**AFFILIATED INSTITUTIONS**

**ANNA UNIVERSITY, CHENNAI**

**REGULATIONS – 2013**

**M.E CONTROL AND INSTRUMENTATION ENGINEERING**

**I TO IV SEMESTERS (FULL TIME) CURRICULUM AND SYLLABUS**

## SEMESTER I

| SL.NO. | CODE | COURSE TITLE | L | T | P | C |
|---|---|---|---|---|---|---|
| **THEORY** | | | | | | |
| 1. | MA7163 | Applied Mathematics for Electrical Engineers | 3 | 1 | 0 | 4 |
| 2. | CL7101 | Control System Design | 3 | 1 | 0 | 4 |
| 3. | CL7102 | Transducers and Measurements | 3 | 1 | 0 | 4 |
| 4. | CL7103 | System Theory | 3 | 0 | 0 | 3 |
| 5. | ET7102 | Microcontroller Based System Design | 3 | 0 | 0 | 3 |
| 6. | | Elective I | 3 | 0 | 0 | 3 |
| | | **TOTAL** | **18** | **3** | **0** | **21** |

## SEMESTER – II

| SL.NO | CODE | COURSE TITLE | L | T | P | C |
|---|---|---|---|---|---|---|
| **THEORY** | | | | | | |
| 1. | CL7201 | Process Dynamics and Control | 3 | 0 | 0 | 3 |
| 2. | CL7202 | Industrial Automation | 3 | 0 | 0 | 3 |
| 3. | CL7203 | Non-Linear Control | 3 | 0 | 0 | 3 |
| 4. | CL7204 | Soft Computing Techniques | 3 | 0 | 0 | 3 |
| 5. | | Elective II | 3 | 0 | 0 | 3 |
| 6. | | Elective III | 3 | 0 | 0 | 3 |
| **PRACTICAL** | | | | | | |
| 7. | CL7211 | Digital Control and Instrumentation Laboratory | 0 | 0 | 3 | 2 |
| | | **TOTAL** | **18** | **0** | **3** | **20** |

## SEMESTER – III

| SL.NO | CODE | COURSE TITLE | L | T | P | C |
|---|---|---|---|---|---|---|
| **THEORY** | | | | | | |
| 1. | | Elective IV | 3 | 0 | 0 | 3 |
| 2. | | Elective V | 3 | 0 | 0 | 3 |
| 3. | | Elective VI | 3 | 0 | 0 | 3 |
| **PRACTICAL** | | | | | | |
| 4. | CL7311 | Project Work (Phase I) | 0 | 0 | 12 | 6 |
| | | **TOTAL** | **9** | **0** | **12** | **15** |

## SEMESTER – IV

| SL.NO | CODE | COURSE TITLE | L | T | P | C |
|---|---|---|---|---|---|---|
| **PRACTICAL** | | | | | | |
| 1. | CL7411 | Project Work (Phase II) | 0 | 0 | 24 | 12 |
| | | **TOTAL** | **0** | **0** | **24** | **12** |

**TOTAL NUMBER OF CREDITS 68**

## ELECTIVES FOR M.E CONTROL AND INSTRUMENTATION ENGINEERING

### ELECTIVE I

| SL. NO | COURSE CODE | COURSE TITLE | L | T | P | C |
|---|---|---|---|---|---|---|
| 1. | ET7101 | Advanced Digital System Design | 3 | 0 | 0 | 3 |
| 2. | ET7104 | Design of Embedded Systems | 3 | 0 | 0 | 3 |
| 3. | PX7102 | Analysis of Power Converters | 3 | 0 | 0 | 3 |

### ELECTIVE II & III

| SL. NO | COURSE CODE | COURSE TITLE | L | T | P | C |
|---|---|---|---|---|---|---|
| 4. | PX7203 | Special Electrical Machines | 3 | 0 | 0 | 3 |
| 5. | ET7006 | Advanced Digital Signal Processing | 3 | 0 | 0 | 3 |
| 6. | ET7004 | Programming with VHDL | 3 | 0 | 0 | 3 |
| 7. | PS7001 | Optimization Techniques | 3 | 0 | 0 | 3 |
| 8. | EB7202 | Control of Electric Drives | 3 | 0 | 0 | 3 |
| 9. | CL7001 | Applied Industrial Instrumentation | 3 | 0 | 0 | 3 |

