M. E. INSTRUMENTATION ENGINEERING

(Regulation 2013)

Minimum Credits to be earned: 74

Semester I

Sl. No.	Code No	Course	Objective(s) & Outcomes		L	T	P	C
			PEOs	POs				
1.	14IE11	Applied Mathematics	I,II,III	a,b,c	3	1	0	4
2.	14IE12	Process Control	I,III	a,b,e	3	0	0	3
3.	14IE13	Linear and Non-Linear Systems Theory	I,II,III	a,c,f	3	0	0	3
4.	14IE14	Industrial Data Networks	I,III	a,b,f	3	0	0	3
5.	14IE15	Transducers and Smart Instruments	I,III	d,f,b	3	0	0	3
6.	14EI16	Virtual Instrumentation	I,II,III	c,e,f	3	0	1	4
7.	14IE17	Modelling and Simulation Laboratory	I,II,III	b,c,d,e	0	0	3	2
8.	14IE18	Industrial Training	II,III	h,i,f	-	-	-	2
		Total			**18**	**1**	**4**	**24**

Semester II

Sl. No.	Code No	Course	Objective(s) & Outcomes		L	T	P	C
			PEOs	POs				
9.	14IE21	Advanced Process control	I,III	a,e,b,f	3	1	0	4
10.	14IE22	Applied Industrial Instrumentation	I,II,III	e,c,b	3	0	0	3
11.	14IE23	Instrumentation System Design	I,III	e,f,j	3	1	0	4
12.		Elective – I			3	0	0	3
13.		Elective – II			3	0	0	3
14.		Elective – III			3	0	0	3
15.	14IE27	Advanced Process Control Laboratory	I,III	a,e,b,f	0	0	3	2
16.	14IE28	Technical Seminar	II,III	c,h,i,f	0	0	2	1
		Total			**18**	**2**	**5**	**23**

Semester III

Sl. No.	Code No	Course	Objective(s) & Outcomes		L	T	P	C
			PEOs	POs				
17.		Elective – IV			3	0	0	3
18.		Elective – V			3	0	0	3
19.		Elective – VI			3	0	0	3
20.	14IE34	Project Work Phase I	I,II,III	a,g,b,f,j		-		6
		Total			**9**	**0**	**0**	**15**

Semester IV

Sl. No.	Code No	Course	Objective(s) & Outcomes		L	T	P	C
			PEOs	POs				
21.	14IE41	Project Work Phase II	I,II,III	a,g,b,f,j		-		12
		Total				**-**		**12**

ELECTIVES

		L	T	P	C
14IE51	Optimal Control	3	0	0	3
14IE52	System Identification and Adaptive Control	3	0	0	3
14IE53	Fault Tolerance Control	3	0	0	3
14IE54	Micro Electro Mechanical System	3	0	0	3
14IE55	Power Plant Instrumentation	3	0	0	3
14IE56	Biomedical Signal Processing	3	0	0	3
14IE57	Industrial Drives and Control	3	0	0	3
14IE58	Robotics and Automation	3	0	0	3
14IE59	Robust Control	3	0	0	3
14IE60	Reliability and Safety Engineering	3	0	0	3
14IE61	Web based Measurement and Control	3	0	0	3
14IE62	Mechatronics	3	0	0	3
14IE63	Optimal State Estimation	3	0	0	3
14IE64	Wireless Sensor Networks	3	0	0	3
14IE65	VLSI System Design	3	0	0	3
14IE66	Real time Embedded System	3	0	0	3
14IE67	Network Security and Cryptography	3	0	0	3
14IE68	Sensors and Networking	3	0	0	3
14IE69	Embedded Networking	3	0	0	3
14IE70	Intelligent Sensors	3	0	0	3

14IE11 APPLIED MATHEMATICS

3 1 0 4

Course Objectives (COs):

- To elaborate the concepts in probability theory, linear algebra and vector space
- To make the students understand the various random process concepts
- To Acquire knowledge in advance matrix theory which has wider application in engineering problems

Course Outcomes (COCs):

1. Ability to acquire adequate knowledge in basic concept of engineering mathematics
2. Ability to improve the problem evaluation skills
3. Ability to choose an appropriate method to solve a practical problem

Program Outcomes (POs):

a. Ability to apply knowledge from undergraduate engineering and other disciplines to identify, formulate, solve, novel advanced instrumentation engineering along with process and automation problems that require advanced knowledge within the field

b. Ability to comprehend and incorporate latest knowledge within the field

c. Ability to apply highly developed technical knowledge in multiple contexts

Unit I

Probability Theory

Probability – Baye's Theorem for conditional probability – random variable – Probability mass function - Probability density functions

9 Hours

Unit II

Two Dimensional Random Variables

Joint distributions - Marginal and conditional distributions – Covariance - Correlation and Regression

9 Hours

Unit III

Random Process

Stochastic process – classification, auto correlation and auto co-variance – cross correlation – stationery process. Markov chain: Definition and example – higher transition probabilities – classification of states and chains

9 Hours

Unit IV

Linear Algebra and Vector Space

Linear system of equation – consistency – test for consistency – linear dependence and independence of vectors – vector space – Bases and dimension – subspace – Inner product space – orthonormal basis – gram – Schmitt orthogonalization process

9 Hours

Unit V

Advanced Matrix Theory

Matrix norms – Jordan canonical form – generalized Eigen vectors – singular value decomposition – pseudo inverse – least square approximations – QR algorithm

9 Hours

Total: 45 + 15 Hours

Reference(s)

1. Richard Johnson, Miller and Freund's, Probability *and Statistics for Engineers*, Prentice Hall, New Delhi, 2007.
2. Louis A Pipes, Lawrence R. Harvill, *Applied Mathematics for Engineers and Physicists*, McGraw-Hill Inc.,US September 1970.
3. J. Medhi, *Stochastic Processes,* 2nd Edition, New Age International 1994.
4. David C Lay, *Linear Algebra and its Applications*, Pearson Education Asia, New Delhi. 2003.
5. Howard Anton, *Elementary Linear Algebra*, John Wiley & Sons, 2008.

14IE12 PROCESS CONTROL

3 0 0 3

Course Objective (COs):

- To obtain the mathematical models for first order and higher order real-time systems and also to understand the characteristics of various controller modes and tuning methods
- To understand the concept of various complex control schemes
- To study about the control and tuning strategies for multivariable systems
- To understand, how to apply the multivariable control schemes for various applications

Course Outcomes (COCs):

1. Ability to determine the mathematical model for real-time first and higher order systems and to design various controller modes with appropriate tuning
2. Ability to implement model based control schemes for various processes
3. Ability to enhance the performance of multi-loop and multivariable control systems
4. Ability to design multi-loop controller for various applications

Program Outcomes (POs):

a.Ability to apply knowledge from undergraduate engineering and other disciplines to identify, formulate, solve, novel advanced instrumentation engineering along with process and automation problems that require advanced knowledge within the field

b.Ability to comprehend and incorporate latest knowledge within the field

e.Ability to exhibit the skills to use contemporary engineering tools, software and equipment to analyze problems

Unit I

Process Dynamics & Control Actions

Need for process control – Hierarchical decomposition of control functions - Continuous and batch processes – P&I Diagram - Self regulation - Interacting and non-interacting systems - Mathematical model of Level, Flow and Thermal processes – Lumped and Distributed parameter models – Linearization of nonlinear systems - Characteristic of ON-OFF, P, P+I, P+D and P+I+D control modes – Digital PID algorithm – Auto/manual transfer - Reset windup – Practical forms of PID Controller

9 Hours

Unit II

PID Controller Tuning – Single Loop Regulatory Control

Evaluation criteria – IAE, ISE, ITAE and ¼ decay ratio – Tuning: - Process reaction curve method: Z-N and Cohen-Coon methods, Continuous cycling method and damped oscillation method – optimization methods – Auto tuning

9 Hours

Unit III

Enhancement to Single Loop Regulatory Control & Model Based Control Schemes

Cascade control – Split-range - Feed-forward control – Ratio control – Inferential control –– override control - Smith predictor control scheme - Internal Model Controller - IMC PID controller – Single Loop Dynamic Matrix Control – Generalized Predictive Control

9 Hours

Unit IV

Multivariable Systems & Multi-Loop Regulatory Control

Multivariable Systems – Transfer Matrix Representation – Poles and Zeros of MIMO System - Multivariable frequency response analysis - Directions in multivariable systems - Singular value decomposition - Multi-loop Control - Introduction – Process Interaction – Pairing of Inputs and Outputs -The Relative Gain Array (RGA) – Properties and Application of RGA - Multi-loop PID Controller – Biggest Log Modulus Tuning Method - Decoupling Control

9 Hours

Unit V

Multivariable Regulatory Control & Case –Studies

Introduction to Multivariable control – Multivariable PID Controller –Multivariable IMC – Multivariable Dynamic Matrix Controller – Multiple Model based Predictive Controller –Predictive PID Control – Case Study: Distillation Column, CSTR, Bioreactor, Four-tank system, pH, and polymerization reactor

9 Hours

Total: 45 Hours

Reference(s)

1. B.Wayne Bequette, *Process Control: Modeling, Design, and Simulation*, Prentice Hall of India, 2004.
2. Dale E. Seborg , Duncan A. Mellichamp , Thomas F. Edgar, and Francis J. Doyle, III *Process Dynamics and Control*, John Wiley and Sons, 3rd Edition, 2010.
3. Jose A. Romagnoli and AhmetPalazoglu , *Introduction to Process Control*, CRC Press, Taylor and Francis Group, Second Edition, First Indian Reprint, 2010.
4. Coleman Brosilow and Babu Joseph, *Techniques of Model-based Control*, Prentice Hall International Series, PTR, New Jersey, 2001.

14IE13 LINEAR AND NON-LINEAR SYSTEMS THEORY

3 0 0 3

Course objectives (COs):

- To develop the skills needed to represent the system in state space form
- To impart knowledge required to design state feedback controller and state estimator
- To impart knowledge and skills needed to classify singular points and construct phase trajectory using delta and isocline methods
- To make the students understand the concepts of stability and introduce techniques to assess the stability of certain class of non-linear system
- To make the students understand the various non-linear behaviours such as Limit cycles, input multiplicity and output multiplicity, Bifurcation and Chaos

Course Outcomes (COCs):

1. Ability to represent the time-invariant systems in state space form as well as to analyze, whether the system is stabilizable, controllable, observable and detectable
2. Ability to design state feedback controller and state estimator
3. Ability to classify singular points and construct phase trajectory using delta and isocline methods
4. Ability to use the techniques such as describing function, Lyapunov Stability, Popov's Stability Criterion and Circle Criterion to assess the stability of certain class of non-linear system
5. Ability to describe non-linear behaviours such as Limit cycles, input multiplicity and output multiplicity, Bifurcation and Chaos

Programme Outcomes (POs):

a. Ability to apply knowledge from undergraduate engineering and other disciplines to identify, formulate, solve, novel advanced instrumentation engineering along with process and automation problems that require advanced knowledge within the field
b. Ability to comprehend and incorporate latest knowledge within the field
f. Ability to plan, conduct an organized and systematic study on significant research topic within the field

Unit I

State Space Approach

Review of state model for systems – Non uniqueness of state model – Role of Eigen values and Eigen vectors - State transition matrix and its properties – free and forced responses – State Diagrams - minimal realization – balanced realization

9 Hours

Unit II
State Feedback Control and State Estimator
Controllability and observability – Stabilizability and Detectability – Kalman Decomposition –State Feedback – Pole placement technique – Full order and reduced order observers

9 Hours

Unit III
Non-Linear Systems
Types of Non-Linearity – Typical Examples – Singular Points – Phase plane analysis (analytical and graphical methods) – Limit cycles – Equivalent Linearization – Describing Function – Analysis, Derivation of describing functions for different non-linear elements

9 Hours

Unit IV
Stability of Non-Linear Systems
Stability concepts – Equilibrium points – BIBO and Asymptotic stability – Stability Analysis by DF method – Lyapunov Stability Criteria – Krasovskil'smethod – Variable Gradient Method – Popov's Stability Criterion – Circle Criterion

9 Hours

Unit V
Non-Linear Systems Analysis
Bifurcation behaviour of Single ODE Systems: - Motivation, Illustration of Bifurcation behaviour and types of bifurcations - Bifurcation behaviour of two-state systems: - Dimensional bifurcations in the phase-plane, Limit cycle behaviour and Hoof Bifurcation - Introduction to Chaos: The Lorenz Equations, Stability analysis of the Lorenz Equations, Numerical study of the Lorenz Equations, Chaos in chemical systems and other issues in Chaos

9 Hours
Total: 45 Hours

Reference(s)

1. K.Ogata, *Modern Control Engineering*, Prentice Hall, Fifth Edition, 2012.
2. M.Gopal, *Digital Control and State Variable Methods: Conventional and Intelligent Control Systems*, Third Edition, Tata Mc-Graw Hill, 2009.
3. B.W.Bequette, Process *Control: Modeling, Design and Simulation*, Prentice Hall International series in Physical and Chemical Engineering Sciences, 2003.

