Curriculum and Syllabus for
M. Tech Programme in
Instrumentation and Control Systems

Department of Electrical Engineering

NATIONAL INSTITUTE OF TECHNOLOGY

CALICUT

Programme Educational Objectives

PEO1. To equip the engineering graduates with adequate knowledge and skills in the areas of Control Systems and Instrumentation so as to excel in advanced level jobs in modern industry and/ or teaching and/or higher education and/or research.

PEO2. To transform engineering graduates to expert engineers so that they could comprehend, analyze, design and create novel products and solutions to problems in the areas of Control Systems and Instrumentation that are technically sound, economically feasible and socially acceptable.

PEO3. To train engineering graduates to exhibit professionalism, keep up ethics in their profession and relate engineering issues to address the technical and social challenges.

PEO4. To improve the communication skills, willingness to work in groups and to develop multidisciplinary approach in problem solving.

Programme Outcomes

No	PO
PO1	Enhanced knowledge in the field of Instrumentation and Control Systems in a global perspective and the ability to utilize the same for evaluating, modelling and analyzing various engineering problems in that area.
PO2	Ability to carry out a detailed analysis of various engineering problems in the field of Instrumentation and Control Systems leading to suitable solutions for the same or significant advances for conducting research in a wider perspective.
PO3	Ability to propose feasible and optimal solutions giving due consideration to safety, cultural, societal and environmental factors for various real-life engineering problems in the field of Instrumentation and Control Systems.
PO4	Ability to design, develop and propose theoretical and practical methodologies for carrying out detailed investigation to complex engineering problems in the field of Instrumentation and Control Systems
PO5	Ability to develop and utilize modern tools for modeling, analyzing and solving various engineering problems in the field of Instrumentation and Control Systems
PO6	Willingness and ability to get involved in a team of engineers/researchers to take up sophisticated challenges, in the field of Instrumentation and Control Systems, having multidisciplinary nature by way of knowledge sharing and collaboration.
PO7	Willingness and ability to take up administrative challenges including the management of various projects of interdisciplinary nature and carry out the same in an efficient manner

	giving due consideration to societal, environmental, economical and financial factors.
PO8	Ability to express ideas clearly and communicate orally as well as in writing with others in an effective manner, adhering to various national and international standards and practices for the documentation and presentation of the content.
PO9	Willingness and ability to maintain lifelong learning process by way of participating in various professional activities with a higher level of enthusiasm and commitment.
PO10	Willingness and ability to upkeep professional ethics and social values while carrying out the activities or responsibilities as an engineer/ researcher.
PO11	Ability to examine, think and devise solutions to real life engineering problems in the field of Instrumentation and Control Systems in an independent manner by way of critical self-evaluation and adaptation of suitable corrective measures continuously.

Curriculum

Semester 1

Course Code	Course Title	L	T	P/S	C
MA6002	Applied Mathematics	3	-	-	3
EE6101	Dynamics of Linear Systems	3	-	-	3
EE6103	Applied Instrumentation	3	-	-	3
	Elective -1	3	-	-	3
	Elective -2	3	-	-	3
	Elective -3	3	-	-	3
EE6191	Instrumentation & Control Systems Lab	-	-	3	2
Total		18	-	3	20

Semester 2

Course Code	Course Title	L	T	P/S	C
EE6102	Optimal and Adaptive Control	3	-	-	3
EE6104	Advanced Instrumentation	3	-	-	3
EE6106	System Identification and Parameter Estimation	3	-	-	3
EE6108	Nonlinear System Analysis	3	-	-	3
	Elective -1	3	-	-	3
	Elective -2	3	-	-	3
EE6192	Mini Project	-	-	3	1
EE6194	Seminar	-	-	3	1
Total		18	-	6	20

Semester 3

Course Code	Course Title	L	T	P/S	C
EE7191	Main Project -1	-	-	16	8
Total		-	-	16	8

Semester 4

Course Code	Course Title	L	T	P/S	C
EE7192	Main Project -2	-	-	24	12
Total		-	-	24	12

LIST OF ELECTIVES

Sl. No	Code	Title	Credits
1	MA7160	Simulation and Modelling	3
2	MA7165	Statistical Digital Signal Processing	3
3	MA8154	Wavelets Theory	3
4	ME6429	Research Methodology	3
5	EE6121	Data Acquisition and Signal Conditioning	3
6	. EE6122	Biomedical Instrumentation	3
7	EE6123	Performance Modeling of Systems-1	3
8	EE6124	Performance Modeling of Systems II	3
9	EE6125	Digital Control Systems	3
10	EE6126	Advanced Topics in Control Systems	3
11	EE6127	Variable Structure Control Systems	3
12	EE6128	Optimal Estimation and Filtering	3
13	EE6129	Artificial Neural Networks and Fuzzy Systems	3
14	EE6304	Advanced Digital Signal Processing	3
15	EE6401	Energy Auditing & Management	3
16	EE6402	Process Control & Automation	3
17	EE6403	Computer Controlled Systems	3
18	EE6404	Industrial Load Modeling & Control	3
19	EE6406	Industrial Instrumentation	3
20	EE6421	Advanced Microcontroller Based Systems	3
21	EE6422	Engineering Optimization	3
22	EE6423	Industrial Communication	3
23	EE6424	Robotic Systems and Applications	3
23	EE6428	SCADA Systems & Applications	3

Course Outcomes and Detailed Syllabus

Core Courses

MA6002: Applied Mathematics

Pre-requisite: Nil

Total hours: 42 Hrs.

L	T	P	C
3	0	0	3

Course Outcomes

CO1: Acquire knowledge about vector spaces, orthogonalization, linear transformation, eigenvalues and eigenvectors of linear operators.

CO2: Acquire knowledge about random variables, probability distribution of random variables and transformation of random variables.

CO3: Acquire knowledge about fundamentals of stochastic processes and their classification.

CO4: Acquire knowledge about discrete and continuous time Markov processes.

CO5: Acquire knowledge about stationary processes, spectral density function, low pass and band pass processes, and linear prediction.

Syllabus

Module 1: Linear Algebra (11 hours)

Vector spaces, subspaces, Linear dependence, Basis and Dimension, Inner product spaces, Gram- Schmidt Orthogonalization, Linear transformations, Kernels and Images , Matrix representation of linear transformation, Change of basis, Eigenvalues and Eigen vectors of linear operator, Quadratic form.

Module 2: Operations on Random Variables (12 hours)

Random Variables, Distributions and Density functions, Moments and Moment generating function, Multivariate distributions, Independent Random Variables, Marginal and Conditional distributions, Conditional Expectation, Transformation of Random Variables , Elements of stochastic processes, Classification of general stochastic processes.

Module 3: Random Processes (11 hours)

Markov Chains: Definition, Examples, Transition Probabilities, Classification of states and chains, Basic limit theorem, Limiting distribution of Markov chains.

Continuous Time Markov Chains: General pure Birth processes and Poisson processes, Birth and death processes, Finite state continuous time Markov chains

Module 4: Second Order Processes (8 hours)

Second Order Stochastic Processes, Stationary processes, Wide sense Stationary processes, Auto covariance and auto correlation function, Spectral density function, Low pass and band pass processes, White noise and white noise integrals, Linear Predictions and Filtering.

References

1. Kenneth Hoffman and Ray Kunze, Linear Algebra, 2nd Edition, PHI, 1992.
2. Erwin Kreyszig, Introductory Functional Analysis with Applications, John Wiley & Sons, 2004.
3. Irwin Miller and Marylees Miller, John E. Freund's Mathematical Statistics, 6th Edition, PHI, 2002.
4. S. Karlin & H.M Taylor, A First Course in Stochastic Processes, 2nd edition, Academic Press, New York, 2007
5. S. M. Ross, Introduction to Probability Models, Harcourt Asia Pvt. Ltd. and Academic Press, 2004
6. J. Medhi, Stochastic Processes, New Age International, New Delhi, 1994
7. A Papoulis, Probability, Random Variables and Stochastic Processes, 3rd Edition, McGraw Hill, 2002
8. John B Thomas, An Introduction to Applied Probability and Random Processes, John Wiley & Sons, 2000.

EE6101: Dynamics of Linear Systems

Pre-requisite: Nil

Total hours: 42 Hrs.

L	T	P	C
3	0	0	3

Course Outcomes

CO1: Acquire knowledge of linear system modeling, analysis and design so as to obtain the ability to apply the same to engineering problems in a global perspective.

CO2: Acquire knowledge on carrying out detailed stability analysis of both linear and non-linear systems with a view to extend this knowledge for controller design to achieve stability of systems.

CO3: Acquire knowledge to design observers and controllers for linear systems so as to be able to implement the methodology for practical control systems.

CO4: Acquire knowledge of discrete time linear systems modeling, analysis and design so as to obtain the ability to apply the same to practical engineering problems in today's world of hybrid systems.

CO5: Acquire knowledge to develop and utilize modern software tools for analysis and design of linear continuous and discrete time systems.

CO6: Acquire ability to extend the knowledge in analysis and design to systems of multidisciplinary nature.

Syllabus

Module 1: State Space Analysis (11 hours)

State variable representations of systems- transfer function and transfer function matrix from state variable form - solutions of state equations – state transition matrix - modal decompositions - observability and controllability - minimal realizations of MIMO systems - analysis of linear time varying systems.

Module 2: Lyapunov Stability Analysis (9 hours)

The concepts of stability- absolute stability and BIBO Stability - eigen values of state matrix – equilibrium states - Lyapunov stability theorems - stability analysis using Lyapunov's first method and second method - Lyapunov function and its properties

Module 3: Control Design Techniques (11 hours)

State variable feedback – controller design - Ackerman's Formula - stabilisation by state and output feedback - observers for state measurement – observer design - combined observer-controller compensators - reduced order observer - observability under feedback and invariant zeros - Design of stable systems using Lyapunov method - MATLAB Exercises.

Module 4: Linear Discrete Time Systems (11 hours)

Difference equation model for LTIV systems - impulse response model - transfer function model – discrete state space representation - solution of state equations - controllability and observabilty - stability analysis using Lyapunov method - state feedback of linear discrete time systems- Design of Observers- MATLAB Exercises.

References

1. Thomas Kailath, Linear Systems, Prentice Hall Inc., Englewood Cliffs, N.J. 1980.

2. K. Ogata, State Space Analysis of Control Systems, Prentice Hall Inc., Englewood Cliffs, N.J., 1965.

3. K. Ogata, Modern Control Engineering, (second edition), Prentice Hall Inc., Englewood Cliffs, N.J., 1990.

4. M. Gopal, Digital Control and State Variable Methods, Tata McGraw Hill Publishing Company Ltd., New Delhi, 1997.

5. C.T. Chen, Linear System Theory and Design, New York: Holt Rinehart and Winston, 1984.

6. R.C. Dorf, and R. T. Bishop, Modern Control Systems, Addison Wesley Longman Inc., 1999.

7. Eronini, Umez- Eronini, System Dynamics and Control, Thomson Asia Pt Ltd., Singapore, ISBN: 981-243-113-6, 2002.

EE6103: Applied Instrumentation

Pre-requisite: Nil

Total hours: 42 Hrs.

L	T	P	C
3	0	0	3

<u>Course Outcomes</u>

CO1: To get knowledge about general modeling principles and degrees of freedom of modeling.

CO2: Acquire knowledge about modeling of automated manufacturing system and their performance measures.

CO3: To explore with petrinet and S-net models.

CO4: To get familiarize with engineered data acquisition and processing system.

<u>Syllabus</u>

Module 1: (10 hours)

Introductory Instrumentation to process control. Modeling philosophies. The rationals for mathematical modeling dynamic versus steady state models. General modeling principles degrees of freedom in modeling. Control systems instrumentation. Transducers and transmitters. Transfer function models. Procedure for developing transfer function models.

Module 2: (10 hours)

Performance modeling. Modeling automated manufacturing system (introduction). Role of performance modeling. Performance measures. Petrinet models. Introduction to petrinets. Basic definitions and analytical techniques. S-net models. Preliminary definition and analytical techniques.

Module 3: (10 hours)

Roll for digital computer system in process control. distributed instrumentation and control system. General purpose digital data acquisition and control hardware.

Module 4: (12 hours)

Engineered Data Acquisition and Processing System. Versatile Modular System Emphasising Analog Signal Processing. Instrument Inter Connection Systems. Sensor based computerized data system. Computer Aided Experimentation. Conditional description of the computer system. Computer aided overall plan of the test sequence.

References

1. Seborg . Process dynamic control, Wiley, 2007

2. Ernest O. Doebelin . Measurement system Application and Design. McGraw Hill International Editions, 1990

3. N. Viswanathan, Y. Narahari . Performance modeling of automated manufacturing system, Prentice Hall of India Private Limited, New Delhi, 2001

4. Proceedings: Conference on Advances in computing, CADCOM 98, Allied Publishers Limited, New Delhi, India, 1999

EE6191: Instrumentation and Control Systems Lab

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
0	0	3	2

Course Outcomes

CO1: Acquire practical knowledge of linear system controller implementation so as to understand the issues in application to engineering problems.

CO2: Acquire practical knowledge of position and velocity control systems and to gain practical information on closed loop behavior of these systems.

CO3: Acquire practical knowledge of level process control systems and to gain practical information on their behavior to different types of controllers.

CO4: Acquire practical knowledge of the issues faced while dealing with nonlinear system controller design and to learn about the performance of nonlinear systems by conducting experiments on the inverted pendulum.

CO5: Acquire practical knowledge of system modeling and the working of closed loop controllers for a regulator system using DC generator and amplidyne.

CO6: Conduct investigations on the role of compensators in control systems through simulation and hardware implementation.

CO7: Acquire knowledge on the use of modern software tools for control system design and system analysis.

Syllabus

12 experiments will be offered in the lab, each experiment being of 3 hours duration. The experiments will be such as to understand the advanced topics in automatic control systems.

1. The feedback MS150 modular servo system – part 1
2. Experiments on BytronicsR Inverted Pendulum
3. Synchro characteristics and synchro systems.
4. Experiments on Level Process Control Station
5. Micro-processor based wave form generation
6. Micro-processor based stepper motor control
7. AC servo system – closed loop position control and closed loop velocity control.
8. The FEEDBACKR MS150 Modular Servo System- Part II. Setting up closed loop control system.
9. Use of Matlab for controlled system design, simulation and performance evaluation.
10. Use of Simulink for controlled system simulation and performance evaluation.
11. Compensators – design, simulation and hardware implementation.
12. To obtain experimentally the transfer function of DC motor and the amplidyne and to set up a closed loop control voltage regulation control for a DC generator using amplidyne.

References

1. Gene F Franklin, J David Powell, Abbas Emami Naeini, Feedback Control of Dynamic Systems, 4th Ed, Pearson Education Asia, 2002
2. Graham C Goodwin, Stefan F Graebe, Mario E Salgado, Control System Design, Prentice Hall India, 2003.
3. John J D'Azzo, Constantine H Houpis, Stuart N. Sheldon, Linear Control System Analysis & Design with MATLAB, 5th Ed, Marcel Dekker, 2003
4. P. C. Sen, Principles of Electrical Machines & Power Electronics, John Wiley, 2003.
5. John E Gibson, Franz B. Tuteur, Control System Components, McGrawHill, 1958.
6. Ramesh S Gaonkar, Microprocessor architecture Programming and application with 8085/8080A 2E, New Age Publications, 1995.
7. Users' Manual for FEEDBACKR MS150 AC Modular Servo System
8. Users' Manual for 8085n Microprocessor kit. www.mathworks.com

EE6102: Optimal and Adaptive Control

Pre-requisite: Nil

Total hours: 42 Hrs.

L	T	P	C
3	0	0	3

Course Outcomes

CO1: Acquire knowledge in the mathematical area of 'calculus of variation' so as to apply the same for solving optimal control problems.

CO2: Acquire knowledge of problem formulation, performance measure and mathematical treatment of optimal control problems so as to apply the same to engineering control problems with the possibility to do further research in this area.

CO3: Acquire knowledge on solving optimal control design problems by taking into consideration the physical constraints on practical control systems.

CO4: Acquire knowledge to obtain optimal solutions to controller design problems taking into consideration the limitation on control energy in the real practical world.

CO5: Acquire knowledge to develop and utilize modern software tools for design and analysis of optimal control problems.

CO6: Acquire knowledge in model reference adaptive control system design and to extend this knowledge to other areas of model following control with the idea of pursuing research in this area.

Syllabus

Module 1: (12 hours)

Optimal control problem – open loop and closed loop form of optimal control- performance measures for optimal control problems – general form of performance measure - fundamental concepts and theorems of calculus of variations – function and functional – Extremal of functionals of a single function - Euler - Language equation and solution- extremal of functionals of several independent functions – various boundary condition equations - piecewise-smooth extremals - extremal of functionals with dependent functions – use of Lagrange multipliers - differential equation constraints – isoperimetric constraints.

Module 2: (10 hours)

The variational approach to solving optimal control problems - necessary conditions for optimal control using Hamiltonian – Different boundary condition equations for solving the optimal control problem – closed loop control for linear regulator problem - linear tracking problem – Pontryagin's minimum principle - state inequality constraints - minimum time problems - minimum control effort problems.

Module 3: (10 hours)

Dynamic programming - principle of optimality - application to multi stage decision making – application to optimal control problem – need for interpolation - recurrence relation of dynamic programming – curse of dimensionality - discrete linear regulator problem - Hamilton-Jacobi-Bellman equation – continuous linear regulator problem.

Module 4: (10 hours)

Model Reference Adaptive systems (MRAS) - the need for MRAS - an over view of adaptive control systems - mathematical description of MRAS - design hypothesis - equivalent representation of MRAS - introduction to design method based on the use of Liapunov function – design and simulation of variable structure adaptive model following control

References

1. Donald E. Kirk, Optimal Control Theory, An introduction, Prentice Hall Inc., 2004
2. A. P. Sage, Optimum Systems Control, Prentice Hall, 1977
3. HSU and Meyer , Modern Control, Principles and Applications, McGraw Hill, 1968
4. Yoan D. Landu, Adaptive Control (Model Reference Approach), Marcel Dekker. 1981
5. K. K. D. Young, Design of Variable Structure Model Following Control Systems., IEEE Transactions on Automatic Control, Vol. 23, pp 1079-1085, 1978.
6. A. S. I. Zinobar, O. M. E. El-Ghezawi and S.A. Billings, Multivariable variable structure adaptive model following control systems. . Proc. IEE., Vol. 129, Pt. D., No.1, pp 6-12, 1982

EE6104: Advanced Instrumentation

Pre-requisite: Nil

Total hours: 42 Hrs.

L	T	P	C
3	0	0	3

<u>Course Outcomes</u>

CO1: Acquire knowledge about the fundamental concepts of measurement systems.

CO2: Acquire knowledge about the static and dynamic characteristics of measuring instruments.

CO3: Get familiarize with the mathematical modeling and time response of first order and second order measurement systems.

CO4: Study and analysis of amplitude modulation of measurements and the design consideration of such amplitudes modulated measurement systems.

CO5: Acquire knowledge about the requirements to ensure accurate measurements.

Syllabus

Module 1: (11 hours)

Generalized input output configuration of measuring system. different methods of correction. General principles. Methods of inherent sensitivity, Principle of filtering, Method of opposing inputs.

Module 2: (11 hours)

Static characteristics of measurement system computer aided calibration and measurement. concept of development of software. Dynamic characteristics. Mathematical Models. General concepts of transfer functions (with special reference to measuring system). Classification of instruments based on their order and their dynamic response and frequency response studies.

Module 3: (10 hours)

Response of general form of instruments to various input (a) periodic (b) transient. Characteristics of random signals. Measurement system response to random inputs.

Module 4: (10 hours)

Study and analysis of amplitude modulation of measurements and design consideration of such amplitudes modulated measurement systems. Requirements on instrument transfer function to ensure accurate measurements.

References

1. Ernest O. Doebelin. Measurement system Application and Design. McGraw Hill International Editions, 1990

2. K. B. Klaasen: Electronic Measurement and Instrumentation, Cambridge University Press, 1996

EE6106: System Identification & Parameter Estimation

Pre-requisite: Nil

Total hours: 42 Hrs.

L	T	P	C
3	0	0	3

Course Outcomes

CO1: Get explored to different system identification methods

CO2: Usage of the above methods for online and offline identification of various systems and finding out its limitation in various situations

CO3: Estimate parameters using statistical framework

CO4: Identify multivariable and closed loop systems.

CO5: Design experiments to identify systems on a practical basis and proposing validation techniques for these models

Syllabus

Module 1: Systems and Models (9 hours)

Time invariant systems- impulse response, disturbances and transfer functions- frequency domain expressions - signal spectra – multivariable systems. Simulation -prediction - observers. Models of linear time invariant systems- linear models and sets of linear models- state space models – distributed parameter models – model sets structures and identifiability – identifiability of some model structures – Models of time varying and nonlinear systems- linear time varying models- nonlinear state space models- nonlinear black box models – neural networks- wavelets and classical models – fuzzy models – formal characterization of models.

Module 2: Model Estimation Methods (12 hours)

Nonparametric time and frequency domain methods- transient response analysis – frequency response analysis- Fourier analysis- Spectral analysis – estimating disturbance spectrum – Parameter estimation methods – guiding principles – minimizing prediction errors – linear regressions- and least squares method, statistical framework for parameter estimation and maximum likelihood estimation - correlation of prediction error with past data - Instrumental variable methods- using frequency domain data to fit linear models.

