 |

**INDIRECT ASSESSMENT –**

1. Student Feedback on Course Outcome

**MAPPING OF COURSE OUTCOMES ONTO PROGRAM OUTCOMES**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 3 | 3 | 3 | |
| CO2 | 3 | 3 | 3 | 3 | 2 | 3 |
| CO3 | 3 | 3 | 3 | 3 | 2 | |
| CO4 | 3 | 3 | | 3 | 3 | |
| CO5 | 3 | 3 | 3 | 3 | 3 | 3 |

**Correlation Levels 1, 2 or 3 as defined below:**

1. Sight (Low) 2. Moderate (Medium) 3. Substantial (High)

**Gaps in the syllabus (to meet Industry/Profession requirements):**

1. Simulation to meet real time implementation of techniques to meet industry requirements

**POs met through Gaps in the Syllabus: 1,2,3,4**

**Topics beyond syllabus/Advanced topics/Design:**

Simulation given to students as assignments

**POs met through Topics beyond syllabus/Advanced topics/Design:**

| CD | Course Delivery methods |
|---|---|
| CD1 | Lecture by use of boards/LCD projectors |
| CD2 | Tutorials/Assignments |
| CD3 | Seminars |
| CD4 | Self- learning such as use of NPTEL materials and internets |
| CD5 | Simulation |

**MAPPING BETWEEN COS AND COURSE DELIVERY (CD) METHODS**

| Course Outcome | Course Delivery Method |
|---|---|
| CO1 | CD1,CD2,CD4 |
| CO2 | CD1,CD2,CD4 |
| CO3 | CD1,CD2,CD3,CD4,CD5 |
| CO4 | CD1,CD2,CD3,CD4,CD5 |
| CO5 | CD1,CD2,CD3,CD4,CD5 |

**Course code: EE551**
**Course title: OPTIMAL CONTROL THEORY**
**Pre-requisite(s): Fundamentals of Mathematics and Physics, Introduction to System Theory, Control Theory**
**Co- requisite(s):**

| **Credits:** | L: | T: | P: |
|---|---|---|---|
| | 3 | 0 | 0 |

**Class schedule per week: 03**
**Class: M.Tech.**
**Semester / Level: II/05**
**Branch: Electrical Engineering**
**Name of Teacher:**

**Course Objectives:** This course enables the students to:

| | |
|---|---|
| A. | to state the performance index of an optimal control system with specific design requirements and design objectives. |
| B. | to understand the concepts of calculus of variations, Euler Lagrange equations and apply it to specific real time numerical problems. |
| C. | to identify and then establish the Hamiltonian and Pontryagin's formulation from a assumed performance index and apply it to specific real time numerical problems. |
| D. | to develop methodologies that uses the concept of finite and infinite time lqr |
| E. | to develop methodologies that uses the concept of dynamic programming procedure to generate control law for a single variable and a multivariable processes subjected to uncertainties. |

**Course Outcomes**

After the completion of this course, students will be able to:

| | |
|---|---|
| CO1 | identify the design objectives and requirements to set up a performance index for an Optimal Control System. |
| CO2 | interpret the concepts of calculus of variations to establish Euler Lagrange Equation and apply it to solve some design problems. |
| CO3 | establish the Hamiltonian and Ponryagin's formulation from the performance index and apply this concept to develop an optimal control law. |
| CO4 | develop methodologies to formulate a control law by Pontryagin's Minimum Principle using Dynamic Programming method and reproduce the results and write effective reports suitable for quality journal and conference publications. |
| CO5 | develop methodologies to formulate a control law using finite time and infinite time, time varying LQR concepts for regulator and tracking problems and Simultaneously recognize the need to learn, to engage and to adapt in a world of constantly changing technology and play role of team leader or supporter of team. |

## Syllabus

**Module 1: Introduction**

Optimization overview, flow chart of linear optimal control technique, Parameter optimization, Minimization problem, Tracking problem, Regulator problem. Calculus of variation. Derivation of Eular-Lagrange equation. The problems of Lagrange, Mayer and Bolza. [8]

**Module 2: Euler-Lagrange Equation**

Application of the Eular-Lagrange Equation to a Linear, first order system, Langrange multiplier, Gradient based unconstrained minimization. [8]

**Module 3: Hamiltonian Formulation**

Formulation of the general nth-order system problem, The Hamiltonian formulation of classical mechanics, Modified Transversality conditions at t = tf. [8]

**Module 4: Pontryagins maximum principle**

Pontryagins maximum principle, Hamilton - Jacobi Equation, Application of variation approach to control problem. [8]

**Module 5: Optimal LQR Formulation**

Quadratic form of performance index; statement of LQR problem, solution of finite time and infinite time regulator problem, solution of Riccati equation, Frequency domain interpretation of LQR design, Stability & robustness properties of LQR design, Linear Quadratic Gaussian (LQG) control. Dynamic Programming: Multistage decision process, Concept of sub-optimization and principle of optimality, Recurrence relationship, computational procedure in dynamic programming. [8]

**TEXTBOOKS:**

6. Optimal control system – D.S. Naidu, CRS Press, 2003.
7. Introduction to optimum design – Jasbir S. Vora – Elsevier 2006.
8. Modern Control Theory – J. T. Tou

**REFERENCE BOOKS:**

1. Digital Control & State Variable Methods – M. Gopal, Tata McGraw Hill Education. (**R1**)

### COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

### DIRECT ASSESSMENT

| Assessment Tool | % Contribution during CO Assessment |
|---|---|
| Quizzes (3) | 3x10 = 30 |
| Seminar | 10 |
| Assignment | 10 |
| Semester End Examination | 50 |

**INDIRECT ASSESSMENT –**

1. Students' Feedback on Course Outcome

## MAPPING OF COURSE OUTCOMES ONTO PROGRAM OUTCOMES

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 3 | 2 | 2 | 1 |
| **CO2** | 3 | 3 | 2 | 2 | 1 | 1 |
| **CO3** | 3 | 2 | 2 | 2 | 1 | 1 |
| **CO4** | 3 | 3 | 2 | 2 | 2 | 2 |
| **CO5** | 3 | 3 | 2 | 3 | 3 | 3 |

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

**Gaps in the syllabus (to meet Industry/Profession requirements):**

(1) Online optimal control design of controllers.

(2) Interfacing the controllers with the real time physical plants to identify the effects on system's performance.

**POs met through Gaps in the Syllabus: PO3, PO4**

**Topics beyond syllabus/Advanced topics/Design:**

(i) Advanced optimal control design methods for different control problems

**POs met through Topics beyond syllabus/Advanced topics/Design: PO4**

**Course Delivery Methods**

| CD | Course Delivery methods |
|---|---|
| CD1 | Lecture by use of boards/LCD projectors |
| CD2 | Tutorials/Assignments |
| CD3 | Seminars |
| CD4 | Industrial visits/in-plant training |
| CD5 | Self- learning such as use of NPTEL materials and internets |
| CD6 | Simulation |

## MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

| **Mapping Between COs and Course Delivery (CD) methods** | |
|---|---|
| **Course Outcome** | **Course Delivery Method** |
| CO1 | CD1 |
| CO2 | CD1,CD2,CD3 |
| CO3 | CD1,CD2,CD3 |
| CO4 | CD1,CD2,CD3 |
| CO5 | CD1,CD2,CD3 |

**Course code: EE553**
**Course title: Nonlinear Control System**
**Pre-requisite(s): Modern Control Theory**
**Co- requisite(s): Control system design**
**Credits: 3** L:3 T:0 P:0
**Class schedule per week: 03**
**Class: M.E.**
**Semester / Level: II/5**
**Branch: EEE**
**Name of Teacher:**

**Course Objectives:** This course enables the students with concepts:

| | |
|---|---|
| A. | of nonlinear properties and their types |
| B. | of linearization of nonlinear state equations |
| C. | to extend comprehensive knowledge of graphical and mathematical analysis of nonlinear physical system for study of stability; |
| D. | to illustrate basics of different design methods; |
| E. | to summarize them on regulation and tracking problems. |

**Course Outcomes:**

After the completion of this course, students will be able to:

| | |
|---|---|
| CO1 | comprehend various nonlinear properties. |
| CO2 | relate an appropriate methodology for analysis of the various types of nonlinearities. |
| CO3 | organize different methodologies to demonstrate stability of different nonlinear control problems. |
| CO4 | categorize different techniques like, feedback linearization, sliding mode, gain scheduling to regulation and tracking problems. |
| CO5 | appraise and compile the different properties and methods of analysis and design for the need of continuous learning in order to create state of art based on advanced mathematical tools and pursue higher studies in premier institutes. |

# Syllabus

**Module 1**

**Introduction to Nonlinear systems**: Types of nonlinearities, Characteristics, Linear approximation of nonlinear systems, Linearization of nonlinear state differential equation, Phase plane analysis: Phase plane representation, Phase portrait, graphical method to obtain phase trajectory, Singular points, Limit cycle. [8L]

**Module – II**

**Describing function analysis**: Definition, Derivation of Describing functions for common nonlinear elements, Determination of amplitude and frequency of limit cycle using describing function technique. [8L]

**Module - III**

**Liapunov methods**: Introduction, Basic concepts, Stability definitions, Stability theorems, Liapunov functions for nonlinear systems, Methods for determination of Liapunov functions, popov stability criteria. [8L]

**Module – IV**

**Feedback Linearization**: Motivation, Input-output linearization, Full state linearization, State feedback control: Stabilization, Tracking [8L]

**Module – V**

**Sliding mode control and Gain Scheduling**: Sliding mode control: Sliding mode control: Motivation, Stabilization, Tracking, Regulation via integral control; Gain Scheduling: Scheduling variables; Gain scheduled controller for nonlinear systems. [8L]

**Text Books**:


1. Slotine and Li, "Applied Nonlinear Control", Prentice Hall, Englewood Cliffs, New Jersey 07632

2. M. Gopal, "Digital Control & State Variable Method", TMH.

3. B. C. Kuo, "Automatic Control System"7th Edition PHI

4. Hassan K. Khalil, "Non Linear Systems".


**Reference**:


5. S. Banerjee, "Nonlinear Dynamics" (NPTEL Lectures)

**COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE**

**DIRECT ASSESSMENT**

| Assessment Tool | % Contribution during CO Assessment |
|---|---|
| Quizzes (3) | 3x10 = 30 |
| Seminar | 10 |
| Assignment | 10 |
| Semester End Examination | 50 |

**INDIRECT ASSESSMENT –**

**1.** Students' Feedback on Course Outcome

**MAPPING OF COURSE OUTCOMES ONTO PROGRAM OUTCOMES**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | 2 | 2 | 2 | 2 | 2 | 2 |
| **CO2** | 3 | 3 | 2 | 3 | 2 | 3 |
| **CO3** | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO4** | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO5** | 3 | 3 | 3 | 3 | 3 | 3 |

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low)   2: Moderate (Medium)   3: Substantial (High)

**Gaps in the syllabus (to meet Industry/Profession requirements):**

**1. Industry related control applications can be undertaken**

**POs met through Gaps in the Syllabus: PO5, PO6**

**Topics beyond syllabus/Advanced topics/Design: Artificial Intelligence**

**POs met through Topics beyond syllabus/Advanced topics/Design: PO5, PO6**

**Course Delivery Methods**

| CD | Course Delivery methods |
|---|---|
| CD1 | Lecture by use of boards/LCD projectors |
| CD2 | Tutorials/Assignments |
| CD3 | Seminars |
| CD4 | Industrial visits/in-plant training |
| CD5 | Self- learning such as use of NPTEL materials and internets |
| CD6 | Simulation |

**MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD**

| **Mapping Between COs and Course Delivery (CD) methods** | |
|---|---|
| **Course Outcome** | **Course Delivery Method** |
| CO1 | CD1, CD2, CD3,CD5 |
| CO2 | CD1, CD2, CD3,CD5 |
| CO3 | CD1, CD2, CD3,CD5 |
| CO4 | CD1, CD2, CD3, CD5 |
| CO5 | CD1, CD2, CD3,CD5 |

**Course Code: EE 555**
**Course Title: Statistical Control Theory**
**Pre-requisite(s):** Mathematics, Statistics, Introduction to System Theory, Control Theory
**Co- requisite(s):**
**Credits:** L: 3 T: 0 P: 0
**Class schedule per week: 03**
**Class: M. Tech.**
**Semester / Level: II/5**
**Branch: Electrical Engineering**
**Name of Teacher:**

## Course Objectives

This course enables the students to:

| | |
|---|---|
| A. | Describe and classify different types of random variables, random processes, probability density function and cumulative distribution function |
| B. | Estimate statistical properties of random variables and random processes such as expected value, variance, standard deviation and correlation functions. |
| C. | Evaluate autocorrelation functions for given power spectral density, correlate the mean square error of any system with the correlation functions and analyse the response of linear system to random inputs. |
| D. | Design real time Wiener filter, stored data Wiener filter and Kalman filter for any system. |
| E. | Recommend the techniques of statistical control to solve a problem and technologically upgrade the skills in the domain of statistical control theory. |

## Course Outcomes

After the completion of this course, students will be able to:

| | |
|---|---|
| CO1 | Enumerate properties of probability density function, cumulative distribution function, correlation functions and power spectral density of a random process |
| CO2 | Describe different types of random variable and random processes |
| CO3 | Calculate expected value, variance, standard deviation and correlation functions of a random variable and random process. |
| CO4 | Analyse the response of linear system to random inputs. |
| CO5 | Design a Wiener and Kalman filter for a system and compare with classical filters |

# Syllabus

**Module 1:**
Review of Probability theory. Random experiments. **Random Variables**: Definition. Classification. Cumulative distribution function. Probability density function. Functions of Random Variables. Expected values. Moments. Variance and Standard deviation. Markov and Chebyshev inequalities. Transform methods: Characteristic function; Probability generating function; Laplace transform of the pdf. Transformation of random variable. [8]