14IE14 INDUSTRIAL DATA NETWORKS

3 0 0 3

Course Objectives (COs):

- To give an overview of the Industrial data communications systems
- To provide a fundamental understanding of common principles, various standards, protocols
- To provide insight into some of the new principles those are evolving for future networks

Course Outcomes (COCs):

1. Ability to develop the most appropriate technologies and standards for a given application
2. Ability to design and ensure the best practice, which is followed in installing and commissioning the data communications links to ensure they run fault-free

Program Outcomes (POs):

a. Ability to apply knowledge from undergraduate engineering and other disciplines to identify, formulate, solve, novel advanced instrumentation engineering along with process and automation problems that require advanced knowledge within the field

d. Ability to understand and design advanced instrumentation systems and conduct experiments, analyze and interpret data

Unit I
Data Network Fundamentals
EIA 232 interface standard – EIA 485 interface standard – EIA 422 interface standard – Serial interface converters – ISO/OSI Reference(s) model – Data link control protocol – Media access protocol:- Command/response, Token passing and CSMA/CD - TCP/IP – Bridges – Routers – Gateways –Standard ETHERNET Configuration

9 Hours

Unit II
PLC, PLC Programming & SCADA
Evolution of PLCs – Programmable Controllers – Architecture – Comparative study of Industrial PLCs – PLC Programming: Ladder logic, Functional block programming, Sequential function chart, Instruction list and structured text programming

SCADA: Remote terminal units, Master station, Communication architectures and Open SCADA protocols

9 Hours

Unit III
Distributed Control System & HART
Evolution – Different architectures – Local control unit –Operator Interface – Displays –Engineering interface – Study of any one DCS available in market – Factors to be considered in selecting DCS – Case studies in DCS. Introduction– Evolution of signal standard – HART communication protocol – Communication modes – HART Networks – HART commands – HART applications – MODBUS protocol structure – Function codes – Troubleshooting

9 Hours

Unit IV
Fieldbus and Profibus
Fieldbus: Introduction, General Fieldbus architecture, Basic requirements of Fieldbus standard, Fieldbus topology, Interoperability and Interchangeability ProfiBus:- Introduction, ProfiBus protocol stack, ProfiBus communication model, Communication objects, System operation and Troubleshooting – Foundation field bus versus ProfiBus

9 Hours

Unit V
AS – Interface (AS-I), Device net and Industrial Ethernet
AS interface: Introduction, Physical layer, Data link layer and Operating characteristics. Device net:- Introduction, Physical layer, Data link layer and Application layer. Industrial Ethernet: - Introduction, 10Mbps Ethernet and 100Mbps Ethernet - Introduction to OLE for process control

9 Hours
Total: 45 Hours

Reference(s)

1. T.A. Hughes, *Programmable Logic Controllers: Resources for Measurements and Control Series*, Third edition, ISA Press, 2004.
2. R.Bowden, *HARTApplication Guide*, HART Communication Foundation, 1999.
3. G.K.McMillan, *Process/Industrial Instrument and Controls Handbook*, Fifth Edition, McGraw-Hill handbook, New York, 1999.
4. J.Berge, *Field Buses for Process Control: Engineering, Operation, and Maintenance*, ISA Press, 2004.
5. S.Mackay, E.Wright, D.Reynders, and J.Park, *Practical Industrial Data Networks: Design, Installation and Troubleshooting*, Newnes Publication, Elsevier, 2004.
6. W.Buchanan, *Computer Busses: Design and Application*, CRC Press, 2000.
7. F.D.Petruzella, *Programmable Logic Controllers*, Third Edition, Tata McGraw-Hill, 2010.
8. G.Clarke, D.Reynders and E.Wright, *Practical Modern SCADA Protocols: DNP3, IEC 60870.5 and Related Systems*, Newness, First Edition, 2004.

14IE15TRANSDUCERS AND SMART INSTRUMENTS

3 0 0 3

Course Objectives (COs):

- To give a detailed knowledge on transducer characteristics and uncertainties measurement.
- To provide a detailed knowledge on error and determination of uncertainties in Measurement.
- To give a comprehensive knowledge on smart sensor Design, Development and Challenges.
- To give exposure to manufacturing techniques and different types of Micro Sensors and actuators.
- To give an overview of latest advancement and trend in transducer systems.

Course Outcomes (COCs):

1. Ability to understand the characteristics of a conventional transducer
2. Ability to analyze and quantify the uncertainties in measurement data
3. Ability to attain the capability to design and develop customized smart sensors
4. Ability to acquire a comprehensive knowledge of manufacturing techniques and design aspects of micro sensors and actuators
5. Ability to get the exposure about latest sensor technology and advanced measurement methodologies

Programme Outcomes (POs):

b. Ability to comprehend and incorporate latest knowledge within the field
d. Ability to understand and design advanced instrumentation systems and conduct experiments, analyze and interpret data
f. Ability to plan, conduct an organized and systematic study on significant research topic within the field

Unit I
Overview of conventional transducers and its characteristics
Overview of conventional sensors - Resistive, Capacitive, Inductive, Piezoelectric, Magneto strictive and Hall effect sensors - Static and Dynamic Characteristics and specifications

9 Hours

Unit II
Measurement error and uncertainty analysis
Importance of error analysis - Uncertainties, precision and accuracy in measurement -Random errors - Distributions, mean, width and standard error - Uncertainty as probability - Gaussian and Poisson probability distribution functions, confidence limits, error bars, and central limit theorem - Error propagation - single and multi-variable functions, propagating error in functions - Data visualization and reduction - Least square fitting of complex functions

9 Hours

Unit III
Smart sensors
Definition – Integrated smart sensors - Interface electronics - Design, sensing elements and parasitic effects, ADC, Accuracy and Dynamic range - Universal Sensor Interface –converters - front end circuits DAQ – Design - Digital conversion techniques - Microcontrollers and digital signal processors for smart sensors – selection - Timer, Analog comparator, ADC and DAC modules - Standards for smart sensor interface

9 Hours

Unit IV
Micro sensors and actuators
Micro system design and fabrication – Micro pressure sensors (Piezo resistive and Capacitive) – Resonant sensors – Acoustic wave sensors – Bio micro sensors – Micro actuators – Micro mechanical motors and pumps- Introduction to Nano sensors

9 Hours

Unit V
Recent trends in sensor technologies
Thick film and thin film sensors- Electro chemical sensors – RFIDs - Sensor arrays - Sensor network - Multisensor data fusion - Soft sensor

9 Hours
Total: 45 Hours

Reference(s)

1. Ernest O Doebelin and Dhanesh N Manik, *Measurement Systems Application and Design*, 5th Edition, Tata Mc-Graw Hill, 2011.
2. Ifan G. Hughes and Thomas P.A. Hase, *Measurements and their Uncertainties: A Practical Guide to Modern Error Analysis*, Oxford University Press, 2010.
3. Gerord C.M. Meijer, *Smart Sensor Systems*, John Wiley and Sons, 2008.
4. Tai-Ran Hsu, *Mems and Micro Systems: Design and Manufacture*, Tata McGraw Hill, 2002.
5. D. Patranabis, *Sensors and Transducers*, Second Edition, PHI, 2004.

14IE16VIRTUAL INSTRUMENTATION

3 0 1 4

Course Objectives (COs):

- To provide basic concepts in virtual instruments
- To know about the programming methods in software used in virtual instrumentation
- To familiarize the students with the applications of virtual instrumentation

Course Outcomes (COCs):

1. Ability to understand the basics concepts and programming in virtual instrumentation
2. Ability to apply virtual instrumentation tool set for a given problem
3. Ability to apply virtual instrumentation concept for a given application

Program Outcomes (POs):

c. Ability to apply highly developed technical knowledge in multiple contexts
e. Ability to exhibit the skills to use contemporary engineering tools, software and equipment to analyze problems
f. Ability to plan, conduct an organized and systematic study on significant research topic within the field

Unit I
Introduction
Virtual Instrumentation: Historical perspective - advantages - block diagram and architecture of a virtual instrument - Conventional Instruments versus Traditional Instruments - data-flow techniques, graphical programming in data flow, comparison with conventional programming

9 Hours

Unit II
VI Programming techniques
VIs and sub-VIs, loops and charts, arrays, clusters and graphs, case and sequence structures, formula nodes, local and global variables, State machine, string and file I/O

9 Hours

Unit III
Data acquisition
Introduction to latest ADCs, DACs. Introduction to PC based data acquisition - typical plug-in data acquisition board - multiplexing of analog inputs - single ended and differential inputs - different strategy for sampling of multi-channel analog inputs. Concept of universal DAQ card - use of timers/counters

9 Hours

Unit IV
VI Toolsets
Use of Analysis tools, Fourier transforms, power spectrum, correlation methods, windowing and filtering. Simulation of level, thermal, reactor processes. On-Off controller PID Controller

9 Hours

Unit V
Applications
DistributedI/O modules-Virtual Laboratory, Virtual Oscilloscope, Virtual function generator, Simulation of systems using VI, Development of Control system, Industrial Communication, Image acquisition and processing, Motion

control. Development of Virtual Instrument using GUI, Real-time systems, Embedded Controller, OPC, HMI / SCADA software, Active X programming

9 Hours

Laboratory Component

1. Creating Virtual Instrumentation for simple applications
2. Programming exercises for loops and charts
3. Programming exercises for clusters and graphs.
4. Programming exercises on case and sequence structures, file Input / Output.
5. Data acquisition through Virtual Instrumentation.
6. Developing voltmeter using DAQ cards.
7. Developing signal generator using DAQ cards.
8. Simulating reactor control using Virtual Instrumentation.
9. Real time temperature control using Virtual Instrumentation.
10. Real time sequential control of any batch process

Total: 45 + 15 Hours

Reference(s)

1. Robert H. Bishop,*LabVIEW 2009 Student Edition*, Pearson College Division, 2009.
2. N.Mathivanan, *PC-based Instrumentation: Concepts and Practice*, Eastern Economy Edition, PHI Learning private Ltd,2007.
3. Kevin James, *PC Interfacing and Data Acquisition: Techniques for Measurement, Instrumentation and Control*, Newness, 2000.
4. Jovitha Jerome, *Virtual Instrumentation Using Lab VIEW*, Eastern Economy Edition, PHI Learning private Ltd., 2010.