Module 3: Converge and Distributions of parameter Estimates (13 hours)

Conditions of data set – prediction error approach – consistency and identifiability – linear time invariant models - correlation methods. Prediction error approach – basic theorem – expressions for asymptotic variance – frequency domain expressions for asymptotic variance – correlation approach – use and relevance. Computing the estimate - linear regression and least squares – computing gradients – two stage and multi stage methods – local solutions and initial values – subspace methods - Recursive methods - recursive forms of least squares , IV , prediction error and pseudo linear regression methods - choice of updating step. Implementation problems.

Module 4: Experiment Design (8 hours)

General Considerations – informative experiments – input design and open loop experiments – closed loop identification –approaches –optimal experiment design – choice of sampling interval – Preprocessing of data – drifts de-trending – outliers and missing data – selecting segments of data and merging experiments – pre-filtering –formal design of pre-filtering and input properties.

References

1. Lennart Ljung, system Identification Theory for the User, Prentice Hall Inc, 1999
2. Sinha N K, Kuztsa, System Identification and Modelling of Systems, 1983
3. Harold W Sorensen, Parameter Estimation: Marcel Dekker Inc, New York. 1980

EE6108: Nonlinear System Analysis

Pre-requisite: Nil

Total hours: 42 Hrs.

L	T	P	C
3	0	0	3

Course Outcomes

CO1: Revise the knowledge on the characteristics of nonlinear systems

CO2: Learn about equilibrium points and periodic orbits

CO3: Learn the perturbation method for solution of nonlinear system dynamics

CO4: Acquire knowledge on Lyapunov stability and L stability

CO5: Understand harmonic linearization and describing function analysis

CO6: Acquire knowledge on analysis of feedback systems having nonlinearity

CO7: Learn various control techniques for nonlinear systems viz. backstepping control, sliding mode control

CO8: Understand the concept of feedback linearization and stabilization

Syllabus

Module 1: Introduction and classical techniques (7 Hours)

Characteristics of nonlinear systems - classification of equilibrium points - limit cycles - analysis of systems with piecewise constant inputs using phase plane analysis - perturbation techniques- periodic orbits - stability of periodic solutions - singular perurbation model - slow and fast manifolds.

Module 2: Lyapunov Stabilty and Design (15 hours)

Stability of Nonlinear Systems - Lyapunov stability - local stability - local linearization and stability in the small - Direct method of Lyapunov - generation of Lyapunov function for linear and nonlinear systems - variable gradient method - Centre manifold theorem - region of attraction - Invariance theorems – Input output stability - L stability - L stability of state models - L2 stability- Lyapunov based design – Lyapunonv redesign - Robust stabilization - Nonlinear Damping - backstepping - sliding mode control – adaptive control - Model controller - model reference adaptive control

Module 3: Harmonic Linearisation and Describing Function Method (10 Hours)

Harmonic linearization - filter hypothesis - describing function of standard nonlinearities- study of limit cycles (amplitude and frequency) using SIDF- Dual Input Describing function - study of sub-harmonic oscillations - correction on describing functions

Module 4: Feedback Control and Feedback Stabilization (10 Hours)

Analysis of feedback systems - Circle Criterion - Popov Criterion - simultaneous Lyapunov functions - Feedback linearization - stabilization - regulation via integral control - gain scheduling - input state linearization - input output linearization - state feedback control - stabilization - tracking - integral control

References

1. Hassan K Khalil, Nonlinear Systems, Prentice - Hall International (UK) 1996
2. Slotine & W.LI, Applied Nonlinear Control Prantece Hall, Engloe wood NewJersey 1991
3. A Isidori, Nonlinear Control systems Springer verlag New york 1995
4. S. Wiggins, Introduction to Applied Nonlinear Dynamical Systems and chaos, Springer Verlag New York, 1990
5. H. Nijmeijer & A.J. Van Der schaft, Nonlinear Dynamic control Systems, Springer Verlag Berlin 1990.
6. Arther E Gelb & Vender Velde, Multiple input Describing function and Nonlinear System Design, MC Graw Hill 1968

EE6192 Mini Project

L	T	P	C
0	0	3	1

Course Outcomes

CO1: Ability to undertake individual short research projects in the area of Control and Instrumentation Systems.

CO2: Ability to design and implement control techniques and instrumentation systems for various processes/plants.

CO3: Acquire skills in preparing detailed report describing the relevance of the problem, modeling aspects, methodologies and analysis of the results.

CO4: Ability to communicate by making oral presentation before an audience

EE6194 Seminar

L	T	P	C
0	0	3	1

Course Outcomes

CO1: Ability to study research papers for understanding emerging technologies in the field of Control and Instrumentation Systems, to summarize and to review them.

CO2: Understand promising new directions of various cutting edge technologies.

CO3: Achieve skills in preparing detailed report describing the reviewed topic.

CO4: Ability to communicate by making an oral presentation before an evaluation committee.

EE7191 Main Project – 1

L	T	P	C
0	0	16	8

Course Outcomes

CO1: Ability to conduct a literature survey, identify a research topic in the area of Control and Instrumentation System, formulate the problem and conduct its feasibility study

CO2: Ability to design and implement control techniques and instrumentation systems for the selected process/problem

CO3: Learn to use new tools effectively and creatively

CO4: Ability to write Technical Project reports, to make oral presentation and to demonstrate the work done to an audience

CO5: Ability to interpret the results, identify the limitations of the work done and make suggestions to rectify them

EE7192 Main Project – 2

L	T	P	C
0	0	24	12

Course Outcomes

CO1: Ability to conduct a literature survey, identify a research topic in the area of Control and Instrumentation System, formulate the problem and conduct its feasibility study

CO2: Ability to design and implement control techniques and instrumentation systems for the selected process/problem

CO3: Learn to use new tools effectively and creatively

CO4: Ability to write Technical Project reports, to make oral presentation and to demonstrate the work done to an audience

CO5: Ability to interpret the results, identify the limitations of the work done and make suggestions to rectify them

Elective Courses

MA7160 Simulation and Modelling

L	T	P	C
3	1	0	3

Total hours: 56 Hrs.

Course Outcomes

CO1: Get introduced the simulation of stochastic systems with a perspective to apply it for various stochastic system studies in the real world.

CO2: To learn deferent kinds of stochastic systems, generation of random samples, modelling and simulation of continuous systems, methodology for discrete system simulation.

CO3: To learn the evaluation of Simulation Experiments and study different Simulation Languages.

CO4: To learn the Simulation of different Queuing Systems and applying it.

CO5: To learn the Simulation of Stochastic Network - Simulation of PERT Network and applying it. The simulation of PERT network plays a vital role in planning and R&D activities.

Syllabus

Module I: (14 hours)
Introduction to system simulation -Introduction: Systems and models – Computer simulation and its applications. Continuous system simulation- Modelling continuous systems, simulation of continuous systems. Discrete system simulation- Methodology, event scheduling and process interaction approaches. Random number generation – testing of randomness, generation of stochastic variates, Random samples from continuous distributions – Uniform distribution, Exponential distribution m-Erlang distribution, Gamma distribution, Normal distribution, Beta distribution, Random samples from discrete distributions – Bernoulli, Discrete uniform, Binomial, Geometric and Poisson.

Module II: (14 hours)
Evaluation of Simulation Experiments and Simulation Languages - Evaluation of simulation experiments-verification and validation of simulation experiments, Statistical reliability in evaluating simulation experiments – Confidence intervals for terminating simulation runs - Simulation Languages: Programming Considerations – General features of GPSS, SIMSCRIPT and SIMULA.

Module III: (14 hours)
Simulation of Queuing Systems - Introduction – Parameters of queue, formulation of queuing problems, generation of arrival pattern, generation of service pattern, simulation of single server queues, simulation of multi-server queues, simulation of tandem queues. Computer simulation of Queuing systems.

Module IV: (14 hours)

Simulation of Stochastic Network - Introduction: Simulation of PERT Network – Definition of network diagrams, forward pass computation, simulation of forward pass, backward pass computations, simulation of backward pass, determination of float and slack times determination of critical path, simulation of complete network, merits of simulation of stochastic networks. Computer simulation of PERT network.

References

1. Deo,N ," (1989), "System Simulation and Digital Computer" , PHI, Delhi.

2. Gordan, G , (1990), "System Simulation" , PHI, Delhi.

3. Banks, J., Carson, J. S., and Nelson, B. L., (2000), "Discrete –Event System Simulation, 2nd edn., PHI, New Delhi.

4. Law, A.M. and Kelton, W.D , (1990), "Simulation Modelling and Analysis", Mc- Graw Hill.

MA7165 Statistical Digital Signal Processing

L	T	P	C
3	1	0	3

Total hours: 56 Hrs.

Course Outcomes

CO1: Acquire knowledge about random variables and random processes.

CO2: To learn about digital signal modeling and various techniques used for stochastic modeling.

CO3: Understanding and applying the concept of filtering in digital signal processing.

CO4: Acquire knowledge about theory and application of various types of filters.

CO5: To learn about parametric and nonparametric methods for spectrum estimation.

Syllabus

Module I: (15 hours)

Discrete-Time Random Processes: Random Variables, Random Processes, Filtering Random Processes, Spectral Factorization, Special Types of Random Processes.

Module II: (12 hours)

Signal Modeling: The Least Squares Method, The Pade Approximtion, Prony's Method, Finite Data Records, Stochastic Models.

Module III: (14 hours)

Lattice Filters and Wiener Filtering: The FIR Lattice Filter, Split Lattice Filter, IIR Lattice Filters, Stochastic Modeling, The FIR Wiener Filter, IIR Wiener Filter, Discrete Kalman Filter.

Module IV: (15 hours)

Spectrum Estimation: Nonparametric Methods, Minimum Variance Spectrum Estimation, The Maximum Entropy Method, Parametric Methods, Frequency Estimation, Principal Components Spectrum Estimation.

References:
1. M. H. Hayes; "Statistical Digital Signal Processing and Modeling", John Wiley & Sons, 2004.
2. G. J. Miao and M. A. Clements; "Digital Signal Processing and Statistical Classification", Artech House, London, 2002.
3. R. M. Gray and L. D. Davisson ; "An Introduction to Statistical Signal Processing", Cambridge University Press, 2004.

MA8154 Wavelets Theory

Pre-requisite: Nil

Total hours: 42 Hrs.

L	T	P	C
3	0	0	3

Course Outcomes

CO1: Acquire knowledge about the basic linear algebra results

CO2: Acquire knowledge about the discrete Fourier transforms and the fast Fourier transforms algorithm

CO3: Acquire knowledge about wavelets on the finite dimensional spaces.

CO4: Acquire knowledge about wavelets on the infinite dimensional spaces.

CO5: Acquire knowledge about construction of multiresolution analysis.

Syllabus

ModuleI: (11hours)
Vector spaces and Bases, Linear transformation, Matrices and change of basis, Inner products, Hilbert Space, Fourier transforms , Parsevl identity and Plancherel theorem, Basic Properties of Discrete Fourier Transforms , Translation invariant Linear Transforms ,The Fast Fourier Transforms.

Module II: (11 hours)
Construction of wavelets on Z_N ,The Haar system, Shannon Wavelets, Real Shannon wavelets , Daubechies's D_6 wavelets on Z_N., Examples and applications.

Module III: (11hours)
Wavelets on Z**:** l^2 (Z), Complete orthonormal sets in Hilbert spaces , and Fourier series ,The Fourier Transform and convolution on l),(2ππ−L^2 (Z) , First stage Wavelets on Z , Implementation and Examples.

Module IV: (9 hours)
Wavelets on R : L^2 (R) and approximate identities , The Fourier transform on R , Multiresolution analysis , Construction of MRA .

References:

1. Michael. W. Frazier, “An Introduction to Wavelets through Linear Algebra”, Springer, Newyork, 1999.
2. Jaideva. C. Goswami, Andrew K Chan, “Fundamentals of Wavelets Theory Algorithms and Applications”, John Wiley and Sons, Newyork. , 1999.
3. Yves Nievergelt, “Wavelets made easy”, Birkhauser, Boston, 1999.
4. G. Bachman, L.Narici and E. Beckenstein, “Fourier and wavelet analysis”, Springer, 2006.

ME6429 Research Methodology

Course Outcomes

CO1: Learn to critically review the methodology of a research study.

CO2: Acquire knowledge to explore the methodological issues regarding the design, implementation, analysis, and interpretation of measures under study.

CO3: Understand the concepts of descriptive and inferential statistics.

CO4: Apply the appropriate statistical procedures to analyze the results.

Syllabus

Module I: Research Methodology- concepts- Types of research- Variables- Literature review-Methods of data collection- Types of data- Primary data- Scales of measurement- Sources-Collection of data- Observation method- interview method- Survey- Questionnaires and Scaling-Experiments- Collection of secondary data- Research design- Different research designs-Processing and analysis of data- Sampling- Steps in sampling design- Characteristics of good sampling design- Types of sampling distributions- Central limit theorem- Concept of standard error- Population mean- Sample size and its determination- Reliability- Validity- Chronbach’s Alpha.

Module II: Statistics in research- Descriptive statistics and inferential statistics- Measures of central tendency- Measures of dispersion- Skewness- Measures of asymmetry- Measures of relationship- Correlation and regression- Logic behind Correlation- Simple regression analysis-Multiple regression-Principal component analysis.

Module III: Hypothesis- Experimental Designs- Testing of hypothesis- Type I and Type II error-Probability distributions- Normal distribution- P-value- Chi square test- Chi-square as a test for comparing variance- Conditions for the application of Chi-square test- Analysis of variance (ANOVA)- basic principle- ANOVA technique- One way ANOVA- Two way ANOVA-Characteristics of non-parametric tests- Multivariate analysis techniques- Characteristics and applications.

Module IV: Introduction to SPSS software- Doing descriptive statistics- Averages and dispersion using SPSS- Correlation and regression using SPSS- ANOVA using SPSS.

EE6121: Data Acquisition & Signal Conditioning

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours: 42 Hrs.

Course Outcomes

CO1: Understand the objectives and configurations of data acquisition systems

CO2: Learn the working and characteristics of transducers

CO3: Learn about signal conditioning systems and noise reduction techniques

CO4: Acquire knowledge on filtering & sampling techniques and filter design

CO5: Acquire knowledge on signal conversion (analog to digital and digital to analog) techniques

CO6: Understand various data transmission techniques

CO7: Learn various interfacing techniques and standards for communication between instruments

Syllabus

Module 1: Transducers & Signal conditioning (11 hours)

Data Acquisition Systems (DAS) - Introduction. Objectives of DAS. Block Diagram Description of DAS General configurations - Single and multichannel DAS-Transducers for the measurement of motion, force, pressure, flow, level, dc and ac voltages and currents (CTs, PTs for supply frequency as well as high frequency, Hall Effect Current Sensors, High Voltage Sensors , Optosensors, Rogowski Coil, Ampflex Sensors etc.) - Signal Conditioning: Requirements - Instrumentation amplifiers: Basic characteristics. Chopped and Modulated DC Amplifiers-Isolation amplifiers - Opto couplers - Buffer amplifiers. Noise Reduction Techniques in Signal Conditioning- Transmitters .Optical Fiber Based Signal Transmission - Piezoelectric Couplers-Intelligent transmitters.

Module 2: Filtering and Sampling (10 hours)

Review of Nyquist.s Sampling Theorem- Aliasing. Need for Prefiltering-First and second order filters - classification and types of filters - Low -pass, High-pass, Band-pass and Band-rejection and All Pass: Butterworth, Bessel, Chebyshev and Elliptic filter . Opamp RC Circuits for Second Order Sections-Design of Higher Order Filters using second order sections using Butterworth Approximation-Narrow Bandpass and Notch Filters and their application in DAS. Sample and Hold Amplifiers

Module 3: Signal Conversion and Transmission (10 hours)

Analog-to-Digital Converters (ADC)-Multiplexers and demultiplexers - Digital multiplexer. A/D Conversion. Conversion Processes, Speed, Quantization Errors. Successive Approximation ADC. Dual Slope ADC. Flash ADC. Digital-to-Analog Conversion (DAC). Techniques, Speed, Conversion

Errors, Post Filtering- Weighted Resistor, R-2R, Weighted Current type of DACs- Multiplying Type DAC-Bipolar DACs- Data transmission systems-Schmitt Trigger-Pulse code formats-Modulation techniques and systems-Telemetry systems.

Module 4: Digital Signal Transmission and Interfacing (11 hours)

DAS Boards-Introduction. Study of a representative DAS Board-Interfacing Issues with DAS Boards, I/O vs Memory Addressing, Software Drivers, Virtual Instruments, Modular Programming Techniques for Robust Systems, Bus standard for communication between instruments - GPIB (IEEE-488bus) - RS-232CUSB- 4-to-20mA current loop serial communication systems. Communication via parallel port. Interrupt based Data Acquisition. Software Design Strategies-Hardware Vs Software Interrupts-Foreground/background Programming Techniques-Limitations of Polling. Circular Queues

References

1. Ernest O Doeblin, Measurement Systems: Application and Design, McGraw Hill (Int. edition) 1990

2. George C. Barney, Intelligent Instrumentation, Prentice Hall of India Pvt Ltd., New Delhi, 1988.

3. Ibrahim, K.E., Instruments and Automatic Test Equipment, Longman Scientific & Technical Group Ltd., UK, 1988.

4. John Uffrenbeck, The 80x86 Family, Design, Programming, and Interfacing, Pearson Education, Asia, 2002

5. Bates Paul, Practical digital and Data Communications with LSI, Prentice Hall of India, 1987.

6. G. B. Clayton, .Operational Amplifiers, Butterworth &Co, 1992

7. A. K Ray, Advanced Microprocessors and Peripherals, Tata McGrawHill, 1991

8. Oliver Cage, Electronic Measurements and Instrumentation, McGraw-Hill, (Int. edition) 1975

EE6122: Biomedical Instrumentation

Pre-requisite: Nil

Total hours: 42 Hrs.

L	T	P	C
3	0	0	3

<u>Course Outcomes</u>

CO1: Provide the students with an insight into the physiological system of the body and also an understanding on the generation of various bioelectric signals like ECG, EEG and EMG, their characteristic features and concepts of transduction.

CO2: Provide the students with an understanding of the various techniques and clinical instruments available for the measurement of various physiological parameters.

CO3: Provide the students the fundamentals of medical instrumentation along with their working principle.

CO4: Equip the students with research potential so that the principles of engineering and basic sciences shall be applied to improve the existing design and make it more economical and biocompatible for the betterment of mankind.

Syllabus

Module 1: (12 hours)

Fundamentals of medical instrumentation – physiological systems of body –regulation of medical devices – origin of bio potentials – Sodium –Potassium pump –Goldman Hodgkin – Katz equation – biomedical transducers – electrode-electrolyte interface – half cell potential – ECG – 12 lead systems – heart rate variability – cardiac pacemakers – defibrillators - EMG – EEG

Module 2: (10 hours)

Measurement of cardiac output – indicator dilution method – ultrasonic blood flow meter – electromagnetic blood flow meter – blood pressure measurement – oximetry – ear oximeter – pulse oximeter –skin reflectance oximeter -measurement on pulmonary system – spirometry – pulmonary function analyzers –ventilators

Module 3: (10 hours)

Lasers in medicine – Argon laser – Carbon dioxide laser -laser safety –X ray applications –X-ray machine – dental X-ray machine – ultra sound in medicine –electro therapy – hemodialysis – artificial kidney – dialyzers –membranes for hemodialysis

Module 4: (10 hours)

Measurement of pH, pCO_2, pO_2 - radiotherapy – Cobalt 60 machine – medical linear accelerator machine – audiometry - electrical safety in hospitals

References

1. Geddes & Baker, Principles of applied biomedical instrumentation Wiley Inter science, 3rd edition, 1975
2. R S Khandpur, Hand book of biomedical instrumentation, TMH, 4th edition, 1987
3. Cromwell Leslie, Biomedical instrumentation and measurements, PHI, 1980
4. Brown Carr, Introduction to Biomedical equipment technology, Prentice Hall, 1981
5. John Enderle, Introduction to Biomedical engineering, Academic Press, 2005
6. Joseph D Bronzino, Biomedical engineering hand book, CRC Press, 2000
7. Metin Akay (editor), Wiley encyclopedia of biomedical engineering, Wiley, 2003

EE6123: Performance Modelling of Systems – I

Pre-requisite: Nil

Total hours: 42 Hrs.

L	T	P	C
3	0	0	3

Course Outcomes

CO1: Acquire knowledge about the general operational characteristics and frequency response studies of instruments.

CO2: Acquire basic knowledge about set theory and different operations involved in it.

CO3: Acquire basic knowledge about general graph theory and different components involved it.

CO4: Acquire basic knowledge about active graph theory and hence to study petrinet and S-net graphs.

Syllabus

Module 1: **General Operational Characteristics (10 hours)**

Input-Output configuration of measuring systems. Static characteristics. Dynamic characteristics.

Mathematical models. General concepts of transfer function. Classification of instruments based on their order. Dynamic response. Frequency response studies.