**Module 2:**
**Multiple Random Variables**: Vector random variables. Pairs of random variables.
Independence of random variables. Conditional probability and conditional expectation. Multiple random variables. Functions of several random variables. Expected value of function of random variables. Jointly Gaussian random variables. Sums of random variables: Mean; Variance; pdf of sum of random variables. Sample mean and law of large numbers. Central Limit theorem. [8]

**Module 3:**
**Random Processes**: Definition. Specification: Joint distribution of time samples; Mean; Autocorrelation and Autocovariance functions. Discrete random processes: iid random processes; sum processes: Binomial counting and Random Walk processes. Continuous-time random processes: Poisson processes; Wiener process and Brownian Motion. Stationarity. Time Averaging and Ergodicity, Minimum mean square error filtering: Estimating a random variable with a constant; stored data wiener filter; Real time wiener filter. [8]

**Module 4:**
**Analysis and Processing of Random signals**: Power spectral Density: Continuous and discrete; Power spectral density as a time average. Response of Linear Systems to random signals. Amplitude modulation by random signals. Optimum Linear systems. Estimating the Power spectral density. White noise. [8]

**Module 5:**
**Markov Chains**: Markov processes. Discrete-time Markov Chains. Continuous-time Markov Chains. Time reversed Markov Chains. **Linear stochastic control**: LQG problem, Kalman filter and separation principle, Introduction to stochastic differential equations and continuous time stochastic, control: Hamilton-Jacobi-Bellman equation, nonlinear filtering, Minimum variance control . [8]

**Text books:**

1. Probability and random Processes for Electrical Engineering- A. Leon-Garcia, 2nd Edition, Pearson Education.

**Reference books:**

1. Probabaility, Random Variables and Stochastic Processes- A. Papoulis and S. Unnikrishnan Pillai, Fourth Edition, McGraw Hill.
2. Random Signals- Detection, Estimation and Data Analysis, K. Sam Shanmugan & A.M Breipohl, Wiley; 1st Edition (July 1988)

**COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE**

**DIRECT ASSESSMENT**

| Assessment Tool | % Contribution during CO Assessment |
|---|---|
| Quizzes (3) | 3x10 = 30 |
| Seminar | 10 |
| Teacher's Assessment | 10 |
| Semester End Examination | 50 |

**INDIRECT ASSESSMENT –**

1. Student Feedback on Course Outcome

**MAPPING OF COURSE OUTCOMES ONTO PROGRAM OUTCOMES**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| CO1 | 3 | | 3 | 3 | 2 | 1 |
| CO2 | 3 | | 3 | 3 | 2 | |
| CO3 | 3 | | 3 | 3 | 2 | 1 |
| CO4 | 3 | 3 | 3 | 3 | 3 | 3 |
| CO5 | 3 | 3 | 3 | 3 | 3 | 2 |

**Correlation Levels 1, 2 or 3 as defined below:**

2. Sight (Low)   2. Moderate (Medium)   3. Substantial (High)

**Gaps in the syllabus (to meet Industry/Profession requirements)**

1. Real time applications to meet industry requirements

**POs met through Gaps in the Syllabus**

1,3,4,5

**Topics beyond syllabus/Advanced topics/Design**

1. Simulation given to students as assignments

**POs met through Topics beyond syllabus/Advanced topics/Design**

1, 2, 3, 4, 5, 6

| CD | Course Delivery methods |
|---|---|
| CD1 | Lecture by use of boards/LCD projectors |
| CD2 | Tutorials/Assignments |
| CD3 | Seminars |
| CD4 | Self- learning such as use of NPTEL materials and internets |
| CD5 | Simulation |

## MAPPING BETWEEN COS AND COURSE DELIVERY (CD) METHODS

| **Mapping Between COs and Course Delivery (CD) methods** | |
|---|---|
| **Course Outcome** | **Course Delivery Method** |
| CO1 | CD1,CD2,CD4 |
| CO2 | CD1, CD4 |
| CO3 | CD1,CD3,CD4, CD5 |
| CO4 | CD1,CD2,CD3,CD4, CD5 |
| CO5 | CD1,CD2,CD3,CD4, CD5 |

**Course code: EE602**
**Course title: Advanced Control System Design Lab**
**Pre-requisite(s):** Mathematics, Statistics, Introduction to System Theory, Control Theory, Control System Design, Optimal Control Theory
**Co- requisite(s):**
**Credits:** L:0 T: 0 P: 4
**Class schedule per week: 04**
**Class: M. Tech.**
**Semester / Level: III/06**
**Branch: EEE**
**Name of Teacher:**

**Course Objectives**

This course enables the students:

| | |
|---|---|
| A. | To define and explain regulators, observers, LQR/LQG based optimal controllers used in control system |
| B. | To illustrate and explain the applications of regulators, observers, LQR/LQG based optimal controllers |
| C. | To analyse stability of a given system and recommend best controller for different applications |
| D. | To appraise regulators, observers, LQR/LQG based optimal controllers and Kalman filter |

**Course Outcomes**

After the completion of this course, students will be:

| | |
|---|---|
| 1. | describe regulators, observers, LQR/LQG based optimal controllers used in control system |
| 2. | explain the applications of regulators, observers, LQR/LQG based optimal controllers |
| 3. | modelling and simulation of regulators, observers, LQR/LQG based optimal controllers and nonlinear systems |
| 4. | investigate stability of a given system for varying gain and recommend best controller for different applications |
| 5. | Design regulators, observers, LQR/LQG based optimal controllers and Kalman filter |

## List of Experiments:

1. Design a regulator for an inverted pendulum on a moving cart to achieve certain specifications.
2. Design a pole placement regulator and full order observer for a plant.
3. Design a Kalman filter.
4. Design a LQG and LQR based optimal controller.
5. Simulation of nonlinear function
6. Control of twin rotor MIMO system (TRMS) (Feedback Instruments)
7. Modelling and control of magnetic levitation system (Feedback Instruments)

8. To investigate the effects of gain on stability of the system (DC motor)
9. To find the best response of a system (DC motor) using PID controller
10. To determine the open loop transfer function of a DC motor

**Books recommended:**

Text Books:

1. B.C. Kuo, "Automatic Control System", 7th Edition PHI. (T1)
2. M. Gopal, "Control Systems Principles & Design", 2nd Edition, TMH. (T2)
3. J.G. Truxal, "Automatic Feedback Control System", McGraw Hill, New York. (T3)
4. K. Ogata, "Discrete Time Control Systems", 2nd Edition, Pearson Education. (T4)

Reference Books:

1. Norman Nise, "Control System Engineering", 4th Edition. (R1)
2. M. Gopal, "Digital Control & State Variable Method", TMH. (R2)
3. B.C. Kuo, "Digital Control System", 2nd Edition, Oxford. (R3)
4. Stephanie, "Design of Feedback Control Systems", 4th Edition, Oxford. (R4)

**COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE**

**DIRECT ASSESSMENT**

| **Assessment Tool** | | **% Contribution during CO Assessment** |
|---|---|---|
| Progressive Evaluation | Day to Day Performance | 30 |
| | Quiz | 10 |
| | Viva | 20 |
| End Sem Examination Marks | Lab Performance | 30 |
| | Quiz | 10 |

**INDIRECT ASSESSMENT –**

**1.** Student Feedback on Course Outcome

**MAPPING OF COURSE OUTCOMES ONTO PROGRAM OUTCOMES**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 3 | 3 | 3 | |
| CO2 | 3 | 3 | 3 | 3 | 2 | 3 |
| CO3 | 3 | 3 | 3 | 3 | 2 | |
| CO4 | 3 | 3 | | 3 | 3 | |
| CO5 | 3 | 3 | 3 | 3 | 3 | 3 |

**Correlation Levels 1, 2 or 3 as defined below:**

3. Sight (Low) 2. Moderate (Medium) 3. Substantial (High)

**Gaps in the syllabus (to meet Industry/Profession requirements)**

Real time applications to meet industry requirements

**POs met through Gaps in the Syllabus**

1,2,3,4

**Topics beyond syllabus/Advanced topics/Design**

Given some design problems suitable for industry needs to solve in a group

**POs met through Topics beyond syllabus/Advanced topics/Design**

1,2,3,4,6

| CD | Course Delivery methods |
|---|---|
| CD1 | Lecture by use of boards/LCD projectors |
| CD2 | Tutorials/Assignments |
| CD3 | Seminars |
| CD4 | Self- learning such as use of NPTEL materials and internets |
| CD5 | Simulation |

**MAPPING BETWEEN COS AND COURSE DELIVERY (CD) METHODS**

| Course Outcome | Course Delivery Method |
|---|---|
| CO1 | CD1,CD4,CD5 |
| CO2 | CD1, CD4, CD5 |
| CO3 | CD1, CD2, CD3, CD4, CD5 |
| CO4 | CD1, CD2, CD4, CD5 |
| CO5 | CD1, CD2, CD4, CD5 |

# PROGRAMME ELECTIVE-I

**Course code: EE511**
**Course title: Optimization in Engineering Design**
**Pre-requisite(s):**B.E./B.Tech. in ECE/EEE
**Co- requisite(s):**
**Credits: 3 L T P**
**3 0 0**

**Class schedule per week: 03**
**Class: M.Tech.**
**Semester / Level: I/05**
**Branch: Electrical Engineering**
**Name of Teacher:**

**Course Objectives:**

This course enables the students to:

1. conceptualize the optimizations in engineering design and model the problem mathematically;
2. develop substantial interest in research, for applying optimization techniques in problems of engineering and technology;
3. analyze and apply mathematical results and numerical techniques for optimization of engineering problems, while being able to demonstrate solutions through computer
4. understand various optimization methods and algorithms for solving optimization problems;
5. formulate the optimization criteria for real time applications.

**Course Outcomes:**

At the end of the course, a student should be able to

| | |
|---|---|
| CO1 | have a basic understanding of traditional and non-traditional optimization algorithms; |
| CO2 | formulate engineering design problems as mathematical optimization problems; |
| CO3 | use mathematical software for the solution of engineering problems; |
| CO4 | differentiate the various optimization concepts and equivalently apply them to engineering problems; |
| CO5 | evaluate pros and cons for different optimization techniques. |

# SYLLABUS

## EE511 Optimization in Engineering Design

**Module I**

**One-dimensional search and multivariable optimization algorithm:** Optimality Criteria,Bracketing methods: Exhaustive search methods, Region – Elimination methods; Interval halving method, Fibonacci search method, Golden section search method, Point-estimation method; Successive quadratic estimation method. Optimality criteria, Unidirectional search, Direct search methods: Simplex search method, Hooke-Jeeves pattern search method (8L)

**Module II**

**Gradient-based methods**: Newton-Raphson method, Bisection method, Secant method,Cauchy's (Steepest descent) method and Newton's method. (8L)

**Module III**

**Linear Programming:** Graphical method, Simplex Method, revised simplex method, Dualityin Linear Programming (LP), Sensitivity analysis, other algorithms for solving LP problems, Transformation, assignment and other applications. (8L)

**Module IV**

**Constrained Optimization Algorithm:**Characteristics of a constrained problem. Directmethods: The complex method, Cutting plane method, Indirect method: Transformation Technique, Basic approach in the penalty function method, Interior penalty function method, convex method. (8L)

**Module V**

**Advanced Optimization Techniques:** Genetic Algorithm, Working principles, GAs forconstrained optimization, Other GA operators, advanced GAs, Differences between GAs and traditional methods. Simulated annealing method, working principles. Particle swarm optimization method, working principles. (8L)

**Books recommended:**


1. Optimization for Engineering Design - Kalyanmoy Deb.
2. Optimization Theory and Applications - S.S. Rao.
3. Analytical Decision Making in Engineering Design – Siddal.

4.Linear Programming – G. Had


## COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

**DIRECT ASSESSMENT**

| Assessment Tool | % Contribution during CO Assessment |
|---|---|
| Quizzes (3) | 3x10 = 30 |
| Seminar | 10 |
| Assignment | 10 |
| Semester End Examination | 50 |

**INDIRECT ASSESSMENT –**

1. Students' Feedback on Course Outcome

**MAPPING OF COURSE OUTCOMES ONTO PROGRAM OUTCOMES**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | 3 | - | 1 | 3 | - | - |
| **CO2** | 3 | - | 1 | 3 | - | 1 |
| **CO3** | 3 | 1 | 2 | 3 | - | 1 |
| **CO4** | 3 | 2 | 2 | 3 | 2 | 2 |
| **CO5** | 3 | 3 | 3 | 3 | 3 | 3 |

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

**Gaps in the syllabus (to meet Industry/Profession requirements):**

Validation of optimization based design for industrial projects.

**POs met through Gaps in the Syllabus: PO6**

**Topics beyond syllabus/Advanced topics/Design:**

Genetic Algorithm based machine design.