14IE17 MODELLING AND SIMULATION LABORTORY

0 0 3 2

Course Objectives (COs):

- To derive expressions that can be used to estimate parameters from different types of data, for different types of model structures
- To simulate complex control algorithm to solve the control system problems
- To understand the frequency-domain multivariable plant analysis
- To apply their understanding in a case of practical relevance
- To learn the variety of modern control techniques and their applicability

Course Outcomes (COCs):

1. Ability to simulate and deduce behaviour of a continuous time system by means of numerical integration
2. Ability to synthesize MATLAB code to simulate a given system or model
3. Ability to implement suitable artificial intelligence based controller for a given problem
4. Ability to deduce the mathematical model of a system using system identification technique

Programme Outcomes (POs):

b. Ability to comprehend and incorporate latest knowledge within the field
c. Ability to apply highly developed technical knowledge in multiple contexts
d. Ability to understand and design advanced instrumentation systems and conduct experiments, analyze and interpret data
e. Ability to exhibit the skills to use contemporary engineering tools, software and equipment to analyze problems

List of Experiments:

1. Simulation of analog and digital control using LabVIEW
2. Modelling and analysis of level process
3. Modelling and analysis of non-linear process
4. Modelling of simple process using system identification technique
5. Modelling and analysis of a inverted pendulum
6. Design of fuzzy logic controller
7. Design of artificial neural network controller
8. Design a full order and reduced order observer for specified pole locations
9. Design and testing of data logger
10. Development of software package for sizing orifice/ control valve / rotameter
11. Mini project

Total: 45 Hours

14IE21 ADVANCED PROCESS CONTROL

3 1 0 4

Course Objective (COs):

- To familiarize about the digital control systems and its stability analysis
- To impart knowledge about digital controller modes using various algorithms
- To get adequate knowledge about Programmable Logic Controllers

Course Outcomes (COCs):

1. Ability to enhance the knowledge about the digital control systems and to analyze the discrete data systems
2. Ability to design and implement digital controller modes using various algorithms
3. Ability to enhance the knowledge about the Programmable Logic Controllers

Program Outcomes (POs):

a. Ability to apply knowledge from undergraduate engineering and other disciplines to identify, formulate, solve, novel advanced instrumentation engineering along with process and automation problems that require advanced knowledge within the field
b. Ability to comprehend and incorporate latest knowledge within the field
e.Ability to exhibit the skills to use contemporary engineering tools, software and equipment to analyze problems
f. Ability to plan, conduct an organized and systematic study on significant research topic within the field

Unit I
Introduction
Introduction to Computer control system: Need for computer in a control system-Building blocks of a computer control system - Sequential control – Direct digital control – supervisory control

9 Hours

Unit II
Analysis of discrete data system
Representation and analysis of sampled data control systems: Z-transform and properties – inverse Z-transform - pulse transfer function - data holds-sampling theorems, aliasing – sampling frequency considerations - analysis of closed loop sampled data control systems – modified Z-transform and applications - stability analysis - multirate sampling

9 Hours

Unit III
Design of digital controller
Digital control algorithms: Design of control algorithm using Z-transform - deadbeat algorithm - Dahlin's method - ringing - Kalman's approach - discrete equivalent to an analog PID controller - design for set point and load changes. - position and velocity forms of PID controllers – tuning - selection of sampling time - algorithms incorporating anti-reset windup and bumpless transfer - Dead time compensation and Smith predictor algorithm

9 Hours

Unit IV
Programmable logic controller
Programmable Logic Controllers (PLCs): Basic components and configuration - discrete, analog and digital types of I/O modules: typical input and output field devices and modules of each type - I/O signal types and typical signal conditioning circuits - common electrical devices and symbols - intelligent I/O modules like control loop module - Communication I/O modules, network communication module - distributed I/O - AS-interface. Memory types used in PLCs - memory map - assigning I/O address and internal address - scan sequence

9 Hours

Unit V
Communication in PLC's & PLC application
Programming Languages: Ladder diagram - Boolean - function blocks - programming devices: hand-held programmer - industrial programming terminal - personal computer based programmer - development of programs for typical applications - editing and testing by simulation of programs. Basic design aspects of I/O systems - electrical, mechanical and environmental specifications. Installation and maintenance of PLCs. Interlocks and alarms: Interlock design principles, fail-safe design - alarms and their types. Case Study: Computer control of a thermal process

9 Hours
Total: 45 +15 Hours

Reference(s)

1. S.K. Singh, *Computer Aided Process Control*, Prentice Hall of India, 2003.
2. M. Chidambaram, *Computer Control of Processes*, Narosa Publications, 2003.
3. P.B.Deshpande and R.H. Ash, *Computer Process Control*, Second Edition, Instrument Society of America, 1988.
4. T.A. Hughes, *Programmable Controllers* ISA 2001, 3rd edition.
5. B.C.Kuo, *Digital Control Systems*, Holt, Rinehart and Winston Inc., 1980.
6. C.L. Smith, *Digital Computer Process Control*, Intext Educational Publishers, 1972.
7. M.Gopal, *Digital Control Engineering*, Wiley Eastern Publishers, 1989.
8. K.J.Astrom and B.Witten mark, *Computer- Controlled Systems*, Second Edition, Prentice-Hall of India, 1994.
9. D.R. Coughanowr, *Process Systems Analysis and Control*, Second Edition, McGraw Hill, 1991.

14IE22 APPLIED INDUSTRIAL INSTRUMENTATION

3 0 0 3

Course Objectives (COs):

- To enable the students to acquire knowledge about the various techniques used for the Measurement of primary industrial parameters like flow, level, temperature and pressure
- To understand the important parameters to be monitored and analyzed in Thermal power Plant
- To get an exposure on the important parameters to be monitored and analyzed in Petrochemical Industry

Course Outcomes (COCs):

1. Ability to apply the instrumentation concepts in thermal and petroleum industry
2. Ability to get knowledge about instrumentation in intrinsic safety techniques adapted in industries
3. Ability to understand the working principle of special purpose instruments

Programme Outcomes (POs):

b. Ability to comprehend and incorporate latest knowledge within the field

c. Ability to apply highly developed technical knowledge in multiple contexts
e. Ability to exhibit the skills to use contemporary engineering tools, software and equipment to analyze problems

Unit I
Review of industrial instrumentation
Overview of Measurement of Flow, level, Temperature and Pressure

9 Hours

Unit II
Measurement in thermal power plant (Boilers)
Selection and Installation of instruments used for the Measurement of fuel flow, Air flow, Drum level, Steam pressure, Steam temperature – Feed water quality measurement- Flue gas Oxygen Analyzers- Coal Analyzer

9 Hours

Unit III
Measurement in petroleum refinery
Parameters to be measured in petroleum industry: Flow, Level, Temperature and Pressure measurement in Distillation, Pyrolysis, catalytic cracking and reforming process-Hydrocarbon analyzers-oil in or on water-sulphur in oil Analyzer

9 Hours

Unit IV
Instrumentation for industrial safety
Electrical and Intrinsic Safety - Explosion Suppression and Deluge systems –Conservation and emergency vents - Flame, fire and smoke detectors - Leak Detectors - Metal Detectors

9 Hours

Unit V
Special purpose instrumentation
Detection of Nuclear Radiation – Corrosion monitoring – Fibre optic sensors-Instrumentation in weather stations – Instrumentation for NDT applications-Image processing technique for measurements

9 Hours
Total: 45 Hours

Reference(s)

1. B.G.Liptak, *Instrumentation Engineers Handbook (Process Measurement & Analysis)*, Fourth Edition, Chilton Book Co, 2003.
2. K.Krishnaswamy and M.Ponnibala, *Power Plant Instrumentation*, PHI Learning Pvt., Ltd, 2011.
3. John G Webster, *The Measurement, Instrumentation, and Sensors Handbook*, CRC and IEEE Press, 1999.
4. HavardDevold, *Oil and Gas Production Handbook - An Introduction to Oil and Gas Production*, ABB ATPA oil and gas, 2006.
5. M.Arumugam, *Optical Fibre Communication and Sensors*, Anuradha Agencies, 2002.
6. Paul E. Mix, *Introduction to Nondestructive Testing*, John Wiley and Sons, 2005

14IE23INSTRUMENTATION SYSTEM DESIGN

3 1 0 4

Course Objective (COs):

- To impart knowledge on the design of signal conditioning circuits for the measurement of Level, temperature and pH
- To develop the skills needed to design, fabricate and test Analog/ Digital PID controller, Data Loggers and Alarm Annunciator
- To make the students to familiarize in designing orifice and control valve sizing

Course Outcomes (COCs):

1. Ability to design signal conditioning circuits for temperature sensors, V/I and I/V converters
2. Ability to design and fabricate smart transmitters
3. Ability to design, fabricate and test PID controllers and alarm circuits
4. Ability to carry out orifice and control valve sizing for Liquid/Steam Services

Programme Outcomes (POs):

e. Ability to exhibit the skills to use contemporary engineering tools, software and equipment to analyze problems
f. Ability to plan, conduct an organized and systematic study on significant research topic within the field
j. Ability to develop confidence for self - education and lifelong learning

Unit I
Design of signal conditioning circuits
Design of V/I Converter and I/V Converter- Analog and Digital filter design and Adaptive filter design – Signal conditioning circuit for pH measurement, Air-purge Level Measurement – Signal conditioning circuit for Temperature measurement: Thermocouple, RTD and Thermistor - Cold Junction Compensation and Linearization – software and hardware approaches

9 Hours

Unit II
Design of transmitters
Study of 2 wire and 4 wire transmitters – Design of RTD based temperature transmitter, thermocouple based temperature transmitter, capacitance based level transmitter and Smart flow transmitters

9 Hours

Unit III
Design of data logger and PID controller
Design of ON / OFF Controller using Linear Integrated Circuits - Electronic PID Controller – Microcontroller based digital two-degree of freedom PID controller - Microcontroller based Data Logger – Design of PC based Data Acquisition Cards

9 Hours

Unit IV
Orifice and control valve sizing
Orifice, Venturi and flow nozzle Sizing: - Liquid, Gas and steam services – Control valve sizing – Liquid, Gas and steam services – Rotameter design

9 Hours

Unit V
Design of alarm and annunciation circuit
Alarm and Annunciation circuits using Analog and Digital Circuits – Design of Programmable Logic Controller - Design of configurable sequential controller using PLDs

9 Hours
Total: 45 + 15 Hours

Reference(s)

1. C. D. Johnson, *Process Control Instrumentation Technology*, Prentice Hall, 2006.
2. *Control Valve Handbook*, Emerson Process Management, Fisher Controls International, 2005.
3. R.W. Miller, *Flow Measurement Engineering Handbok*, Mc-Graw Hill, New York 1996.
4. Bela G. Liptak, *Instrument Engineers Handbook - Process Control and Optimization*,CRC Press, 2008

14IE27 ADVANCED PROCESS CONTROL LABORATORY

0 0 3 2

Course Objectives (COs):

- To obtain the mathematical models and to understand the characteristics of various controllers
- To get adequate knowledge about Programmable Logic Controllers and also various programming languages
- To understand the advanced control systems
- To attain knowledge about various drives
- To get awareness about calibration of transmitters
- To familiarize about analog and digital controllers

- To acquire knowledge about different communication protocols

Course Outcomes (COCs):

1. Ability to enhance knowledge about configuring advanced controller for given application
2. Ability to calibrate the transmitters used in industries
3. Ability to design and develop the analog and digital controllers
4. Ability to implement the different communication protocols for industrial applications

Programme Outcome (POs):

a) Ability to apply knowledge from undergraduate engineering and other disciplines to identify, formulate, solve, novel advanced instrumentation engineering along with process and automation problems that require advanced knowledge within the field
b) Ability to comprehend and incorporate latest knowledge within the field
e) Ability to exhibit the skills to use contemporary engineering tools, software and equipment to analyze problems
f) Ability to plan, conduct an organized and systematic study on significant research topic within the field

List of Experiments:

1. Analysis of control system hierarchy (ON-OFF, single loop PID controller and Hybrid control System)
2. Control of real time processes using programmable logic controller
3. Configuration of Human machine interface and SCADA for a given application
4. Implementation of continuous control using DCS
5. Configuration of Variable Frequency Drive
6. Configuration of Servo Drive
7. Calibration of flow and level transmitter
8. Design and Testing of Alarm Annunciation Circuits for a thermal process.
9. Design and Testing of PID Controllers (Analog / Digital)
10. Industrial networking
11. Mini project

Total: 45 Hours

14IE28 TECHNICAL SEMINAR

0 0 1 1

Course Objectives (COs):

- To develop the reading and understanding skill
- To improve communication and presentation skill of students

Course Outcomes (COCs):

1. Able to select the method, analysis and optimize the given problem for the given field applications

Programme Outcomes (POs):

c. Ability to apply highly developed technical knowledge in multiple contexts
h. Ability to communicate professionally
i. Ability to become familiar about modern developments
f. Ability to plan, conduct an organized and systematic study on significant research topic within the field

14IE31 Project Work Phase I

0 0 0 6

Course Objectives (COs):

- To apply basic and fundamental knowledge form instrumentation and control system for the given application
- To identify and analyze the evolution of the problem from the earlier research work

Course Outcomes (COCs):