Module 2: General Concepts in Set Theory (10 hours)

Preliminaries. Basic set theory. Terminology. Functions. Relations - Combinatorics. Theory of counting - Multiplication rule- Ordered samples and permutations-Ordered samples with and without repetitions - Brief theory of bags.

Module 3: General Graph Theory (10 hours)

Graphs and algorithms. Concepts of Nodes and Arcs- Trees. Spanning of trees. Minimal spanning trees; Prime's algorithm- Binary trees and tree searching- Planar graphs and Euler's theorem- Cut sets. Adjacency/incidence matrices. Graph having multiple edges. Determination of Euler cycles- The shortest path problem.

Module 4: Active Graph Theory (12 hours)

Performance models. Petrinet graph- Concepts of places. Transitions. Arcs and Tokens. Concurrency and conflict- Deadlocks- Markings- Reachability sets-Matrix equations-Reachability problems- Popular extensions. S-Nets. Introduction to Petrinet and S Net Models.

References

1. Ernest O Doeblin, Measurement Systems: Application and Design, McGraw Hill (Int. edition) 1990

2. Oliver and Cage, Electronic measurements and Instrumentation, McGraw Hill Int. Editions, 1971

3. C. L. Liu, Elements of Discrete Mathematics, McGraw Hill Int. Editions, 1985.

4. Robert J. McEliece, Robert B Ash, Carol Ash, Introduction to Discrete Mathematics, McGraw Hill Int. Editions, 1989.

5. J.L. Peterson., Petrinet Theory and Modelling of Systems, Prentice Hall Inc., Englewood Cliffs, N. J., 1981.

6. John O. Moody, Panos J Antsaklis, Supervisory Control of Discrete Event System Using Petrinets, Kluwer academic Publishers Boston/Dordrecht/ London, 1998.

7. N. Viswanathan, Y. Narahari, Performance Modelling of Automated Manufacturing Systems, Prentice Hall of India Pvt. Ltd., New Delhi, 1994.
8. Proceedings: Conference on Advances in Computing CAD CAM 98, Allied Publishers Ltd., New Delhi, India, 1999

EE6124: Performance Modelling of Systems – II

Pre-requisite: EE6123: Performance Modelling of Systems - I

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

Course Outcomes

CO1: Acquire knowledge about modeling philosophies of different systems.

CO2: Acquire knowledge about modeling tools such as petrinet and S-net.

CO3: To develop a model of automated manufacturing systems using petrinet and S-net tools.

CO4: Familiarization of modeling with active graph theory and enable the students to model the standard problems like dining philosophers problem and readers/writers problem.

CO5: To give an insight to popular extensions of petrinet and S-net theory and different case studies.

Syllabus

Module 1: Modelling Philosophies (10 hours)
Modelling philosophies. Rationales for mathematical modeling. Dynamic versus steady state models. General modelling principles. Degrees of freedom in modelling Transfer function models. Procedure for developing transfer function models.

Module 2: Modelling Tools and Applied Systems (10 hours)
Performance measures. Petrinet models. Introduction to Petrinet. Basic definitions and analytical
techniques. S-Net models. Preliminary definitions and analytical techniques. Performance modelling. Modelling of automated manufacturing systems. Role of performance modelling.

Module 3: Active Graphical Modelling Tools (10 hours)
Modelling with active graph theory. General concepts. Events and conditions. Synchronisation. Mutual exclusion problems. Standard Problems - Dining philosopher’s problems. Readers/ writers problems.

Module 4: Analysis of Modelling Tools (12 hours)
Analysis problems of active graph. Petrinets. S-Nets. Their popular extensions. Different case studies of Petrinet and S-Net models related to super computer pipe line. Flexible manufacturing systems. Computer communication system. Computer controlled data acquisition system- computer communication network. Process control systems.

References

1. Ernest O Doeblin., Measurement Systems: Application and Design, McGraw Hill (Int. edition) 1990

2. Oliver and Cage, Electronic measurements and Instrumentation, McGraw Hill Int. Editions, 1971

3. C. L. Liu, Elements of Discrete Mathematics, McGraw Hill Int. Editions, 1985.

4. Robert J. McEliece, Robert B Ash, Carol Ash, Introduction to Discrete Mathematics, McGraw Hill Int. Editions, 1989.

5. J. L. Peterson., Petrinet Theory and Modelling of Systems , Prentice Hall Inc., Englewood Cliffs, N. J., 1981.

6. John O. Moody, Panos J. Antsaklis, Supervisory Control of Discrete Event System Using Petrinets, Kluwer academic Publishers Boston/Dordrecht/ London, 1998.

7. N. Viswanathan, Y. Narahari, Performance Modelling of Automated Manufacturing Systems, Prentice Hall of India Pvt. Ltd., New Delhi, 1994.

8. Proceedings: Conference on Advances in Computing CAD CAM 98, Allied Publishers Ltd., New Delhi, India, 1999.

9. Seborg. Process dynamic control, Wiley, 2007

EE6125: Digital Control Systems

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

Course Outcomes

CO1: Acquire knowledge about the modeling of Digital Control Systems

CO2: Acquire knowledge about analysis of digital control systems in the z-domain as well as state space domain

CO3: Acquire knowledge about classical techniques for design of digital controllers with case study examples using MATLAB

CO4: Acquire knowledge about techniques based on state-space for design of digital controllers with case study examples using MATLAB

CO5: Acquire knowledge about the finite wordlength effects on system performance.

Syllabus

Module 1: Introduction to Digital Control systems (11 hours)

Data conversion and quantisation - Sampling process- Mathematical modeling- Data reconstruction and filtering of sampled signals- Hold devices- z transform and inverse z transform - Relationship between s plane and z- plane- Difference equation - Solution by recursion and z-transform- Discretisation Methods

Module 2: Analysis of Digital Control Systems (10 hours)

Digital control systems- Pulse transfer function - z transform analysis of closed loop and open loop systems- Modified z- transfer function- Multirate z-transform - Stability of linear digital control systems - Stability tests- Steady state error analysis- Root loci - Frequency domain analysis- Bode plots- Nyquist plot s- Gain margin and phase margin.

Module 3: Classical Design of Digital Control Systems (10 hours)

Cascade and feedback compensation by continuous data controllers- Digital controllers-Design using bilinear transformation- Root locus based design- Digital PID controllers- Dead beat control design – Case study examples using MATLAB

Module 4: Advanced Design of Digital Control Systems (11 hours)

State variable models- Interrelations between z- transform models and state variable models - Controllability and Observability - Response between sampling instants using state variable approach - Pole placement using state feedback – Servo Design- State feedback with Integral Control-Deadbeat Control by state feedback and deadbeat observers- Dynamic output feedback- Effects of finite wordlength on controllability and closed loop pole placement- Case study examples using MATLAB.

References

1. B. C Kuo, Digital Control Systems (second Edition), Oxford University Press, Inc., New York, 1992.

2. G. F. Franklin, J.D. Powell, and M.L. Workman, Digital control of Dynamic Systems, Addison-Wesley
Longman, Inc., Menlo Park, CA, 1998.

3. M. Gopal, Digital Control and State Variable Methods, Tata McGraw Hill Publishing Company, Third Edition, 2009.

4. John F. Walkerly, Microcomputer architecture and Programs, John Wiley and Sons Inc., New York, 1981.

5. K. Ogata, Discrete Time Control Systems, Addison-Wesley Longman Pte. Ltd., Indian Branch, Delhi, 1995.

6. C. H. Houpis and G.B. Lamont, Digital Control Systems, McGraw Hill Book Company, 1985.

7. C. L. Philips and H.T NagleJr., Digital Control System Analysis and Design, Prentice Hall, Inc., Englewood Cliffs, N.J., 1984.

EE6126: Advanced Topics in Control System

Pre-requisite: EE6101: Dynamics of Linear Systems

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

Course Outcomes

CO1: Acquire knowledge in the theory of some of the advanced topics in control systems like fuzzy and neuro-fuzzy systems, aerospace guidance systems, chaotic systems and variable structure systems.

CO2: Acquire knowledge of adaptive neuro-fuzzy systems and use software tools for simulation studies of such systems.

CO3: Acquire knowledge of multi-input multi-output system modeling and controller design for such systems.

CO4: Acquire knowledge of chaotic systems and their synthesis using neural network.

CO5: Acquire knowledge of chaos in medicine and physiology.

CO6: Acquire knowledge of guidance and control of aerospace systems.

CO7: Acquire knowledge of guidance for cruise vehicles, rockets and ballistic missiles.

Syllabus

Module 1: Neuro-Fuzzy Modelling and Control of Systems (9 hours)

Fuzzy Models- Mamdani and Takagi Sugeno Models- Construction of fuzzy models. Neural networks. Adaptive networks. supervised learning. Adaptive neuro-fuzzy inference systems-ANFIS architecture - ANFIS as a universal approximator - Simulation examples.

References

1. Robert Babuska :Fuzzy Modelling and Control - . International Series in Intelligent Technologies, Kluwer Academic Publications . (1998)
2. Jang J SR ,Sun C T, Mizutani E : Neuro-fuzzy and Soft Computing . MATLAB curriculum Series, Prentice Hall International (1997)
3. Selected papers on Neuro-fuzzy Modelling and Control.

Module 2: Linear Multi-Input-Multi-Output Control Systems (10 hours)

Representations of MIMO systems- Equivalent transformations- Canonical forms- Solution of state equations- System response- Controllability and pole allocation- Observability and state estimator- System characterization by transfer matrix- Noninteractive and model matching control design.

References

1. Apte Y.S., Linear Multivariable Control Theory, Tata McGraw Hill Publishing Co. Ltd., 1994.
2. Chen C.T., Linear System Theory and Design, Holt Reinhart and Winston Inc., 1984
3. Wolovich W.A., Linear Multivariable Systems, Springer- Verlag , New york- Heidelberg- Berlin, 1974.
4. Thomas Kailath, Linear Systems, Prentice Hall Inc., Englewood Cliffs, N.J. , 1980

Module 3: Chaos, fractals, applications and Aerospace Guidance Systems (14 hours)

Non linear systems. chaos. fractals. dimensions. attractors. Lorenz attractor. Mandelbrot set, bifurcations. synthesis of some chaotic systems using neural net work. some control applications. fractals and chaos in medicine and physiology. Introduction. trajectory aspects. inertial and optical sensors. inertial guidance for cruise vehicles. guidance and control of rocket vehicles . guidance and control of mobile-launched ballistic missiles.

References

1. Selected papers and case studies

2. Leondis C T, Guidance and Control of Aerospace Vehicles. McGraw Hill Book Company Inc New York, 1963

Module 4: Variable Structure Systems (9 hours)

Introduction. Variable Structure Systems (VSS). VSS for fast response. VSS for stability. VSS with sliding mode. Sliding mode motion. Existence Condition - Second order control problem. Sliding mode motion on switching line. Sliding mode motion on switching surface. Design of stable switching surface. Invariance Conditions in VSS. Variable structure model following control (VSMFC)

References

1. U. Itkis. Control Systems of variable structure, New York, Wiley, 1976

2. A.S.I. Zinober (Edited by) - Deterministic Control of Uncertain Systems, British Library Cataloguing in Publication Data, Peter Peregrinus Ltd. 1990

3. B. Drazenovic . The invariance conditions in variable structure systems, Automatica, Vol. 5, pp 287-295, 1969.

4. K. K. D. Young. Design of Variable Structure Model Following Control Systems, IEEE Transactions on Automatic Control, Vol. 23, pp-1079-1085 - 1978

5. A. S. I. Zinobar, O.M.E. EI-Ghezawi and S.A.Billings - Multivariable variable structure adaptive model following control systems . Proc. IEE., Vol. 129., Pt. D., No.1, pp-6-12, 1982

EE6127: Variable Structure Control Systems

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

Course Outcomes

CO1: Acquire knowledge in the method of combining system structures during the control process so as to achieve system stability and better performance characteristics.

CO2: Acquire knowledge of variable structure systems with sliding mode motion so as to design sliding mode controllers for both linear and nonlinear systems so as to achieve desired performance characteristics while fulfilling the controlled systems' goal like set point regulation, tracking, stability etc.

CO3: Acquire knowledge on the design of switching surfaces for higher order systems and design variable structure controllers for such systems taking into consideration possible parameter variations in the system.

CO4: Acquire knowledge on chattering reduction techniques so as to be able to implement variable structure controllers to physical systems.

CO5: Acquire knowledge of variable structure model following control systems so as to utilize the merits of model following in variable structure control systems.

CO6: Acquire knowledge to develop and utilize modern software tools for design and analysis of both variable structure control systems and variable structure model following control systems.

CO7: Apply the knowledge of variable structure controller design to practical systems

<u>Syllabus</u>

Module 1: (8 hours)

Variable Structure Systems (VSS)-Introduction- Synthesis of stable systems from unstable structures- VSS for improving speed of response,-VSS for stability- simulation using MATLAB-Simulation using SIMULINK.

Module 2: (10 hours)

Variable structure systems with sliding mode- sliding mode motion- existence condition-equivalent control for sliding mode motion- sliding mode motion on switching line- Invariance conditions- Design of sliding mode controllers using feedback linearisation for non-linear systems- simulation of sliding mode controller using Matlab and Simulink.

Module 3: (12 hours)

Sliding mode motion on switching surface- design of stable switching surfaces- design of sliding mode controller for higher order systems- Sliding mode controller design for a robotic manipulator- Chattering- Chattering reduction techniques.

Module 4: (12 hours)

Variable Structure Model Following Control (VSMFC) Systems - Conditions for perfect model following sliding mode equivalent control - Sliding mode discontinuous control - Design of VSMFC for second order system - Design of VSMFC for higher order systems - Simulation using MATLAB and SIMULINK.

References

1. U Itkis - Control Systems of Variable Structure., New York,Wiley, 1976.
2. A S I Zinober (Edited by) - Deterministic Control of Uncertain Systems., British Library, 1990
3. Cataloguing in Publication Data, Peter Peregrinus Ltd.1990.
4. B. Drazenovic - The invariance conditions in variable structure systems, Automatica., Vol. 5, pp 287. 295, 1969.
5. K. K. D. Young - Design of Variable Structure Model Following Control Systems., IEEE Transactions on Automatic Control, Vol. 23, pp 1079-1085, 1978.

6. A. S. I. Zinobar, O. M. E. El-Ghezawi and S. A. Billings. Multivariable variable structure adaptive model following control systems. Proc. IEE., Vol. 129, Pt.D., No.1, pp 6-12, 1982.
7. J. J. Slotine and S.S. Sastry, Tracking control of non-linear systems using sliding surfaces, with application to robot manipulators. International Journal of Control, 1983, Vol. 38, No.2, pp 465-492.
8. Vadim I. Utkin, Variable Structure Systems with Sliding Modes., IEEE Transactions on Automatic Control, April 1977, pp 212-222.

EE6128: Optimal Estimation and Filtering

Pre-requisite: EE6101: Dynamics of Linear Systems

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

<u>Course Outcomes</u>

CO1: Acquire knowledge on properties of random variables and processes

CO2: Acquire knowledge on linear random process models

CO3: Learn about optimal filters and predictors, Kalman filter and its applications

CO4: Understand the concept of smoothers and their implementation methods

CO5: Learn about nonlinear filters

<u>Syllabus</u>

Module 1: Random Process and Stochastic Systems (6 hours)

Probability and random variables – statistical properties of random variables and random processes – linear random process models – shaping filters and state augmentation – mean and covariance propagation – relationship with model parameters – orthogonality principle

Module 2: Linear Optimal Filters and Predictors (12 hours)

Kalman filter – Kalman Bucy Filter – Optimal linear predictors – Correlated noise sources – relation between Kalman Bucy and winer filters- Quadratic loss function – Matrix Riccati differential equation and discrete time – model equations for transformed variables – Application of Kalman filters

Module 3: Optimal Smoothers & Implementation Methods (10 hours)

Fixed Interval, fixed lag and fixed point smoothers – algorithms. Computer round off –effect of round off errors on Kalman filters- factorization methods for square root filtering – square root UD filters – other implementation methods

Module4: Nonlinear Filtering & Practical Considerations (14 hours)

Quasi-linear filtering —extended Kalman filers – iterated EKF - sampling methods for nonlinear filtering. Detecting and correcting anomalies – bad data and missing data – stability of Kalman filters – Suboptimal and reduced order filters – Memory throughput. Word length considerations - computational efforts – reduction – Error budgets and sensitivity analysis – optimizing measurement selection policies

References

1. Mohinder S. Grewal and Angus P Andrews,: Kalman Filtering Theory and Practice Using MATLAB, John Wiley and Sons , 2008.
2. B D O Anderson, John B Moore: Optimal Filtering, Prentice Hall Inc. 1979
3. Meditch J S: Stochastic Optimal Estimation and Control, 1982

EE6129: Artificial Neural Networks and Fuzzy Systems

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

Course Outcomes

CO1: To introduce the basic model of an artificial neuron and its relationship to biological neurons.

CO2: Acquire knowledge about the learning methods and training of the artificial neural networks.

CO3: Attack problems like weather forecasting, finger print identification, and optical character recognition using ANN.

CO4: Control applications like system identification, Parameter optimization, feedback controller design etc.

CO5: To understand the fuzzy logic and develop fuzzy rule based systems and its applications.

Syllabus

Module 1: (10 hours)

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

Module 2: (10 hours)

Learning process. Supervised and unsupervised learning. Error-correction learning, Hebbian learning, Boltzmen learning, Single layer and multilayer perceptrons, Least mean square algorithm, Back propagation algorithm, Applications in forecasting and pattern recognition and other engineering problems.

Module 3: (10 hours)

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

Module 4: (12 hours)

Fuzzy control systems. Introduction, simple fuzzy logic controllers with examples, special forms of fuzzy logic models, classical fuzzy control problems. inverter pendulum, image processing. home heating system. Adaptive fuzzy systems, hybrid systems.

References

1. J. M. Zurada, .Introduction to artificial neural systems., Jaico Publishers, 1992.

2. Simon Haykins, .Neural Networks . A comprehensive foundation., Macmillan College, Proc, Con, Inc, New York, 1994.

3. D. Driankov, H. Hellendorn, M. Reinfrank, Fuzzy Control An Introduction, Narora Publishing House, New Delhi, 1993.

4. H. J. Zimmermann, Fuzzy set theory and its applications, III Edition, Kluwer Academic Publishers, London. 2001

5. G. J. Klir, Boyuan, .Fuzzy sets and fuzzy logic., Prentice Hall of India (P) Ltd., 1997.

6. Stamatios V Kartalopoulos, .Understanding neural networks and fuzzy logic basic concepts and applications, Prentice Hall of India (P) Ltd., New Delhi, 2000.

7. Timothy J. Ross, .Fuzzy logic with engineering applications, McGraw Hill, New York.

8. Suran Goonatilake, Sukhdev Khebbal (Eds), Intelligent hybrid systems, John Wiley & Sons, New York, 1995.

EE6304: Advanced Digital Signal Processing

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

Course Outcomes

CO1: Acquire knowledge about the time domain and frequency domain representations as well as analysis of discrete time signals and systems

CO2: Acquire knowledge about the design of techniques for IIR and FIR filters and their realization structures.

CO3: Acquire knowledge about the finite word length effects in implementation of digital filters.

CO4: Acquire knowledge about the various linear signal models and estimation of power spectrum of stationary random signals

CO5: Acquire knowledge about the design of optimum FIR and IIR filters.

Syllabus

Module1: Discrete Time Signals, Systems and Their Representations (12 hours)

Discrete time signals- Linear shift invariant systems- Stability and causality- Sampling of continuous time signals- Discrete time Fourier transform- Discrete Fourier series- Discrete

Fourier transform- Z- transform- Properties of different transforms- Linear convolution using DFT- Computation of DFT

Module 2: Digital Filter Design and Realization Structures (9 hours)

Design of IIR digital filters from analog filters- Impulse invariance method and Bilinear transformation method- FIR filter design using window functions- Comparison of IIR and FIR digital filters- Basic IIR and FIR filter realization structures- Signal flow graph representations

Module 3: Analysis of Finite Word-length Effects (9 hours)

Quantization process and errors- Coefficient quantisation effects in IIR and FIR filters- A/D conversion noise- Arithmetic round-off errors- Dynamic range scaling- Overflow oscillations and zero input limit cycles in IIR filters

Module 4: Statistical Signal Processing (12 hours)

Linear Signal Models, All pole, All zero and Pole-zero models, Power spectrum estimation- Spectral analysis of deterministic signals. Estimation of power spectrum of stationary random signals-Optimum linear filters-Optimum signal estimation-Mean square error estimation- Optimum FIR and IIR filters.

References

1. Sanjit K Mitra, Digital Signal Processing: A computer-based approach, Tata Mc Grow-Hill edition, 1998.
2. Dimitris G. Manolakis, Vinay K. Ingle and Stephen M. Kogon, Statistical and Adaptive Signal Processing, Mc Grow Hill international editions, 2000.
3. Alan V. Oppenheim, Ronald W. Schafer, Discrete-Time Signal Processing, Prentice-Hall of India Pvt. Ltd., New Delhi, 1997.
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EE6401: Energy Auditing & Management

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

Course Outcomes

CO1: Acquire the background required for engineers to meet the role of energy managers and to acquire the skills and techniques required to implement energy management.

CO2: Identify and quantify the energy intensive business activities in an organization.