**POs met through Topics beyond syllabus/Advanced topics/Design: PO6**

**Course Delivery Methods**

| CD | Course Delivery methods |
|---|---|
| CD1 | Lecture by use of boards/LCD projectors |
| CD2 | Tutorials/Assignments |

| | |
|---|---|
| CD3 | Seminars |
| CD4 | Industrial visits/in-plant training |
| CD5 | Self- learning such as use of NPTEL materials and internets |
| CD6 | Simulation |

**MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD**

| **Mapping Between COs and Course Delivery (CD) methods** | |
|---|---|
| **Course Outcome** | **Course Delivery Method** |
| CO1 | CD1, CD2, CD3,CD5 |
| CO2 | CD1, CD2, CD3,CD5 |
| CO3 | CD1, CD2, CD3,CD5 |
| CO4 | CD1, CD2, CD3, CD5 |
| CO5 | CD1, CD2, CD3,CD5 |

**Course code: EE515**
**Course title: Control system Design**
**Pre-requisite(s):Fundamentals of Mathematics and Physics, Introduction to System Theory, Control Theory**
**Credits: L T P**
**3 0 0**
**Class schedule per week: 3**
**Class :M.Tech**
**Semester/level: I/05**
**Branch: Electrical Engineering**
**Name of Teacher:**
**Course Co-ordinator:**

## Course Objectives

This course enables the students to:

| | |
|---|---|
| F. | To state the performance characteristics of control systems with specific design requirements and design objectives |
| G. | To understand the concepts of PD, PI, PID, lead, lag and lag lead controller design in time domain and frequency domain and apply it to specific real time numerical problems |
| H. | To apply the state feedback controller and observer design techniques to modern control problems |
| I. | To analyse the effects of different controllers and compensators on transient and frequency domain response |
| J. | To realize and then design digital and analog compensators. |

## Course Outcomes

After the completion of this course, students will be able to:

| | |
|---|---|
| CO1 | Identify the design objectives and requirements of control systems |
| CO2 | Interpret the concepts of PD, PI, PID, lead, lag, lag lead, and discrete data controller design and apply it to solve some design problems |
| CO3 | Apply the state feedback controller design and techniques and outline its effects on system’s performance which includes transient response and robustness |
| CO4 | To develop methodologies to design real time digital and analog compensators and reproduce the results and write effective reports suitable for quality journal and conference publications |
| CO5 | aspire for pursuing a career in control, recognize the need to learn, to engage and to adapt in a world of constantly changing technology and play role of team leader or supporter of team |

# Syllabus

**Module 1:**
Performance characteristics of feedback control system & design specification of control loop. Different types of control system applications and their functional requirement. Derivation of load-locus (toque/ speed characteristics of load). Selection of motors, sensors, drives. Choice of design domain & general guidelines for choice of domain. Controller configuration and choice of controller configuration for specific design requirement. Fundamental principles of control system design. Experimental evaluation of system dynamics in time domain and frequency domain. [8]

**Module 2:**
Design with PD Controller: Time domain interpretation of PD controller, frequency domain interpretation of PD controller, summary of the effects of PD controller. Design with PI controller: Time domain interpretation of PI controller frequency domain interpretation of PI controller, summary of the effects of PI controller, design with PID controller, Ziegler Nichols tuning & other methods. [8]

**Module 3:**
Design with lag/lead/lag-lead compensator, time domain interpretation of lag/lead/lag-lead compensator, frequency domain interpretation of lag/lead/lag-lead compensator, summary of the effects of lag/lead/lag-lead compensator. Forward & feed-forward controller, minor loop feedback control, concept of robust design for control system, pole-zero cancellation design. [8]

**Module 4:**
Sate feedback control, pole placement design through state feedback, state feedback with integral control, design full order and reduced order state observer. [8]

**Module 5:**
Design of Discrete Data Control System: Digital implementation of analog controller (PID) and lag-lead controllers, Design of discrete data control systems in frequency domain and Z plane.[8]

**Books recommended:**
Text Books:

1. B.C. Kuo, "Automatic Control System", 7th Edition PHI. (T1)
2. M. Gopal, "Control Systems Principles & Design", 2nd Edition, TMH. (T2)
3. J.G. Truxal, "Automatic Feedback Control System", McGraw Hill, New York. (T3)
4. K. Ogata, "Discrete Time Control Systems", 2nd Edition, Pearson Education. (T4)

Reference Books:

1. Norman Nise, "Control System Engineering", 4th Edition. (R1)
2. M. Gopal, "Digital Control & State Variable Method", TMH. (R2)
3. B.C. Kuo, "Digital Control System", 2nd Edition, Oxford. (R3)
4. Stephanie, “Design of Feedback Control Systems”, 4th Edition, Oxford. (R4)

**COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE**

**DIRECT ASSESSMENT**

| Assessment Tool | % Contribution during CO Assessment |
|---|---|
| Quizzes (3) | 3x10 = 30 |
| Seminar | 10 |
| Teacher's Assessment | 10 |
| Semester End Examination | 50 |

**INDIRECT ASSESSMENT –**

1. Student Feedback on Course Outcome

**MAPPING OF COURSE OUTCOMES ONTO PROGRAM OUTCOMES**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 3 | 3 | 3 | 2 |
| CO2 | 3 | 2 | 3 | 3 | 3 | 3 |
| CO3 | 3 | 3 | 3 | 3 | 3 | 2 |
| CO4 | 3 | 3 | 3 | 3 | 3 | 3 |
| CO5 | 2 | 2 | 3 | 3 | 3 | 2 |

**Correlation Levels 1, 2 or 3 as defined below:**

4. Sight (Low) 2. Moderate (Medium) 3. Substantial (High)

**Gaps in the syllabus (to meet Industry/Profession requirements)**

(1) Real time analog design of controllers.
(2) Interfacing the controllers with the real time physical plants to identify the effects on system's performance.

**POs met through Gaps in the Syllabus** 3,4

**Topics beyond syllabus/Advanced topics/Design**

Simulation problems related to industry

**POs met through Topics beyond syllabus/Advanced topics/Design** 4, 5

| **CD** | **Course Delivery methods** |
|---|---|
| CD1 | Lecture by use of boards/LCD projectors |
| CD2 | Tutorials/Assignments |
| CD3 | Seminars |
| CD4 | Self- learning such as use of NPTEL materials and internets |
| CD5 | Simulation |

**MAPPING BETWEEN COS AND COURSE DELIVERY (CD) METHODS**

| **Mapping Between COs and Course Delivery (CD) methods** | |
|---|---|
| **Course Outcome** | **Course Delivery Method** |
| CO1 | CD1,CD2,CD4 |
| CO2 | CD1, CD4 |
| CO3 | CD1,CD3,CD4, CD5 |
| CO4 | CD1,CD2,CD3,CD4, CD5 |
| CO5 | CD1,CD2,CD3,CD4, CD5 |

**Course code: EE513**
**Course title: ROBOTICS AND AUTOMATION**
**Pre-requisite(s):** Engineering Mathematics, Signal and Systems, Control Theory, Basic programming knowledge.
**Co- requisite(s):**
**Credits:** L:3 T:0 P:0
**Class schedule per week: 03**
**Class: M.Tech.**
**Semester / Level: I/05**
**Branch: Electrical Engineering**
**Name of Teacher:**

**Course Objectives:**

This course enables the students to:

| | |
|---|---|
| A. | To explain the characteristics of robots, discuss different types of sensors and basic programming languages used for robotics |
| B. | To relate direct and inverse kinematics problem of robots and apply methods to solve them and to use techniques for planning robot motions. |
| C. | To explain different methods for control of robotic manipulators. |
| D. | To recommend the use of robotic vision in different applications of robots. |
| E. | To relate real life problems with direct and inverse kinematics, appraise different controllers for the robots. |

**Course Outcomes:**

At the end of the course, a student should be able to:

| | |
|---|---|
| CO1 | enumerate and explain characteristics of robots, sensors used in robots and basic programming languages |
| CO2 | correlate direct and inverse kinematics to real life problems and apply the algorithm to solve them |
| CO3 | explain and analyse different control techniques and evaluate planning algorithms for robot motions |
| CO4 | assess the use of computer vision/machine vision to different robot applications and appraise the use of artificial intelligence in different field of robotics |
| CO5 | solve real life applications using direct and inverse kinematics and simulate different controllers. |

## SYLLABUS

**Module I:**
Basic components of robotic systems.Robot classification. Robot specifications. Applications. Direct Kinematics: Coordinateframes; Rotations; Homogeneous coordinates; D-H representation; The Arm Equation. [8]

**Module II:**
**Inverse Kinematics**: Inverse kinematics problem, General properties of solutions, Tool configuration, Robotic work cell, Workspace analysis. Trajectory planning. Workspace envelope.Workspace fixtures. Pick and place operation. Continuous-path motion. Interpolated motion.Straight line motion. [8]

**Module III:**
**Sensing and Control of Robot Manipulators**: Different sensors in robotics: Range; Proximity; Touch; Torque; Force and others. Computed torque control; Near Minimum time control;Variable structure control; Non-Linear decoupled feedback control; Resolved motion and Adaptive control. [8]

**Module IV:**
**Robotic Vision**: Image acquisition and Geometry. Pre-processing; Segmentation and Description of 3-D structures; Recognition and Interpretation. [8]

**Module V:**
**Robot Arm Dynamics**: Lagrange-Euler formulation; Newton Euler formulation; Generalized D'Alembert's equation.
**Robot Programming Languages, Robot Intelligence and Task Planning**: Characteristics of Robot level languages. Task level languages- with examples C, prolog. Assembly etc. Problem reduction; Use of predicate logic; Robot learning; Expert systems. [8]

## TEXT BOOKS

1. Fundamental of Robotics: Analysis and Control- Robert J. Schilling.
2. Robotics: Control , Sensing ,Vision and Intelligence- K.S. Fu, R.C. Gonzalez and Lee.

## REFERENCE BOOK

1. Robotics and Control – R. K. Mittal and I. J. Nagrath.

**COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE**

**DIRECT ASSESSMENT**

| Assessment Tool | % Contribution during CO Assessment |
|---|---|
| Quizzes (3) | 3x10 = 30 |
| Seminar | 10 |
| Teacher's Assessment | 10 |
| Semester End Examination | 50 |

**INDIRECT ASSESSMENT –**

**1.** Students' Feedback on Course Outcome

**MAPPING OF COURSE OUTCOMES ONTO PROGRAM OUTCOMES**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | 2 | 1 | 3 | 3 | 3 | 2 |
| **CO2** | 3 | | 3 | 3 | 3 | 3 |
| **CO3** | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO4** | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO5** | 3 | | 3 | 3 | 3 | 3 |

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

**Gaps in the syllabus (to meet Industry/Profession requirements):**
Simulation to meet real time implementation of techniques for control of robots

POs met through Gaps in the Syllabus: **1,2,3,4,5,6**

**Topics beyond syllabus/Advanced topics/Design:**
Simulation given to students as assignments

POs met through Topics beyond syllabus/Advanced topics/Design: **1,2,3,4,5,6**

## Course Delivery Methods

| CD | Course Delivery Methods |
|---|---|
| CD1 | Lecture by use of boards/LCD projectors |
| CD2 | Tutorials/Assignments |
| CD3 | Seminars |
| CD4 | Self- learning such as use of NPTEL materials and internets |
| CD5 | Simulation |

## MAPPING BETEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

| Mapping Between COs and Course Delivery (CD) methods | |
|---|---|
| **Course Outcome** | **Course Delivery Method** |
| CO1 | CD1,CD2,CD4 |
| CO2 | CD1,CD2,CD4 |
| CO3 | CD1,CD2,CD3,CD4,CD5 |
| CO4 | CD1,CD2,CD3,CD4,CD5 |
| CO5 | CD1,CD2,CD3,CD4,CD5 |

**Course code: EE517**
**Course title: Image Processing and Computer Vision**
**Pre-requisite(s):** Basics of signals and systems, transform methods, Filter theory.
**Credits:** LT P
3 0 0
**Class schedule per week: 03**
**Class :M.Tech**
**Semester / Level: I/05**
**Branch: Electrical Engineering**
**Name of Teacher:**

**Course Objectives:**

This course enables the students to:

| | |
|---|---|
| 6. | understand the basic steps of thedigital image processing and basic of computer vision. |
| 7. | understand the concepts of Image Transform, Image Restoration, Segmentation and Compression. |
| 8. | illustrate and summarize the technique of shape representation, feature extraction, boundary descriptors, and regional descriptors. |
| 9. | design adaptive algorithm suitable for image denoising, object tracking, vision based control etc. |
| 10. | develop adaptive algorithm for other image processing and computer vision applications. |

**Course Outcomes:**

At the end of the course, a student should be able to:

| | |
|---|---|
| CO1 | recognise the basic steps of the digital image processing such as Image Transform, Image Restoration, Segmentation and Compression. |
| CO2 | understand the basic concept of computer vision and investigate different associated methodology. |
| CO3 | recapitulate the technique of shape representation, feature extraction, shape representation, feature extraction, edge detection, boundary descriptors, and regional descriptors. |
| CO4 | apply various techniques of image processing for object recognition, motion estimation, object tracking. |
| CO5 | design apply various adaptive algorithm for vision based control, vision for human computer interaction etc. |

# SYLLABUS

## Module 1 Digital Image Fundamentals:

Fundamental steps in Digital Image Processing, Components of an Image processing system, Digital Image Representation, Basic relationship between pixels, Color Modules, Image negatives, Histogram Equalization, Local Enhancement, Image Subtraction, Image Averaging, Smoothing Spatial Filters, Sharpening Spatial Filters. **8L**

## Module 2 Image Transform:

Fourier Transform ,Discrete Fourier Transform, Fast Fourier Transform, Smoothing Frequency Domain filters, Sharpening Frequency Domain filters, Homomorphic filtering, Convolution and Correlation Theorems, Wavelet Transforms, The Fast Wavelet Transforms.**8L**

## Module 3 Image Restoration, Segmentation and Compression:

Noise Models, Mean filters, Median Filter, Minimum Mean Square Error(Wiener) Filtering, Geometric Mean Filter, Adaptive filters, Periodic Noise Reduction by Frequency Domain filtering , Inverse Filtering, Detection of Discontinuities, Point Detection, Line detection, Edge Detection,Fundamentals of image compression, Redundancy, Image Compression Models, Error-free and Lossy Compression techniques. **8L**

## Module 4

**Computer vision Fundamentals:** Shape Representation, Description and Feature Extraction: Deformable curves and surfaces, Snakes and active contours, Level set representations, Linear Filters, Texture, Edge detection, Boundary Descriptors, Regional Descriptors.**8L**

## Module 5

**Image processing and Computer vision applications**: Denoising of Image as pre-processing, Object recognition, Motion estimation, Object Tracking, Vision based control, vision for human computer interaction. **8L**

**Text Books:**

1. R.C.Gonzalez and Richard E Woods, Digital Image Processing, 2e, Pearson Education.
2. D. A. Forsyth, J. Ponce, Computer Vision: A Modern Approach, PHI Learning 2009

**Reference Book**:

1. B.Chanda and D. Dutta Majumdar, Digital Image Processing and Analysis, PHI.

## Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

**Gaps in the syllabus (to meet Industry/Profession requirements):**

Design of real-time industrial projects.

POs met through Gaps in the Syllabus:**PO4 & PO5**

**Topics beyond syllabus/Advanced topics/Design:**

Object Tracking, Video compression.