1. Ability to carry out literature survey in their respective research area
2. To identify the drawbacks from the earlier research work and to propose solution
3. To identify tools and techniques to solve the identified problem
4. Able to write papers, articles for the identified problems and solution

Programme Outcomes (POs):

a. Ability to apply knowledge from undergraduate engineering and other disciplines to identify, formulate, solve, novel advanced instrumentation engineering along with process and automation problems that require advanced knowledge within the field
b. Ability to comprehend and incorporate latest knowledge within the field
f.Ability to plan, conduct an organized and systematic study on significant research topic within the field
g. Ability to express their technical knowledge through formal written reports which satisfy established standards of writing style
j. Ability to develop confidence for self-education and lifelong learning

14IE41 Project Work Phase II

0 0 0 12

Course Objectives (COs):

- To develop the simulation for the given application using modern software tools
- To Infer the information from simulation / literature survey for the given application
- To develop prototype / working model for identified solution

Course Outcomes (COCs):

1. Ability toidentify solution for the identified problem using modern tools and techniques
2. Ability to develop prototype / working model for the identified problem
3. Ability to write reports/research papers for conferences and journals and to publish patents

Programme Outcomes (POs):

a. Ability to apply knowledge from undergraduate engineering and other disciplines to identify, formulate, solve, novel advanced instrumentation engineering along with process and automation problems that require advanced knowledge within the field
b. Ability to comprehend and incorporate latest knowledge within the field
f.Ability to plan, conduct an organized and systematic study on significant research topic within the field
g. Ability to express their technical knowledge through formal written reports which satisfy established standards of writing style

j. Ability to develop confidence for self-education and lifelong learning

14IE51 OPTIMAL CONTROL

3 0 0 3

Course Objective (COs):

- To realize the concepts of optimality and its control
- To develop a vast knowledge about dynamic programming and its principles
- To develop technical concise about various regulator problems
- To understand the concept of dynamic programming and it's methods

Course Outcomes (CLOs):

1. Ability to understand the principles and mathematical concepts involved in optimal control
2. Ability to acquire the skill of selecting appropriate parameter for the chosen optimal control configuration

Program Outcome(s):

a) Ability to apply knowledge from undergraduate engineering and other disciplines to identify, formulate, solve, novel advanced instrumentation engineering along with process and automation problems that require advanced knowledge within the field
d) Ability to understand and design advanced instrumentation systems and conduct experiments, analyze and interpret data
e) Ability to exhibit the skills to use contemporary engineering tools, software and equipment to analyze problems

Unit I
Calculus of Variations and Optimal Control
Introduction – Performance Index- Constraints – Formal statement of optimal control system – Calculus of variations – Function, Functional, Increment, Differential and variation and optimum of function and functional – The basic variational problem Extrema of functions and functionals with conditions – variational approach to optimal control system

9 Hours

Unit II
Linear Quadratic Optimal Control System
Problem formulation – Finite time Linear Quadratic regulator – Infinite time LQR system: Time Varying case- Time-invariant case – Stability issues of Time-invariant regulator – Linear Quadratic Tracking system: Fine time case and Infinite time case

9 Hours

Unit III
Discrete Time Optimal Control Systems
Variational calculus for Discrete time systems – Discrete time optimal control systems:- Fixed-final state and open-loop optimal control and Free-final state and open-loop optimal control - Discrete time linear state regulator system – Steady state regulator system

9 Hours

Unit IV
Pontryagin Minimum Principle
Pontryagin Minimum Principle – Dynamic Programming:- Principle of optimality, optimal control using Dynamic Programming – Optimal Control of Continuous time and Discrete-time systems – Hamilton-Jacobi-Bellman Equation – LQR system using H-J-B equation

9 Hours

Unit V
Constrained Optimal Control Systems
Time optimal control systems – Fuel Optimal Control Systems- Energy Optimal Control Systems – Optimal Control systems with state constraints

9 Hours
Total: 45 Hours

Reference(s)

1. Donald E. Kirk, *Optimal Control Theory: An Introduction*, Dover Publications, 2012.
2. DesineniSubbaram Naidu, *Optimal Control Systems*, CRC Press, 2002.
3. Frank L. Lewis, DragunaVrabie, Vassilis L. Syrmos, *Optimal Control*, John Wiley and Sons, 2012.

14IE52 SYSTEM IDENTIFICATION AND ADAPTIVE CONTROL

3 0 0 3

Course objectives (COs):

1. To impart knowledge on how to estimate the parameters of input –output models (ARX/ARMAX etc) using various estimation methods
2. To make the student understand the principles of adaptive control schemes like STR, MRAC and Gain scheduling
3. To make the student to design simple adaptive controllers for linear systems using above methods

Course Outcomes (COCs):

1. Ability to design simple adaptive controllers for linear and non-linear systems
2. Ability to identify, formulate, analyze the implementation of adaptive controllers
3. Ability to develop various models from the experimental data
4. Ability to select a suitable model and parameter estimation algorithm for the identification of systems

Programme Outcomes (POs):

a. Ability to apply knowledge from undergraduate engineering and other disciplines to identify, formulate, solve, novel advanced instrumentation engineering along with process and automation problems that require advanced knowledge within the field
c. Ability to apply highly developed technical knowledge in multiple contexts
f. Ability to plan, conduct an organized and systematic study on significant research topic within the field
i. Ability to become familiar about modern developments

Unit I
Non - Parametric System Identification
System Identification-motivation and overview - Non-parametric methods: Impulse response, step response and Frequency response methods, correlation and spectral analysis methods

9 Hours

Unit II
Parameter Estimation Methods
Parametric model structures - ARX, ARMAX, OE, BJ models - Linear regression - Least square estimates, statistical properties of LS Estimates. Weighted least squares, maximum likelihood estimation, Prediction error methods, Instrumental variable methods, Recursive Least square method- Exercises using system identification toolbox

9 Hours

Unit III
Practical aspects of Identification
Experimental design – Input design for open loop experiments, identification in closed loop: Identifiability, approaches to closed loop identification, optimal experimental design for higher order black box models, choice of sampling interval and pre sampling filters - robustness – Model validation and Model structure determination - Case studies. Introduction to Non-linear System Identification

9 Hours

Unit IV
Adaptive Control Schemes
Introduction – Adaptive Schemes – auto tuning - types of adaptive control - gain scheduling controller - model Reference(s) adaptive control schemes – self tuning controller. MRAC and STC approaches: The Gradient approach – Lyapunov functions – Passivity theory – Pole placement method - Minimum variance control – Stochastic control - Predictive control

9 Hours

Unit V

Practical Issues and Implementation

Adaptive controller implementation- controller design, estimator implementation, square root algorithms, interaction of estimation and control, prototype algorithms, operational issues- Stability – Convergence – Robustness – Case studies: Adaptive linear/non-linear system identification - CSTR, Distillation Coloumn, Thermal Cracker, Desalination Plant

9 Hours

Total: 45 Hours

Reference(s)

1. Karel J. Keesman, *System Identification an Introduction*, Springer, 2011.
2. LennartLjung, *System Identification: Theory for the User*, Second Edition, Prentice Hall, 2008.
3. Tao Liu, FurongGao, *Industrial Process Identification and control design, Step-test and relay-experiment-based methods*, Springer- Verilog London Ltd, 2012.
4. B.Roffel, B.H.L.Betlem, *Advanced Practical Process Control*, Springer-verlog Berlin Heidelberg, 2004.
5. K.J. Astrom and B. J. Wittenmark, *Adaptive Control*, Second Edition, Pearson Education Inc., 1995.
6. T. Soderstorm and PetreStoica, *System Identification*, Prentice Hall International (UK) Ltd., 1989.
7. N.Mathivanan, *PC-based Instrumentation Concepts and Practice*, Eastern Economy Edition, PHI Learning private ltd ,2009

14IE53 FAULT TOLERANCE CONTROL

3 0 0 3

Course Objective (COs):

- To understand the fault detection and isolation of industrial processes and systems, additionally to fault-tolerant control with a special emphasis to model based techniques
- To review the basic concept of fault detection systems
- To understand the concept of fault diagnosis systems

Course Outcomes (COCs):

1. Ability to design fault tolerant controllers for given processes
2. Ability to select appropriate fault detection method for the given system
3. Ability to implement fault-tolerant control systems for a simple industrial process

Program Outcomes (POs):

a. Ability to apply knowledge from undergraduate engineering and other disciplines to identify, formulate, solve, novel advanced instrumentation engineering along with process and automation problems that require advanced knowledge within the field

d. Ability to understand and design advanced instrumentation systems and conduct experiments, analyze and interpret data

e. Ability to exhibit the skills to use contemporary engineering tools, software and equipment to analyze problems

Unit I

Introduction & Analytical Redundancy Concepts

Introduction - Types of faults and different tasks of Fault Diagnosis and Implementation - Different approaches to FDD: Model free and Model based approaches-Introduction- Mathematical representation of Faults and Disturbances: Additive and Multiplicative types – Residual Generation: Detection, Isolation, Computational and stability properties – Design of Residual generator – Residual specification and Implementation

9 Hours

Unit II

Design of Structured Residuals & Directional Structured Residuals

Introduction- Residual structure of single fault Isolation: Structural and Canonical structures- Residual structure of multiple fault Isolation: Diagonal and Full Row canonical concepts – Introduction to parity equation implementation and alternative representation - Directional Specifications: Directional specification with and without disturbances – Parity Equation Implementation

9 Hours

Unit III
Fault Diagnosis Using State Estimators
Introduction – State Observer – State Estimators – Norms based residual evaluation and threshold computation - Statistical methods based residual evaluation and threshold settings: Generalized Likelihood Ratio Approach – Marginalized Likelihood Ratio Approach

9 Hours

Unit IV
Fault Tolerant Control
Introduction – Passive Fault-tolerant Control- Active Fault tolerant Control - Actuator and Sensor Fault tolerance Principles: - Compensation for actuator – Sensor Fault-tolerant Control Design – Fault-tolerant Control Architecture - Fault-tolerant Control design against major actuator failures

9 Hours

Unit V
Case Studies
Fault tolerant Control of Three-tank System – Diagnosis and Fault-tolerant control of chemical process – supervision of steam generator – Different types of faults in Control valves – Automatic detection, quantification and compensation of valve stiction

9 Hours
Total: 45 Hours

Reference(s)

1. Steven X. Ding, *Model based Fault Diagnosis Techniques: Schemes, Algorithms, and Tools*, Springer Publication, 2008.
2. Rolf Isermann, *Fault-Diagnosis Systems an Introduction from Fault Detection to Fault Tolerance*, Springer Verlag, 2006.
3. Hassan Noura, Didier Theilliol, Jean-Christophe Ponsart, Abbas Chamseddine, *Fault-Tolerant Control Systems: Design and Practical Applications*, Springer Publication, 2009.
4. MogensBlanke, *Diagnosis and Fault-Tolerant Control*, Springer, 2003.
5. Ali AhammadShoukat Choudhury, Sirish L. Shah, Nina F. Thornhill, *Diagnosis of Process Nonlinearities and Valve Stiction: Data Driven Approaches*, Springer, 2008.
6. Janos J. Gertler, *Fault Detection and Diagnosis in Engineering systems* –2nd Edition, Marcel Dekker, 1998.