CO3: Acquire knowledge about standard methodologies for measuring energy in the workplace and energy audit instruments.

CO4: Acquire knowledge about energy efficient motors, load matching and selection of motors.

CO5: Acquire knowledge about reactive power management, capacitor sizing and degree of compensation.

CO6: Acquire knowledge about cogeneration - types and schemes, optimal operation of cogeneration plants with case studies.

CO7: Acquire knowledge about variable frequency drives, soft starters, and eddy current drives.

CO8: Acquire knowledge about energy conservation in motors, pumps, fans, compressors, transformers, geysers, lighting schemes, air conditioning, refrigeration, cool storage.

CO9: Gain hands-on experiences by encouraging students to conduct a walkthrough audit in various industries

<u>Syllabus</u>

Module 1: (9 hours)
System approach and End use approach to efficient use of Electricity; Electricity tariff types; Energy auditing: Types and objectives-audit instruments- ECO assessment and Economic methods-specific energy analysis-Minimum energy paths-consumption models-Case study.

Module 2: (11 hours)

Electric motors-Energy efficient controls and starting efficiency-Motor Efficiency and Load Analysis - Energy efficient /high efficient Motors-Case study; Load Matching and selection of motors. Variable speed drives; Pumps and Fans-Efficient Control strategies- Optimal selection and sizing –Optimal operation and Storage; Case study

Module 3: (11 hours)

Transformer Loading/Efficiency analysis, Feeder/cable loss evaluation, case study. Reactive Power management-Capacitor Sizing-Degree of Compensation-Capacitor losses-Location - Placement-Maintenance, case study. Peak Demand controls- Methodologies-Types of Industrial loads-Optimal Load scheduling-case study. Lighting- Energy efficient light sources-Energy conservation in Lighting Schemes- Electronic ballast- Power quality issues-Luminaries, case study.

Module 4: (11 hours)

Cogeneration-Types and Schemes-Optimal operation of cogeneration plants-case study; Electric loads of Air conditioning & Refrigeration-Energy conservation measures- Cool storage. Types-Optimal operation-case study; Electric water heating-Gysers-Solar Water Heaters- Power Consumption in Compressors, Energy conservation measures; Electrolytic Process; Computer Controls- software-EMS

References

1. Handbook on Energy Audit and Environment Management , Y P Abbi and Shashank Jain, TERI, 2006

2. Handbook of Energy Audits Albert Thumann, William J. Younger, Terry Niehus, 20093. Giovanni Petrecca, .Industrial Energy Management: Principles and Applications., The Kluwer international series - 207,1999

4. Anthony J. Pansini, Kenneth D. Smalling, .Guide to Electric Load Management., Pennwell Pub; (1998)

5. Howard E. Jordan, .Energy-Efficient Electric Motors and Their Applications., Plenum Pub Corp; 2^{nd} edition (1994)

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7. Albert Thumann , .Handbook of Energy Audits., Fairmont Pr; 5th edition (1998)

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11. Partab H., 'Art and Science of Utilisation of Electrical Energy', Dhanpat Rai and Sons, New Delhi. 1975

12. Tripathy S.C.,'Electric Energy Utilization And Conservation', Tata McGraw Hill, 1991

13. NESCAP-Guide Book on Promotion of Sustainable Energy Consumption, 2004

14. IEEE Bronze Book, IEEE STD 739

15.IEEE Recommended Practices for Energy Management in Industrial and Commercial Facilities

16. Guide to Energy Management, Sixth Edition , Barney L. Capehart (Author), Wayne C. Turner (Author), William J. Kennedy, Fairmont Press; 6 edition (April 23, 2008)

17. Energy Efficiency Manual: for everyone who uses energy, pays for utilities, designs and builds, is interested in energy conservation and the environment, Donald R. Wulfinghoff, Energy Institute Press (March 2000)

18. Handbook of Energy Audits, Seventh Edition, Albert Thumann., William J. Younger, Fairmont Press; 7 edition (November 12, 2007)

19. Certified Energy Manager Exam Secrets Study Guide: CEM Test Review for the Certified Energy Manager Exam CEM Exam Secrets Test Prep Team Mometrix Media LLC (2009)

20. Handbook of Energy Engineering, Sixth Edition Albert Thumann , D. Paul Mehta Fairmont Press; 6 edition (June 24, 2008)

EE6402: Process Control & Automation

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

Course Outcomes

CO1 Acquire knowledge about the process modelling, control and instrumentation.

CO2: Study the effect of applying advanced control strategies to improve the process control system when working as SISO system and MIMO system

CO3: Get proficiency in multi loop and multi variable Control Systems, effect of process and controller interactions and methods to eliminate these effects.

CO4: Study and design of modern control strategies such as DMC, MPC, MRAS etc. its plant wide design giving importance to hierarchical control

CO5: Application of modern control devices in real time systems as case study

Syllabus

Module 1: (10 hours)
Process Modeling- Introduction to Process control and process instrumentation-Hierarchies in process control systems-Theoretical models-Transfer function-State space models-Time series models-Development of empirical models from process data-chemical reactor - modelling Analysis using softwares

Module 2: (10 hours)
Feedback & Feedforward Control- Feedback controllers-PID design, tuning, trouble shooting-Cascade control- Selective control loops-Ratio control-Control system design based on Frequency response Analysis-Direct digital design-Feedforward and ratio control-State feedback control- LQR problem- Pole placement -Simulation using softwares-Control system instrumentation-Control valves- Codes and standards- Preparation of P& I Diagrams.

Module 3: (11 hours)
Advanced process control-Multi-loop and multivariable control-Process Interactions-Singular value analysis-tuning of multi loop PID control systems-decoupling control-strategies for reducing control loop interactions-Real-time optimization-Simulation using softwares

Module 4: (11 hours)
Model predictive control-Batch Process control-Plant-wide control & monitoring- Plant wide control design- Instrumentation for process monitoring-Statistical process control-Introduction to Fuzzy Logic in Process Control-Introduction to OPC-Introduction to environmental issues and sustainable development relating to process industries. Comparison of performance different types of control with examples on softwares

References

1. Seborg, D.E., T.F. Edgar, and D.A. Mellichamp, Process Dynamics and Control, John Wiley, 2004
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3. Bob Connel, Process Instrumentation Applications Manual, McGrawHill, 1996.
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10. K. Krishnaswamy, Process Control, New Age International, 2007

EE6403: Computer Controlled Systems

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

Course Outcomes

CO1: Learn the basics of MIMO systems and calculation of system norms

CO2: Study the concept of robustness and robust stability using H-infinity theory

CO3: Understand the hardware and programming of programmable logic controllers

CO4: Familiarize real time systems and inter task communication

CO5: Build knowledge on supervisory control, distributed control and PC based automation

Syllabus

Module 1: Multivariable Control (12 hours)

Multivariable control- Basic expressions for MIMO systems- Singular values- Stability norms- Calculation of system norms- Robustness- Robust stability- H2 / H∞ Theory- Solution for design using H2 / H∞ - Case studies. Interaction and decoupling- Relative gain analysis- Effects of interaction- Response to disturbances- Decoupling- Introduction to batch process control.

Module 2: Programmable Logic Controllers (10 hours)

Programmable logic controllers- Organisation- Hardware details- I/O- Power supply- CPU- Standards- Programming aspects- Ladder programming- Sequential function charts- Man-machine interface- Detailed study of one model- Case studies.

Module 3: Large Scale Control System (12 hours)

SCADA: Introduction, SCADA Architecture, Different Commnication Protocols, Common System Components, Supervision and Control, HMI, RTU and Supervisory Stations, Trends in SCADA, Security Issues DCS: Introduction, DCS Architecture, Local Control (LCU) architecture, LCU languages, LCU – Process interfacing issues, communication facilities, configuration of DCS, displays, redundancy concept – case studies in DCS.

Module 4: Real Time Systems (8 hours)

Real time systems- Real time specifications and design techniques- Real time kernels- Inter task communication and synchronization- Real time memory management- Supervisory control-direct digital control- Distributed control- PC based automation.

References

1. Shinskey F.G., Process control systems: application , Design and Tuning, McGraw Hill International Edition ,Singapore,1988.

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3. Dorf, R.C. and Bishop R. T. , Modern Control Systems , Addison Wesley Longman Inc., 1999

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EE6404: Industrial Load Modelling & Control

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

<u>Course Outcomes</u>

CO1: Acquire knowledge about load control techniques in industries and its application.

CO2: Acquire knowledge about different types of industrial processes and optimize the process using tools like LINDO and LINGO.

CO3: Acquire knowledge about load management to reduce demand of electricity during peak time.

CO4: Analyse and understand different energy saving opportunities in industries.

CO5: Acquire knowledge about reactive power control in industries and analyse different power factor improvement methods.

CO6: Learn mathematical modelling and profiling of various loads such as cool storage, cooling and heating loads

Syllabus

Module 1: (12 hours)

Electric Energy Scenario-Demand Side Management-Industrial Load Management; Load Curves-Load Shaping Objectives-Methodologies-Barriers; Classification of Industrial Loads- Continuous and Batch processes -Load Modelling; Electricity pricing – Dynamic and spot pricing –Models

Module 2: (10 hours)

Direct load control- Interruptible load control; Bottom up approach- scheduling- Formulation of load models- optimisation and control algorithms - Case studies

Reactive power management in industries-controls-power quality impacts-application of filters

Module 3: (10 hours)

Cooling and heating loads- load profiling- Modeling- Cool storage-Types-Control strategies-Optimal operation-Problem formulation- Case studies

Module 4: (10 hours)

Captive power units- Operating and control strategies- Power Pooling- Operation models; Energy Banking-Industrial Cogeneration; Selection of Schemes Optimal Operating Strategies-Peak load saving-Constraints-Problem formulation- Case study; Integrated Load management for Industries

References

1 C.O. Bjork " Industrial Load Management - Theory, Practice and Simulations", Elsevier, the Netherlands, 1989.

2. C. W. Gellings and S.N. Talukdar, . Load management concepts. IEEE Press, New York, 1986, pp. 3-28.

3. Various Authors, " Demand side management - Alternatives", IEEE Proceedings on DSM , Oct 1985

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5. H. G. Stoll, "Least cost Electricity Utility Planning., Wiley Interscience Publication, USA, 1989.

6. I.J.Nagarath and D.P.Kothari, .Modern Power System Engineering. , Tata McGraw Hill publishers, New Delhi, 1995.

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8. IEEE Bronze Book- .Recommended Practice for Energy Conservation and cost effective planning in Industrial facilities., IEEE Inc, USA.

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10. Richard E. Putman, industrial energy systems: analysis, optimization, and control, ASME Press, 2004.

EE6406: Industrial Instrumentation

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

Course Outcomes

CO1: To get basic knowledge about industrial measurement system and different elements involved in it.

CO2: Acquire knowledge about sensors and transducers for different industrial variables like torque, pressure, etc.

CO3: Acquire knowledge about signal conditional circuits like amplifiers, filters, ADC, etc. for working industrial measurement systems.

CO4: Impart knowledge about static and response characteristics of first order and higher order measurement system.

CO5: Get familiarized with the operation and applications in measurement systems of servo motors, stepper motor and hybrid stepper motors, etc.

Syllabus

Module 1: (12 hours)
Industrial measurement systems – different types of industrial variables and measurement systems elements – sensors and transducers for different industrial variables like pressure, torque, speed, temperature etc– sensor principles – examples of sensors – sensor scaling – Industrial signal conditioning systems- Amplifiers – Filters – A/D converters for industrial measurements systems –review of general Industrial instruments.

Module 2: (8 hours)
Calibration and response of industrial instrumentation - standard testing methods and procedures – Generalized performance characteristics – static response characterization – dynamic response characterization - zero order system dynamic response characterizations – first order system dynamic response second order system dynamic response – higher order systems - Response to different forcing functions such as step, sinusoidal etc. to zero, first, second third and higher orders of systems.

Module 3: (12 hours)
Regulators and power supplies for industrial instrumentation – linear series voltage regulators – linear shunt voltage regulators – integrated circuit voltage regulators – fixed positive and

negative voltage regulators – adjustable positive and negative linear voltage regulators – application of linear IC voltage regulators - switching regulators –single ended isolated forward regulators- half and full bridge rectifiers. pH and conductivity sensors. Piezo-electric and ultrasonic sensors and its application in process and biomedical Instrumentation. Measurement of viscosity, humidity and thermal conductivity

Module 4: (10 hours)

Servo drives – servo drive performance criteria – servomotors shaft sensors and coupling – sensors for servo drives – servo control loop design issues- stepper motor drives types and characteristics – hybrid stepper motor – permanent magnet stepper motor – hybrid and permanent magnet motors – single and multi step responses.

References

1. Ernest O. Doebelin Measurement systems applications and design, McGraw – Hill International Editions, McGraw- Hill Publishing Company, 1990
2. Patric F. Dunn University of Notre Dame, Measurement and Data Analysis for engineering and science, Mc Graw Hill Higher education, 1995
3. Randy Frank, Understanding Smart Sensors, Artec House Boston. London, 2000
4. Muhamad H Rashid, Power electronics handbook, ACADEMIC PRESS, 2007
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8. John O Moody, Paros J Antsaklis, Supervisory Control of discrete event systems using petrinets, PHI, 2002
9. James L Peterson, Petrinet theory and modeling of system, 1981.

EE6421: Advanced Microcontroller Based Systems

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

Course Outcomes

CO1: To understand the working of advanced microprocessor/controller.

CO2: To learn how to program a processor in assembly language and develop an advanced processor based system.

CO3: To learn configuring and using different peripherals in a digital system.

CO4: To compile and debug a Program.

CO5: To generate an executable file and use it.

Syllabus

Module 1: (10 Hours)

Basic Computer Organization - Accumulator Based Processors - Architecture - Memory Organizations - I/O Organizations - Assembly Language Programming - Addressing - Operations - Stack and Subroutines. Interrupts - DMA - Stages of Microprocessor based Program Development.

Module 2: (12 Hours)

Introduction to Microcontrollers - Motorola 68HC11 - Intel 8051 - Intel 8096 - Registers - Memories - I/O Ports - Serial Communications - Timers - Interrupts

Module 3: (10 Hours)

PIC 16F877- Architecture - Memory Interfacing - Interfacing I/O devices - Instruction Set - Serial I/O and Data Communication. Digital Signal Processor (DSP) - Architecture – Programming. Introduction to FPGA.

Module 4: (10 Hours)

Instructions in Microcontrollers - Interfaces - Introduction to Development of a Microcontroller Based System - Concept of a Programmable Logic Controller (PLC) - Features and Parts in a PLC unit.

References

1. John. F. Wakerly: Microcomputer Architecture and Programming, John Wiley and Sons 1981
2. Ramesh S. Gaonker: Microprocessor Architecture, Programming and Applications with the 8085, Penram International Publishing (India), 1994
3. Raj Kamal: The Concepts and Features of Microcontrollers, Wheeler Publishing, 2005
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5. John Morton, The PIC microcontroller: your personal introductory course, Elsevier, 2005
6. Dogan Ibrahim, Advanced PIC microcontroller projects in C: from USB to RTOS with the PIC18F Series, Elsevier, 2008
7. Micro chip datasheets for PIC16F877

EE6422: Engineering Optimization

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

Course Outcomes

CO1: Understand the concept of optimization and classical methods of optimization.

CO2: Apply optimization techniques to typical engineering problems.

CO3: Learn the concepts and techniques of nonlinear and unconstrained optimization.

CO4: Acquire knowledge on direct and indirect methods for constrained optimization.

CO5: Learn the application of dynamic programming and genetic algorithms for engineering optimization.

Syllabus

Module 1: (11 hours)

Concepts of optimization: Engineering applications-Statement of optimization problem-Classification - type and size of the problem. Classical Optimization Techniques: Single and multi variable problems-Types of Constraints .Semi definite case-saddle point. Linear programming: Standard form- Geometry of LP problems-Theorem of LP-Relation to convexity - formulation of LP problems - simplex method and algorithm -Matrix form- two phase method. Duality- dual simplex method- LU Decomposition. Sensitivity analysis .Artificial variables and complementary solutions-QP. Engineering Applications: Minimum cost flow problem, Network problems - transportation, assignment & allocation, scheduling. Karmarkar method - unbalanced and routing problems.

Module 2: (11 hours)

Nonlinear programming: Non linearity concepts-convex and concave functions- non-linear programming - gradient and Hessian. Unconstrained optimization: First & Second order necessary conditions-Minimisation & Maximisation- Local & Global convergence-Speed of convergence. Basic decent methods: Fibonacci & Golden section search - Gradient methods - Newton Method-Lagrange multiplier method - Kuhn-tucker conditions . Quasi-Newton method-separable convex programming - Frank and Wolfe method, Engineering Applications.

Module 3: (10 hours)

Nonlinear programming- Constrained optimization: Characteristics of constraints-Direct methods - SLP,SQP-Indirect methods-Transformation techniques-penalty function-Langrange multiplier methods - checking convergence- Engineering applications

Module 4: (10 hours)

Dynamic programming: Multistage decision process- Concept of sub optimization and principle of optimality- Computational procedure- Engineering applications. Genetic algorithms-Simulated Annealing Methods-Optimization programming, tools and Software packages.

References

1. David G Luenberger, .Linear and Non Linear Programming., 2nd Ed, Addison-Wesley Pub.Co.,Massachusetts, 2003
2. W. L. Winston, .Operation Research-Applications & Algorithms.,2nd Ed., PWS-KENT Pub.Co., Boston, 2007
3. S. S. Rao, .Engineering Optimization., 3rd Ed.,New Age International (P) Ltd,New Delhi, 2007
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5. G. B. Dantzig, .Linear Programming and Extensions. Princeton University Press, N.J., 1963.
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9. Godfrey C. Onwubolu, B. V. Babu, New optimization techniques in engineering, Springer, 2004
10. Kalyanmoy Deb, Optimisation for Engineering Design-Algorithms and Examples., Prentice Hall India-1998.

EE6423: Industrial Communication

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

Course Outcomes

CO1: To develop a comprehensive understanding of the industrial data communication systems.

CO2: To educate on the basic concepts of inter-networking and serial communications.

CO3: To provide a fundamental understanding of common principles, various standards and protocol stack in networking

CO4: To introduce industrial Ethernet and wireless communication.

CO5: To familiarize the SCADA communication network and other open standard communication Protocols

Syllabus

Module 1: (10 hrs)
Characteristics of Communication Networks- Traffic characterisation and Services- Circuit Switched and Packet Switched Networks- Virtual circuit Switched networks- OSI Model-Protocol Layers and Services-The physical layer-Theoretical basis for data communication-signalling and modulation multiplexing - Transmission media-Physical interface and protocols

Module 2: (10 hrs)
The transport layer- Connectionless transport-UDP –TCP- Congestion control - Network layer series and routing- internet protocol (IP) - Network layer addressing- hierarchical addresses-address resolution-services- Datagram- virtual circuits- routing algorithm (Bellman Ford, Dijkstra)

Module 3: (10 hrs)
Direct link Networks: Framing; Error detection; Reliable transmission; Multiple access protocols; Concept of LAN- Ethernet LAN – Ethernet frame structure-Ethernet (IEEE 802.3); Token Rings (IEEE 802.5 & FDDI); Address Resolution Protocol- IEEE 802.11 LAN's- architecture and media access protocols, hubs, bridges, switches, PPP, ATM, wireless LAN

Module 4: (12 hrs)

Introduction to industrial networks – SCADA networks - Remote Terminal Unit (RTU), Intelligent Electronic Devices (IED) - Communication Network, SCADA Server, SCADA/HMI Systems - single unified standard architecture -IEC 61850 - SCADA Communication: various industrial communication technologies -wired and wireless methods and fiber optics, open standard communication protocols

References

1. Karanjith S. Siyan, .Inside TCP/IP., 3rd edition, Techmedia, 1998
2. Alberto, Leon, Garcia, Indra, and Wadjaja, .Communication networks., Tata Mc Graw Hill,2000
3. James F Kurose.Keith W Ross, .Computer networking A Top down Approach featured internet, Pearson Education, 2003.
4. Keshav, .An engineering approach to computer networking, Addison-Wesley, 1999
5. Radia Perlmal, .Interconnections second edition, Addison Wesley, 2000
6. Douglas E comer, .Inter networking with TCP/IP, Vol 1, Prentice Hall India, 1999.
7. Andrew S. Tannebaum, .Computer Networks., Fourth Edition., Prentice Hall,2003
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13. Raimond Pigan, Mark Metter, Automating with PROFINET: Industrial Communication Based on Industrial Ethernet, Publicis Publishing 2008

EE6424: Robotics Systems and Applications

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

Course Outcomes

CO1: Learn the mathematics of spatial descriptions and transformations

CO2: Acquire knowledge about robot definition, classification, robot system components that combines embedded hardware, software and mechanical systems

CO3: Learn manipulator kinematics and mechanics of robot motion, forward and inverse kinematic transformation of position, forward and inverse kinematic transformation of velocity, end effector force transformations

CO4: Learn about manipulator dynamics, transformation of acceleration, trajectory planning, Lagrangian formulation, Newton-Euler equations of motion, robot control architectures

CO5: Acquire knowledge about robot sensing and vision systems

CO6: Acquire knowledge about robot programming languages

CO7: Acquire knowledge about artificial intelligence techniques in robotics

CO8: Learn about various robotics applications and their associated components and control systems in manufacturing, construction, service, etc

Syllabus

Module 1: (8 hours)

Mathematics of Spatial Descriptions and Transformations-Robot definition. Robot classification. Robotic system components- Notations- Position definitions- Coordinate frames – Different orientation descriptions - Free vectors- Translations, rotations and relative motion – Homogeneous transformations.