POs met through Topics beyond syllabus/Advanced topics/Design: **PO5 & PO6**

## Course Delivery Methods

| | |
|---|---|
| CD1 | Lecture by use of boards/LCD projectors/OHP projectors |
| CD2 | Assignments/Seminars |
| CD3 | Laboratory experiments/teaching aids |
| CD4 | Industrial/guest lectures |
| CD5 | Industrial visits/in-plant training |
| CD6 | Self- learning such as use of NPTEL materials and internets |
| CD7 | Simulation |

## MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | 3 | 2 | 2 | 3 | 1 | 1 |
| **CO2** | 2 | 1 | 1 | 3 | 1 | 1 |
| **CO3** | 2 | 2 | 3 | 3 | 2 | 1 |
| **CO4** | 1 | 1 | 2 | 3 | 2 | 2 |
| **CO5** | 1 | 1 | 3 | 3 | 3 | 3 |

**< 34% = 1, 34-66% = 2, > 66% = 3**

## MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

| Course Outcomes | Course Delivery Method |
|---|---|
| CO1 | CD1,CD6 |
| CO2 | CD1, CD6,CD7 |
| CO3 | CD1, CD2, CD3,CD6,CD7 |
| CO4 | CD1, CD3,CD6,CD7 |
| CO5 | CD1,CD2,CD3,CD4,CD5,CD7 |

# PROGRAMME ELECTIVE II

**Course Code: EE573**
**Course title: Embedded System and Applications**
**Pre-requisite(s):** Fundamental of Electronic Devices
**Co- requisite(s):**
**Credits: 03** L: 03 T: 0 P: 0 C: 03
**Class schedule per week: 03**
**Class: M.Tech**
**Semester / Level: II/05**
**Branch: EEE**

**Course Objectives**

This course enables the students to:

| | |
|---|---|
| A. | Comprehend the basic functions, structure, concept and definition of embedded systems. |
| B. | Interpret ATMEGA8 microcontroller, FPGA & CPLD, TMS320C6713 processors in the development of embedded systems. |
| C. | Correlate different serial interfacing protocols (SPI, TWI, I2C, USART). |
| D. | Interface different peripherals (ADC, DAC, LCD, motors). |
| E. | Evaluate design cost of any given embedded system application. |

**Course Outcomes**

After the completion of this course, students will be:

| | |
|---|---|
| 1. | Visualize the basic elements and functions of ATMEGA8 and FPGA/CPLD in building an embedded system. |
| 2. | Work with modern hardware/software tools (Xilinx project navigator for synthesis of VHDL codes) for building prototypes of embedded systems. |
| 3. | Interface various sensors, ADC, DAC, LCD, stepper motors with FPGA/CPLDand ATMEGA8. |
| 4. | Employ various bus protocols like SPI, TWI, I2C for interfacing peripherals. |
| 5. | Apply design methodologies for embedded systems, while appreciating the considerations for embedded systems design: specification, technological choice, development process, technical, economic, environmental and manufacturing constraints, reliability, security and safety, power and performance. |

## Syllabus

### Module 1

**Introduction &Basic Concepts of Computer Architecture:**

Embedded Systems Overview Processor technology- General purpose processors (Software), Single purpose processors (Hardware), Application- Specific processors; IC Technology- Full-custom/VLSI, Semicustom ASIC (Gate Array and standard cell), PLD, etc. Concepts, Memory, Input/ Output, DMA, Parallel and Distributed computers, Embedded Computer Architecture, etc. [8L]

### Module 2

**Embedded Processors & Systems:**

Atmel AVR ATMEGA 8 Micro-controller: Introduction, Major features, Architecture, Application and programming. Timers/Counters, ADC, USART, SPI, TWI, Vectored Interrupts. [8L]

### Module 3 IIIFPGA:

Xilinx XC3S400 FPGA Architecture, XC9572 CPLD Architecture, VHDL Programming (VHDL Synthesis) [8L]

### Module 4

**DSP-Based Controllers:**

TexasInstrument‟s TMS320C6713 DSP processor: Introduction, Major features, Architecture, Application and programming. [8L]

### Module 5

**Peripherals and Interfacing**:

Adding Peripherals and Interfacing- Serial Peripherals and Interfacing- Serial Peripheral Interface (SPI), Inter Integrated Circuit (I2C), Adding a Real-Time Clock with I2C, Adding a Small Display with I2C; Serial Ports - UARTs, RS-232C & RS-422, Infrared Communication, USB, Networks- RS-485, Controller Area Network (CAN), Ethernet, Analog Sensors - Interfacing External ADC, Temperature Sensor, Light Sensor, Accelerometer, Pressure Sensors, Magnetic - Field Sensor, DAC, PWM; Embedded System Applications - Motor Control, and Switching Big Loads. [8L]

**Text books:**

1. Catsoulis, John, "Designing Embedded Hardware", First/Second Edition, Shroff Publishers & Distributors Pvt. Ltd., New Delhi, India.
2. Vahid, Frank and Givargis, Tony, "Embedded System Design - A Unified hardware/Software Introduction", John Wiley & Sons, (Asia) Pvt Ltd., Replika Press Pvt., Delhi - 110040.
3. Douglas Perry, “VHDL Programming by Example”, TMH publication

4. J. Bhaskar, “A VHDL Primer”, Pearson Education
5. Mazidi&Mazidi, "AVR Microcontrollers & Embedded Systems using Assembly & C Pearson Education
6. RulphChassaing, “Digital Signal Processing and Applications with C6713 and C6416 DSK”, John Wiley and Sons publication

**Reference books:**

1. Stuart R. Ball, “Embedded Microprocessor Systems, Real World Design”, Second Edition, Newnes publication.
2. Nasser Kehtarnavaz, “Real Time Digital Signal Processing based on the TMS320C6000”, Elsevier publication.

**COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE**

**DIRECT ASSESSMENT**

| Assessment Tool | % Contribution during CO Assessment |
|---|---|
| Quizzes (3) | 3x10 = 30 |
| Seminar | 10 |
| Teacher’s Assessment | 10 |
| Semester End Examination | 50 |

**INDIRECT ASSESSMENT –**

1. Students’ Feedback on Course Outcome

**Mapping between Objectives and Outcomes**

**Mapping of Course Outcomes onto Program Outcomes**

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| 1 | 3 | 3 | 3 | 2 | 2 | 2 |
| 2 | 3 | 3 | 3 | 3 | 2 | 2 |
| 3 | 3 | 3 | 3 | 3 | 2 | 2 |
| 4 | 3 | 3 | 3 | 3 | 3 | 2 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 5 | 3 | 3 | 3 | 3 | 3 | 3 |

**Correlation Levels 1, 2 or 3 as defined below:**

1: Slight (Low)   2: Moderate (Medium)   3: Substantial (High)

**Gaps in the syllabus (to meet Industry/Profession requirements):**
Practical implementation of microcontroller based system design.

**POs met through Gaps in the Syllabus:** PO5

**Topics beyond syllabus/Advanced topics/Design:**
Assignments: Hardware design of closed loop Temperature control using AVR microcontroller

**POs met through Topics beyond syllabus/Advanced topics/Design:** PO5

**Course Delivery methods**

| | |
|---|---|
| CD1 | Lecture by use of boards/LCD projectors/OHP projectors |
| CD2 | Tutorials/Assignments |
| CD3 | Seminars |
| CD4 | Mini projects/Projects |
| CD5 | Laboratory experiments/teaching aids |
| CD6 | Industrial/guest lectures |
| CD7 | Industrial visits/in-plant training |
| CD8 | Self- learning such as use of NPTEL materials and internets |
| CD9 | Simulation |

**Mapping Between COs and Course Delivery (CD) methods**

| Course Outcomes | Course Delivery Method |
|---|---|
| CO1 | CD1,CD6 |
| CO2 | CD1, CD6,CD7 |
| CO3 | CD1, CD2, CD3,CD6,CD7 |
| CO4 | CD1, CD3,CD6,CD7 |
| CO5 | CD1,CD2,CD3,CD4,CD5,CD7 |

**Course code:** EE571
**Course title:** Soft Computing Techniques in Electrical Engineering
**Pre-requisite(s):** Basics of signals and systems, Digital Signal Processing, Filter theory.
**Credits:** L:3 T:0 P:0 C:0
**Class schedule per week:**3 lecturesper week
**Class :** M.Tech
**Semester/level:** II/05
**Branch:** Electrical and Electronics Engineering
**Name of Teacher:**

**Course Objectives:**
This course enables the students to:

| | |
|---|---|
| A. | Understand the basic of Soft Computing Techniques. |
| B. | Acquainted with the solving methodology of soft computing technique in power systems operation and control. |
| C. | Analysis of ANN based systems for function approximation in application to load forecasting. |
| D. | Evaluatefuzzy based systems for load frequency control in power systems. |
| E. | Design of different problems of optimization in power systems and power electronics. |

**Course Outcomes:**
After the completion of this course, a student will be able to:

| | |
|---|---|
| 1. | Identify the soft computing techniques and their roles in building intelligent machines. |
| 2. | Recognize an appropriate soft computing methodology for an engineering problem. |
| 3. | Apply fuzzy logic and reasoning to handle uncertainty while solving engineering problems. |
| 4. | Analysis of neural network and genetic algorithms to combinatorial optimization problems. |
| 5. | Classify neural networks to pattern classification and regression problems and evaluated its imparts while being able to demonstrate solutions through computer programs. |

# SYLLABUS

## Module - 1

**Introduction to Soft Computing:**Introduction, Definition of Soft Computing Techniques, Importance of Soft Computing, Main Components of Soft Computing: Fuzzy Logic, Artificial Neural Networks, Introduction to Evolutionary Algorithms, Hybrid Intelligent Systems, Single and Multi-Objective Optimization. **8L**

## Module –2

**Artificial Neural Network and Applications:**Introduction, Artificial Neuron Structure, ANN Learning; Back-Propagation Learning, Properties of Neural Networks, Unsupervised learnings, Hopfield networks, Application of GN Models to Electrical Machine Modeling, Short Term Electrical Load Forecasting Using Generalized Neuron Model, Aircraft Landing Control System Using GN Model.

## Module - 3

**Introduction to Fuzzy Logic and Genetic Algorithm:**Introduction, Uncertainty and Information, Types of Uncertainty, Introduction of Fuzzy Logic, Fuzzy Set, Operations on Fuzzy Sets, Fuzzy Intersection, Fuzzy Union, Fuzzy Complement, Fuzzy Concentration, Fuzzy Dilation, Fuzzy Intensification, α-Cuts, Characteristics of Fuzzy Sets, Demorgan's Law, Fuzzy Cartesian Product, Various Shapes of Fuzzy Membership Functions, Methods of Defining of Membership Functions, Fuzzy Relation, Defuzzification Methods.Introduction to Genetic Algorithm, Crossover, Mutation, Survival of Fittest, Population Size, Evaluation of Fitness Function. **8L**

### Module-4

**Applications of Fuzzy Rule Based System:**Introduction, System's Modeling and Simulation Using Fuzzy Logic Approach, Selection of Variables, Normalization Range and Number of Linguistic Values, Selection of Shape of Membership Functions for Each Linguistic Value, Selection of Fuzzy Union and intersection Operators, Selection of Defuzzification Method, Steady State D.C. Machine Model, Transient Model of D.C. Machine, Fuzzy Control System, Power System Stabilizer Using Fuzzy Logic. **8L**

### Module-5

**Applications of Soft Computing Techniques to Electrical Engineering:**Applications of Artificial Neural Network, Genetic Algorithms, Fuzzy and Hybrid Systems for Power System Applications: voltage control, voltage stability, Economic load dispatch, Unit commitment, Condition monitoring. Applications of Soft Computing Techniques for Power Electronics and Control Applications.

**8L**

### Text Books:

1. Neural Networks: A Comprehensive Foundation – SimonHaykin, IEEE, Press, MacMillan, N.Y. 1994.
2. S. Rajasekaran, G. A. Vijayalakshmi, Neural Networks, Fuzzy logic and Genetic algorithms, PHI publication.
3. Fuzzy logic with Engineering Applications - Timothy J. Ross, McGraw-Hill International Editions.
4. Fuzzy Sets and Fuzzy logic: Theory and Applications - George J. Klir and Bo. Yuan, Prentice- Hall of India Private Limited.

**Reference Books:**

1. Chaturvedi, Devendra K, Soft Computing Techniques and its Applications in Electrical Engineering, Hardcover ISBN:- 978-3-540-77480-8, Springer.
2. Kalyanmoy Deb, Optimization for Engineering Design, PHI publication
3. Kalyanmoy Deb, Multi-objective Optimization using Evolutionary Algorithms, Willey Publication
4.Kevin Warwick, Arthur Ekwue, Rag Aggarwal, Artificial intelligence techniques in power systems. IEE Power Engineering Series-22.

## Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

## Gaps in the syllabus (to meet Industry/Profession requirements)

1. Visualize different soft computing techniques in real time.
2. Hardware implementation of soft computing techniques in real time.

POs met through Gaps in the Syllabus:**PO5,PO6**

## Topics beyond syllabus/Advanced topics/Design

Soft computing application to image processing, video processing.