14IE54MICRO ELECTRO MECHANICAL SYSTEM

3 0 0 3

Course Objective (COs):

- To acquire knowledge about fabrication process in MEMS
- To know about various etching techniques in micromachining
- To have knowledge about applications in micromachining techniques

Course Outcomes (COCs):

1. Able to understand the concepts of fabrication methods and materials used in MEMS
2. Ability to identify the application of MEMS in sensing and actuating process
3. Able to understand the usage of polymer and Optical in MEMS

Program Outcomes (POs):

a. Ability to apply knowledge from undergraduate engineering and other disciplines to identify, formulate, solve, novel advanced instrumentation engineering along with process and automation problems that require advanced knowledge within the field.
b. Ability to comprehend and incorporate latest knowledge within the field
f. Ability to plan, conduct an organized and systematic study on significant research topic within the field

Unit I
Introduction

Intrinsic Characteristics of MEMS - Energy Domains and Transducers - Sensors and Actuators - Introduction to Micro fabrication - Silicon based MEMS processes - New Materials - Review of Electrical and Mechanical concepts in MEMS - Stress and strain analysis - Flexural beam bending - Torsional deflection

9Hours

Unit II
Sensors and Actuators-I
Electrostatic sensors - Parallel plate capacitors - Applications - Interdigitated Finger capacitor - Comb drive devices - Thermal Sensing and Actuation - Thermal expansion - Thermal couples - Thermal resistors - Applications - Magnetic Actuators - Micromagnetic components - Case studies of MEMS in magnetic actuators

9 Hours

Unit III
Sensors and Actuators-II
Piezoresistive sensors - Piezoresistive sensor materials - Stress analysis of mechanical elements – Applications to Inertia, Pressure, Tactile and Flow sensors

Piezoelectric sensors and actuators - piezoelectric effects - piezoelectric materials - Applications to Inertia, Acoustic, Tactile and Flow sensors – micropumps

9 Hours

Unit IV
Micromachining
Silicon anisotropic etching - Anisotrophic wet etching - Dry etching of silicon - Plasma etching – Deep Reaction Ion Etching (DRIE) - Isotropic wet etching - Gas phase etchants - Case studies: Basic surface micromachining processes - Structural and sacrificial materials - Acceleration of sacrificial etch - Striction and antistriction methods - Assembly of 3D MEMS - Foundry process

9 Hours

Unit V
Polymer and Optical MEMS
Polymers in MEMS - Polyimide - SU-8 - Liquid Crystal Polymer (LCP) - PDMS - PMMA - Parylene - Fluorocarbon - Application to Acceleration, Pressure, Flow and Tactile sensors - Optical MEMS - Lenses and Mirrors - Actuators for Active Optical MEMS

9 Hours
Total: 45 Hours

Reference(s)

1. Chang Liu, *Foundations of MEMS*, Pearson Education Inc., 2011
2. James J.Allen, *Micro Electro Mechanical System Design*, CRC Press published in 2005
3. NadimMaluf, *An Introduction to Micro Electro Mechanical System Design*, Artech House, 2004
4. Mohamed Gad-el-Hak, *The MEMS Handbook*, CRC press Baco Raton, 2005
5. Tai Ran Hsu, *MEMS & Micro systems Design and Manufacture*, Tata McGraw Hill, New Delhi, 2008
6. Julian W. Gardner, Vijay K. Varadan and Osama O.Awadelkarim, *Micro Sensors MEMS and Smart Devices*, John Wiley & son LTD, 2002

14IE55POWER PLANT INSTRUMENTATION

3 0 0 3

Course Objectives (COs):

- To gain knowledge on the operation of various conventional power plants & also on the different types of controls being used in boilers
- To acquire knowledge in solar radiation measurements, solar photovoltaic systems and applications of solar energy
- To understand the prospective ideas about wind energy conversion systems and biomass conversion technologies
- To extend the views in the analysis of Geothermal resources, Ocean energy and additional alternate energy resources

Course Outcomes (COCs):

1. Ability to know the overview of all power generation plant
2. Ability to select the instrumentation system for power plant
3. Ability to design control loops for power plant

Program Outcomes (POs):

b. Ability to comprehend and incorporate latest knowledge within the field
c. Ability to apply highly developed technical knowledge in multiple contexts
f. Ability to plan, conduct an organized and systematic study on significant research topic within the field

Unit I
Overview of conventional power generation and Control loops in boiler
Brief survey of methods of power generation – Thermal Power plant, Hydro-Electric Power plant, Nuclear Power plant and Cogeneration – Control system diagramming – P&I diagram of boiler – Control loops in boiler – Combustion control – Measurement of furnace draft – Drum level control – Main steam and reheat steam temperature control – Deaerator – Combustion air flow control.

9 Hours

Unit II
Solar Energy
Solar radiation – Solar radiation measurements, Estimation of average solar radiation, Solar radiation on tilted surfaces – Solar energy collectors – Solar photovoltaic systems – Solar cell characteristics, Solar cell classification, construction of PV module, panel and array, MPPT, Classification of PV systems – Applications of solar energy – Solar water heaters, Solar thermal electric conversion, Solar PV power generation, Solar cooking.

9 Hours

Unit III
Wind and Biomass Energy
Wind Energy – Origin of winds, nature of winds, site selection considerations, wind turbine aerodynamics, basic components of a wind energy conversion system, wind turbine types and their construction, design consideration of horizontal axis type wind turbine, schemes for electrical energy generation (CSCF, VSCF, VSVF), environmental aspects
Biomass energy – Biomass resources, Biomass conversion technologies, Biomass gasification, Constant pressure type and constant volume type biogas plants.

9 Hours

Unit IV
Geothermal and Ocean Energy
Geothermal energy – Types of Geothermal resources, analysis of geothermal resources, environmental consideration. Ocean energy – Tidal energy – Conversion scheme, Estimation of power – Wave energy – Power in waves, wave energy technology – Ocean Thermal Energy Conversion (OTEC) schemes – Claude cycle, Anderson cycle, Hybrid cycle, Environmental impacts

9 Hours

Unit V
Additional Alternate Energy Resources
Magneto Hydro Dynamic (MHD) power generation – Principles, MHD systems, Voltage and power output of MHD generator, Materials for MHD generator. Thermoelectric power generation – Basic principles, Thermoelectric power generator and its performance analysis, Selection of materials. Thermionic power generation – Principle, Thermionic generator and its performance analysis

9 Hours
Total: 45 Hours

Reference(s)

1. G.D.Rai, *Non-Conventional Energy Resources*, 5th Edition, Khanna Publishers, 2011.
2. B.H. Khan, *Non-Conventional Energy Resources*, 11th Edition, Tata McGraw Hill, New Delhi, 2012.
3. G.F. Gilman, *Boiler Control Systems Engineering*, 2005, ISA Publication.
4. E.Al. Wakil, *Power Plant Engineering*, Tata McGraw Hill, 1984.

14IE56 BIOMEDICAL SIGNAL PROCESSING

3 0 0 3

Course Objectives (COs):

- To understand the application of signal processing methods in biomedical systems
- To demonstrate how to use a computer workstation as part of a measurement/signal- processing system
- To understand how to measure various biochemical and nonelectrical parameters of human system

Course Outcomes (COCs):

1. Ability to learn the usage of signal processing methods to analyze signals originating in biomedical systems
2. Ability to understand the concept of signal filtering
3. Ability to develop substantial computer programs (using MATLAB) to model biomedical systems

Programme Outcomes (POs):

b. Ability to comprehend and incorporate latest knowledge within the field
f. Ability to plan, conduct an organized and systematic study on significant research topic within the field
i. Ability to become familiar about modern developments

Unit I
Introduction to Signals
Sources of biomedical signals, types of signals – Deterministic, stochastic, fractal and chaotic, auto correlation, cross correlation, auto covariance, DFT, FFT algorithm – Digital filters – Introduction to FIR and IIR filter

9 Hours

Unit II
Classical Spectral Estimation Techniques
Periodogram, blackman – Tukey spectral estimation applications – Analysis of the doppler signal using the periodogram, analysis of Auditory Evoked Potentials (AEP) using periodogram, analysis of heart rate variability using the periodogramcepstrum analysis – Cepstra, power cepstrum, applications of cepstrum analysis – Analysis of the ECG signal using cepstrum technique, analysis of diastolic heart sound using cepstrum technique

9 Hours

Unit III
Adaptive Noise Cancellation
Introduction, principle of adaptive noise canceling, adaptive Noise cancellation with the LMS and RLS adaptation algorithm - applications – adaptive noise canceling method to enhance ECG monitoring, adaptive noise canceling method to enhance Fetal ECG monitoring, adaptive noise canceling method to enhance Electro gastric measurements

9 Hours

Unit IV
Parametric Modeling Methods
Autoregressive (AR) methods – Linear Prediction and Autoregressive methods, the autocorrelation (Yule - walker) methods, applications of AR methods AR modeling of seizure EEG, ECG signals and surface EMG. Autoregressive Moving Average (ARMA) method – MLE method, Akaike method, Durbin method, applications – ARMA modeling of somatosensory Evoked Potentials (SEPs), Diastolic Heart sounds and cutaneous Electro gastric signals

9 Hours

Unit V
Non-Linear Biosignal Processing and Wavelet Transform
Clustering methods – hard and fuzzy clustering, applications of Fuzzy clustering to Biomedical signal processing, Neural Networks (NN): Introduction – NN in processing and analysis of Biomedical signals wavelet transform – Introduction, Filter bank implementation of discrete wavelet transform, signal de-noising using wavelet transform, wavelet based compression

9 Hours
Total: 45 Hours

Reference(s)

1. M.Akay, *Biomedical Signal Processing*, Academic Press, San Diego, 2001.
2. M.Akay, *Nonlinear Biomedical Signal Processing*, Fuzzy Logic, Neural Networks and New Algorithms, vol.1, IEEE Press Series on Biomedical Engineering, New York, 2000.
3. Eugene N.Bruce, *Biomedical Signal Processing and Signal Modeling*, John Wiley & Sons, First Edition, 2007.

14IE57 INDUSTRIAL DRIVES AND CONTROL

3 0 0 3

Course Objectives (COs):

- To introduce the different types of drives and applications in various industries
- To know the characteristics of various motors and loads
- To gain the knowledge about operation of d.c motor speed control using converters and choppers
- To understand the modes of operation of a drive in various applications

Course Outcomes (COCs):

- Acquire the knowledge of different speed control methods in a.c motors
- Identify the use of drives in industries using Fuzzy logic and Artificial Neural Network
- Identify the need and choice for various drives

Program Outcomes (POs):

b. Ability to comprehend and incorporate latest knowledge within the field
c. Ability to apply highly developed technical knowledge in multiple contexts
i. Ability to become familiar about modern developments

Unit I
Introduction to Electric Drives

Motor - load system – Dynamics, load torque, steady state stability, Multi quadrant operations of drives. DC motors - speed reversal, speed control and breaking techniques, Characteristics of Induction motor and Synchronous motors - Dynamic and regenerative breaking ac drives

9 Hours

Unit II
Modelling of DC and AC Machines

Circuit model of Electric machines - Transfer function and state space models of series and separately excited DC motor - AC Machines – Dynamic modelling – Linear transformations - Equations in stator, rotor and synchronously rotating Reference(s) frames - Flux linkage equations - Dynamic state space model - Modelling of synchronous motor

9 Hours

Unit III
Control of DC Drives

Analysis of series and separately excited DC motor with single phase and three phase converters operating in different modes and configurations - Analysis of series and separately excited DC motor fed from different choppers - Two quadrant and four quadrant operation - Closed loop control of dc drives - Design of controllers

9 Hours

Unit IV
Control of AC Drives

Operation of induction motor with non-sinusoidal supply waveforms, Variable frequency operation of 3-phase induction motors, constant flux operation, current fed operations, constant torque operations, static rotor resistance control and slip power recovery scheme –Synchronous motor control, control of stepped motors, parameter sensitivity of ac drives

9 Hours

Unit V
Advanced Control of AC Drives
Principles of vector control – Direct and indirect vector control of induction motor – DTC - sensor less vector control - Speed estimation methods - Applications of Fuzzy logic and Artificial Neural Network for the control of AC drives

9 Hours
Total: 45 Hours

Reference(s)

1. G.K.Dubey, *Power Semiconductor Controlled Drives*, Prentice Hall International, New Jersey, 2001.
2. Paul.C.Krause, Olegwasynczuk and Scott D.Sudhoff, *Analysis of Electric Machinery and Drive Systems*, 2nd Edition, Wiley-IEEE Press, 2002.
3. Bimal K Bose, *Modern Power electronics and AC Drives*, Pearson education Asia, 2002.
4. R .Krishnan, *Electrical Motor Drives- Modelling, Analysis and Control*, Prentice Hall of India Pvt Ltd., 2nd Edition, 2003.