Module 2: (12 hours)

Manipulator Kinematics and Mechanics of Robot Motion-Link coordinate frames- Denavit-Hartenberg convention - Joint and end-effector Cartesian space-Forward kinematics transformations of position-Inverse kinematics of position-Translational and rotational velocities -Velocity Transformations-Manipulator Jacobian -Forward and inverse kinematics of velocity- Singularities of robot motion-Static Forces-Transformations of velocities and static forces –Joint and End Effector force/torque transformations-Derivation for two link planar robot arm as example.

Module 3: (13 hours)

Manipulator Dynamics- Transformations of acceleration- Trajectory Planning- Control-Lagrangian formulation- Model properties - Newton-Euler equations of motion- Derivation for two link planar robot arm as example- Joint space-based motion planning - Cartesian space-based path planning- Independent joint control- Feed-forward control-Inverse dynamics control-Robot controller architectures. Implementation problems.

Module 4: (9 hours)

Robot Sensing and Vision Systems- Sensors-Force and torque sensors-low level vision-high level vision-Robot Programming languages-Introduction to Intelligent Robots-Robots in manufacturing automation.

References

1. Fu, K.S., R.C. Gonzalez, C.S.G. Lee, Robotics: Control, Sensing, Vision & Intelligence, McGrawHill, 1987.

2. Craig, John J., Introduction to Robotics: Mechanics & Control, 2nd Edition, Pearson Education, 1989.

3. Gray J.O., D.G. Caldwell(Ed), Advanced Robotics & Intelligent machines, The Institution of Electrical Engineers, UK, 1996.
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9. Oliver Brock, Jeff Trinkle and Fabio Ramos, "Robotics-Science and Systems" Vol. IV, MIT Press

EE6428: SCADA Systems and Applications

Pre-requisite: Nil

Total hours: 42 Hrs

L	T	P	C
3	0	0	3

Course Outcomes

CO1: Describe the basic tasks of Supervisory Control Systems (SCADA) as well as their typical applications

CO2: Acquire knowledge about SCADA architecture, various advantages and disadvantages of each system

CO3: Acquire knowledge about single unified standard architecture IEC 61850

CO4: Acquire knowledge about SCADA system components: remote terminal units, PLCs, intelligent electronic devices, HMI systems, SCADA server

CO5: Acquire knowledge about SCADA communication, various industrial communication technologies, open standard communication protocols

CO6: Learn and understand about SCADA applications in transmission and distribution sector, industries etc.

CO7: Gain knowledge and understanding for the design and implementation of a SCADA system.

Syllabus

Module 1: (10 hours)

Introduction to SCADA**:** Data acquisition systems, Evolution of SCADA, Communication technologies, Monitoring and supervisory functions, SCADA applications in Utility Automation, Industries

Module 2: (11 hours)

SCADA System Components**:** Schemes- Remote Terminal Unit (RTU), Intelligent Electronic Devices (IED),Programmable Logic Controller (PLC), Communication Network, SCADA Server, SCADA/HMI Systems

Module 3: (11 hours)

SCADA Architecture**: V**arious SCADA architectures, advantages and disadvantages of each system - single unified standard architecture -IEC 61850 SCADA Communication**:** various industrial communication technologies -wired and wireless methods and fiber optics. open standard communication protocols

Module 4: (10 hours)

SCADA Applications**:** Utility applications- Transmission and Distribution sector -operations, monitoring, analysis and improvement. Industries - oil, gas and water. Case studies, Implementation, Simulation Exercises

References

1. Stuart A. Boyer: SCADA-Supervisory Control and Data Acquisition, Instrument Society of America Publications, USA, 2004.

2. Gordon Clarke, Deon Reynders: Practical Modern SCADA Protocols: DNP3, 60870.5 and Related Systems, Newnes Publications, Oxford, UK,2004

3. William T. Shaw, Cybersecurity for SCADA systems, PennWell Books, 2006

4. David Bailey, Edwin Wright, Practical SCADA for industry, Newnes, 2003

5. Michael Wiebe, A guide to utility automation: AMR, SCADA, and IT systems for electric power, PennWell 1999.

Department of Electrical Engineering

Brief Syllabus for courses for M Tech in Instrumentation and Control Systems

MA6002: Applied Mathematics

Pre-requisite: Nil

L	T	P	C
3	0	0	3

Total hours: 42 Hrs.

Vector spaces, subspaces, Inner product spaces, Gram- Schmidt Orthogonalization, Linear transformations, Eigenvalues and Eigen vectors of linear operator, Quadratic form. Random Variables, Distributions Multivariate distributions, Marginal and Conditional distributions , Transformation of Random Variables , Elements of stochastic processes, Markov Chains, Limiting distribution of Markov chains,General pure Birth processes and Poisson processes, Birth and death processes, Finite state continuous time Markov chains, Second Order Stochastic Processes, Stationary processes, Wide sense Stationary processes, Spectral density function.

EE6101: Dynamics of Linear Systems

Pre-requisite: Nil

L	T	P	C
3	0	0	3

Total hours: 42 Hrs.

State variable representations of systems - transfer function and transfer function matrix - solutions of state equations – observability and controllability - minimal realization of MIMO systems - analysis of linear time varying systems - the concepts of stability - Lyapunov stability analysis - Lyapunov function and its properties - controllability by state variable feedback - Ackerman's Formula - stabilisation by output feedback - asymptotic observers for state measurement - observer design - state space representation of discrete systems - solution of state equations, controllability and observabilty - stability analysis using Lyapunov method - state feedback of linear discrete time systems- design of observers - MATLAB Exercises.

EE6102: Optimal and Adaptive Control

Pre-requisite: Nil

L	T	P	C
3	0	0	3

Total hours: 42 Hrs.

Optimal control problem –- fundamental concepts and theorems of calculus of variations – Euler - Language equation and extremal of functionals - the variational approach to solving optimal control problems - Hamiltonian and different boundary conditions for optimal control problem – linear regulator problem - Pontryagin's minimum principle - dynamic programming - principle of optimality and its application to optimal control problem - Hamilton-Jacobi-Bellman equation - model reference adaptivesystems (MRAS) - design hypothesis - introduction to design method based on the use of Liapunov function – design and simulation of variable structure adaptive model following control

EE6103: Applied Instrumentation

Pre-requisite: Nil

L	T	P	C
3	0	0	3

Total hours: 42 Hrs.

Generalized performance characteristics of measuring systems-general static and dynamic characteristics-mathematically models-general concepts of transfer functions related to instrumentation system. Response of general form of instruments to different types of inputs like periodic, transient and random signals, their characteristics etc. Study, analysis etc of modulation and demodulation problems of instrumentation systems. Design considerations of instrumentation systems.

EE6104: Advanced Instrumentation

Pre-requisite: Nil

L	T	P	C
3	0	0	3

Total hours: 42 Hrs.

Instrumentation to process control-,rationales for mathematical modeling-transfer function models and related aspects-advanced performance modeling tools and characteristics- definitions and analytical techniques-roll of digital computers in modern instrumentation systems and their related hardware-computer aided instrumentation systems - hardware and their functions-different measurements and instrumentation related problems related to micro and nano technology.

EE6106: System Identification & Parameter Estimation

Pre-requisite: Nil

L	T	P	C
3	0	0	3

Total hours: 42 Hrs.

Systems and models – models of time varying and nonlinear systems – Model estimation methods – Nonparametric and parametric – non-recursive and recursive algorithms- convergence and distribution of parameter estimates - computational aspects of estimation – experiment design – choice of inputs for estimation – preprocessing of data for estimation .

EE6108: Nonlinear System Analysis

Pre-requisite: Nil

L	T	P	C
3	0	0	3

Total hours: 42 Hrs.

Characteristics of nonlinear systems - limit cycles - phase plane analysis - periodic orbits - stability of periodic solutions - slow and fast manifolds - stability of nonlinear systems - Lyapunov stability - local linearization and stability in the small - direct method of Lyapunov - Lyapunov function for linear and nonlinear systems - variable gradient method - centre manifold theorem - Input output stability - L stability - L stability of state models - L2 stability- Lyapunov Based Design - Robust stabilization - Nonlinear Damping - backstepping - sliding mode control - adaptive control - harmonic linearization - filter hypothesis - describing function - study of limit cycles (amplitude and frequency) - dual Input describing function - study of sub-harmonic oscillations - analysis of feedback systems - circle Criterion - Popov Criterion - simultaneous Lyapunov functions - Feedback linearization - stabilization - regulation via integral control - gain scheduling - Input state linearization - input output linearization - integral control.

EE6121: Data Acquisition & Signal Conditioning

Pre-requisite: Nil

L	T	P	C
3	0	0	3

Total hours: 42 Hrs.

Data Acquisition Systems(DAS) - Objectives - General configurations - Transducers - Signal Conditioning - Instrumentation amplifiers - Noise Reduction Techniques in Signal Conditioning-Transmitters -Piezoelectric Couplers- Nyquist's Sampling Theorem- classification and types of filters - Design of Filters- Butterworth Approximation-Narrow Bandpass and Notch Filters and their application in DAS-Analog-to-Digital Converters(ADC)-Multiplexers and demultiplexers -Digital-to-Analog Conversion(DAC)- Data transmission systems- Modulation techniques and systems-Telemetry systems-Study of a representative DAS Board-Interfacing issues with DAS Boards- Software Drivers, Virtual Instruments, Modular Programming Techniques-Bus standard for communication between instruments - Software Design Strategies for DAS.

EE6122: Biomedical Instrumentation

Pre-requisite: Nil

L	T	P	C
3	0	0	3

Total hours: 42 Hrs.

Fundamental of Biomedical Instrumentation – origin of bio potentials – biomedical transducers – bio signals ,ECG,EMG,EEG etc – measurement of cardiac out put, blood flow, blood pressure etc – oximeters- measurements on pulmonary system – blood gas analyzers – audiometers – patient safety – lasers in medicine – X –ray applications – ultrasound in medicine – pacemakers – defibrillators – electrotherapy – hemodialysis – ventilators –radiotherapy

EE6123: Performance Modelling of Systems – I

Pre-requisite: Nil

L	T	P	C
3	0	0	3

Total hours: 42 Hrs.

General operational characteristics – dynamic response and frequency response studies- general concepts in set theory- terminology functions- combinatorics - brief theory of bags etc-algorithms-graphs having multiple edges-Euler cycles-the shortest path problems-active graph theory concepts of concurrency-conflict-dead lock problems etc. popular extensions like Petri nets-s-net etc.

EE6124: Performance Modelling of Systems – II

Pre-requisite: EE6123: Performance Modelling of Systems - I

L	T	P	C
3	0	0	3

Total hours: 42 Hrs

Modeling philosophies and related aspects like degrees of freedom-algorithm for the development of models-modeling tools and applied systems-performance modeling - Petri nets models-s-net models-basic definitions and analytical techniques standard problems like synchronizations mutual exclusions- dining philosophies problems-etc. dynamic graphical models of supercomputers-computer communication systems- super computer computer pipeline-computer communication network and process control systems etc.

EE6125: Digital Control Systems

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours: 42 Hrs

Data conversion and quantisation- z transform and inverse z transform - Difference equation - Solution by recursion and z- transform- Discretisation Methods- z transform analysis of closed loop and open loop systems- Modified z- transfer function- Multirate z-transform- Stability of linear digital control systems- Steady state error analysis- Root loci - Frequency domain analysis- Digital controller design using bilinear transformation- Root locus based design- Digital PID controllers- Dead beat control design- Case study examples using MATLAB- State variable models- Controllability and Observability - Response between sampling instants using state variable approach-Pole placement using state feedback – Servo Design- State feedback with Integral Control-Deadbeat Control by state feedback and deadbeat observers - Dynamic output feedback - Effects of finite wordlength on controllability and closed loop pole placement- Case study examples using MATLAB.

EE6126: Advanced Topics in Control System

Pre-requisite: EE6101: Dynamics of Linear Systems

L	T	P	C
3	0	0	3

Total hours: 42 Hrs

Fuzzy Models- Construction of fuzzy models - Neural networks - Adaptive neuro-fuzzy inference systems-ANFIS architecture.Representations of MIMO systems - Solution of state equations - Controllability and pole allocation- observability and state estimator- model matching control design. Introduction - trajectory aspects -inertial guidance for cruise vehicles - guidance and control of rocket vehicles - guidance and control of mobile-launched ballistic missiles.Variable Structure Systems (VSS) - VSS with sliding mode - Sliding mode motion on switching surface - Design of stable switching surface - Variable structure model following control (VSMFC), Non linear systems - chaos . fractals . attractors . synthesis of some chaotic systems using neural net work. control applications. fractals and chaos in medicine and physiology

EE6127: Variable Structure Control Systems

Pre-requisite: Nil

L	T	P	C
3	0	0	3

Total hours: 42 Hrs

Variable Structure Systems (VSS) - synthesis of stable systems from unstable structures - VSS for system stability and for improved performance - variable structure systems with sliding mode - equivalent control for sliding mode motion - invariance conditions - design of sliding mode controllers using feedback linearisation for non-linear systems - design of stable switching surface - design of sliding mode controller for higher order systems - Chattering- and Chattering reduction techniques - Variable Structure Model Following Control (VSMFC) Systems - simulation using MATLAB® - Simulation using SIMULINK®

EE6128: Optimal Estimation and Filtering

Pre-requisite: EE6101: Dynamics of Linear Systems

L	T	P	C
3	0	0	3

Total hours: 42 Hrs

Random processes and stochastic systems- linear optimal filters and predictors – Kalman, Kaman-Bucy filters-comparison with Wiener filter – Optimal smoothers – implementation details- Nonlinear filtering and practical considerations. Quasi-linear filtering-extended Kalman filtering - stability of Kalman filters .

EE6129: Artificial Neural Networks and Fuzzy Systems

Pre-requisite: Nil

L	T	P	C
3	0	0	3

Total hours: 42 Hrs

Biological foundations - ANN models - network architectures - learning processes - single layer and multilayer perceptrs - least mean square algorithm - back propagation algorithm - applications in engineering problems - fuzzy sets - fuzzy set operations - membership functions - fuzzy to crisp conversion
- fuzzification and defuzzification methods - applications in engineering problems - fuzzy control systems
- fuzzy logic controllers with examples - special forms of fuzzy logic models - classical fuzzy control problems - image processing - adaptive fuzzy systems - hybrid systems.

EE6191: Instrumentation and Control Systems Lab

Pre-requisite: Nil

L	T	P	C
0	0	3	2

Total hours: 42 Hrs

12 experiments will be offered in the lab, each experiment being of 3 hours duration. The experiments will be such as to understand the advanced topics in automatic control systems.

EE6304: Advanced Digital Signal Processing

Pre-requisite: Nil

L	T	P	C
3	0	0	3

Total hours: 42 Hrs

Discrete time signals, systems and their representations - Discrete Fourier series- Discrete Fourier transform- Z- transform- Computation of DFT Digital filter design and realization structures Basic IIR and FIR filter realization structures- Signal flow graph representations Quantization process and errors-Coefficient quantisation effects in IIR and FIR filters- A/D conversion noise- Arithmetic round-off errors-Dynamic range scaling- Overflow oscillations and zero input limit cycles in IIR filters Statistical signal processing Linear Signal Models -Power spectrum estimation- Spectral analysis of deterministic signals . Estimation of power spectrum of stationary random signals-Optimum linear filters-Optimum signal estimation-Mean square error estimation-Optimum FIR and IIR filters.

EE6401: Energy Auditing & Management

Pre-requisite: Nil

L	T	P	C
3	0	0	3

Total hours: 42 Hrs

Energy auditing: Types and objectives-audit instruments, Energy efficient /high efficient Motors-Case study; Load Matching and selection of motors, Reactive Power management-Capacitor Sizing-Degree of Compensation-Capacitor losses-Location-Placement-Maintenance, case study, Cogeneration-Types and Schemes-Optimal operation of cogeneration plants-case study, Energy conservation in Lighting Schemes, VFD, Energy conservation measures in Gysers, Transformer, Feeder, Pumps and Fans

EE6402: Process Control & Automation

Pre-requisite: Nil

L	T	P	C
3	0	0	3

Total hours: 42 Hrs

Process Modeling, Transfer function-State space models-Time series models, Feedback & Feedforward Control, PID design and tuning, Cascade control- Selective control loops-Ratio control-Control, State feedback control- LQR problem- Pole placement, Process Interactions-Singular value analysis-tuning of multi loop PID control systems- decoupling control, Real-time optimization, Model predictive control-Batch Process control-Plant-wide control & monitoring, Introduction to Fuzzy Logic in Process Control, Introduction to OPC, . Comparison of performance different types of control with examples on software packages

EE6403: Computer Controlled Systems

Pre-requisite: Nil

L	T	P	C
3	0	0	3

Total hours: 42 Hrs

Multivariable control, Singular values- Stability norms, Robustness- Robust stability- H2 / H∞ Theory, Interaction and decoupling- Relative gain analysis, Decoupling control, Programmable logic controllers, SCADA, DCS, Real time systems, Supervisory control- direct digital control- Distributed control- PC based automation.

EE6404: Industrial Load Modelling & Control

Pre-requisite: Nil

L	T	P	C
3	0	0	3

Total hours: 42 Hrs

Load Management, Load Modeling; Electricity pricing, Direct load control- Interruptible load control, Load scheduling- Continuous and Batch processes, Computer methods of optimization, -Reactive power control in industries- Cooling and heating load profiling, Energy Storage devices and limitations, Captive power units- Operating strategies- Power Pooling, Integrated Load management for Industries; Software packages-Case study.

EE6406: Industrial Instrumentation

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours: 42 Hrs

Industrial measurement systems, sensors and transducers for different industrial variables, Amplifiers – Filters – A/D converters for industrial measurements systems, Calibration and response of industrial instrumentation, Generalized performance characteristics – static response characterization – dynamic response characterization, Response to different forcing functions such as step, sinusoidal etc. to zero, first, second third and higher orders of systems, Regulators and power supplies for industrial instrumentation, Servo drives, stepper motor drives types and characteristics, hybrid and permanent magnet motors. Advanced modeling tools and their characteristics for automated control instrumentation application

EE6421: Advanced Microcontroller Based Systems

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours: 42 Hrs

Basic Computer Organization, Assembly Language Programming, Stack and Subroutines. Interrupts, DMA, Intel 8051, PIC 16F877, Digital Signal Processor (DSP) - Architecture – Programming, Microcontroller development for motor control applications, stepper motor control using micro controller

EE6422: Engineering Optimization

Pre-requisite: Nil

L	T	P	C
3	0	0	3

Total hours: 42 Hrs

Concepts of optimization, Classical Optimization Techniques, Linear programming, dual simplex method, Minimum cost flow problem, Network problems-transportation, assignment & allocation, Nonlinear programming, Unconstrained optimization, Constrained optimization, Dynamic programming, Genetic algorithms, optimization using software packages

EE6423: Industrial Communication

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours: 42 Hrs

Characteristics of Communication Networks, OSI Model, Theoretical basis for data communication, Direct link Networks, Ethernet (IEEE 802.3); Token Rings (IEEE 802.5 & FDDI); Address Resolution Protocol-IEEE 802.11 LAN's- architecture and media access protocols, wireless LAN, Network layer series and routing, The transport layer, SCADA networks, Remote Terminal Unit (RTU), Intelligent Electronic Devices (IED) - Communication Network, IEC 61850, various industrial communication technologies, wired and wireless methods and fiber optics, open standard communication protocols

EE6424: Robotics Systems and Applications

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours: 42 Hrs

Mathematics of Spatial Descriptions and Transformations-Robot definition, Robot classification. Robotic system components, Different orientation descriptions, Manipulator Kinematics and Mechanics of Robot Motion, Velocity Transformations, Static Forces Transformations, Manipulator Dynamics, Trajectory Planning, Inverse dynamics control, Robot controller architectures, Robot Sensing and Vision Systems, Introduction to Intelligent Robots, Robots in manufacturing automation

EE6428: SCADA Systems and Applications

Pre-requisite: Nil

L	T	P	C
3	0	0	3

Total hours: 42 Hrs

Introduction to SCADA, Monitoring and supervisory functions, SCADA applications in Utility Automation, SCADA System Components, RTU, IED, PLC, Communication Network, SCADA Server, SCADA/HMI Systems, Various SCADA architectures, single unified standard architecture -IEC 61850, SCADA Communication, open standard communication protocols.

Department of Electrical Engineering

Detailed Syllabus for courses for M Tech in Instrumentation and Control Systems

MA6002: Applied Mathematics

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours: 42 Hrs.

Module 1: Linear Algebra (11 hours)

Vector spaces, subspaces, Linear dependence, Basis and Dimension, Inner product spaces, Gram- Schmidt Orthogonalization, Linear transformations, Kernels and Images , Matrix representation of linear transformation, Change of basis, Eigenvalues and Eigen vectors of linear operator, Quadratic form.