### ELECTIVE IV, V & VI

| SL. NO | COURSE CODE | COURSE TITLE | L | T | P | C |
|---|---|---|---|---|---|---|
| 10. | CL7002 | Robust Control | 3 | 0 | 0 | 3 |
| 11. | CL7003 | Wireless Sensor Networks | 3 | 0 | 0 | 3 |
| 12. | ET7014 | Application of MEMS Technology | 3 | 0 | 0 | 3 |
| 13. | CL7004 | Robotics and Control | 3 | 0 | 0 | 3 |
| 14. | CL7005 | Optimal Control and Filtering | 3 | 0 | 0 | 3 |
| 15. | CL7006 | Advanced Topics in Nonlinear Control | 3 | 0 | 0 | 3 |
| 16. | CL7007 | System Identification and Adaptive Control | 3 | 0 | 0 | 3 |
| 17. | CL7008 | Fault Tolerant Control | 3 | 0 | 0 | 3 |
| 18. | ET7011 | Smart Meter and Smart Grid Communication | 3 | 0 | 0 | 3 |

**MA7163 APPLIED MATHEMATICS FOR ELECTRICAL ENGINEERS** **L T P C**
**3 1 0 4**

**OBJECTIVES:**

- To develop the ability to apply the concepts of Matrix theory and Linear programming in Electrical Engineering problems.
- To achieve an understanding of the basic concepts of one dimensional random variables and apply in electrical engineering problems.
- To familiarize the students in calculus of variations and solve problems using Fourier transforms associated with engineering applications.

**UNIT I MATRIX THEORY (9+3)**

The Cholesky decomposition - Generalized Eigen vectors, Canonical basis - QR factorization - Least squares method - Singular value decomposition.

**UNIT II CALCULUS OF VARIATIONS (9+3)**

Concept of variation and its properties – Euler's equation – Functional dependant on first and higher order derivatives – Functionals dependant on functions of several independent variables – Variational problems with moving boundaries – problems with constraints - Direct methods: Ritz and Kantorovich methods.

**UNIT III ONE DIMENSIONAL RANDOM VARIABLES (9+3)**

Random variables - Probability function – moments – moment generating functions and their properties – Binomial, Poisson, Geometric, Uniform, Exponential, Gamma and Normal distributions – Function of a Random Variable.

**UNIT IV LINEAR PROGRAMMING (9+3)**

Formulation – Graphical solution – Simplex method – Two phase method - Transportation and Assignment Models

**UNIT V FOURIER SERIES (9+3)**

Fourier Trigonometric series: Periodic function as power signals – Convergence of series – Even and odd function: cosine and sine series – Non-periodic function: Extension to other intervals - Power signals: Exponential Fourier series – Parseval's theorem and power spectrum – Eigen value problems and orthogonal functions – Regular Sturm-Liouville systems – Generalized Fourier series.

**L:45 +T: 15 TOTAL: 60 PERIODS**

**REFERENCES:**


1. Richard Bronson, "Matrix Operation", Schaum's outline series, 2nd Edition, McGraw Hill, 2011.
2. Gupta, A.S., Calculus of Variations with Applications, Prentice Hall of India Pvt. Ltd., New Delhi, 1997.
3. Oliver C. Ibe, "Fundamentals of Applied Probability and Random Processes, Academic Press, (An imprint of Elsevier), 2010.
4. Taha, H.A., "Operations Research, An introduction", 10th edition, Pearson education, New Delhi, 2010.
5. Andrews L.C. and Phillips R.L., Mathematical Techniques for Engineers and Scientists, Prentice Hall of India Pvt.Ltd., New Delhi, 2005.
6. Elsgolts, L., Differential Equations and the Calculus of Variations, MIR Publishers, Moscow, 1973.

7. Grewal, B.S., Higher Engineering Mathematics, 42nd edition, Khanna Publishers, 2012.
8. O'Neil, P.V., Advanced Engineering Mathematics, Thomson Asia Pvt. Ltd., Singapore, 2003.
9. Johnson R. A. and Gupta C. B., “Miller & Freund’s Probability and Statistics for Engineers”, Pearson Education, Asia, 7th Edition, 2007.