POs met through Topics beyond syllabus/Advanced topics/Design: **PO5, PO6**

## Course Delivery Methods

| | |
|---|---|
| CD1 | Lecture by use of boards/LCD projectors/OHP projectors |
| CD2 | Assignments/Seminars |
| CD3 | Laboratory experiments/teaching aids |
| CD4 | Industrial/guest lectures |
| CD5 | Industrial visits/in-plant training |
| CD6 | Self- learning such as use of NPTEL materials and internets |
| CD7 | Simulation |

**MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | 3 | 2 | 1 | 1 | 1 | 1 |
| **CO2** | 3 | 2 | 1 | 2 | 1 | 1 |
| **CO3** | 3 | 1 | 2 | 3 | 1 | 1 |
| **CO4** | 2 | 2 | 2 | 3 | 2 | 2 |
| **CO5** | 2 | 2 | 3 | 1 | 3 | 3 |

**< 34% = 1, 34-66% = 2, > 66% = 3**

**MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD**

| Course Outcomes | Course Delivery Method |
|---|---|
| CO1 | CD1,CD6 |
| CO2 | CD1, CD6,CD7 |
| CO3 | CD1, CD2, CD3,CD6,CD7 |
| CO4 | CD1, CD3,CD6,CD7 |
| CO5 | CD1,CD2,CD3,CD4,CD5,CD7 |

**Course code: EE577**
**Course title: Control of Electric Drives**
**Pre-requisite(s): Power electronics and Machine**
**Co- requisite(s):**
**Credits:** L: 3 T: 0 P: 0 C: 3
**Class schedule per week:** 03
**Class: M.Tech**
**Semester / Level**: II/05
**Branch: EEE**
**Name of Teacher:**

**Course Objectives:** This course enables the students to:

| | |
|---|---|
| 1 | Understand different types of electrical drives system. |
| 2 | Explanation of working principle of power converters and relate them with different types of drives system |
| 3 | Analysis of closed loop control of electrical drives based on power converters. |
| 4 | Differentiation between different control strategy of electrical drives in terms of dynamic parameters of system and overall efficiency. |
| 5 | Performance evaluation, planning and design procedure for a complex power electronics based drives system. |

**Course Outcomes:** After the completion of this course, students will be able to:

| | |
|---|---|
| CO1 | List different types of electrical drives. |
| CO2 | Associate different types of power converters with different type's electrical drives. Show suitability of a power converter for a particular application. Solve power management related problems with application of power electronics based topologies. |
| CO3 | Outline shortcomings of each class of conventional drives control strategy and solve them using proper modifications. Identify potential area for power electronics applications. |
| CO4 | Estimate the cost and long-term impact of power electronics-based drives technology on a large-scale project of socio-economic importance. |
| CO5 | Modify existing power electronics-based installations. Design new power converter topologies and Plan to develop a power processing unit for a particular requirement in industrial plants as well as domestic applications. Lead or support a team of skilled professionals. |

# Syllabus

**Module1:**

**Introduction to Electrical Drives:**

Drive concepts, different machines & load characteristics, equilibrium and steady state stability, four quadrant operations, referred inertia and load torque for different coupling mechanism, thermal selection of machines

**[8L]**

**Module 2:**

**DC Motor drives:**

Operating limits using armature voltage control and field control techniques, dynamic model (armature voltage control only) of machine and converters (continuous conduction only), open loop dynamic performance, closed loop control using single (speed) and two loops (speed, current), implementation of four quadrant operation. Modelling and control of separately excited dc machine in field weakening region and discontinuous converter conduction mode, design of close loop speed controller for separately excited dc motors. **[8L]**

**Module 3:**

**Induction motor drives:**

Review of scalar control methods (voltage, constant V/f & frequency) of three phase symmetrical Induction machines, speed control using current controlled VSI drives, close loop speed control with constant v/f control strategy, effects of harmonics and power factor [8L]

**Module 4:**

**Vector control of Induction machines &**Speed control of wound rotor induction machine**:**

Review of vector control, Implementation of direct & indirect vector control schemes, methods of flux estimation, effect of machine parameter variation on vector control performance, speed sensorless control, Direct Torque Control. Static rotor resistance control, static Scherbius Drive using line commutated converter cascade &Cyclo-converter, close loop speed control using slip power recovery, vector control of woundrotor induction machine using Cyclo-converter, introduction to Variable Speed ConstantFrequency (VSCF) generation. **[8L]**

**Module 5:**

**Control of synchronous machine:**

Wound field synchronous machine: Constant volts/Hz control, scalar self-control (commutator less control), vector control. Control of permanent magnet synchronous machine: Brushless DC machine, surface permanent magnet machine. [8L]

**Text Books (T):**

1. Fundamental of Electrical Drives: G K Dubey
2. Electric Motor Drives, modelling analysis and control: R Krishnan

**Reference Books (R):**

1. Modern Power Electronics & Drives: B K Bose

## COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

## DIRECT ASSESSMENT

| Assessment Tool | % Contribution during CO Assessment |
| --- | --- |
| Quizzes (3) | 3x10 = 30 |
| Seminar | 10 |
| Teacher's Assessment | 10 |
| Semester EndExamination | 50 |

## INDIRECT ASSESSMENT –

1. Students' Feedback on Course Outcome

## MAPPING OF COURSE OUTCOMES ONTO PROGRAM OUTCOMES

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
| --- | --- | --- | --- | --- | --- | --- |
| **CO1** | 3 | 3 | 2 | 2 | 2 | 1 |
| **CO2** | 3 | 3 | 3 | 3 | 2 | 2 |
| **CO3** | 3 | 3 | 3 | 3 | 3 | 2 |
| **CO4** | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO5** | 3 | 3 | 3 | 3 | 3 | 3 |

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low)   2: Moderate (Medium)   3: Substantial (High)

**Gaps in the syllabus (to meet Industry/Profession requirements):**

Practical implementation of microcontroller based electric drive design.

**POs met through Gaps in the Syllabus: PO5**

**Topics beyond syllabus/Advanced topics/Design:**

Assignments: Hardware design of closed loop Temperature control using AVR microcontroller

**POs met through Topics beyond syllabus/Advanced topics/Design: PO5**

**Course Delivery Methods**

| CD | Course Delivery methods |
|---|---|
| CD1 | Lecture by use of boards/LCD projectors |
| CD2 | Tutorials/Assignments |
| CD3 | Seminars |
| CD4 | Industrial visits/in-plant training |
| CD5 | Self- learning such as use of NPTEL materials and internets |
| CD6 | Simulation |

**MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD**

| **Mapping Between COs and Course Delivery (CD) methods** | |
|---|---|
| **Course Outcome** | **Course Delivery Method** |
| CO1 | CD1, CD2, CD3,CD5 |
| CO2 | CD1, CD2, CD3,CD5 |
| CO3 | CD1, CD2, CD3,CD5 |
| CO4 | CD1, CD2, CD3, CD5 |
| CO5 | CD1, CD2, CD3,CD5 |

**Course code: EE565**
**Course title: Power System Operation and Control**
**Pre-requisite(s): Power system, Control system.**
**Credits:** L: 3 T: 0 P: 0 C: 3
**Class schedule per week: 3**
**Class: M. Tech**
**Semester / Level:II**
**Branch: EEE**
**Name of Teacher:**

**Course Objectives**:This course enables the students to:

| | |
|---|---|
| 1 | To analyse different states in power system and transition between the states following the dynamic changes happened in power system. |
| 2 | To evaluate the nature of frequency change in Isolated and integrated system and thereby the control strategy for Generator. |
| 3 | To investigate different methods for economic operation of the power plant by fuel saving and scheduling of thermal and hydel units. |
| 4 | To provide the introductory concept on power system deregulation and its effect on power system operation. |

**Course outcome:** At the end of the course, a student should be able to:

| | |
|---|---|
| CO1 | To apply different operating condition and methods and technologies involved in control action according to different operating states of power system. |
| CO2 | To design the primary and secondary controllers for automatic generation control. |
| CO3 | To evaluate the economic generation scheduling in case of thermal units and combination of hydro-thermal units using different solution techniques. |
| CO4 | To execute the frequency controller in multi-area system. |
| CO5 | To identify the responsibilities of different agencies in power system operation and control in India and the charges in operation and control in deregulated environment. |

# Syllabus

**Module - 1**

Introduction - Operating States, Preventive and Emergency control, Indian Electricity Grid Code, Co-ordination between different agencies in India, Power System Restructuring: Introduction, Regulation vs. Deregulation, Competitive Market for Generation, Advantages of Deregulation, Electric supply industry structure under deregulation in India. Restructuring Models [8L]

**Module - 2**

Load Frequency Control - Introduction, Types of speed governing system and modelling, Mechanical, Electro-hydraulic, Digital electro-hydraulic governing system, Turbine modelling, Generator-load modelling, Steady-state and dynamic response of ALFC loop, the secondary ALFC loop, Integral control.[8L]

**Module -3**

Multi-control-Area System - Introduction, Pool operation, Two-area system, Modelling the tie line, Static and dynamic response of two area system, Tie-line bias control, State space representation of two-area system, Generation allocation, Modern implementation of AGC scheme [8L]

**Module - 4**

Optimum Operating Strategies- Introduction, Generation mix, Characteristic of steam and Hydro-electric units, Optimum economic dispatch- neglecting Loss and with transmission loss, Computational steps, Derivation of loss formula, Short-term Hydro-thermal scheduling, Reactive power scheduling.

Excitation System- Introduction, elements of an excitation system, Types of excitation system [8L]

**Module - 5**

Unit Commitment - Introduction, Constraints in unit commitment, Thermal unit constraints, Hydro-constraints, Unit commitment solution method - Priority list method, Dynamic programming solution, Genetic Algorithm. [8L]

**Text Books:**

1. Electric Energy Systems Theory- An Introduction - Olle I. Elgerd, TMH, Edition 1983.

2. Power Generation Operation and Control - A.J. Wood, B.F. Wollenberg, John Wiley 7 Sons, 2$^{nd}$

Edition

**Reference Books:**

1. Power System Restructuring and Deregulation- Trading, Performance and Information Technology- Loi Lei Lai (Editor), Wiley

2. Power System Stability and Control - P. Kundur, TMH
3. Indian Electricity Grid Code -Central Electricity Regulatory Commissionwww.cercind.gov.in/2010/ORDER/February2010/IEGC_Review_Proposal.pdf
4. Power System Analysis – John J. Grainger & W.D. Stevenson, TMH, Edition 1994.

## COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

## DIRECT ASSESSMENT

| Assessment Tool | % Contribution during CO Assessment |
|---|---|
| Quizzes (3) | 3x10 = 30 |
| Seminar | 10 |
| Teacher's Assessment | 10 |
| Semester EndExamination | 50 |

## INDIRECT ASSESSMENT –

1. Students' Feedback on Course Outcome

## MAPPING OF COURSE OUTCOMES ONTO PROGRAM OUTCOMES

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | 2 | 2 | 2 | 3 | 3 | 2 |
| **CO2** | 3 | 2 | 3 | 3 | 2 | 3 |
| **CO3** | 3 | 2 | 3 | 3 | 3 | 3 |
| **CO4** | 2 | 2 | 1 | 2 | 2 | 2 |
| **CO5** | 3 | 2 | 3 | 3 | 3 | 3 |

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low)   2: Moderate (Medium)   3: Substantial (High)

**Gaps in the syllabus (to meet Industry/Profession requirements):**

**POs met through Gaps in the Syllabus:**

**Topics beyond syllabus/Advanced topics/Design:**

**POs met through Topics beyond syllabus/Advanced topics/Design:**

**Course Delivery Methods**

| CD | Course Delivery methods |
|---|---|
| CD1 | Lecture by use of boards/LCD projectors |
| CD2 | Tutorials/Assignments |

| | |
|---|---|
| CD3 | Seminars |
| CD4 | Industrial visits/in-plant training |
| CD5 | Self- learning such as use of NPTEL materials and internets |
| CD6 | Simulation |

**MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD**

| **Mapping Between COs and Course Delivery (CD) methods** | |
|---|---|
| **Course Outcome** | **Course Delivery Method** |
| CO1 | CD1, CD2, CD3,CD5 |
| CO2 | CD1, CD2, CD3,CD5 |
| CO3 | CD1, CD2, CD3,CD5 |
| CO4 | CD1, CD2, CD3, CD5 |
| CO5 | CD1, CD2, CD3,CD5 |

# PROGRAMME ELECTIVE III

**Course code: EE611**
**Course title: Physiological Control Systems**
**Pre-requisite(s): Knowledge on basic biomedical instrumentation**
**Co- requisite(s):**
**Credits:** L:3 T:0 P:0
**Class schedule per week: 3**
**Class: M. Tech**
**Semester / Level:III/6**
**Branch: EEE**
**Name of Teacher:**

## Course Objectives

This course enables the students:

| | |
|---|---|
| A. | Introduction to the physiological concepts and mathematical tools that they will need to understand and analyse these physiological control systems. |
| B. | Extend comprehensive knowledge of Structures and mechanisms responsible for the proper functioning of these systems. |
| C. | Enhance skills how these complex systems operate in a healthy human body |
| D. | Use linear control theory to model and analyse biological systems |
| .E | Nonlinear Analysis of Physiological Control Systems |

## Course Outcomes

After the completion of this course, students will be:

| | |
|---|---|
| CO1 | Understanding of different physiological system |
| CO2 | Able to model and simulate |
| CO3 | Can designed a control strategy |
| CO4 | Identification of complex control system |
| CO5 | aspire to take active role in developing state-of-the-art biomedical and allied system solutions and indulge in life-long learning. |

# Syllabus

**Module-1**: **Introduction**: Systems Analysis, Physiological Control Systems Analysis, Differences between Engineering and Physiological Control Systems, Mathematical Modeling: Generalized System Properties, Models with Combinations of System Elements, Linear Models of Physiological Systems, Distributed-Parameter versus Lumped Parameter Models, Linear Systems and the Superposition Principle [8]

**Module-2**: **Static Analysis of Physiological Systems**: Open-Loop versus Closed-Loop Systems, Determination of the Steady-State Operating Point, closed and open loop Regulation of Cardiac Output, Regulation of Glucose, Chemical Regulation of Ventilation, The Gas Exchanger, The Respiratory Controller, Closed-Loop Analysis: Lungs and Controller Combined. [8]

Module-3: **Time-Domain Analysis of Linear Control Systems**: Linearized Respiratory Mechanics: Open Loop versus Closed-Loop, Open-Loop and Closed-Loop Transient Responses: First and second-Order Model, Impulse Response, Step Response, Open-Loop versus Closed-Loop Transient Responses, Reduction of the Effects of External Disturbances, Reduction of the Effects of Parameter Variations, Integral Control, Derivative Feedback, Transient Response Analysis, Frequency Response of a Model of Circulatory ontrol, requency Response of the Model, Frequency Response of Glucose-Insulin Regulation. [8]