14IE58 ROBOTICS AND AUTOMATION

3 0 0 3

Course Objectives (COs):

- To understand the basic concepts of robots, their kinematics and trajectory planning
- To elaborate the modelling of robot dynamics using tools such as euler dynamic model andlagrangian formulation
- To give an overview of the various methods of control of robots, robotic applications, mobile robots and the related issues in industrial automation

Course Outcomes (COCs):

1. Ability to analyze the workspace and trajectory planning of robots
2. Ability to model the motion of Robots
3. Ability to develop application based Robots
4. Ability to formulate models for the control of mobile robots in various industrial applications

Program Outcomes (POs):

a. Ability to apply knowledge from undergraduate engineering and other disciplines to identify, formulate, solve, novel advanced instrumentation engineering along with process and automation problems that require advanced knowledge within the field
b. Ability to comprehend and incorporate latest knowledge within the field
c. Ability to apply highly developed technical knowledge in multiple contexts
e. Ability to exhibit the skills to use contemporary engineering tools, software and equipment to analyze problems
i. Ability to become familiar about modern developments

Unit I
Introduction and Robot Kinematics
Basic concepts of Robots and automation – classification – specifications – Application – Notation - Direct Kinematics - Co-ordinate frames – rotations - Homogeneous co-ordinates - The Arm equation - Kinematic analysis of a typical Robot - Inverse Kinematics - Tool configuration - Inverse kinematics of a typical Robot - Workspace analysis and trajectory planning - Work envelope of different robots - The pick and place operation

9 Hours

Unit II
Dynamic of Robots
Continuous path motion - interpolated motion - Straight line motion - Tool configuration Jacobian matrix and manipulator Jacobian - Manipulator Dynamics - Kinetic of potential energy - Energized forces - Lagrange's Equation - Euler Dynamic model

9 Hours

Unit III
Robot Control and Micro Robotics
The control problem - state equation - Single axis PID control - PD gravity control - Computed torque control - Variable structure control - Impedance control. Micro Robotics and MEMS - Fabrication technology for micro robotics, Stability issues in legged robots, under actuated manipulators

9 Hours

Unit IV
Robot Vision
Fundamentals of Robot applications - Robot vision – Image representation – Template – matching - polyhedral objects - Shape analysis - Segmentation – Iterative processing - Robot cell design - Types of applications - Material handling applications - Machine loading and unloading - Spot welding - Arc welding - Spray painting

9 Hours

Unit V
Mobile Robots and Control Issues
Industrial automation - General layout - General configuration of an automated flow line - Conveyor systems - Major features – Types - Roller, State wheel, Belt, Chain and overhead trolley - Inspection station with feedback loops to up steam workstations - Shop floor control - 3 Phases - Order scheduling **9 Hours**

Total: 45 Hours

Reference(s)

1. Saeed B. Niku, *An Introduction to Robotics- Analysis, Systems, Applications*, Second Edition, John Wiley & Sons Inc., 2010.
2. Thomas R. Kurfess, *Robotics and Automation Handbook*, CRC Press, 2004.
3. Robert Joseph Schilling, *Fundamentals of Robotics: Analysis and Control*, Prentice Hall of India Pvt. Ltd., 1990

14IE59 ROBUST CONTROL

3 0 0 3

Course Objectives (COs):
- To understand the concepts and techniques of multivariable robust control
- To acquire knowledge in H2 optimal control and estimation techniques
- To apply knowledge in H-infinity optimal control techniques
- To understand the concepts in LMI approach of H-infinity control

Course Outcomes (COCs):

1. Ability to understand the basic aspects of multivariable linear system theory and control, from both an input/output and a state space point of view
2. Ability to solve basic problem in multivariable linear system theory and multivariable control design
3. Ability to synthesis techniques for robust controllers
4. Ability to acquire awareness of the variety of modern control techniques and their applicability

Programme Outcomes (POs):

c. Ability to apply highly developed technical knowledge in multiple contexts
f. Ability to plan, conduct an organized and systematic study on significant research topic with in the field
i. Ability to become familiar about modern developments

Unit I
Introduction
Norms of vectors and Matrices – Norms of Systems – Calculation of operator Norms – Vector Random spaces - Specification for feedback systems – Co-prime factorization and Inner functions – Structured and unstructured uncertainty - Robustness

9 Hours

Unit II
H2 Optimal Control
Linear Quadratic Controllers – Characterization of H2 optimal controllers – H2 optimal estimation - KalmanBucy Filter – LQG Controller

9 Hours

Unit III
H-Infinity Optimal Control-Riccati Approach
Formulation – Characterization of H-infinity sub-optimal controllers by means of Riccati equations – H-infinity control with full information – H infinity estimation

9 Hours

Unit IV
H-Infinity Optimal Control- LMI Approach
Formulation – Characterization of H-infinity sub-optimal controllers by means of LMI Approach – Properties of H-infinity sub-optimal controllers – H-infinity synthesis with pole-placement constraints

9 Hours

Unit V
Synthesis of Robust Controllers and Case Studies
Synthesis of Robust Controllers – Small Gain Theorem – D-K –iteration- Control of Inverted Pendulum- Control of CSTR – Control of Aircraft – Robust Control of Second-order Plant- Robust Control of Distillation Column

9 Hours
Total: 45 Hours

Reference(s)

1. U. Mackenroth, *Robust Control Systems: Theory and Case Studies,* Springer International Edition, 2010.
2. J. B. Burl, *Linear optimal control H2 and H-infinity methods*, Addison W Wesley, 1998
3. D. Xue, Y.Q. Chen, D. P. Atherton, *Linear Feedback Control Analysis and Design with MATLAB, Advances In Design and Control*, Society for Industrial and Applied Mathematics, 2007.
4. I. R. Petersen, V.A. Ugrinovskii and A. V. Savkin, *Robust Control Design using H- infinity Methods*, Springer, 2000.
5. M. J. Grimble, *Robust Industrial Control Systems: Optimal Design Approach for Polynomial Systems*, John Wiley and Sons Ltd., Publication, 2006.

14IE60 RELIABILITY AND SAFETY ENGINEERING

3 0 0 3

Course Objectives (COs):

- To acquire in depth knowledge about the concept of reliability
- To gain knowledge on various reliability Improvement Methods
- To recognize techniques to maintain reliability in Industries
- To develop knowledge on risk assessment study
- To recognize and identify the safe operation of equipment in process industry

Course Outcomes (COCs):

1. Ability to understand the concepts of reliability
2. Ability to know various failure mode of any equipment and their effects
3. Ability to maintain reliability by reducing failure time in Industry to maintain safety and productivity
4. Ability to effectively conduct risk assessment study by applying reliability in hazardous industries

Programme Outcomes (POs):
f. Ability to plan, conduct an organized and systematic study on significant research topic within the field.
i. Ability to become familiar about modern developments
j. Ability to develop confidence for self-education and lifelong learning

Unit I
Reliability
Definition and basic concepts – Failure data – Failure modes– Reliability in terms of hazard rates and failure density function. Hazard models and 'bath-tub' curve. Applicability of Weibull distribution. Reliability calculation for series, parallel series and K-out of M systems

9 Hours

Unit II
Use of Redundancy and System Reliability Improvement Methods
Objectives – Types of maintenance – Preventive – Condition - based and reliability centered maintenance. Terotechnology – Total Productive Maintenance (TPM)

9 Hours

Unit III
Maintainability
Definition – basic concepts – relationship betweenreliability – maintainability and availability – corrective maintenance time distributions and maintainability demonstration. Design considerations for maintainability

9 Hours

Unit IV
Introduction to Life-Testing
Destructive and non-destructive tests – estimation of parameters for exponential and Weibull distributions – component reliability and MIL standards

9 Hours

Unit V
Safety
Causes of failure and unreliability – Measurement and prediction of human reliability – Human reliability and operator training – Reliability and safety: Safety margins in critical devices. Origins of consumerism and importance of product knowledge, product safety, product liability and product safety improvement program

9 Hours
Total: 45 Hours

Reference(s)

1. Govil A. K, *Reliability Engineering*, Tata McGraw Hill, New Delhi, 2002
2. Sinha and Kale, *Introduction to Life-Testing*, Wiley Eastern, New Delhi, 2005
3. Wisley, *Human Engineering Guide for Equipment Designers*, University of California Press, California, 2007.

14IE61WEB BASED MEASUREMENT AND CONTROL

3 0 0 3

Course Objectives (COs):

- To acquire knowledge about internet and various IP layers
- To study about various network layers and its applications
- To impart a good knowledge about protocols
- To identify and describe various measurements and Internet based controls

Course Outcomes (COCs):

1. Ability to understand the Internet protocols
2. Ability to analyze various network layers and their applications
3. Ability to use internet protocols in measurement using internet
4. Ability to develop web based measurement control through internet

Program Outcomes (POs):

a. Ability to apply knowledge from undergraduate engineering and other disciplines to identify, formulate, solve, novel advanced instrumentation engineering along with process and automation problems that require advanced knowledge within the field
b. Ability to comprehend and incorporate latest knowledge within the field
c. Ability to apply highly developed technical knowledge in multiple contexts

Unit I
Introduction to Internet
Origin of Internet – Overview of TCP / IP layers – IP addressing – DNS – Packet switching – Routing – SMTP, POP, MIME, NNTP, FTP, Telnet, HTML, HTTP, URL, SNMP, RFCs, FYIs – STDs

9 Hours

Unit II
Network Layers
Physical Layer Aspects: Backbone network – Trunks, Routers, Bridges – Access network – MODEMs, WILL, ISDN, XDSL, VSAT

9 Hours

Unit III
Protocol
Network Layer Aspects and Network Security: IPVG, Mobile IP – IPSEC – IPSO – Public key cryptography – digital signature standard – firewall – Secure socket Layer SSL – Secure Data Network System SDNS – Network layer security Protocol NLSP – Point to point Tunneling Protocol PPTP – SHTTP

9 Hours

Unit IV
Measurements through Internet
Web based data acquisition – Monitoring of plant parameters through Internet – Calibration of measuring instruments through Internet

9 Hours

Unit V
Internet based Control
Virtual laboratory – Web based Control – Tuning of controllers through Internet

9 Hours
Total: 45 Hours

Reference(s)

1. Douglas E. Camer, *Internet working with TCP/IP*, Prentice Hall, 6th Edition,2013.
2. Richard Stevens, *TCP/IP illustrated*, Addison Wesley, 1999.
3. Richard E. Smith, *Internet Cryptography*, Addison Wesley, 1999.
4. Alessandri Ferrero and Vincenzo Piuri, *A Simulation Tool for Virtual Laboratory Experiments in WWW environment*, IEEE Transactions on IM, Vol. 48, 1999.
5. Kang B. Lee and Richard D. Schneeman, *Internet-based Distributed Measurement and Control Application*, IEEE magazine IM, June 1999.

14IE62MECHATRONICS

3 0 0 3

Course Objectives (COs):

- To understand combination of electronics and mechanical concepts
- To know about real time applications in mechatronics
- To impart a technical knowledge in stages of designing in mechatronics

Course Outcomes (COCs):

1. Ability to design static and dynamic Boolean logic systems using Combinational, synchronous and asynchronous sequential logic
2. Ability to understand the operation of the fundamental elements of microprocessor and PLC systems
3. Ability to select suitable actuators and sensors for given applications

Program Outcomes (POs):

a. Ability to apply knowledge from undergraduate engineering and other disciplines to identify, formulate, solve, novel advanced instrumentation engineering along with process and automation problems that require advanced knowledge within the field

e. Ability to exhibit the skills to use contemporary engineering tools, software and equipment to analyze problems

Unit I
Sensors and Transducers
Introduction to Mechatronics systems – measurement systems – control systems –microprocessor based controllers – sensors and transducers – performance terminology – sensors for displacement, position and proximity; velocity, motion, force, fluid pressure, liquid flow, liquid level, temperature, light sensors – selection of sensors

9 Hours

Unit II
Actuation Systems
Pneumatic and hydraulic systems – directional control valves – rotary actuators mechanical actuation systems – cams – gear trains – ratchet and pawl – belt and chain drives – bearings. electrical actuation systems – mechanical switches – solid state switches – solenoids – construction and working principle of dc and ac motors – Speed control of ac and dc drives, stepper motors-switching circuitries for stepper motor – ac & dc servo motors

9 Hours

Unit III
System Models and Controllers
Building blocks of mechanical, electrical, fluid and thermal systems, rotational – Transational systems, electromechanical systems – hydraulic – mechanical systems – continuous and discrete process controllers – control mode – two-step mode –proportional mode – derivative mode – integral mode – PID controllers – digital controllers – velocity control – adaptive control – digital logic control – micro processors control

9 Hours

Unit IV
Programmable Logic Controllers
Programmable logic controllers – basic structure – input/output processing –programming – mnemonics – timers, internal relays and counters – shift registers –master and jump controls – data handling – analogs input / output – selection of a PLC – Applications: CNC machines, moulding, die casting

9 Hours

Unit V
Design of Mechatronics System
Stages in designingMechatronics systems – Traditional and mechatronic design - Possible design solutions. Case studies of Mechatronics systems - Pick and place robot- Autonomous mobile robot - Wireless surveillance balloon - Engine management system - Automatic car park barrier

9 Hours
Total: 45 Hours

Reference(s)

1. W. Bolton, *Mechatronics*, Pearson education, 2011.
2. A. Smaili and F. Mrad, *Mechatronics Integrated Technologies for Intelligent Machines*, Oxford university press, 2008
3. R.K. Rajput, *A Textbook of Mechatronics*, S. Chand & Co, 2007.
4. Michael B. Histand and David G. Alciatore, *Introduction to Mechatronics and Measurement Systems*, McGraw-Hill International edition, 2007.
5. D. A. Bradley, D. Dawson, N.C. Buru and A.J. Loade, *Mechatronics*, Chapman and Hall, 2008.
6. Dan Necsulesu, *Mechatronics*, Pearson Education Asia, 2013
7. Lawrence J. Kamm, *Understanding Electro – Mechanical Engineering: An Introduction to Mechatronics*, Prentice – Hall of India Pvt., Ltd., 2000
8. NitaigourPremchandMahadik, *Mechatronics*, Tata McGraw-Hill publishing Company Ltd, 2009.