Module 2: Operations on Random Variables (12 hours)

Random Variables, Distributions and Density functions, Moments and Moment generating function, Multivariate distributions, Independent Random Variables, Marginal and Conditional distributions , Conditional Expectation, Transformation of Random Variables , Elements of stochastic processes, Classification of general stochastic processes.

Module 3: Random Processes (11 hours)

Markov Chains: Definition, Examples, Transition Probabilities, Classification of states and chains, Basic limit theorem, Limiting distribution of Markov chains.

Continuous Time Markov Chains: General pure Birth processes and Poisson processes, Birth and death processes, Finite state continuous time Markov chains

Module 4: Second Order Processes (8 hours)

Second Order Stochastic Processes, Stationary processes, Wide sense Stationary processes, Auto covariance and auto correlation function, Spectral density function, Low pass and band pass processes, White noise and white noise integrals, Linear Predictions and Filtering.

References

1. Kenneth Hoffman and Ray Kunze, Linear Algebra, 2nd Edition, PHI, 1992.

2. Erwin Kreyszig, Introductory Functional Analysis with Applications, John Wiley & Sons, 2004.

3. Irwin Miller and Marylees Miller, John E. Freund's Mathematical Statistics, 6th Edition, PHI, 2002.

4. S. Karlin & H.M Taylor, A First Course in Stochastic Processes, 2nd edition, Academic Press, New York, 2007

5. S. M. Ross, Introduction to Probability Models, Harcourt Asia Pvt. Ltd. and Academic Press, 2004

6. J. Medhi, Stochastic Processes, New Age International, New Delhi, 1994

7. A Papoulis, Probability, Random Variables and Stochastic Processes, 3rd Edition, McGraw Hill, 2002

8. John B Thomas, An Introduction to Applied Probability and Random Processes, John Wiley & Sons, 2000.

EE6101: Dynamics of Linear Systems

Pre-requisite: Nil

L	T	P	C
3	0	0	3

Total hours: 42 Hrs.

Module 1: State Space Analysis (11 hours)

State variable representations of systems- transfer function and transfer function matrix from state variable form - solutions of state equations – state transition matrix - modal decompositions - observability and controllability - minimal realizations of MIMO systems - analysis of linear time varying systems.

Module 2: Lyapunov Stability Analysis (9 hours)

The concepts of stability- absolute stability and BIBO Stability - eigen values of state matrix - equilibrium states - Lyapunov stability theorems - stability analysis using Lyapunov's first method and second method - Lyapunov function and its properties

Module 3: Control Design Techniques (11 hours)

State variable feedback – controller design - Ackerman's Formula - stabilisation by state and output feedback - observers for state measurement – observer design - combined observer-controller compensators - reduced order observer - observability under feedback and invariant zeros - Design of stable systems using Lyapunov method - MATLAB Exercises.

Module 4: Linear Discrete Time Systems (11 hours)

Difference equation model for LTIV systems - impulse response model - transfer function model - discrete state space representation - solution of state equations - controllability and observabilty - stability analysis using Lyapunov method - state feedback of linear discrete time systems- Design of Observers- MATLAB Exercises.

References

1. Thomas Kailath, Linear Systems, Prentice Hall Inc., Englewood Cliffs, N.J. 1980.

2. K. Ogata, State Space Analysis of Control Systems, Prentice Hall Inc., Englewood Cliffs, N.J., 1965.

3. K. Ogata, Modern Control Engineering, (second edition) , Prentice Hall Inc., Englewood Cliffs, N.J., 1990.

4. M.Gopal, Digital Control and State Variable Methods, Tata McGraw Hill Publishing Company Ltd., New Delhi, 1997.

5. C.T. Chen, Linear System Theory and Design, New York: Holt Rinehart and Winston ,1984.

6. R.C. Dorf, and R. T. Bishop, Modern Control Systems, Addison Wesley Longman Inc., 1999.

7. Eronini,Umez- Eronini, System Dynamics and Control, Thomson Asia Pte Ltd.,Singapore,ISBN: 981-243-113-6, 2002.

EE6102: Optimal and Adaptive Control

Pre-requisite: Nil

L	T	P	C
3	0	0	3

Total hours: 42 Hrs.

Module 1: (12 hours)

Optimal control problem – open loop and closed loop form of optimal control- performance measures for optimal control problems – general form of performance measure - fundamental concepts and theorems of calculus of variations – function and functional – Extremal of functionals of a single function - Euler - Language equation and solution- extremal of functionals of several independent functions – various boundary condition equations - piecewise-smooth extremals - extremal of functionals with dependent functions – use of Lagrange multipliers - differential equation constraints – isoperimetric constraints.

Module 2: (10 hours)

The variational approach to solving optimal control problems - necessary conditions for optimal control using Hamiltonian – Different boundary condition equations for solving the optimal control problem – closed loop control for linear regulator problem - linear tracking problem – Pontryagin's minimum principle - state inequality constraints - minimum time problems - minimum control effort problems.

Module 3: (10 hours)

Dynamic programming - principle of optimality - application to multi stage decision making – application to optimal control problem – need for interpolation - recurrence relation of dynamic programming - curse of dimensionality - discrete linear regulator problem - Hamilton-Jacobi-Bellman equation - continuous linear regulator problem.

Module 4: (10 hours)

Model Reference Adaptive systems (MRAS) - the need for MRAS - an over view of adaptive control systems - mathematical description of MRAS - design hypothesis - equivalent representation of MRAS - introduction to design method based on the use of Liapunov function – design and simulation of variable structure adaptive model following control

References

1. Donald E. Kirk, Optimal Control Theory, An introduction, Prentice Hall Inc., 2004

2. A.P. Sage, Optimum Systems Control, Prentice Hall, 1977

3. HSU and Meyer , Modern Control, Principles and Applications, McGraw Hill, 1968

4. Yoan D. Landu, Adaptive Control (Model Reference Approach), Marcel Dekker. 1981

5. K.K.D.Young, Design of Variable Structure Model Following Control Systems., IEEE Transactions on Automatic Control, Vol. 23, pp 1079-1085, 1978.

6. A.S.I. Zinobar, O.M.E. EI-Ghezawi and S.A. Billings, Multivariable variable structure adaptive model following control systems. . Proc. IEE., Vol. 129, Pt.D., No.1, pp 6-12, 1982

EE6103: Applied Instrumentation

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours: 42 Hrs.

Module 1: (10 hours)

Introductory Instrumentation to process control . Modeling philosophies. The rationals for mathematical modeling dynamic versus steady state models . General modeling principles degrees of freedom in modeling . Control systems instrumentation . Transducers and transmitters . Transfer function models . Procedure for developing transfer function models.

Module 2: (10 hours)

Performance modeling . Modeling automated manufacturing system (introduction) . Role of performance modeling . Performance measures . Petrinet models . Introduction to petrinets . Basic definitions and analytical techniques. S-net models . Preliminary definition and analytical techniques.

Module 3: (10 hours)

Roll for digital computer system in process control . distributed instrumentation and control system . General purpose digital data acquisition and control hardware.

Module 4: (12 hours)

Engineered Data Acquisition and Processing System . Versatile Modular System Emphasising Analog Signal Processing . Instrument Inter Connection Systems . Sensor based computerized data system. Computer Aided Experimentation . Conditional description of the computer system . Computer aided over all plan of the test sequence.

References

1. Seborg . Process dynamic control, Wiley, 2007

2. Ernest O. Doebelin . Measurement system Application and Design . McGraw Hill International Editions, 1990

3. N. Viswanathan, Y. Narahari . Performance modeling of automated manufacturing system, Prentice Hall of India Private Limited, New Delhi, 2001

4. Proceedings: Conference on Advances in computing , CADCOM 98, Allied Publishers Limited, New Delhi, India, 1999

EE6104: Advanced Instrumentation

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours: 42 Hrs.

Module 1: (11 hours)

Generalized input . output configuration of measuring system . different methods of correction . General principles . Methods of inherent sensitivity, Principle of filtering, Method of opposing inputs.

Module 2: (11 hours)

Static characteristics of measurement system computer aided calibration and measurement . concepts of development of software . Dynamic characteristics . Mathematical Models . General concepts of transfer functions (with special reference to measuring system) . classification of instruments based on their order and their dynamic response and frequency response studies.

Module 3: (10 hours)

Response of general form of instruments to various input (a) periodic (b) transient. Characteristics of random signals . Measurement system response to random inputs.

Module 4: (10 hours)

Study and analysis of amplitude modulation of measurements and design consideration of such amplitudes modulated measurement systems. Requirements on instrument transfer function to ensure accurate measurements.

References

1. Ernest O. Doebelin . Measurement system Application and Design . McGraw Hill International Editions, 1990

2. K.B. Klaasen : Electronic Measurement and Instrumentation, Cambridge University Press, 1996

EE6106: System Identification & Parameter Estimation

Pre-requisite: Nil

L	T	P	C
3	0	0	3

Total hours: 42 Hrs.

Module 1: Systems and Models (9 hours)

Time invariant systems- impulse response, disturbances and transfer functions- frequency domain expressions- signal spectra – multivariable systems. Simulation -prediction - observers. Models of linear time invariant systems- linear models and sets of linear models- state space models – distributed parameter models – model sets structures and identifiability – identifiability of some model structures – Models of time varying and nonlinear systems- linear time varying models- nonlinear state space models- nonlinear black box models – neural networks- wavelets and classical models – fuzzy models – formal characterization of models.

Module 2: Model Estimation Methods (12 hours)

Nonparametric time and frequency domain methods- transient response analysis – frequency response analysis- Fourier analysis- Spectral analysis – estimating disturbance spectrum – Parameter estimation methods – guiding principles – minimizing prediction errors – linear regressions- and least squares method- statistical framework for parameter estimation and maximum likelihood estimation - correlation of prediction error with past data - Instrumental variable methods- using frequency domain data to fit linear models .

Module 3: Converge and Distributions of parameter Estimates (13 hours)

Conditions of data set – prediction error approach – consistency and identifiability – linear time invariant models - correlation methods. Prediction error approach – basic theorem – expressions for asymptotic variance – frequency domain expressions for asymptotic variance – correlation approach – use and relevance. Computing the estimate - linear regression and least squares – computing gradients – two stage and multi stage methods – local solutions and initial values – subspace methods - Recursive methods - recursive forms of least squares , IV , prediction error and pseudo linear regression methods. - choice of updating step. Implementation problems.

Module 4: Experiment Design (8 hours)
General Considerations – informative experiments – input design and open loop experiments – closed loop identification –approaches –optimal experiment design – choice of sampling interval – Preprocessing of data – drifts de-trending – outliers and missing data – selecting segments of data and merging experiments – pre-filtering –formal design of pre-filtering and input properties.

References

1. Lennart Ljung, system Identification Theory for the User, Prentice Hall Inc, 1999

2. Sinha N K , Kuztsa, System Identification And Modelling of Systems, 1983

3. Harold W Sorensen, Parameter Estimation : Marcel Dekker Inc, New York. 1980

EE6108: Nonlinear System Analysis

Pre-requisite: Nil

L	T	P	C
3	0	0	3

Total hours: 42 Hrs.

Module 1: Introduction and classical techniques (7 Hours)

Characteristics of nonlinear systems - classification of equilibrium points - limit cycles - analysis of systems with piecewise constant inputs using phase plane analysis - perturbation techniques- periodic orbits - stability of periodic solutions - singular perurbation model - slow and fast manifolds.

Module 2: Lyapunov Stabilty and Design (15 hours)

Stability of Nonlinear Systems - Lyapunov stability - local stability - local linearization and stability in the small - Direct method of Lyapunov - generation of Lyapunov function for linear and nonlinear systems - variable gradient method - Centre manifold theorem - region of attraction - Invariance theorems - Input output stability - L stability - L stability of state models - L2 stability- Lyapunov based design - Lyapunonv redesign - Robust stabilization - Nonlinear Damping - backstepping - sliding mode control - adaptive control - Model controller - model reference adaptive control

Module 3: Harmonic Linearisation and Describing Function Method (10 Hours)

Harmonic linearization - filter hypothesis - describing function of standard nonlinearities- study of limit cycles (amplitude and frequency) using SIDF- Dual Input Describing function - study of sub-harmonic oscillations - correction on describing functions

Module 4: Feedback Control and Feedback Stabilization (10 Hours)

Analysis of feedback systems - Circle Criterion - Popov Criterion - simultaneous Lyapunov functions - Feedback linearization - stabilization - regulation via integral control - gain scheduling - input state linearization - input output linearization - state feedback control - stabilization - tracking - integral control

References

1. Hassan K Khalil, Nonlinear Systems, Prentice - Hall International (UK) 1996

2. Slotine & W.LI, Applied Nonlinear Control Prantece Hall, Engloe wood NewJersey 1991

3. A Isidori, Nonlinear Control systems Springer verlag New york 1995

4. S. Wiggins, Introduction to Applied Nonlinear Dynamical Systems and chaos, Springer Verlag New York 1990

5. H. Nijmeijer & A.J. Van Der schaft, Nonlinear Dynamic control Systems, Springer Verlag Berlin 1990.

6. Arther E Gelb & Vender Velde, Multiple input Describing function and Nonlinear System Design, MC Graw Hill 1968

EE6121: Data Acquisition & Signal Conditioning

Pre-requisite: Nil

L	T	P	C
3	0	0	3

Total hours: 42 Hrs.

Module 1: Transducers & Signal Conditioning (11 hours)

Data Acquisition Systems(DAS)- Introduction . Objectives of DAS . Block Diagram Description of DAS- General configurations - Single and multichannel DAS-Transducers for the measurement of motion, force, pressure, flow, level, dc and ac voltages and currents (CTs, PTs for supply frequency as well as high frequency, Hall Effect Current Sensors, High Voltage Sensors , Optosensors, Rogowski Coil, Ampflex Sensors etc.) - Signal Conditioning: Requirements - Instrumentation amplifiers: Basic characteristics . Chopped and Modulated DC Amplifiers-Isolation amplifiers - Opto couplers - Buffer amplifiers .Noise Reduction Techniques in Signal Conditioning- Transmitters .Optical Fiber Based Signal Transmission-Piezoelectric Couplers- Intelligent transmitters.

Module 2: Filtering and Sampling (10 hours)

Review of Nyquist.s Sampling Theorem- Aliasing . Need for Prefiltering-First and second order filters - classification and types of filters - Low -pass, High-pass, Band-pass and Band-rejection and All Pass: Butterworth, Bessel, Chebyshev and Elliptic filters . Opamp RC Circuits for Second Order Sections-Design of Higher Order Filters using second order sections using Butterworth Approximation-Narrow Bandpass and Notch Filters and their application in DAS. Sample and Hold Amplifiers

Module 3: Signal Conversion and Transmission (10 hours)

Analog-to-Digital Converters(ADC)-Multiplexers and demultiplexers - Digital multiplexer . A/D Conversion . Conversion Processes , Speed, Quantization Errors . Successive Approximation ADC . Dual Slope ADC . Flash ADC . Digital-to-Analog Conversion(DAC) . Techniques, Speed, Conversion Errors, Post Filtering- Weighted Resistor, R-2R, Weighted Current type of DACs- Multiplying Type DAC-Bipolar DACs- Data transmission systems-Schmitt Trigger-Pulse code formats- Modulation techniques and systems-Telemetry systems.

Module 4: Digital Signal Transmission And Interfacing (11 hours)
DAS Boards-Introduction . Study of a representative DAS Board-Interfacing Issues with DAS Boards, I/O vs Memory Addressing, Software Drivers, Virtual Instruments, Modular Programming Techniques for Robust Systems, Bus standard for communication between instruments - GPIB (IEEE-488bus) - RS-232C-USB-4-to-20mA current loop serial communication systems.Communication via parallel port . Interrupt-based Data Acquisition.Software Design Strategies-Hardware Vs Software Interrupts-Foreground/ background Programming Techniques- Limitations of Polling . Circular Queues

References

1. Ernest O Doeblin., Measurement Systems: Application and Design, McGraw Hill (Int. edition) 1990

2. George C.Barney, Intelligent Instrumentation, Prentice Hall of India Pvt Ltd., New Delhi, 1988.

3. Ibrahim, K.E., Instruments and Automatic Test Equipment, Longman Scientific & Technical Group Ltd., UK, 1988.

4. John Uffrenbeck, The 80x86 Family ,Design, Programming, And Interfacing, Pearson Education , Asia, 2002

5. Bates Paul, Practical digital and Data Communications with LSI, Prentice Hall of India, 1987.

6. G.B. Clayton, .Operational Amplifiers, Butterworth &Co, 1992

7. A.K Ray, Advanced Microprocessors and Peripherals, Tata McGrawHill, 1991

8. Oliver Cage, .Electronic Measurements and Instrumentation., McGraw-Hill, (Int. edition) 1975

EE6122: Biomedical Instrumentation

Pre-requisite: Nil

L	T	P	C
3	0	0	3

Total hours: 42 Hrs.

Module 1: (12 hours)

Fundamentals of medical instrumentation – physiological systems of body –regulation of medical devices – origin of bio potentials – Sodium –Potassium pump –Goldman Hodgkin – Katz equation – biomedical transducers – electrode-electrolyte interface – half cell potential – ECG – 12 lead systems – heart rate variability – cardiac pacemakers – defibrillators - EMG – EEG

Module 2: (10 hours)

Measurement of cardiac out put – indicator dilution method – ultrasonic blood flow meter – electromagnetic blood flow meter – blood pressure measurement – oximetry – ear oximeter – pulse oximeter –skin reflectance oximeter -measurement on pulmonary system – spirometry –pulmonary function analyzers –ventilators

Module 3: (10 hours)
Lasers in medicine – Argon laser – Carbon dioxide laser -laser safety –X ray applications –X-ray machine – dental X-ray machine – ultra sound in medicine –electro therapy – hemodialysis –artificial kidney – dialyzers –membranes for hemodialysis

Module 4: (10 hours)

Measurement of p_H, pCO_2 , pO_2 - radiotherapy – Cobalt 60 machine – medical linear accelerator machine – audiometry - electrical safety in hospitals

References

1. Geddes & Baker , Principles of applied biomedical instrumentation Wiley Inter science , 3rd edition, 1975

2. R S Khandpur, Hand book of Biomedical instrumentation, TMH,4th edition, 1987

3. Cromwell Leslie, Biomedical instrumentation and measurements, PHI, 1980

4. Brown Carr, Introduction to Biomedical equipment technology , Printice Hall, 1981

5. John Enderle, Introduction to Biomedical engineering , Academic Press, 2005

6. Joseph D Bronzino, Biomedical engineering hand book, CRC Press, 2000

7. Metin Akay (editor), Wiley encyclopedia of biomedical engineering , Wiley, 2003

EE6123: Performance Modelling of Systems – I

Pre-requisite: Nil

L	T	P	C
3	0	0	3

Total hours: 42 Hrs.

Module 1: **General Operational Characteristics (10 hours)**

Input-Output configuration of measuring systems . Static characteristics . Dynamic characteristics . Mathematical models . General concepts of transfer functions . Classification of instruments based on their order . dynamic response . frequency response studies.

Module 2: General Concepts in Set Theory (10 hours)

Preliminaries . Basic set theory . Terminology . Functions . Relations - Combinatorics . Theory of counting-Multiplication rule- Ordered samples and permutations-Ordered samples with and without repetitions.-Brief theory of bags .

Module 3: General Graph Theory (10 hours)

Graphs and algorithms . Concepts of Nodes and Arcs- Trees . Spanning of trees .Minimal spanning trees; Prime.s algorithm- Binary trees and tree searching- Planar graphs and Euler.s theorem- Cut sets .Adjacency /incidence matrices . Graph having multiple edges . Determination of Euler cycles- The shortest path problem.

Module 4: Active Graph Theory (12 hours)

Performance models . Petrinet graph- Concepts of places . Transitions . Arcs and Tokens .Concurrency and conflict- Deadlocks- Markings- Reachability sets-Matrx equations- Reachability problems- Popular extensions . S-Nets . Introduction to Petrinet and S Net Models.

References

1. Ernest O Doeblin., Measurement Systems: Application and Design, McGraw Hill (Int. edition) 1990

2. Oliver and Cage, Electronic measurements and Instrumentation , McGraw Hill Int. Editions, 1971

3. C.L. Liu, Elements of Discrete Mathematics, McGraw Hill Int. Editions, 1985.

4. Robert J. McEliece ,Robert B Ash, Carol Ash , Introduction to Discrete Mathematics, McGraw Hill Int. Editions, 1989.

5. J.L. Peterson., Petrinet Theory and Modelling of Systems , Prentice Hall Inc., Englewood Cliffs, N.J ., 1981.

6. John O. Moody ,Panos J Antsaklis, ,Supervisory Control of Discrete Event System Using Petrinets, Kluwer academic Publishers Boston/Dordrecht/ London, 1998.

7. N. Viswanathan, Y. Narahari, Performance Modelling of Automated Manufacturing Systems , Prentice Hall of India Pvt. Ltd., New Delhi,1994.

8. Proceedings : Conference on Advances in Computing CAD CAM 98 , Allied Publishers Ltd., New Delhi, India, 1999

EE6124: Performance Modelling of Systems – II

Pre-requisite: Performance Modelling of Systems - I

L	T	P	C
3	0	0	3

Total hours: 42 Hrs

Module 1: Modelling Philosophies (10 hours)

Modelling philosophies . Rationales for mathematical modeling . Dynamic versus steady state models . General modelling principles . Degrees of freedom in modelling Transfer function models . Procedure for developing transfer function models.