Module-4: **Stability Analysis**: Model of Cheyne-Stokes BreathinCO2 Exchange in the Lungs Transport Delays Contents Controller Responses Loop Transfer Functions [8]

Module-5: **Nonlinear Analysis of Physiological Control Systems**: Nonlinear versus Linear Closed-Loop Systems Phase-Plane Analysis Local Stability: Singular Points Method of Isoclines Nonlinear Oscillators Limit Cycles The van der Pol Oscillator Modeling Cardiac Dysrhythmias The Describing Function Method Methodology Application: Periodic Breathing with Apnea Models of Neuronal Dynamics Hodgkin-Huxley Mode The Bonhoeffer-van der Pol Model [8]

**Text book:**

**1. Physiological Control Systems by M. C. K. Khoo, PHI, 2001**

**COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE**

**DIRECT ASSESSMENT**

| Assessment Tool | % Contribution during CO Assessment |
|---|---|
| Quizzes (3) | 3x10 = 30 |
| Seminar | 10 |
| Assignment | 10 |
| Semester EndExamination | 50 |

**INDIRECT ASSESSMENT –**

1. Students' Feedback on Course Outcome

**MAPPING OF COURSE OUTCOMES ONTO PROGRAM OUTCOMES**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | 2 | 2 | 2 | 2 | 3 | 3 |
| **CO2** | 1 | 2 | 3 | 3 | 3 | 3 |
| **CO3** | 3 | 2 | 2 | 2 | 2 | 3 |
| **CO4** | 3 | 3 | 2 | 3 | 3 | 3 |
| **CO5** | 2 | 2 | 3 | 3 | 3 | 3 |

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low)   2: Moderate (Medium)   3: Substantial (High)

**Gaps in the syllabus (to meet Industry/Profession requirements):**
**1. Biomedical related concept can be undertaken**

**POs met through Gaps in the Syllabus:**
**PO5,PO6**

**Topics beyond syllabus/Advanced topics/Design:**
**1. Electrophysiology systems**
**2. correlation between Actual system and simulation result**
**3. Process Measurement of physiology**

**Course Delivery Methods**

| CD | Course Delivery methods |
|---|---|
| CD1 | Lecture by use of boards/LCD projectors |
| CD2 | Tutorials/Assignments |
| CD3 | Seminars |
| CD4 | Industrial visits/in-plant training |
| CD5 | Self- learning such as use of NPTEL materials and internets |
| CD6 | Simulation |

## MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

| **Mapping Between COs and Course Delivery (CD) methods** | |
|---|---|
| **Course Outcome** | **Course Delivery Method** |
| CO1 | CD1, CD2, CD3,CD5 |
| CO2 | CD1, CD2, CD3,CD5 |
| CO3 | CD1, CD2, CD3,CD5 |
| CO4 | CD1, CD2, CD3, CD5 |
| CO5 | CD1, CD2, CD3,CD5 |

**Course Code: EE605**
**Course Title: Micro-Grid Operation and Control**
**Pre-requisite(s): EE307 Electrical Power System Transmission and Distribution, EE351 Control System and EE353 Power Electronics**
**Credits:** L: 3 T: 1 P: 0
**Class schedule per week: 04**
**Class: M.Tech.**
**Semester / Level: III/Elective**
**Branch: Electrical & Electronics Engineering**
**Name of Teacher: Professor T.Ghose**

**Course Objectives**

This course envisions imparting the following objectives to the students:

| | |
|---|---|
| A. | To enumerate the necessity of active distribution network and understand the principle of operation of microgrid. |
| B. | To expose the responsibility of controllers connected with DERs through IEEE standards 1547-2018. |
| C. | To feature the maximum power extraction from SPV and PMSG based wind turbine system and the working procedure of controllers. |
| D. | To assess different controllers for voltage and frequency restoration in microgrid. |
| E. | To outline the basic principles of protection of microgrids. |

**Course Outcomes**

After the completion of this course, students will be able to:

| | |
|---|---|
| 1. | To explain the factors that require to develop a microgrid. |
| 2. | Apply IEEE standard 1547-2018 while understanding the expectation from the controllers. |
| 3. | Apply PWM based controllers to extract maximum power from SPV system |
| 4. | Outline the steps and accordingly design primary controllers and evaluate their performance |
| 5. | Explain the protection philosophy of islanding detection technique and the general microgrid protection. |

# Syllabus

**Module 1: Concept of Microgrid**

Distributed generation and Microgrid concept: Introduction, Power System Structure, Traditional Grid, Microgrid definition and characteristics, typical micro grid configuration, distributed renewable energy technologies, non- renewable distributed generation technologies, interconnection of microgrids, technical and economical advantages of micro grid, key challenges, **6L**

**Module 2: DER integration -I**

IEEE Standard for Interconnection (IEEE Std 1547™-2018 ) : concept of area electric power system, point of common coupling, point of coupling, General interconnection technical specifications and performance **6L**

Requirements, Reactive power capability and voltage/power control requirement, Voltage and Frequency disturbance ride-through requirements

**Module 3 : DER integration-II**

Integration of solar sources: Modeling of the Entire PV Energy Conversion System, PV Controller, EES Controller, Grid Connection Control. Steps of control of entire PV energy system. **12L**

Integration of wind power: Speed and power relations, Power extracted from the wind, Aerodynamic torque control, Control of a PMSG based wind energy generation system.

**Module-4: DER Integration - III**

Hierarchical Microgrid Control, Local or primary Control :Droop Control, Droop Control in Inverter-based Distributed Generators, performance of primary controller, Secondary Control and Tertiary Control. Centralized and decentralized Energy Management System (EMS) in microgrids. **8L**

**Module-5:**

Microgrid Protection: Challenges in microgrid protection systems, Classification for microgrid protection: current limiter, centralized protection, distance protection. Islanding: Non-detection zone, Anti-islanding techniques, different islanding scenarios. **8L**

Course Evaluation: Individual assignment, Seminar before a committee, Theory (Quiz and End semester) examinations

**Gaps in the syllabus (to meet Industry/Profession requirements):**

1. More focus on secondary and tertiary control in decentralized environment.
2. Detail in protection system for microgrid

**POs met through Gaps in the Syllabus:** 4 and 5

**Topics beyond syllabus/Advanced topics/Design:**

1. Risk evaluation with high penetration of RESs.
2. The infrastructure for implementing Demand Response programs.
3. Market operation in Indian context.

**POs met through Topics beyond syllabus/Advanced topics/Design**: 4 and 5 with higher level of satisfaction.

**Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure**

**Direct Assessment**

| Assessment Tool | % Contribution during CO Assessment |
|---|---|
| First Quiz | 10 |
| Mid Semester Examination | 25 |
| Second Quiz | 10 |
| Teacher's Assessment | 5 |
| End Semester Examination | 50 |

**Indirect Assessment**

1. Students' Feedback on Course Outcome.

**Mapping of Course Outcomes onto Program Outcomes**

| Course Outcome | Program Outcomes (POs) | | | | | | | | | | | | Program Specific Outcomes (PSOs) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| **CO1** | 1 | 2 | 1 | 1 | 1 | 1 | 2 | 2 | | 1 | | 1 | 3 | 2 | |
| **CO2** | 2 | 2 | 1 | 1 | 1 | 2 | 1 | 2 | | 1 | | 3 | 3 | 2 | 2 |
| **CO3** | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 1 | 1 | 2 | 2 | 3 | 3 | 3 |
| **CO4** | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 2 | 2 | 3 | 3 | 3 |
| **CO5** | 3 | 3 | 3 | 1 | 2 | 2 | 2 | 2 | 1 | 1 | 2 | 2 | 3 | 3 | 2 |

**Correlation Levels 1, 2 or 3 as defined below:**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

**Mapping Between COs and Course Delivery (CD) methods**

| CD Code | Course Delivery Methods | Course Outcome | Course Delivery Method Used |
|---|---|---|---|
| CD1 | Lecture by use of Boards/LCD Projectors | CO1 | CD1, CD7, CD 8 |
| CD2 | Tutorials/Assignments | CO2 | CD1 and CD9 |
| CD3 | Seminars | CO3 | CD1, CD2 and CD3 |
| CD4 | Mini Projects/Projects | CO4 | CD1 and CD2 |
| CD5 | Laboratory Experiments/Teaching Aids | CO5 | CD1 and CD2 |

| | | | |
|---|---|---|---|
| CD6 | Industrial/Guest Lectures | | |
| CD7 | Industrial Visits/In-plant Training | | |
| CD8 | Self- learning such as use of NPTEL Materials and Internets | | |
| CD9 | Simulation | | |

# OPEN ELECTIVES

**Course code: EE585**
**Course title: Hybrid Electric Vehicles**

**Pre-requisite(s):** Electrical Machines, Power Electronics and Electrical Drives

**Co- requisite(s):** Induction Motor, BLDC Motor, Battery, Power Converters

**Credits: 03** L:3 T:0 P:0 C: 03

**Class schedule per week: 03**

**Class: M.TECH.**
**Semester / Level: XX/05**

**Branch: EEE**

**Course Objectives**

This course enables the students to:

| | |
|---|---|
| A | Understand basic working principle of power converter controlled traction drive. |
| B | Apply power converters in order to provide proper power modulation. |
| C | Analyze transient performance of power converters for meeting traction load requirement. |
| D | Evaluate cost of design of HEV |
| E | Design a suitable power converter for HEV. |

**Course Outcomes**

At the end of the course, a student should be able to:

| | |
|---|---|
| CO1 | Describe fundamental working principle of power converter controlled traction drive. |
| CO2 | Apply power converters in conjunction with IC engine for obtaining dynamic requirement of traction drive. |
| CO3 | Analyze mutual effect of power converter and IC engine for obtaining optimal performance of HEV. |
| CO4. | Evaluate cost effectiveness and optimize performance parameters. |
| CO5. | Design an HEV for a particular application with the help of interdisciplinary teamwork. |

## Syllabus

**Module I: Introduction**

Hybrid and Electric Vehicles (HEV): History Overview and Modern Applications, Ground vehicles with mechanical powertrain and reasons for HEV development, HEV configurations and ground vehicle applications, Advantages and challenges in HEV design. [8L]

**Module II: Power Flow and Power Management Strategies in HEV**

Mechanical power: generation, storage and transmission to the wheels, Vehicle motion and the dynamic equations for the vehicle., Vehicle power plant and transmission characteristics and vehicle performance including braking performance., Fuel economy characteristics of internal combustion engine, Basic architecture of hybrid drive train and analysis series drive train., Analysis of parallel, series parallel and complex drive trains and power flow in each case., Drive cycle implications and fuel efficiency estimations. [8L]

**Module III: Hybrid Electric Vehicle**

Concept of Hybrid Electric Drive Trains, Architectures of Hybrid Electric Drive Trains, Series Hybrid Electric Drive Trains, Parallel Hybrid Electric Drive Trains, Torque-Coupling Parallel Hybrid Electric Drive Trains, Speed-Coupling Parallel Hybrid Electric Drive Trains, Torque-Coupling and Speed-Coupling Parallel Hybrid Electric Drives. [8L]

**Module IV: Electric Vehicles**

Traction Motor Characteristics, Tractive Effort and Transmission Requirement, Vehicle Performance, Tractive Effort in Normal Driving, Energy Consumption[8L]

**Module V: Design of Hybrid Electric Vehicles**

Design of Series Hybrid Electric Vehicle, Design of Parallel Hybrid Electric Vehicle, Design of Electric Vehicle, Impact on Environment [8L]

**Books recommended:**
**TEXT BOOK**


1. Modern Electric, Hybrid Electric and Fuel Cell Vehicles. MehrdadEhsani, CRC Press
2. Modern Electric Vehicle Technology, C.C. Chan and K.T. Chau, Oxford University Press


**REFERENCE BOOK**


1. R.Krishnan, „Electric motor drives‟ , Prentice hall of India,2002
2. T.J.E. Miller, „Brushless magnet and Reluctance motor drives‟,

**COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE**

**DIRECT ASSESSMENT**

| Assessment Tool | % Contribution during CO Assessment |
|---|---|
| Quizzes (3) | 3x10 = 30 |
| Seminar | 10 |
| Teacher's Assessment | 10 |
| Semester End Examination | 50 |

**INDIRECT ASSESSMENT –**

1. Students' Feedback on Course Outcome

**MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES**

| CO | PO1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 |
|---|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 2 | 2 | 2 | 1 |
| **CO2** | 3 | 3 | 3 | 2 | 2 | 1 |
| **CO3** | 3 | 3 | 3 | 3 | 2 | 2 |
| **CO4** | 3 | 3 | 3 | 3 | 3 | 2 |
| **CO5** | 3 | 3 | 3 | 3 | 2 | 3 |

**Correlation Levels 1, 2 or 3 as defined below:**

1: Slight (Low)   2: Moderate (Medium)   3: Substantial (High)

**Gaps in the syllabus (to meet Industry/Profession requirements):**
Design of Battery Charging Infrastructure for Hybrid Electric Vehicle

**POs met through Gaps in the Syllabus:** PO6

**Topics beyond syllabus/Advanced topics/Design**

Assignments: Regenerative Braking, Self -Driven HEV

**<u>POs met through Topics beyond syllabus/Advanced topics/Design</u>:** PO5

**Course Delivery Methods**

| | |
|---|---|
| CD1 | Lecture by use of boards/LCD projectors/OHP projectors |
| CD2 | Tutorials/Assignments |
| CD3 | Seminars |
| CD4 | Mini projects/Projects |
| CD5 | Laboratory experiments/teaching aids |
| CD6 | Industrial/guest lectures |
| CD7 | Industrial visits/in-plant training |
| CD8 | Self- learning such as use of NPTEL materials and internets |
| CD9 | Simulation |

**MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD**

| **Mapping Between COs and Course Delivery (CD) methods** | |
|---|---|
| **Course Outcome** | **Course Delivery Method** |
| CO1 | CD1, CD2, CD3, CD5 |
| CO2 | CD1, CD2, CD3, CD5 |
| CO3 | CD1, CD2, CD3, CD5 |
| CO4 | CD1, CD2, CD3, CD5 |
| CO5 | CD1, CD2, CD3, CD5 |