14IE63 OPTIMAL STATE ESTIMATION

3 0 0 3

Course Objectives (COs):

- To impart knowledge and skills
- To design and implement a discrete Kalman filter
- To design and implement extended Kalman filter, Iterated extended Kalman filter, and second - order extended Kalman filter

- To design and implement derivative free Kalman filter such as unscented Kalman filter and its variants and ensemble Kalman filter
- To design and implement particle filter, Unscented particle filter

Course Outcomes (COCs):

1. Ability to design and Implement Kalman filter for linear systems
2. Ability to design and Implement variants of derivative based Kalman filters such as extended Kalman filter, Iterated extended Kalman filter, second order extended Kalman filter for non-linear systems
3. Ability to design and Implement variants of derivative free Kalman filters such as unscented Kalman filter, spherical and simplex transformations based unscented Kalman filter
4. Ability to design and Implement variants of H-infinity filters
5. Ability to design and Implement various types of particle filters for non-linear and non-gaussian systems

Program Outcomes (POs):

a. Ability to apply knowledge from undergraduate engineering and other disciplines to identify, formulate, solve, novel advanced instrumentation engineering along with process and automation problems that require advanced knowledge within the field

d. Ability to understand and design advanced instrumentation systems and conduct experiments, analyze and interpret data

g. Ability to plan, conduct an organized and systematic study on significant research topic within the field

Unit I
Introduction to state estimation and kalman filter
Review of Matrix Algebra and Matrix Calculus and Probability Theory – Least Square Estimation – Review of state observers for Deterministic System- Derivation of the Discrete – time Kalman filter – Kalman filter properties - Kalman filter generalization: Correlated Process and Measurement Noise – Case Studies

9 Hours

Unit II
Extended Kalman Filter
Linearized Kalman filter – Extended Kalman filter – The iterated extended Kalman filter – The second order extended Kalman filter – Constrained extended Kalman filter – Simultaneous State and Parameter estimation using EKF – Dual extended Kalman Filter - Case Studies

9 Hours

Unit III
Unscented Kalman Filter
Means and Covariance of non-linear transformations – Unscented transformation – Unscented Kalman filtering - General - Unscented transformation - The simplex Unscented transformation – Spherical Unscented transformation - Simultaneous State and Parameter Estimation using UKF Constrained Unscented Kalman filter – Case Studies

9 Hours

Unit IV
The H-Infinity Filter
The H- infinity filter – Introduction - Kalman filter Limitations - A game theory Approach to H- infinity filtering – Steady state H- infinity Filtering - Mixed Kalman / H- Infinity filtering - Robust Kalman / H- infinity filtering - Constrained H- infinity filtering – Case Studies

9 Hours

Unit V
Ensemble Kalman Filter & Particle Filter
Bayesian state Estimation - Ensemble Kalman filter – Introduction to Particle filtering – SIS – Implementation issues: Sample Impoverishment - SIR - Particle filter with EKF as proposal - Unscented Particle filter - Case Studies

9 Hours
Total: 45 Hours

Reference(s)

1. Dan Simon, *Optimal State Estimation Kalman, H-infinity and Non-linear Approaches*, John Wiley and Sons, 2006.
2. BrankoRistic, SanjeevArulampalam, Neil Goodon, *Beyond the Kalman Filter: Particle filters for Tracking Application,*Artech House Publishers, Boston, London, 2004.
3. Bruce P. Gibbs, *Advanced Kalman Filtering, Least-Squares and Modeling: A Practical Handbook*, Wiley, 2011.

14IE64 WIRELESS SENSOR NETWORKS

3 0 0 3

Course Objectives (COs):

- To obtain a broad understanding of the technologies and applications for the emerging and exciting domain of wireless sensor networks
- To study the challenges and latest research results related to the design and management of wireless sensor networks
- To focus on network architectures and security

Course Outcomes (COCs):

1. Ability to learn the basics of wireless sensor networks and its applications in enabling technologies
2. Ability to understand the architecture and elements of wireless sensor networks
3. Ability to get an idea on mac protocols for wireless sensor networks
4. Ability to study the tools and platforms needed to establish sensor networks

Program Outcomes (POs):

c.Ability to apply highly developed technical knowledge in multiple contexts

e. Ability to exhibit the skills to use contemporary engineering tools, software and equipment to analyze problems

Unit I

Introduction

Challenges for wireless sensor networks, Comparison of sensor network with adhoc network, Single node architecture – Hardware components, energy consumption of sensor nodes, Network architecture – Sensor network scenarios, types of sources and sinks, single hop versus multi-hop networks, multiple sinks and sources, design principles, Development of wireless sensor networks

9 Hours

Unit II

Physical Layer

Wireless channel and communication fundamentals – frequency allocation, modulation and demodulation, wave propagation effects and noise, channels models, spread spectrum communication, packet transmission and synchronization, quality of wireless channels and measures for improvement, physical layer and transceiver design consideration in wireless sensor networks, energy usage profile, choice of modulation, power management

9 Hours

Unit III

Data Link Layer

MAC protocols – Fundamentals of wireless MAC protocols, low duty cycle protocols and wakeup concepts, contention-based protocols, Schedule-based protocols, Link Layer protocols – Fundamentals task and requirements, error control, framing, link management

9 Hours

Unit IV

Network Layer

Gossiping and agent-based unicast forwarding , Energy-efficient unicast, Broadcast and multicast, geographic routing , mobile nodes, Data –centric and content - Based networking – Data – Centric routing, Data aggregation, Data-centric storage, Higher layer design issue

9 Hours

Unit V
Case Studies
Target detection and tracking, Habitat monitoring, Environmental disaster monitoring, Practical implementation issues, IEEE 802.15.4 low rate WPAN, Sensor Network Platforms and tools-Sensor node hardware, Node-level software platforms, node –level simulators

9 Hours
Total: 45 Hours

Reference(s)

1. Feng Zhao and Leonidas J. Guibas, *Wireless Sensor Networks: An Information Processing Approach*, Elsevier, 2004.
2. Holger Karl and Andreas Willig, *Protocols And Architectures for Wireless Sensor Networks*, John Wiley, 2007.
3. Ivan Stojmenovic, *Handbook of Sensor Networks: Algorithms and Architectures*, Wiley, 2005.
4. KazemSohraby, Daniel Minoli and TaiebZnati, *Wireless Sensor Networks: Technology, Protocols and Applications*, John Wiley, 2007.
5. BhaskarKrishnamachari, *Networking Wireless Sensors*, Cambridge University Press, 2011.

14IE65 VLSI SYSTEM DESIGN

3 0 0 3

Course Objectives (COs):
- To acquire knowledge about VLSI Design Process
- To understand the types of faults and fault tolerant systems
- To understand the concepts of System Design Using VHDL and Programmable Devices

Course Outcomes (COCs):
1. Ability to understand the basics concepts of VLSI design
2. Ability to acquire knowledge in design of VLSI system using different techniques
3. Ability to explore fault diagnosis and testable algorithms

Program Outcomes (POs):

b.Ability to comprehend and incorporate latest knowledge within the field
c. Ability to apply highly developed technical knowledge in multiple contexts

Unit I
Overview of VLSI Design Methodology
VLSI design process - Architectural design - Logical Design – Physical design – Layout styles – Full custom, Semi custom approaches.
Layout Design Rules: Need for design rules – Mead Conway design rules for silicon gate NMOS process – CMOS n well / p well design rules – simple layout examples – sheet resistance – Area capacitance – wiring Capacitance

9 Hours

Unit II
Introduction to VHDL
Design process flow - Software tools – Hardware Description Language - VHDL: Date Objects –Data types – Operators – Entitles and Architectures – Components and Configurations – Concurrent signal assignment - Conditional signal assignment – Selected signal assignment – Concurrent statements - Sequential statements – Transport and Inertial delays – Delta delays – Behavioral, Data flow and structural modelling –Attributes - Generics – Packages and Libraries – Multivalued logic and Signal resolution – IEEE 1164 std logic – Subprograms: Functions and Procedures – Operator overloading – Test Benches – Design Examples

9 Hours

Unit III
System Design Using PLDs
Basic concepts – Programming technologies – Programmable Logic Element (PLE) –Programmable Logic Array (PLA) – Programmable Array Logic (PAL) – Programmable Logic Architectures – 16L8 -16R4 - 22V10 - Design of combinational and sequential circuits using PLDs – Complex PLDs (CPLDs) – Design of state machines using Algorithmic State Machine (ASM) chart as a design tool

9 Hours

Unit IV
Field Programmable Gate Arrays
Types of FPGA – Xilinx XC3000 series – Logical Cell Array (LCA) – Configurable Logic Blocks (CLB) – Input/Output Blocks (IOB) – Programmable Interconnection Points (PIP) Xilinx XC4000 series - Introduction to Xilinx SPARTAN, VIRTEX FPGA - Design examples

8 Hours

Unit V
Fault Modelling
Defects, Errors, Faults, Levels of Fault models. Types, Fault Detection and Redundancy in Combinational Logic circuits: Path sensitization method, Boolean difference method. Fault Detection in sequential logic circuit, Design for testability: Scan path Testing, Boundary Scan Test, Built in Self-Test for testing memories

9 Hours
Total: 45 Hours

Reference(s)

1. Kamran Eshraghian, Douglas A. Pucknell, "*Essentials of VLSI Circuits and Systems*" Prentice Hall of India, 2008.
2. Neil Weste and Kamran Eshranghian, *Principles of CMOS VLSI Design*, Addison Wiley, 2000.
3. Charles H. Roth, *Digital Systems Design Using VHDL*, Thomson Publishers, 2004.
4. Michael L. Bushnell and Vishwani D. Agrawal, *Essentials of Electronic Testing for Digital Memory and Mixed Signal VLSI Circuits*, Kluwer Academic Publications, 2001.
5. D. K. Pradhan, *Fault –Tolerant Computing –Theory and Techniques*, Prentice Hall, 2002
6. S. Srinivasan, *Digital Circuits and Systems*, NPTEL Courseware, 2005.