Module 2: Modelling Tools and Applied Systems (10 hours)

Performance modelling . Modelling of automated manufacturing systems . Role of performance modelling .

Performance measures . Petrinet models . Introduction to Petrinet . Basic definitions and analytical techniques . S-Net models . Preliminary definitions and analytical techniques.

Module 3: Active Graphical Modelling Tools (10 hours)
Modelling with active graph theory . General concepts . Events and conditions . Synchronisation . Mutual exclusion problems . Standard Problems - Dining philosophers problems . Readers/ writers problems .

Module 4: Analysis of Modelling Tools (12 hours)

Analysis problems of active graph . Petrinets . S-Nets . Their popular extensions . Different case studies of Petrinet and S-Net models related to super computer pipe line . Flexible manufacturing systems . Computer communication system . Computer controlled data acquisition system- computer communication network . Process control systems.

References

1. Ernest O Doeblin., Measurement Systems: Application and Design, McGraw Hill (Int. edition) 1990

2. Oliver and Cage, Electronic measurements and Instrumentation , McGraw Hill Int. Editions, 1971

3. C.L. Liu, Elements of Discrete Mathematics, McGraw Hill Int. Editions, 1985.

4. Robert J. McEliece ,Robert B Ash, Carol Ash , Introduction to Discrete Mathematics, McGraw Hill Int. Editions, 1989.

5. J.L. Peterson., Petrinet Theory and Modelling of Systems , Prentice Hall Inc., Englewood Cliffs, N.J ., 1981.

6. John O. Moody ,Panos J Antsaklis, ,Supervisory Control of Discrete Event System Using Petrinets, Kluwer academic Publishers Boston/Dordrecht/ London, 1998.

7. N. Viswanathan, Y. Narahari, Performance Modelling of Automated Manufacturing Systems , Prentice Hall of India Pvt. Ltd., New Delhi,1994.

8. Proceedings : Conference on Advances in Computing CAD CAM 98 , Allied Publishers Ltd., New Delhi, India, 1999

9. Seborg . Process dynamic control, Wiley, 2007

EE6125: Digital Control Systems

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours: 42 Hrs

Module 1: Introduction to Digital Control systems (11 hours)

Data conversion and quantisation - Sampling process- Mathematical modeling- Data reconstruction and filtering of sampled signals- Hold devices- z transform and inverse z transform - Relationship between s-plane and z- plane- Difference equation - Solution by recursion and z-transform- Discretisation Methods

Module 2: Analysis of Digital Control Systems (10 hours)

Digital control systems- Pulse transfer function - z transform analysis of closed loop and open loop systems- Modified z- transfer function- Multirate z-transform - Stability of linear digital control systems- Stability tests- Steady state error analysis- Root loci - Frequency domain analysis- Bode plots- Nyquist plots- Gain margin and phase margin.

Module 3: Classical Design of Digital Control Systems (10 hours)

Cascade and feedback compensation by continuous data controllers- Digital controllers-Design using bilinear transformation- Root locus based design- Digital PID controllers- Dead beat control design- Case study examples using MATLAB

Module 4: Advanced Design of Digital Control Systems (11 hours)

State variable models- Interrelations between z- transform models and state variable models- Controllability and Observability - Response between sampling instants using state variable approach- Pole placement using state feedback – Servo Design- State feedback with Integral Control-Deadbeat Control by state feedback and deadbeat observers- Dynamic output feedback- Effects of finite wordlength on controllability and closed loop pole placement- Case study examples using MATLAB.

References

1. B.C Kuo , Digital Control Systems (second Edition),Oxford University Press, Inc., New York, 1992.

2. G.F. Franklin, J.D. Powell, and M.L. Workman, Digital control of Dynamic Systems, Addison-Wesley Longman, Inc., Menlo Park, CA , 1998.

3. M. Gopal, Digital Control and State Variable Methods, Tata McGraw Hill Publishing Company, Third Edition,2009.

4. John F. Walkerly, Microcomputer architecture and Programs, John Wiley and Sons Inc., New York, 1981.

5. K. Ogata, Discrete Time Control Systems, Addison-Wesley Longman Pte. Ltd., Indian Branch ,Delhi,1995.

6. C. H. Houpis and G.B. Lamont, Digital Control Systems, McGraw Hill Book Company, 1985.

7. C.L.Philips and H.T Nagle,Jr., Digital Control System Analysis and Design, Prentice Hall, Inc., Englewood Cliffs,N.J.,1984.

EE6126: Advanced Topics in Control System

Pre-requisite: EE6101: Dynamics of Linear Systems

L	T	P	C
3	0	0	3

Total hours: 42 Hrs

Module 1: Neuro-Fuzzy Modelling and Control of Systems (9 hours)

Fuzzy Models- Mamdani and Takagi Sugeno Models- Construction of fuzzy models . Neural networks . Adaptive networks . supervised learning . Adaptive neuro-fuzzy inference systems- ANFIS architecture- ANFIS as a universal approximator - Simulation examples.

References

1. Robert Babuska :Fuzzy Modelling and Control - . International Series in Intelligent Technologies, Kluwer Academic Publications . (1998)

2. Jang J SR ,Sun C T, Mizutani E : Neuro-fuzzy and Soft Computing . MATLAB curriculum Series, Prentice Hall International (1997)

3. Selected papers on Neuro-fuzzy Modelling and Control.

Module 2: Linear Multi-Input-Multi-Output Control Systems (10 hours)

Representations of MIMO systems- Equivalent transformations- Canonical forms- Solution of state equations- System response- Controllability and pole allocation- Observability and state estimator- System characterization by transfer matrix- Noninteractive and model matching control design.

References

1. Apte Y.S., Linear Multivariable Control Theory, Tata McGraw Hill Publishing Co. Ltd., 1994.

2. Chen C.T., Linear System Theory and Design, Holt Reinhart and Winston Inc., 1984

3. Wolovich W.A., Linear Multivariable Systems, Springer- Verlag , New york- Heidelberg- Berlin, 1974.

4. Thomas Kailath, Linear Systems, Prentice Hall Inc., Englewood Cliffs, N.J. , 1980

Module 3: Chaos, fractals, applications and Aerospace Guidance Systems (14 hours)

Non linear systems . chaos . fractals . dimensions . attractors .Lorenz attractor . Mandelbrot set, bifurcations .synthesis of some chaotic systems using neural net work. some control applications. fractals and chaos in medicine and physiology .

Introduction . trajectory aspects . inertial and optical sensors . inertial guidance for cruise vehicles . guidance and control of rocket vehicles . guidance and control of mobile-launched ballistic missiles.

References

1. Selected papers and case studies

2. Leondis C T . guidance and Control of Aerospace Vehicles . McGraw Hill Book Company Inc New York 1963

Module 4: Variable Structure Systems (9 hours)

Introduction . Variable Structure Systems (VSS) . VSS for fast response . VSS for stability . VSS with sliding mode . Sliding mode motion . Existence Condition - Second order control problem . Sliding mode motion on switching line . Sliding mode motion on switching surface . Design of stable switching surface . Invariance Conditions in VSS . Variable structure model following control (VSMFC)

References

1. U. Itkis . Control Systems of variable structure, New York, Wiley, 1976

2. A.S.I. Zinober (Edited by) - Deterministic Control of Uncertain Systems, British Library Cataloguing in Publication Data, Peter Peregrinus Ltd. 1990

3. B. Drazenovic . The invariance conditions in variable structure systems, Automatica, Vol. 5, pp 287-295, 1969.

4. K.K.D. Young . Design of Variable Structure Model Following Control Systems, IEEE Transactions on Automatic Control, Vol. 23, pp-1079-1085 - 1978

5. A.S.I. Zinobar, O.M.E. EI-Ghezawi and S.A.Billings - Multivariable variable structure adaptive model following control systems . Proc. IEE., Vol. 129., Pt. D., No.1, pp-6-12, 1982

EE6127: Variable Structure Control Systems

Pre-requisite: Nil

L	T	P	C
3	0	0	3

Total hours: 42 Hrs

Module 1: (8 hours)

Variable Structure Systems(VSS)-Introduction- Synthesis of stable systems from unstable structures- VSS for improving speed of response,-VSS for stability- simulation using MATLAB®-Simulation using SIMULINK®.

Module 2: (10 hours)

Variable structure systems with sliding mode- sliding mode motion- existence condition- equivalent control for sliding mode motion- sliding mode motion on switching line- Invariance conditions- Design of sliding mode controllers using feedback linearisation for non-linear systems- simulation of sliding mode controller using Matlab and simulink.

Module 3: (12 hours)

Sliding mode motion on switching surface- design of stable switching surfaces- design of sliding mode controller for higher order systems- Sliding mode controller design for a robotic manipulator- Chattering- Chattering reduction techniques.

Module 4: (12 hours)

Variable Structure Model Following Control (VSMFC) Systems- Conditions for perfect model following- sliding mode equivalent control- Sliding mode discontinuous control- Design of VSMFC for second order system- Design of VSMFC for higher order systems- Simulation using MATLAB and SIMULINK.

References

1. U Itkis - Control Systems of Variable Structure., New York,Wiley, 1976.

2. A S I Zinober (Edited by) - Deterministic Control of Uncertain Systems., British Library, 1990

3. Cataloguing in Publication Data, Peter Peregrinus Ltd.1990.

4. B. Drazenovic - The invariance conditions in variable structure systems, Automatica., Vol. 5, pp 287 . 295, 1969.

5. K.K.D.Young - Design of Variable Structure Model Following Control Systems., IEEE Transactions on Automatic Control, Vol. 23, pp 1079-1085, 1978.

6. A.S.I. Zinobar, O.M.E. EI-Ghezawi and S.A. Billings . .Multivariable variable structure adaptive model following control systems. . Proc. IEE., Vol. 129, Pt.D., No.1, pp 6-12, 1982.

7. J.J. Slotine and S.S. Sastry, .Tracking control of non-linear systems using sliding surfaces, with application to robot manipulators. International Journal of Control, 1983, Vol. 38, No.2, pp 465-492.

8. Vadim I. Utkin, .Variable Structure Systems with Sliding Modes., IEEE Transactions on Automatic Control, April 1977, pp 212-222.

EE6128: Optimal Estimation and Filtering

Pre-requisite: EE6101 Dynamics of Linear Systems

L	T	P	C
3	0	0	3

Total hours: 42 Hrs

Module 1: Random Process and Stochastic Systems (6 hours)

Probability and random variables – statistical properties of random variables and random processes – linear random process models – shaping filters and state augmentation – mean and covariance propagation – relationship with model parameters – orthogonality principle

Module 2: Linear Optimal Filters and Predictors (12 hours)

Kalman filter – Kalman Bucy Filter – Optimal linear predictors – Correlated noise sources – relation between Kalman Bucy and winer filters- Quadratic loss function – Matrix Riccati differential equation and in discrete time – model equations for transformed variables – Application of Kalman filters

Module 3: Optimal Smoothers & Implementation Methods (10 hours)

Fixed Interval, fixed lag and fixed point smoothers – algorithms . Computer round off –effect of round off errors on Kalman filters- factorization methods for square root filtering – square root UD filters – other implementation methods

Module4: Nonlinear Filtering & Practical Considerations (14 hours)

Quasi-linear filtering —extended Kalman filers – iterated EKF - sampling methods for nonlinear filtering.

Detecting and correcting anomalies – bad data and missing data – stability of Kalman filters – Suboptimal and reduced order filters – Memory throughput. Word length considerations - computational efforts – reduction – Error budgets and sensitivity analysis – optimizing measurement selection policies

References

1. Mohinder S Grewal and angus P Andrews,: Kalman Filtering Theory and Practice Using MATLAB , John Wiley and Sons , 2008

2. B D O Anderson, John B Moore : Optimal Filtering , Prentice Hall Inc. 1979

3. Meditch J S : Stochastic Optimal Estimation and Control, 1982

EE6129: Artificial Neural Networks and Fuzzy Systems

Pre-requisite: Nil

L	T	P	C
3	0	0	3

Total hours: 42 Hrs

Module 1: (10 hours)

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

Module 2: (10 hours)

Learning process . Supervised and unsupervised learning . Error-correction learning, Hebbian learning, Boltzmen learning, Single layer and multilayer perceptturs, Least mean square algorithm, Back propagation algorithm, Applications in forecasting and pattern recognition and other engineering problems.

Module 3: (10 hours)

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

Module 4: (12 hours)

Fuzzy control systems . Introduction, simple fuzzy logic controllers with examples, special forms of fuzzy logic models, classical fuzzy control problems . inverter pendulum, image processing . home heating system . Adaptive fuzzy systems, hybrid systems.

References

1. J.M. Zurada, .Introduction to artificial neural systems., Jaico Publishers, 1992.

2. Simon Haykins, .Neural Networks . A comprehensive foundation., Macmillan College, Proc, Con, Inc, New York, 1994.

3. D. Driankov, H. Hellendorn, M. Reinfrank, .Fuzzy Control . An Introduction. , Narora Publishing House, New Delhi, 1993.

4. H.J. Zimmermann, .Fuzzy set theory and its applications., III Edition, Kluwer Academic Publishers, London. 2001

5. G.J. Klir, Boyuan, .Fuzzy sets and fuzzy logic., Prentice Hall of India (P) Ltd., 1997.

6. Stamatios V Kartalopoulos, .Understanding neural networks and fuzzy logic .basic concepts and applications., Prentice Hall of India (P) Ltd., New Delhi, 2000.

7. Timothy J. Ross, .Fuzzy logic with engineering applications., McGraw Hill, New York.

8. Suran Goonatilake, Sukhdev Khebbal (Eds), .Intelligent hybrid systems., John Wiley & Sons, New York, 1995.

EE6191: Instrumentation and Control Systems Lab

L	T	P	C
0	0	3	2

Pre-requisite: Nil

Total hours: 42 Hrs

12 experiments will be offered in the lab, each experiment being of 3 hours duration. The experiments will be such as to understand the advanced topics in automatic control systems.

1.The feedback MS150 modular servo system – part 1

2.Experiments on Bytronics® Inverted Pendulum

3.Synchro characteristics and synchro systems.

4.Experiments on Level Process Control Station

5.Micro-processor based wave form generation

6.Micro-processor based stepper motor control

7.AC servo system – closed loop position control and closed loop velocity control.

8.The FEEDBACK® MS150 Modular Servo System- Part II. Setting up closed loop control system.

9.Use of Matlab for controlled system design, simulation and performance evaluation.

10.Use of Simulink for controlled system simulation and performance evaluation.

11.Compensators – design, simulation and hardware implementation.

12.To obtain experimentally the transfer function of DC motor and the amplidyne and to set up a closed loop control voltage regulation control for a DC generator using amplidyne.

References

1. Gene F Franklin, J David Powell, Abbas Emami Naeini, Feedback Control of Dynamic Systems, 4th Ed, Pearson Education Asia, 2002

2. Graham C Goodwin, Stefan F Graebe, Mario E Salgado, Control System Design, Prentice Hall India, 2003.

3. John J D'Azzo, Constantine H Houpis, Stuart N. Sheldon, Linear Control System Analysis & Design with MATLAB, 5th Ed, Marcel Dekker, 2003

4. P.C. Sen, Principles of Electrical Machines & Power Electronics, John Wiley, 2003.

5. John E Gibson, Franz B. Tuteur, Control System Components, McGrawHill, 1958.

6. Ramesh S Gaonkar, Microprocessor architecture Programming and application with 8085/8080A 2E, New Age Publications, 1995.

7. Users' Manual for FEEDBACK® MS150 AC Modular Servo System

8. Users' Manual for 8085n Microprocessor kit. www.mathworks.com

EE6304: Advanced Digital Signal Processing

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours: 42 Hrs

Module1: Discrete Time Signals, Systems and Their Representations (12 hours)

Discrete time signals- Linear shift invariant systems- Stability and causality- Sampling of continuous time signals- Discrete time Fourier transform- Discrete Fourier series- Discrete Fourier transform- Z- transform- Properties of different transforms- Linear convolution using DFT- Computation of DFT

Module 2: Digital Filter Design and Realization Structures (9 hours)

Design of IIR digital filters from analog filters- Impulse invariance method and Bilinear transformation method- FIR filter design using window functions- Comparison of IIR and FIR digital filters- Basic IIR and FIR filter realization structures- Signal flow graph representations

Module 3: Analysis of Finite Word-length Effects (9 hours)

Quantization process and errors- Coefficient quantisation effects in IIR and FIR filters- A/D conversion noise- Arithmetic round-off errors- Dynamic range scaling- Overflow oscillations and zero input limit cycles in IIR filters

Module 4: Statistical Signal Processing (12 hours)

Linear Signal Models . All pole, All zero and Pole-zero models .Power spectrum estimation- Spectral analysis of deterministic signals . Estimation of power spectrum of stationary random signals-Optimum linear filters-Optimum signal estimation-Mean square error estimation-Optimum FIR and IIR filters.

References

1. Sanjit K Mitra, Digital Signal Processing: A computer-based approach ,Tata Mc Grow-Hill edition .1998

2. Dimitris G .Manolakis, Vinay K. Ingle and Stephen M. Kogon, Statistical and Adaptive Signal Processing, Mc Grow Hill international editions, 2000

3. Alan V. Oppenheim, Ronald W. Schafer, Discrete-Time Signal Processing, Prentice-Hall of India Pvt. Ltd., New Delhi, 1997

4. John G. Proakis, and Dimitris G. Manolakis, Digital Signal Processing(third edition), Prentice-Hall of India Pvt.Ltd, New Delhi, 1997

5. Emmanuel C. Ifeachor, Barrie W. Jervis , Digital Signal Processing-A practical Approach, Addison . Wesley,1993

6. Abraham Peled and Bede Liu, Digital Signal Processing, John Wiley and Sons, 1976

EE6401: Energy Auditing & Management

Pre-requisite: Nil

L	T	P	C
3	0	0	3

Total hours: 42 Hrs

Objective: Understanding, analysis and application of electrical energy management-measurement and accounting techniques-consumption patterns- conservation methods-application in industrial cases.

Module 1: (9 hours)

System approach and End use approach to efficient use of Electricity; Electricity tariff types; Energy auditing: Types and objectives-audit instruments- ECO assessment and Economic methods-specific energy analysis-Minimum energy paths-consumption models-Case study.

Module 2: (11 hours)

Electric motors-Energy efficient controls and starting efficiency-Motor Efficiency and Load Analysis-Energy efficient /high efficient Motors-Case study; Load Matching and selection of motors.

Variable speed drives; Pumps and Fans-Efficient Control strategies- Optimal selection and sizing -Optimal operation and Storage; Case study

Module 3: (11 hours)

Transformer Loading/Efficiency analysis, Feeder/cable loss evaluation, case study.

Reactive Power management-Capacitor Sizing-Degree of Compensation-Capacitor losses-Location-Placement-Maintenance, case study.

Peak Demand controls- Methodologies-Types of Industrial loads-Optimal Load scheduling-case study.

Lighting- Energy efficient light sources-Energy conservation in Lighting Schemes- Electronic ballast-Power quality issues-Luminaries, case study.

Module 4: (11 hours)

Cogeneration-Types and Schemes-Optimal operation of cogeneration plants-case study;

Electric loads of Air conditioning & Refrigeration-Energy conservation measures- Cool storage. Types-Optimal operation-case study; Electric water heating-Gysers-Solar Water Heaters- Power Consumption in Compressors, Energy conservation measures; Electrolytic Process; Computer Controls- software-EMS

References

1. Handbook on Energy Audit and Environment Management , Y P Abbi and Shashank Jain, TERI, 2006

2. Handbook of Energy Audits Albert Thumann, William J. Younger, Terry Niehus, 20093. Giovanni Petrecca, .Industrial Energy Management: Principles and Applications., The Kluwer international series - 207,1999

4. Anthony J. Pansini, Kenneth D. Smalling, .Guide to Electric Load Management., Pennwell Pub; (1998)

5. Howard E. Jordan, .Energy-Efficient Electric Motors and Their Applications., Plenum Pub Corp; 2nd edition (1994)

6. Turner, Wayne C., .Energy Management Handbook., Lilburn, The Fairmont Press, 2001

7. Albert Thumann , .Handbook of Energy Audits., Fairmont Pr; 5th edition (1998)

8. IEEE Bronze Book- .Recommended Practice for Energy Conservation and cost effective planning in Industrial facilities., IEEE Inc, USA. 2008

9. Albert Thumann, P.W, -.Plant Engineers and Managers Guide to Energy Conservation. - Seventh Edition-TWI Press Inc, Terre Haute, 2007

10. Donald R. W., .Energy Efficiency Manual., Energy Institute Press, 1986

11. Partab H., 'Art and Science of Utilisation of Electrical Energy', Dhanpat Rai and Sons, New Delhi. 1975

12. Tripathy S.C.,'Electric Energy Utilization And Conservation', Tata McGraw Hill, 1991

13. NESCAP-Guide Book on Promotion of Sustainable Energy Consumption, 2004

14. IEEE Bronze Book, IEEE STD 739

15. IEEE Recommended Practices for Energy Management in Industrial and Commercial Facilities

16. Guide to Energy Management, Sixth Edition , Barney L. Capehart (Author), Wayne C. Turner (Author), William J. Kennedy, Fairmont Press; 6 edition (April 23, 2008)

17. Energy Efficiency Manual: for everyone who uses energy, pays for utilities, designs and builds, is interested in energy conservation and the environment, Donald R. Wulfinghoff, Energy Institute Press (March 2000)

18. Handbook of Energy Audits, Seventh Edition, Albert Thumann., William J. Younger, Fairmont Press;
7 edition (November 12, 2007)

19. Certified Energy Manager Exam Secrets Study Guide: CEM Test Review for the Certified Energy Manager Exam CEM Exam Secrets Test Prep Team Mometrix Media LLC (2009)

20.Handbook of Energy Engineering, Sixth Edition Albert Thumann , D. Paul Mehta Fairmont Press; 6 edition (June 24, 2008)

L	T	P
3	0	0

EE6402: Process Control & Automation

Pre-requisite: Nil

Total hours: 42 Hrs

Module 1: (10 hours)

Process Modeling- Introduction to Process control and process instrumentation-Hierarchies in process control systems-Theoretical models-Transfer function-State space models-Time series models-Development of empirical models from process data-chemical reactor modeling-. Analysis using softwares

Module 2: (10 hours)

Feedback & Feedforward Control- Feedback controllers-PID design, tuning, trouble shooting-Cascade control- Selective control loops-Ratio control-Control system design based on Frequency response Analysis-Direct digital design-Feedforward and ratio control-State feedback control- LQR problem- Pole placement -Simulation using softwares-Control system instrumentation-Control valves- Codes and standards- Preparation of P& I Diagrams.