**Course Code: EE587**
**Course title: ELECTROMECHANICAL ENERGY CONVERSION**
**Pre-requisite(s): Basic Laws of Electromagnetism**
**Credits:** L:03 T:0 P:0 C: 03
**Class schedule per week: 03**
**Class: M.Tech.**
**Semester / Level: I/05**
**Branch: Electrical Engineering**

**Course Objectives:**

This course enables the students to:

| | |
|---|---|
| A | Explore the basic principles of transformer, dc and ac machines and analyse comprehensively their steady –state behaviours |
| B | Examine characteristics of static and dynamic dc and ac machines |
| C | Explore the technique to draw armature winding of dc machine |
| D | Analyse the Magnetic circuit of transformer in order to evaluate their performance, |
| E | Design and recommend low cost and high-performance machines which finds applications in modern industries, homes and offices. |

**Course Outcomes:**

At the end of the course, a student should be able to:

| | |
|---|---|
| CO1 | State and explain working principle, constructions as well as steady- state behaviour ofan ac static and dc machines. |
| CO2 | Interprete the different transformer and dc machines |
| CO3 | Identify, formulate and solve problems related to power transformer and dc machines. |
| CO4 | Specify, interpret data, design an electrical machine and make a judgment about thebest design in all respect. |
| CO5 | Evaluate the design of electrical machine. |

# SYLLABUS

**Module I: Basic Concepts of Electromechanical Energy Conversion:**

Electromagnetic induction, flux linkage, Classification and description of electrical machines, Rotor, Stator and field excitation. Generator and motor action, EMF and torque equations, Classification and description of electrical machines, Leakage flux, Losses and efficiency, Rating, Electrical and mechanical degrees. [8L]

**Module II: Transformers:**

Construction, Principle of operation, Ideal and physical transformer, emf equation, transformation ratio, Phasor diagram. Equivalent circuit, Losses and efficiency, Autotransformer, 3-phase transformer, Three-phase transformer connections- Star-star, Delta- delta, Star-delta, Delta-star. [8L**]**

**Module III: Introduction to D.C. Machines:**

Principle of operation, Armature winding- Lap and wave, Simplex and duplex, Method of excitation, emf and torque equations, commutation.

**DC Generators:** Magnetization characteristics, Critical resistance and critical speed, Process of building up of voltage.

**D.C.Motors:**Basicequationforvoltage, Power, Torque andspeed,Operating characteristics-Torque-current, and Speed-current and Torque-speed characteristics. Starters,Speed control methods, Swinburnes. [8L]

**Module IV: Synchronous Machine:**

Principle of operation, Excitation system, Effect of winding factor on EMF, Circuit model, Phasor diagram, O.C. and S.C. tests, Short-circuit ratio, Determination of voltage regulation by synchronous impedance, MMF and zero power factor methods. Two reaction theory, Power-angle characteristic of synchronous generators, synchronizing power and torque, synchronizing methods. [8L]

**Module V: 3-phase Induction Motor:**

Principle of operation, Slip and rotor frequency, Comparison with transformer, Equivalent circuit model, Torque and power output, Losses and efficiency, Torque-slip characteristics, Effect of rotor resistance, Starting torque and maximum torque, Starting and speed control methods.**1-phase Induction Motor:** Introduction, Double revolving field theory, Crossfield theory, Torque-speed characteristic, Equivalent circuit model. [8L]

**Books recommended:**

**TEXT BOOK:**

1. I. J. Nagrath, D.P. Kothari, Electric Machines, 4th Edition, TMH, New Delhi, 2014.
2. “P. S. Bimbhra, Electrical Machines, Khanna Publishers, New Delhi, 7th Edition 2014.

**REFERENCE BOOKS:**

1. A.E. Fitzgerald, Charles Kinsley, Stephen D. Umansd; Electric Machinery, McGraw Hill

Education (India) Pvt. Ltd, Noida, Indian 6th Edition 2003.
2. E.H. Langsdorf; Theory of Alternating Current Machinery, McGraw-Hill, New York 1955.M.G. Say.
3. "Alternating Current Machines", Pitman Publishing Ltd. 1976.

**COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE**

**DIRECT ASSESSMENT**

| Assessment Tool | % Contribution during CO Assessment |
|---|---|
| Quizzes (3) | 3x10 = 30 |
| Seminar | 10 |
| Assignment | 10 |
| Semester End Examination | 50 |

**INDIRECT ASSESSMENT –**

**1.** Students' Feedback on Course Outcome

**MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 2 | 2 | 2 | 1 |
| **CO2** | 3 | 3 | 3 | 3 | 2 | 2 |
| **CO3** | 3 | 3 | 3 | 3 | 3 | 2 |
| **CO4** | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO5** | 3 | 3 | 3 | 3 | 3 | 3 |

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

**Gaps in the syllabus (to meet Industry/Profession requirements):**

(1) Cost Evaluation of Electrical drive in electrical machines based on reliability.
(2) Application of artificial intelligence in Electrical Machines.
(3) Study of impact of Electrical Machine on society and environment

**POs met through Gaps in the Syllabus:** PO6

**Topics beyond syllabus/Advanced topics/Design:**

(1) Reliability analysis in Electrical Machine topologies
(2) Application of adaptive algorithms in Electrical Machine based systems.

**POs met through Topics beyond syllabus/Advanced topics/Design**: PO6

**Course Delivery Methods**

| | |
|---|---|
| CD1 | Lecture by use of boards/LCD projectors/OHP projectors |
| CD2 | Assignments/Seminars |
| CD3 | Laboratory experiments/teaching aids |
| CD4 | Industrial/guest lectures |
| CD5 | Industrial visits/in-plant training |
| CD6 | Self- learning such as use of NPTEL materials and internets |
| CD7 | Simulation |

**MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD**

| Course Outcomes | Course Delivery Method |
|---|---|
| CO1 | CD1,CD6 |
| CO2 | CD1, CD6,CD7 |
| CO3 | CD1, CD2, CD3,CD6,CD7 |
| CO4 | CD1, CD3,CD6,CD7 |
| CO5 | CD1,CD2,CD3,CD4,CD5,CD7 |

**Course Code: EE589**
**Course title: POWER SEMICONDUCTOR DEVICES**
**Pre-requisite(s): Basic Electronics**
**Credits: 03** L:3 T:0 P:0 C: 03
**Class schedule per week: 03**
**Class: M.Tech.**
**Semester / Level: I/05**
**Branch: Electrical Engineering**

**Course Objectives:**

This course enables the students to:

| | |
|---|---|
| A. | Identify different type of modern semiconductor based switching devices and theiroperating characteristics. |
| B | Explain working principle of semiconductor devices such as Thyristors and PMOSFET. |
| C. | Analyze protection circuit and firing circuit. |
| D. | Evaluate performance parameters of a semiconductor device |
| E. | Design protection for power semiconductor devices. |

**Course Outcomes:**
At the end of the course, a student should be able to:

| | |
|---|---|
| CO1. | List different types of semiconductor devices and remember their operatingcharacteristics. Explain the working principle of different semiconductor devices. |
| CO2. | Classify different types of power converters. Show suitability of a power converter for a particular application. Solve power management related problems with application of power electronics based topologies. |
| CO3. | Outline shortcomings of each class of power devices and solve them using proper circuits such as firing circuit and protection circuit. |
| CO4. | Estimate the cost and long term impact of power electronics technology on alarge scale project of socio-economic importance. |
| CO5 | Design protection circuit such as therma protection, dv/dt protection and di/dt protection. |

# SYLLABUS

**Module I:**

**Introduction:** Power switching devices overview – Attributes of an ideal switch, application requirements, circuit symbols; Power handling capability – (SOA); Device selection strategy– On-state and switching losses – EMI due to switching – Power diodes – Types, forward and reverse characteristics, switching characteristics – rating. [8L]

**Module II:**

**Current Controlled Devices:** BJT‟s – Construction, static characteristics, switching characteristics; Negative temperature coefficient and second breakdown; – Thyristors – Physical and electrical principle underlying operating mode, Two transistor analogy – concept of latching; Gate and switching characteristics; converter grade and inverter grade and other types; series and parallel operation; comparison of BJT and Thyristor – steady state and dynamic models of BJT &Thyristor- Basics of GTO, MCT, FCT, RCT. [8L]

**Module III:**

**Voltage Controlled Devices:** Power MOSFETs and IGBTs – Principle of voltage-controlled devices, construction, types, static and switching characteristics, steady state and dynamic models of MOSFET and IGBTs – and IGCT. New semiconductor materials for devices – Intelligent power modules- Integrated gate commutated thyristor (IGCT) – Comparison of all power devices. [8L]

**Module IV:**

**Firing and Protection Circuits:** Necessity of isolation, pulse transformer, optocoupler – Gate drives circuit: SCR, MOSFET, IGBTs and base driving for power BJT. – Over voltage, over current and gate protections; Design of snubbers. [8L]

**Module V:**

**Thermal Protection:** Heat transfer – conduction, convection and radiation; Cooling – liquid cooling, vapour – phase cooling; Guidance for hear sink selection – Thermal resistance and impedance **-**Electrical analogy of thermal components, heat sink types and design – Mounting types- switching loss calculation for power device. [8L]

**Books recommended:**

**Text Books:**


1. M.H. Rashid,"Power Electronics: Circuits, Device and Applications",2nd Ed.n, PHI, New Jersey, 1993.
2. Mohan, Underland, Robbins; Power Electronics Converters, Applications and Design, 3rd Edn., 2003, John Wiley & Sons Pte. Ltd.

3. M. D. Singh, K. B. Khanchandani, “Power Electronics”, 2nd Edn., Tata McGraw- Hill, 2007.

**Reference Books:**


1. R. Krishnan, “Electric Motor Drives: Modeling, Analysis and Control”, 1$^{st}$Edn., Prentice Hall,2001.
2. B. K. Bose, “Modern Power Electronics & AC Drives” , 1$^{st}$Edn., Prentice Hall, 2001
3. L. Umanand, “Power Electronics: Essentials & Applications”, 1$^{st}$Edn. Wiley India Private Limited, 2009.
4. Jeremy Rifkin, “Third Industrial Revolution: How Lateral Power Is Transforming Energy, the Economy, and the World”, 1$^{st}$Edn., St. Martin‟s, Press, 2011.


**COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE**

**DIRECT ASSESSMENT**

| Assessment Tool | % Contribution during CO Assessment |
|---|---|
| Quizzes (3) | 3x10 = 30 |
| Seminar | 10 |
| Teacher’s Assessment | 10 |
| Semester End Examination | 50 |

**INDIRECT ASSESSMENT –**

**1.** Students’ Feedback on Course Outcome

**MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 2 | 2 | 2 | 1 |
| CO2 | 3 | 3 | 2 | 2 | 1 | 1 |
| CO3 | 3 | 3 | 3 | 2 | 1 | 1 |
| CO4 | 3 | 3 | 3 | 3 | 2 | 1 |

| | | | | | | |
|---|---|---|---|---|---|---|
| CO5 | 3 | 3 | 3 | 3 | 3 | 2 |

**Correlation Levels 1, 2 or 3 as defined below:**

1: Slight (Low)   2: Moderate (Medium)   3: Substantial (High)

**Gaps in the syllabus (to meet Industry/Profession requirements) :**

**(1)** Cost Evaluation of Power Electronics based installation based on reliability
**(2)** Study of impact of power electronics on society and environment

**POs met through Gaps in the Syllabus: PO6**

**Topics beyond syllabus/Advanced topics/Design:**

(1) Reliability analysis in power electronics topologies

(2) Application of power electronics in the field of Renewable Energy.

**POs met through Topics beyond syllabus/Advanced topics/Design: PO6**

**Course Delivery Methods**

| | |
|---|---|
| CD1 | Lecture by use of boards/LCD projectors/OHP projectors |
| CD2 | Assignments/Seminars |
| CD3 | Laboratory experiments/teaching aids |
| CD4 | Industrial/guest lectures |
| CD5 | Industrial visits/in-plant training |
| CD6 | Self- learning such as use of NPTEL materials and internets |
| CD7 | Simulation |

**MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERYMETHOD**

| Course Outcomes | Course Delivery Method |
|---|---|
| CO1 | CD1,CD6 |
| CO2 | CD1, CD6,CD7 |
| CO3 | CD1, CD2, CD3,CD6,CD7 |
| CO4 | CD1, CD3,CD6,CD7 |
| CO5 | CD1,CD2,CD3,CD4,CD5,CD7 |

**Course code: EE595**
**Course title: Smart Grid**
**Pre-requisite(s):** Power system courses, power electronics
**Co- requisite(s): Credits: 3**

| L | T | P |
|---|---|---|
| 3 | 0 | 0 |

**Class schedule per week: 03**
**Class: M. Tech**
**Semester / Level: I/05**
**Branch: EEE**
**Name of Teacher: Prof. T.Ghose**

**Course Objectives:**

The course objectives are:

| | |
|---|---|
| 1. | introduction to grid operation, necessity of making grid more smart, and basic components of today's grid; |
| 2. | to extend knowledge on different design challenges with grid interfacing systems for Renewable Energy Sources; |
| 3. | to illustrate the basics of the working principle of PMU and its application; |
| 4. | to educate the students about communication protocol and its application in smart grid; |
| 5. | to make the students understood about different demand response programmes. |

**Course Outcomes:**

After the completion of this course, students will be able to:

| | |
|---|---|
| CO1 | demonstrate steps about building blocks of the smart grid; |
| CO2 | organise the steps involved in working principles of PMU and WAMS through PMUs; |
| CO3 | analysis the challenges involved with grid interactive converters connected with RES; |
| CO4 | understand the design concept involved with demand response Programmes, |

| | |
|---|---|
| | communication standards, cyber security etc; |
| CO5 | aspire and confident for taking up challenge to adopt new technology needed for monitoring, control and operation of power system. |

# SYLLABUS

**Module I**

**Introduction:** Basics about Power Grid operation, Concept of Smart Grid, necessity forpushing smart grid concept, operation and control architecture, Basic components. (8L)

**Module II**

**Smart Grid and Generation:** Renewable energy generation, Solar, Wind, Hydroelectric,Biomass, fuel cell, challenges with RE generation, uncertainty and risk estimation, concept of Converter design for grid tied RE sources. (8L)

**Module III**

**Smart Grid and transmission system**:Introduction, Wide area monitoring system, Phasormeasurement units (PMUs) smart meters, multi-agent system technology, phasor measurement techniques: introduction, phasor estimation of nominal frequency signals, phasorupdation using non-recursive and recursive updates, phasor estimation at off-nominal frequency input, hierarchy of phasor measurement systems, communication options for PMUs, functional requirements of PMUs and phasor data concentrators (PDCs). (8L)

**Module IV**

**Smart Grid and Communication system**: Introduction, communication requirement, list ofthe standards, architecture of the communication system, wired and wireless communication, security and safety. (8L)

**Module V**

**Smart Grid and Demand Response:** Introduction, demand response, Types of demandResponse Programmes, Aggregator concept, Advanced metering infrastructure, Smart home and building automation standards. Basic concept of Big data analysis.(8L)

**Books recommended:**

**Text Book:**

1.Smart Grid Standards : Specifications, Requirements, and Technologies by byTakuro Sato, Daniel M. Kammen, , Bin Duan, , Martin Macuha, , Zhenyu Zhou, , Jun Wu, , Muhammad Tariq, , and Solomon A. Asfaw**PUBLISHER** John Wiley & Sons, Incorporated.