14IE66 REAL TIME EMBEDDED SYSTEM

3 0 0 3

Course Objective (COs):

- To study the various components within an embedded system and their interactions
- To study the basic operation of operating system
- To know about the basic concepts of systems programming like operating system, assembler, compliers etc., and to understand the management task needed for developing embedded system

Course Outcomes (COCs):

1. Ability to understand the concept of embedded system lifecycle with multi-tasking
2. Ability to understand the inter process communication in an Operating System
3. Ability to understand the networking concepts in embedded system

Program Outcomes (POs):

b. Ability to comprehend and incorporate latest knowledge within the field

c. Ability to apply highly developed technical knowledge in multiple contexts

e. Ability to exhibit the skills to use contemporary engineering tools, software and equipment to analyze problems

Unit I
Introduction to Embedded Computing
Complex systems and microprocessors – Design example: Model train controller – Embedded system design process – Formalism for system design – Instruction sets Preliminaries – ARM Processor – CPU: Programming input and output – Supervisor mode, exception and traps – Coprocessor – Memory system mechanism – CPU performance – CPU power consumption

9 Hours

Unit II
Computing Platform and Design Analysis
CPU buses – Memory devices – I/O devices – Component interfacing – Design with microprocessors – Development and Debugging – Program design – Model of programs – Assembly and Linking – Basic compilation techniques – Analysis and optimization of execution time, power, energy, program size – Program validation and testing

9 Hours

Unit III
Process and Operating Systems
Multiple tasks and multi processes – Processes – Context Switching – Operating Systems – Scheduling policies - Multiprocessor – Inter Process Communication mechanisms – Evaluating operating system performance – Power optimization strategies for processes

9 Hours

Unit IV
Hardware Accelerates & Networks
Accelerators – Accelerated system design – Distributed Embedded Architecture – Networks for Embedded Systems – Network based design – Internet enabled systems

9 Hours

Unit V
Case Studies
Hardware and software co-design - Data Compressor - Software Modem – Personal Digital Assistants – Set-Top-Box – System-on-Silicon – FOSS Tools for embedded system development

9 Hours
Total: 45 Hours

Reference(s):

1. Wayne Wolf, *Computers as Components - Principles of Embedded Computer System Design*, Morgan Kaufmann Publisher, 2006.
2. David E-Simon, *An Embedded Software Primer*, Pearson Education, 2007.
3. K.V.K.K.Prasad, *Embedded Real-Time Systems: Concepts, Design & Programming*, dreamtech press, 2005.
4. Tim Wilmshurst, *An Introduction to the Design of Small Scale Embedded Systems*, Pal grave Publisher, 2004.
5. Sriram V Iyer, Pankaj Gupta, *Embedded Real Time Systems Programming*, Tata Mc-Graw Hill, 2004.
6. Tammy Noergaard, *Embedded Systems Architecture*, Elsevier, 2006.

14IE67 NETWORK SECURITY AND CRYPTOGRAPHY

3 0 0 3

Course Objectives (COs):

- To understand OSI security architecture and classical encryption techniques
- To acquire fundamental knowledge on the concepts of finite fields and number theory
- To understand various block cipher and stream cipher models
- To describe the principles of public key cryptosystems, hash functions and digital signature

Course Outcomes (COCs):

1. Ability to compare various Cryptographic Techniques
2. Ability to design Secure applications
3. Ability to inject secure coding in the developed applications

Program Outcomes (POs):

b. Ability to comprehend and incorporate latest knowledge within the field
e. Ability to exhibit the skills to use contemporary engineering tools, software and equipment to analyze problems
g. Ability to express their technical knowledge through formal written reports which satisfy the established standards of writing style

Unit I
Symmetric Ciphers
Overview – classical Encryption Techniques – Block Ciphers and the Data Encryption standard – Introduction to Finite Fields – Advanced Encryption standard – Contemporary Symmetric Ciphers – Confidentiality using Symmetric Encryption

9 Hours

Unit II
Public-Key Encryption and Hash Functions
Introduction to Number Theory – Public-Key Cryptography and RSA – Key Management – Diffie-Hellman Key Exchange – Elliptic Curve Cryptography – Message Authentication and Hash Functions – Hash Algorithms – Digital Signatures and Authentication Protocols

9 Hours

Unit III
Network Security Practice
Authentication applications – Kerberos – X.509 Authentication Service – Electronic mail Security – Pretty Good Privacy – S/MIME – IP Security architecture – Authentication header – Encapsulating Security Payload – Key Management

9 Hours

Unit IV
System Security
Intruders – Intrusion detection – Password Management – Malicious software – Firewalls – Firewall design principles –Trusted systems

9 Hours

Unit V
Wireless Security
Introduction to Wireless LAN Security Standards – Wireless LAN Security Factors and Issues

9 Hours
Total: 45 Hours

Reference(s)

1. William Stallings, *Cryptography and Network Security – Principles and Practices*, Pearson Education, 3rd Edition, 2011
2. AtulKahate, *Cryptography and Network Security*, TataMcGrawHill, 2013.
3. Behrouz A. Forouzon, *Cryptographyand Network Security*, TataMcGrawHill., 2008.
4. I A Dhotre, V S Bagad, *Cryptographyand Network Security*, Technical Publications Pune. 2008.

14IE68 SENSORS AND NETWORKING

3 0 0 3

Course Outcomes (COs)

- To obtain a broad understanding of the technologies and applications for the emerging and exciting domain of networks
- To study the challenges and latest research results related to the design and management of sensor networks
- To focus on architecture of Sensor networks and Wireless Embedded Networking

Course Outcomes (COCs):

1. Ability to understand the architecture and elements of sensor networks
2. Ability to get an idea on MAC protocols for wireless sensor networks
3. Ability to study the tools and platforms needed to establish sensor networks

Program Outcomes (POs):

c. Ability to apply highly developed technical knowledge in multiple contexts
e. Ability to exhibit the skills to use contemporary engineering tools, software and equipment to analyze problems

Unit – I
Overview of Communication Protocols for Sensor Networks
Applications/Application Layer Protocols - Localization Protocols - Time Synchronization Protocols – Transport Layer Protocols - Network Layer Protocols - Data Link Layer Protocols

9 Hours

Unit II
Basics of In-vehicle networking
Over view of Data communication and networking – Layers of OSI Reference(s) model – Overview of general purpose networks and protocols - Ethernet, TCP/IP - Wireless communication (Ip56, Ip58)

9 Hours

Unit III
Sensor Network Architecture
Sensor Node's (SNs) Global View and Requirements - Individual Components of SN Nodes – Sensor Network Node - Wireless SNs as Embedded Systems

9 Hours

Unit – IV
Industrial Sensor Networking
Introduction - Industrial Sensor Fitting Communication Protocols - IEEE 1451 Family of Smart Transducer Interface Standards – Internet - based Sensor Networking - Industrial Network Interconnections – Wireless Sensor Networks in Industry.

9 Hours

Unit V
Case Studies
Wireless Pet Dog Management Systems - Agriculture Monitoring - Medical Care Applications - Fire Emergency Applications

9 Hours
Total: 45 Hours

Reference(s)

1. Nitaigour P. Mahalik, *Sensor Networks and Configuration : Fundamentals, Standards, Platforms, and Applications*, Springer, 2011
2. Mohammad Ilyas and ImadMahgoub, *Handbook of Sensor Networks: Compact Wireless and Wired Sensing System,* CRC PRESS, 2010.
3. Subhas Chandra Mukhopadhyay, Henry Leung, *Advances in Wireless Sensors and Sensor Networks*, Springer, 2010.
4. KazemSohraby, Daniel Minoli, TaiebZnati, *Wireless Sensor Networks: Technology, Protocols, and Applications*, John Wiley & Sons, 2009.

14IE69 EMBEDDED NETWORKING

3 0 0 3

Course Objectives (COs):

- To study the fundamentals of embedded networking
- To understand about the design methodologies in wireless networks

Course Outcomes (COCs):

1. Ability to understand serial and parallel communication protocols
2. Ability to understand application development using USB and CAN bus for PIC microcontrollers
3. Ability to understand application development using Embedded Ethernet for Rabbit processors
4. Ability to understand wireless sensor network communication protocols

Programme Outcomes (POs):

b. Ability to comprehend and incorporate latest knowledge within the field
c. Ability to apply highly developed technical knowledge in multiple contexts

Unit I
Embedded Communication Protocols
Embedded Networking: Introduction – Serial/Parallel Communication – Serial communication protocols - RS232 standard – RS485 – Synchronous Serial Protocols - Serial Peripheral Interface (SPI) – Inter Integrated Circuits (I^2C) – PC Parallel port programming - ISA/PCI Bus protocols – Firewire

9 Hours

Unit II
USB and CAN Bus
USB bus – Introduction – Speed Identification on the bus – USB States – USB bus communication: Packets –Data flow types – Enumeration – Descriptors – PIC18 Microcontroller USB Interface – C Programs –CAN Bus – Introduction - Frames – Bit stuffing – Types of errors – Nominal Bit Timing – PIC microcontroller CAN Interface – A simple application with CAN

9 Hours

Unit III
Ethernet Basics
Elements of a network – Inside Ethernet – Building a Network: Hardware options – Cables, Connections and network speed – Design choices: Selecting components – Ethernet Controllers – Using the internet in local and internet communications – Inside the Internet protocol

9 Hours

Unit IV
Embedded Ethernet
Exchanging messages using UDP and TCP – Serving web pages with dynamic data – Serving web pages that respond to user Input – Email for Embedded Systems – Using FTP – Keeping Devices and Network secure

9 Hours

Unit V
Wireless Embedded Networking
Wireless sensor networks – Introduction – Applications – Network Topology – Localization – Time Synchronization - Energy efficient MAC protocols – SMAC – Energy efficient and robust routing – Data Centric routing

9 Hours
Total: 45 Hours

Reference(s)

1. Frank Vahid, *GivargisEmbedded Systems Design: A Unified Hardware/Software Introduction*, Wiley Publications, 2002.
2. Jan Axelson, *Parallel Port Complete*, Penram publications, 2011.
3. Dogan Ibrahim, *Advanced PIC microcontroller projects in C*, Elsevier 2008.
4. Jan Axelson, *Embedded Ethernet and Internet Complete*, Penram publications, 2005.
5. BhaskarKrishnamachari, *Networking wireless sensors*, Cambridge press 2005.

14IE70 INTELLIGENT SENSORS

3 0 0 3

Course Objectives (COs):

- To give a knowledge on Intelligent Sensor and uncertainties measurement
- To give a comprehensive knowledge on interfacing intelligent sensor with microcontroller and DSP
- To give an overview of applications of Intelligent Sensor

Course Outcomes (COCs):

1. Ability analyze the architectural difference between sensor and intelligent sensor
2. Ability to attain the capability to interface intelligent sensors and microcontroller
3. Ability to get the exposure about applications of intelligent sensor

Programme Outcomes (POs):

a. Ability to apply knowledge from undergraduate engineering and other disciplines to identify, formulate, solve, novel advanced instrumentation engineering along with process and automation problems that require advanced knowledge within the field
b. Ability to comprehend and incorporate latest knowledge within the field
c. Ability to apply highly developed technical knowledge in multiple contexts

Unit I
Introduction to Intelligent sensors
Sensor principles and characteristics review - Amplification and Signal conditioning – Smart - Sensor structure and standards - Sensor networks

9 Hours

Unit II
Microcontrollers and Digital Signal Processors for Smart Sensor Systems
Microcontroller and DSP Architectures - Choosing a Low-Power MCU or DSP - Timer Modules - Analog Comparators, ADCs, and DACs as Modules of Microcontrollers

9 Hours

Unit III
Signal processing and Architecture of dsPIC DSC
Foundational concepts for Signal Processing - Issues Related to Signal Sampling - General Sensor Signal-processing Framework - dsPIC DSC's Data Processing Architecture - The On-chip Peripherals

9 Hours

Unit IV
Communicating with dsPIC DSC and Toolkit for the dsPIC DSC
Types of Communications - Communication options available on the dsPIC30F - High-level Protocols - Overview of the Firmware - Implementation of the Framework modules

9 Hours

Unit V
Sensor Application
Case Study: Temperature Sensor - Pressure and Load Sensors - Flow Sensors - Hall Magnetic Sensors

9 Hours

Total: 45 Hours

Reference(s)

1. Gerard C.M. Meijer, *Smart Sensor Systems,* A John Wiley and Sons, Ltd, Publication, 2011.
2. Creed Huddleston, *Intelligent Sensor Design Using the Microchip dsPIC*, Elsevier, 2010.
3. PavelRipka, AloisTipek, *Modern Sensors Handbook,*John Wiley and Sons, Ltd, Publication, 2008.