Module 3: (11 hours)

Advanced process control-Multi-loop and multivariable control-Process Interactions-Singular value analysis-tuning of multi loop PID control systems-decoupling control-strategies for reducing control loop interactions-Real-time optimization-Simulation using softwares

Module 4: (11 hours)

Model predictive control-Batch Process control-Plant-wide control & monitoring- Plant wide control design- Instrumentation for process monitoring-Statistical process control-Introduction to Fuzzy Logic in Process Control-Introduction to OPC-Introduction to environmental issues and sustainable development relating to process industries. Comparison of performance different types of control with examples on softwares

References

1. Seborg, D.E., T.F. Edgar, and D.A. Mellichamp, Process Dynamics and Control, John Wiley , 2004

2. Johnson D Curtis, Instrumentation Technology, (7th Edition) Prentice Hall India, 2002.

3. Bob Connel, Process Instrumentation Applications Manual, McGrawHill, 1996.

4. Edgar, T.F. & D.M. Himmelblau, Optimization of Chemical Processes, McGrawHill Book Co, 1988.

5. Macari Emir Joe and Michael F Saunders, Environmental Quality Innovative Technologies 7 Sustainable Development, American Society of Civil Engineers, 1997.

6. Nisenfeld(Ed) batch Control, Instrument Society of America, 1996.

7. Sherman, R.E. (Ed), Analytical instrumentation, Instrument Society of America, 1996.

8. Shinskey, F.G., Process Conrol Systems: Applications, Design and Tuning (3rd Edition) McGrawHill Book Co, 1988.

9. B. Wayne Bequette, Process control: modeling, design, and simulation Prentice Hall PTR, 2003

10. K. Krishnaswamy, Process Control, New Age International, 2007

EE6403: Computer Controlled Systems

Pre-requisite: Nil

L	T	P	C
3	0	0	3

Total hours: 42 Hrs

Module 1: Multivariable Control (12 hours)

Multivariable control- Basic expressions for MIMO systems- Singular values- Stability norms- Calculation of system norms- Robustness- Robust stability- H^2 / H^∞ Theory- Solution for design using H^2 / H^∞ - Case studies. Interaction and decoupling- Relative gain analysis- Effects of interaction- Response to disturbances- Decoupling- Introduction to batch process control.

Module 2: Programmable Logic Controllers (10 hours)

Programmable logic controllers- Organisation- Hardware details- I/O- Power supply- CPU- Standards- Programming aspects- Ladder programming- Sequential function charts- Man- machine interface- Detailed study of one model- Case studies.

Module 3: Large Scale Control System (12 hours)

SCADA: Introduction, SCADA Architecture, Different Commnication Protocols, Common System Components, Supervision and Control, HMI, RTU and Supervisory Stations, Trends in SCADA, Security Issues

DCS: Introduction, DCS Architecture, Local Control (LCU) architecture, LCU languages, LCU - Process interfacing issues, communication facilities, configuration of DCS, displays, redundancy concept - case studies in DCS.

Module 4: Real Time Systems (8 hours)

Real time systems- Real time specifications and design techniques- Real time kernels- Inter task communication and synchronization- Real time memory management- Supervisory control- direct digital control- Distributed control- PC based automation.

References

1. Shinskey F.G., Process control systems: application , Design and Tuning, McGraw Hill International Edition ,Singapore,1988.

2. Be.langer P.R. , Control Engineering: A Modern Approach, Saunders College Publishing , USA, 1995.

3. Dorf, R.C. and Bishop R. T. , Modern Control Systems , Addison Wesley Longman Inc., 1999

4. Laplante P.A., Real Time Systems: An Engineer.s Handbook, Prentice Hall of India Pvt. Ltd., New Delhi, 2002.

5. Constantin H. Houpis and Gary B. Lamont, Digital Control systems, McGraw Hill Book Company, Singapore, 1985.

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

7. Gordon Clarke, Deon Reynders:Practical Modern SCADA Protocols: DNP3, 60870.5 and Related Systems, Newnes Publications, Oxford, UK,2004

8. Efim Rosenwasser, Bernhard P. Lampe, Multivariable computer-controlled systems: a transfer function approach, Springer, 2006

EE6404: Industrial Load Modelling & Control

Pre-requisite: Nil

L	T	P	C
3	0	0	3

Total hours: 42 Hrs

Objective: Analysis and application of load control techniques in Industries.

Module 1: (12 hours)

Electric Energy Scenario-Demand Side Management-Industrial Load Management; Load Curves-Load Shaping Objectives-Methodologies-Barriers; Classification of Industrial Loads- Continuous and Batch processes -Load Modelling; Electricity pricing – Dynamic and spot pricing -Models;

Module 2: (10 hours)

Direct load control- Interruptible load control; Bottom up approach- scheduling- Formulation of load models- optimisation and control algorithms - Case studies;

Reactive power management in industries-controls-power quality impacts-application of filters;

Module 3: (10 hours)

Cooling and heating loads- load profiling- Modeling- Cool storage-Types-Control strategies-Optimal operation-Problem formulation- Case studies;

Module 4: (10 hours)

Captive power units- Operating and control strategies- Power Pooling- Operation models; Energy Banking-Industrial Cogeneration; Selection of Schemes Optimal Operating Strategies-Peak load saving-Constraints-Problem formulation- Case study; Integrated Load management for Industries;

References

1 C.O. Bjork " Industrial Load Management - Theory, Practice and Simulations", Elsevier, the Netherlands, 1989.

2. C.W. Gellings and S.N. Talukdar, . Load management concepts. IEEE Press, New York, 1986, pp. 3-28.

3. Various Authors, " Demand side management - Alternatives", IEEE Proceedings on DSM , Oct 1985

4. Y. Manichaikul and F.C. Schweppe ," Physically based Industrial load", IEEE Trans. on PAS, April 1981

5. H. G. Stoll, "Least cost Electricity Utility Planning., Wiley Interscience Publication, USA, 1989.

6. I.J.Nagarath and D.P.Kothari, .Modern Power System Engineering. , Tata McGraw Hill publishers, New Delhi, 1995.

7. Cogeneration as a means of pollution control and energy efficiency in Asia 2000. Guide book by UNESC for ASIA and the Pacific , Book No: ST/ESCAP/2026, UNESCAP, Bangkok

8. IEEE Bronze Book- .Recommended Practice for Energy Conservation and cost effective planning in Industrial facilities., IEEE Inc, USA.

9. ASHRAE Handbooks-1997-2000, American Society of Heating, Refrigerating and Air-conditioning Engineers Inc., Atlanta, GA.

10. Richard E. Putman, industrial energy systems: analysis, optimization, and control, ASME Press, 2004

EE6406: Industrial Instrumentation

L	T	P	C
3	0	0	3

Pre-requisite: Nil
Total hours: 42 Hrs

Module 1: (12 hours)

Industrial measurement systems – different types of industrial variables and measurement systems elements – sensors and transducers for different industrial variables like pressure, torque, speed, temperature etc– sensor principles – examples of sensors – sensor scaling – Industrial signal conditioning systems-Amplifiers – Filters – A/D converters for industrial measurements systems –review of general Industrial instruments.

Module 2: (8 hours)

Calibration and response of industrial instrumentation - standard testing methods and procedures – Generalized performance characteristics – static response characterization – dynamic response characterization - zero order system dynamic response characterizations – first order system dynamic response second order system dynamic response – higher order systems - Response to different forcing functions such as step, sinusoidal etc. to zero, first, second third and higher orders of systems.

Module 3: (12 hours)

Regulators and power supplies for industrial instrumentation – linear series voltage regulators – linear shunt voltage regulators – integrated circuit voltage regulators – fixed positive and negative voltage regulators – adjustable positive and negative linear voltage regulators – application of linear IC voltage regulators - switching regulators –single ended isolated forward regulators- half and full bridge rectifiers. pH and conductivity sensors. Piezo-electric and ultrasonic sensors and its application in process and biomedical Instrumentation. Measurement of viscosity, humidity and thermal conductivity

Module 4: (10 hours)

Servo drives – servo drive performance criteria – servomotors shaft sensors and coupling – sensors for servo drives – servo control loop design issues- stepper motor drives types and characteristics – hybrid stepper motor – permanent magnet stepper motor – hybrid and permanent magnet motors – single and multi step responses.

References

1. Ernest O. Doebelin Measurement systems applications and design, McGraw – Hill International Editions, McGraw- Hill Publishing Company, 1990

2. Patric F. Dunn University of Notre Dame, Measurement and Data Analysis for engineering and science, Mc Graw Hill Higher education, 1995

3. Randy Frank, Understanding Smart Sensors, Artec House Boston. London, 2000

4. Muhamad H Rashid, Power electronics handbook, ACADEMIC PRESS, 2007

5. K Krishnaswamy, Industrial Instrumentation, New Age International Publishers, New Delhi, 2003

6. Gregory K. McMillan, Douglas M. Considine , Process/Industrial Instruments and Controls Handbook,5th Edition, Mc Graw Hill 1999

7. Steve Mackay, Edwin Wright, John Park, Practical Data Communications for Instrumentation and Control, Newness Publications, UK, 2003

8. John O Moody, Paros J Antsaklis, Supervisory Control of discrete event systems using petrinets, PHI, 2002

9. James L Peterson, Petrinet theory and modeling of system, 1981

EE6421: Advanced Microcontroller Based Systems

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours: 42 Hrs

Module 1: (10 Hours)

Basic Computer Organization - Accumulator Based Processors - Architecture - Memory Organizations - I/O Organizations - Assembly Language Programming - Addressing - Operations - Stack and Subroutines . Interrupts - DMA - Stages of Microprocessor based Program Development.

Module 2: (12 Hours)

Introduction to Microcontrollers - Motorola 68HC11 - Intel 8051 - Intel 8096 - Registers - Memories - I/O Ports - Serial Communications - Timers - Interrupts

Module 3: (10 Hours)

PIC 16F877- Architecture - Memory Interfacing - Interfacing I/O devices - Instruction Set - Serial I/O and Data Communication. Digital Signal Processor (DSP) - Architecture – Programming. Introduction to FPGA.

Module 4: (10 Hours)

Instructions in Microcontrollers - Interfaces - Introduction to Development of a Microcontroller Based System - Concept of a Programmable Logic Controller (PLC) - Features and Parts in a PLC unit.

References

1. John.F.Wakerly: Microcomputer Architecture and Programming, John Wiley and Sons 1981

2. Ramesh S.Gaonker: Microprocessor Architecture, Programming and Applications with the 8085, Penram International Publishing (India), 1994

3. Raj Kamal: The Concepts and Features of Microcontrollers, Wheeler Publishing, 2005

4. Kenneth J. Ayala, The 8051 microcontroller, Cengage Learning, 2004

5. John Morton, The PIC microcontroller: your personal introductory course, Elsevier, 2005

6. Dogan Ibrahim, Advanced PIC microcontroller projects in C: from USB to RTOS with the PIC18F Series, Elsevier, 2008

7. Micro chip datasheets for PIC16F877

EE6422: Engineering Optimization

Pre-requisite: Nil

L	T	P	C
3	0	0	3

Total hours: 42 Hrs

Module 1: (11 hours)

Concepts of optimization: Engineering applications-Statement of optimization problem-Classification - type and size of the problem.

Classical Optimization Techniques: Single and multi variable problems-Types of Constraints .Semi definite case-saddle point.

Linear programming: Standard form- Geometry of LP problems-Theorem of LP-Relation to convexity - formulation of LP problems - simplex method and algorithm -Matrix form- two phase method.

Duality- dual simplex method- LU Decomposition. Sensitivity analysis .Artificial variables and complementary solutions-QP.

Engineering Applications: Minimum cost flow problem, Network problems -transportation, assignment & allocation, scheduling . Karmarkar method-unbalanced and routing problems.

Module 2: (11 hours)

Nonlinear programming: Non linearity concepts-convex and concave functions- non-linear programming - gradient and Hessian.

Unconstrained optimization: First & Second order necessary conditions-Minimisation & Maximisation-Local & Global convergence-Speed of convergence.

Basic decent methods: Fibonacci & Golden section search - Gradient methods - Newton Method-Lagrange multiplier method - Kuhn-tucker conditions . Quasi-Newton method- separable convex programming -

Frank and Wolfe method, Engineering Applications.

Module 3: (10 hours)

Nonlinear programming- Constrained optimization: Characteristics of constraints-Direct methods-SLP,SQP-Indirect methods-Transformation techniques-penalty function-Langrange multiplier methods-checking convergence- Engineering applications

Module 4: (10 hours)

Dynamic programming: Multistage decision process- Concept of sub optimization and principle of optimality- Computational procedure- Engineering applications.

Genetic algorithms- Simulated Annealing Methods-Optimization programming, tools and Software packages.

References

1. David G Luenberger, .Linear and Non Linear Programming., 2nd Ed, Addison-Wesley Pub.Co.,Massachusetts, 2003

2. W.L.Winston, .Operation Research-Applications & Algorithms.,2nd Ed., PWS-KENT Pub.Co.,Boston, 2007

3. S.S.Rao, .Engineering Optimization., 3rd Ed.,New Age International (P) Ltd,New Delhi, 2007

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7. Bazarra M.S., Sherali H.D. & Shetty C.M., .Nonlinear Programming Theory and Algorithms., John Wiley,New York,1979.

8 A. Ravindran, K. M. Ragsdell, G. V. Reklaitis, Engineering Optimization: Methods And Applications, Wiley, 2008

9 Godfrey C. Onwubolu, B. V. Babu, New optimization techniques in engineering, Springer, 2004

10.Kalyanmoy Deb,.Optimisation for Engineering Design-Algorithms and Examples., Prentice Hall India-1998

EE6423: Industrial Communication

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours: 42 Hrs

Module 1: (10 hrs)

Characteristics of Communication Networks- Traffic characterisation and Services- Circuit Switched and Packet Switched Networks- Virtual circuit Switched networks- OSI Model- Protocol Layers and Services-The physical layer-Theoretical basis for data communication- signalling and modulation-multiplexing-Transmission media-Physical interface and protocols

Module 2: (10 hrs)

The transport layer- Connectionless transport-UDP –TCP- Congestion control - Network layer series and routing- internet protocol (IP) - Network layer addressing- hierarchical addresses-address resolution-services- Datagram- virtual circuits- routing algorithm (Bellman Ford,Dijkstra)

Module 3: (10 hrs)

Direct link Networks: Framing; Error detection; Reliable transmission; Multiple access protocols; Concept of LAN- Ethernet LAN – Ethernet frame structure-Ethernet (IEEE 802.3); Token Rings (IEEE 802.5 & FDDI); Address Resolution Protocol- IEEE 802.11 LAN's- architecture and media access protocols, hubs, bridges, switches, PPP, ATM, wireless LAN

Module 4: (12 hrs)

Introduction to industrial networks – SCADA networks - Remote Terminal Unit (RTU), Intelligent Electronic Devices (IED) - Communication Network, SCADA Server, SCADA/HMI Systems - single unified standard architecture -IEC 61850 - SCADA Communication: various industrial communication technologies -wired and wireless methods and fiber optics, open standard communication protocols

References

1. Karanjith S.Siyan, .Inside TCP/IP., 3rd edition, Techmedia, 1998

2. Alberto,Leon,Garcia, Indra, and Wadjaja, .Communication networks., Tata Mc Graw Hill,2000

3. James F Kurose.Keith W Ross, .Computer networking A Top down Approach featured internet, Pearson Education, 2003.

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10. Afritech Panel, Industrial communication, Afritech, 2006

11. Michael William Ivens, The practice of industrial communication, Business Publications, 1963

12. Richard Zurawski, The industrial communication technology handbook, CRC Press, 2005

13. Raimond Pigan, Mark Metter, Automating with PROFINET: Industrial Communication Based on Industrial Ethernet, Publicis Publishing 2008

EE6424: Robotic Systems and Applications

L	T	P	C
3	0	0	3

Pre-requisite: Nil

Total hours: 42 Hrs

Module 1: (8 hours)

Mathematics of Spatial Descriptions and Transformations-Robot definition. Robot classification. Robotic system components- Notations- Position definitions- Coordinate frames - Different orientation descriptions - Free vectors- Translations, rotations and relative motion - Homogeneous transformations.

Module 2: (12 hours)

Manipulator Kinematics and Mechanics of Robot Motion-Link coordinate frames- Denavit-Hartenberg convention - Joint and end-effector Cartesian space-Forward kinematics transformations of position-Inverse kinematics of position-Translational and rotational velocities -Velocity Transformations-Manipulator Jacobian -Forward and inverse kinematics of velocity-Singularities of robot motion-Static Forces-Transformations of velocities and static forces -Joint and End Effector force/torque transformations-Derivation for two link planar robot arm as example.

Module 3: (13 hours)

Manipulator Dynamics- Transformations of acceleration- Trajectory Planning- Control-Lagrangian formulation- Model properties - Newton-Euler equations of motion- Derivation for two link planar robot arm as example- Joint space-based motion planning - Cartesian space-based path planning-Independent joint control- Feed-forward control-Inverse dynamics control-Robot controller architectures . Implementation problems.

Module 4: (9 hours)

Robot Sensing and Vision Systems- Sensors-Force and torque sensors-low level vision-high level vision-Robot Programming languages-Introduction to Intelligent Robots-Robots in manufacturing automation.

References

1. Fu, K.S., R.C. Gonzalez, C.S.G. Lee, Robotics: Control, Sensing, Vision & Intelligence, McGrawHill, 1987.

2. Craig, John J., Introduction to Robotics: Mechanics & Control, 2nd Edition, Pearson Education, 1989.

3. Gray J.O., D.G. Caldwell(Ed), Advanced Robotics & Intelligent machines, The Institution of Electrical Engineers, UK, 1996.

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7. Sciavicco, L., B. Siciliano, Modelling & Control of Robot Manipulators, 2nd Edition, Springer Verlag, 2000.

8. Robin R. Murphy, “An introduction to AI Robotics”, MIT Press, 2008

9. Oliver Brock, Jeff Trinkle and Fabio Ramos, “Robotics-Science and Systems” Vol. IV, MIT Press 2009

EE6428: SCADA Systems and Applications

Pre-requisite: Nil

L	T	P	C
3	0	0	3

Total hours: 42 Hrs

Module 1: (10 hours)

Introduction to SCADA**:** Data acquisition systems, Evolution of SCADA, Communication technologies, Monitoring and supervisory functions, SCADA applications in Utility Automation, Industries

Module 2: (11 hours)

SCADA System Components**:** Schemes- Remote Terminal Unit (RTU),Intelligent Electronic Devices (IED),Programmable Logic Controller (PLC), Communication Network, SCADA Server, SCADA/HMI Systems

Module 3: (11 hours)

SCADA Architecture**: V**arious SCADA architectures, advantages and disadvantages of each system - single unified standard architecture -IEC 61850

SCADA Communication**:** various industrial communication technologies -wired and wireless methods and fiber optics. open standard communication protocols

Module 4: (10 hours)

SCADA Applications**:** Utility applications- Transmission and Distribution sector -operations, monitoring, analysis and improvement. Industries - oil, gas and water. Case studies, Implementation, Simulation Exercises

References

1. Stuart A. Boyer: SCADA-Supervisory Control and Data Acquisition, Instrument Society of America Publications,USA,2004

2. Gordon Clarke, Deon Reynders: Practical Modern SCADA Protocols: DNP3, 60870.5 and Related Systems, Newnes Publications, Oxford, UK,2004

3. William T. Shaw, Cybersecurity for SCADA systems, PennWell Books, 2006

4. David Bailey, Edwin Wright, Practical SCADA for industry, Newnes, 2003

5. Michael Wiebe, A guide to utility automation: AMR, SCADA, and IT systems for electric power, PennWell 1999