2.A.G. Phadke J.S. Thorp, “Synchronized Phasor Measurements and their Applications”, springer 2008.

3.JamesMomoh**, “**SMART GRID: Fundamentals of Design and Analysis”, IEEE (Power engineering series) – Wiley- Blackwell, April 2012.

4.JanakaEkanayake, KithsiriLiyanage, JianzhongWu, Akihiko Yokoyama, Nick Jenkins “Smart Grid Technology and Applications”, Wiley, New- Delhi, August 2015.

**COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE**

**DIRECT ASSESSMENT**

| Assessment Tool | % Contribution during CO Assessment |
|---|---|
| Quizzes (3) | 3x10 = 30 |
| Seminar | 10 |
| Assignment | 10 |
| Semester End Examination | 50 |

**INDIRECT ASSESSMENT –**

1. Students’ Feedback on Course Outcome

**MAPPING OF COURSE OUTCOMES ONTO PROGRAM OUTCOMES**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | 2 | 1 | 3 | 3 | 2 | 2 |
| **CO2** | 3 | 3 | 3 | 2 | 1 | 2 |
| **CO3** | 2 | 3 | 2 | 3 | 2 | 3 |
| **CO4** | 3 | 2 | 3 | 3 | 3 | 3 |
| **CO5** | 3 | 2 | 3 | 2 | 2 | 1 |

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low)   2: Moderate (Medium)   3: Substantial (High)

**Gaps in the syllabus (to meet Industry/Profession requirements):**

1. Design of real-time industrial projects.

**POs met through Gaps in the Syllabus: PO5 & PO6**

**Topics beyond syllabus/Advanced topics/Design:**

**POs met through Topics beyond syllabus/Advanced topics/Design: PO5 & PO6**

**Course Delivery Methods**

| CD | Course Delivery methods |
|---|---|
| CD1 | Lecture by use of boards/LCD projectors |

| | |
|---|---|
| CD2 | Tutorials/Assignments |
| CD3 | Seminars |
| CD4 | Industrial visits/in-plant training |
| CD5 | Self- learning such as use of NPTEL materials and internets |
| CD6 | Simulation |

**MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD**

| **Mapping Between COs and Course Delivery (CD) methods** | |
|---|---|
| **Course Outcome** | **Course Delivery Method** |
| CO1 | CD1, CD2, CD3,CD5 |
| CO2 | CD1, CD2, CD3,CD5 |
| CO3 | CD1, CD2, CD3,CD5 |
| CO4 | CD1, CD2, CD3, CD5 |
| CO5 | CD1, CD2, CD3,CD5 |

**Course code: EE 597**
**Course title: Reliability Engineering**
**Pre-requisite(s):** Engineering Mathematics, Probability Theory
**Co- requisite(s):**
**Credits: 3 L T P**
**3 0 0**
**Class schedule per week: 3**
**Class: M.Tech.**
**Semester / Level: I/05**
**Branch:**
**Name of Teacher:**

**Course Objectives**

This course enables the students to:

| | |
|---|---|
| | |
| 1. | define probability theory and relate the concept of reliability of systems; |
| 2. | understand general reliability mathematics applicable to all systems; |
| 3. | understand Markov chains, and application of Markov models in reliability analysis of systems; |
| 4. | evaluate reliability of systems using Markov models and available reliability parameters of systems; |
| 5. | use frequency and duration technique for various reliability analysis problems. |

**Course Outcomes**

After the completion of this course, students will be able to:

| | |
|---|---|
| CO1 | understand the general reliability concept and mathematics |
| CO2 | identify events or causes responsible for unreliability of systems through failures; |
| CO3 | evaluate the associated system risk and thus finding solutions for minimizing the risks to an acceptable level; |
| CO4 | apply engineering knowledge and design techniques to prevent or to reduce the likelihood or frequency of failures for different systems; |
| CO5 | apply methods for estimating the reliability of new designs, and for analyzing reliability data. |

# SYLLABUS

## EE597 Reliability Engineering

**Module I**

**Introduction:** Types of systems, Qualitative and quantitative assessment, Reliabilitydefinitions and concepts, Reliability indices and criteria, Reliability evaluation techniques, Reliability improvements, Reliability economics, Reliability monitoring and growth, Basic probability theory**,** Probability concepts, Permutations and combinations, Application in probability evaluation, Practical engineering concepts, Venn diagrams, Rules for combining probabilities, Probability distributions.(8L)

**Reliability Mathematics:** The general reliability function, The exponential distribution,Mean time to failure and repair, series and parallel systems, Markov processes, System reliability using network and state space method.(8L)

**Module III**

**Network Modeling and Evaluation of Simple and Complex Systems:** Service qualitycriterion, Conditional probability approach, Two-plant single load and two load systems. The probability array for two interconnected systems, Loss of load approach, Interconnection benefits.(8L)

**Module IV**

**Discrete Markov Chains and Continuous Markov Processes:** Introduction toDiscreteMarkov chain, Stochastic transitional probability matrix by Discrete Markov chain, Time dependent probability evaluation by Discrete Markov chain**,** Limiting state probability evaluation**,** Absorbing states, Application of discrete Markov techniques, Introduction to Continuous Markov process**,** General modeling concepts, State space diagrams, Stochastic transitional probability matrix by Continuous Markov process , Evaluating limiting state probabilities by Continuous Markov process, Reliability evaluation in repairable systems, Application of techniques to complex systems.(8L)

**Module V**

**Frequency and Duration Techniques:** Frequency and duration concepts, Application tomulti-state problems: Two component repairable system, State probabilities, Frequency of encountering individual states**,** Mean duration of individual states, Cycle time between individual states , Frequency of encountering cumulated states**,** Recursive evaluation of cumulative frequency**,** Mean duration of cumulated states, Frequency balance approach, Two stage repair and installation process :One component system-no spare available**,** one spare available**,** two spares available**,** one spare available**,** Limiting number of spares, Application of the techniques.(8L)

**Text Books:**

1. Roy Billinton, Ronald N. Allan, "Reliability Evaluation of Engineering Systems Concepts and Techniques", $2^{nd}$ Edition, Springer Science + Business Media New York 1992.
2. Hoang Pham, "Handbook of Reliability Engineering", Springer 2003.
3. Alessandro Birolini, "Reliability Engineering: Theory and Practice", Springer 1999.

**Reference Books:**

1. Donald W. Benbow, "The Certified Reliability Engineer Handbook", 2009.

## COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

## DIRECT ASSESSMENT

| Assessment Tool | % Contribution during CO Assessment |
|---|---|
| Quizzes (3) | 3x10 = 30 |
| Seminar | 10 |
| Teacher's Assessment | 10 |
| Semester EndExamination | 50 |

## INDIRECT ASSESSMENT –

**1.** Students' Feedback on Course Outcome

## MAPPING OF COURSE OUTCOMES ONTO PROGRAM OUTCOMES

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 2 | 3 | - | 2 |
| **CO2** | 3 | 3 | 2 | 2 | 1 | 2 |
| **CO3** | 3 | 3 | 2 | 2 | 1 | 2 |
| **CO4** | 3 | 3 | 2 | 2 | 1 | 2 |
| **CO5** | 3 | 3 | 2 | 2 | 1 | 2 |

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

**Gaps in the syllabus (to meet Industry/Profession requirements):**

1. Application of reliability engineering in various fields.

**POs met through Gaps in the Syllabus: PO5 & PO6**

**Topics beyond syllabus/Advanced topics/Design:**

**Modern reliability analysis methodologies**

**POs met through Topics beyond syllabus/Advanced topics/Design: PO5 & PO6**

**Course Delivery Methods**

| CD | Course Delivery methods |
|---|---|
| CD1 | Lecture by use of boards/LCD projectors |
| CD2 | Tutorials/Assignments |
| CD3 | Seminars |
| CD4 | Industrial visits/in-plant training |
| CD5 | Self- learning such as use of NPTEL materials and internets |
| CD6 | Simulation |

**MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD**

| **Mapping Between COs and Course Delivery (CD) methods** | |
|---|---|
| **Course Outcome** | **Course Delivery Method** |
| CO1 | CD1, CD2, CD3,CD5 |
| CO2 | CD1, CD2, CD3,CD5 |
| CO3 | CD1, CD2, CD3,CD5 |
| CO4 | CD1, CD2, CD3, CD5 |
| CO5 | CD1, CD2, CD3,CD5 |

**Course code: EE601**
**Course title: Process Measurement and Control**
**Pre-requisite(s): Instrumentation and Measurement**
**Co- requisite(s): control system**
**Credits: L:3 T:0 P:0**
**Class schedule per week: 03**
**Class: Mtech**
**Semester / Level: 0X**
**Branch: control/ EEE**
**Name of Teacher:**

## Course Objectives

This course enables the students:

| | |
|---|---|
| A. | Expose students to the advanced control methods used in industries and research. |
| B. | Understand various process model |
| C. | Understand process control |
| D. | Control system analysis and design |
| E | Understand various process model |

## Course Outcomes

After the completion of this course, students will be:

| | |
|---|---|
| CO1 | controller tuning |
| CO2 | type of controller that can be used for specific problems in industry |
| CO3 | design of controllers for interacting multivariable systems |
| CO4 | design of digital control systems |
| CO5 | Understanding of production line |

## Syllabus

**Module 1 Fundamentals of Process:** Control Elements of process control loop, Process Characteristics and their significance. Process gain, Process reaction curve, process time constant, step analysis method, finding time constant, dead time. [8L]

**Module 2 Feedback Controller Tuning**: Types of Controllers, Tuning methods, Selection of controller for specific application, Controller settings- evaluation criteria – 1/4th decay ratio, IEA, ISE, ITAE - determination of optimum settings for mathematically described process using time response and frequency response. [8L]

**Module 3 Stability Analysis and Performance of Feedback Control systems**: Concept of stability, Stability analysis of linear and linearised systems, principles, Bode Method, Controller tuning based on stability Control Performance via closed loop frequency Response, Control system factors influencing control Performance. [8L]

**Module 4 Control strategies**: Multi loop process control systems, Feedback-feed forward control,adaptive control, Smith predictor, internal model control. Cascade Control, Ratio Control, Selective Control, and Split-range Control with industrial applications. [8L]

**Module 5 Analysis of Multivariable Systems Process Interaction:** Effects of Interaction, Block representation and transfer function matrix interaction, relative gain array, resiliency, Morari resiliency index, Niederlinsky index Multivariable Control Singular Value Analysis, Selection of manipulated and Controlled Variables, Tuning of multiloop PID control systems, Decoupling and Multivariable control Strategies. [8L]

**Text books:**

1. "Process Control", F. G. Shinskey, McGraw Hill Book Company
2. "Process, Modeling, Simulation and Control for Chemical Engineers", W. L. Luyben, McGraw Hill.
3. D.R. Coughanour, 'Process Systems analysis and Control', McGraw-Hill, 2nd Edition, 1991.

**COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE**

**DIRECT ASSESSMENT**

| Assessment Tool | % Contribution during CO Assessment |
|---|---|
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**INDIRECT ASSESSMENT –**

1. Students' Feedback on Course Outcome

**MAPPING OF COURSE OUTCOMES ONTO PROGRAM OUTCOMES**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | 2 | 2 | 2 | 2 | 3 | 3 |
| **CO2** | 1 | 3 | 3 | 3 | 3 | 3 |
| **CO3** | 3 | 2 | 2 | 2 | 2 | 3 |
| **CO4** | 3 | 3 | 2 | 3 | 3 | 3 |
| **CO5** | 2 | 2 | 3 | 2 | 3 | 3 |

Correlation Levels 1, 2 or 3 as defined below:

1: Slight (Low)   2: Moderate (Medium)   3: Substantial (High)

**Gaps in the syllabus (to meet Industry/Profession requirements):**
**1. Production related concept can be undertaken**

**POs met through Gaps in the Syllabus:**
**PO5,PO6**

**Topics beyond syllabus/Advanced topics/Design:**
**1. AI system**
**2. fluid mechanics**
**3. Industrial instrumentation and measurement**

**Course Delivery Methods**

| CD | Course Delivery methods |
|---|---|
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## MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

| **Mapping Between COs and Course Delivery (CD) methods** | |
|---|---|
| **Course Outcome** | **Course Delivery Method** |
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| CO2 | CD1, CD2, CD3,CD5 |
| CO3 | CD1, CD2, CD3,CD5 |
| CO4 | CD1, CD2, CD3, CD5 |
| CO5 | CD1, CD2, CD3,CD5 |