**CL7101 CONTROL SYSTEM DESIGN LT P C**
**3 1 0 4**

**OBJECTIVES**

- To impart knowledge on performance specification, limitations and structure of controllers
- To impart knowledge on design of controllers using root-locus and frequency domain techniques
- To introduce the techniques of extending the theory on continuous systems to discrete time systems
- To introduce design in discrete state space systems
- To introduce the linear quadratic regulator and estimation in the presence of noise

**UNIT I BASICS AND ROOT-LOCUS DESIGN 9**
Design specifications-sensitivity and stability- Limitations- Controller structure- one and two degrees of freedom- PID controllers and Lag-lead compensators- Root locus design- Design examples

**UNIT II FREQUENCY RESPONSE BASED DESIGN 9**
PID controllers and Lag-lead compensators – Design using Bode plots- use of Nyquist plots and Routh-Hurwitz Criterion-Design examples

**UNIT III DESIGN IN DISCRETE DOMAIN 9**
Sample and Hold devices -Discretisation - Effect of sampling on transfer function – Discrete root locus, Nyquist plots –Jury’s stability test- Direct discrete design -Design examples

**UNIT IV DISCRETE STATE VARIABLE DESIGN 9**
Effect of sampling on Controlability, observability- state and output feedback- observers - estimated state feedback –Design examples

**UNIT V LQR AND LQG DESIGN 9**
Formulation of LQR problem- Pontryagin’s minimum principle and Hamiltonian solutions- Ricatti’s equation – Optimal estimation- Kalman filter –solution to continuous and discrete systems - Design examples.

**L=45, T=15, TOTAL= 60 PERIODS**

**REFERENCES**

1. M. Gopal “Modern control system Theory” New Age International, 2005.
2. Arthur G. O. Mutambara, “Design and Analysis of Control Systems”, CRC Press, Indian reprint 2009.
3. G. F. Franklin, J. D. Powell and A. E. Naeini “Feedback Control of Dynamic Systems”, PHI (Pearson), 2002.
4. Graham C. Goodwin, Stefan F. Graebe and Mario E. Salgado “Control system Design”, PHI (Pearson), 2003.
5. G. F. Franklin, J. D. Powell and M Workman, “Digital Control of Dynamic Systems”, PHI (Pearson), 2002.
6. B.D.O. Anderson and J.B. Moore., ‘Optimal Filtering’, Prentice hall Inc., N.J., 1979.
7. Loan D. Landau, Gianluca Zito,” Digital Control Systems, Design, Identification and Implementation”, Springer, 2006.
8. Benjamin C. Kuo “Digital control systems”, Oxford University Press, 2004.


**CL7102 TRANSDUCERS AND MEASUREMENTS L T P C**
**3 1 0 4**

**OBJECTIVES**

- To introduce the resistive, inductive and capacitive transducers and their transduction principles
- To educate on magnetic transducer elements
- Study of acoustic, mechanical and flow metering elements , their working principle
- To introduce various optical sensors, their transduction principles and their applications
- To introduce various advanced and miniature sensors and their applications

**UNIT I RESISTIVE, INDUCTIVE AND CAPACITIVE ELEMENTS 9**

Potentiometric, strain-gage and electrode elements – Inductive and Capacitive elements: structures, equivalent circuits and characteristics, single, differential and angle displacement elements, displacement to phase converters, and proximity elements, magnetostrictive elements, temperature instabilities and features.

**UNIT II TRANSFORMER, ELECTRODYNAMIC, SERVO AND RESONANT ELEMENTS 9**

Transformer elements: Single core, differential, rotating coil and synchro transformers, weak-field sensors - Electrodynamic elements: Moving-coil, variable-reluctance- - Resonant elements: vibrating strings, vibrating beams, vibrating cylinders, piezoelectric resonators, acoustical resonators, microwave cavity resonators.

**UNIT III MECHANICAL, ACOUSTICAL AND FLOWMETERING ELEMENTS 9**

Stresses state of diaphragm, dynamic characteristics of diaphragm, temperature drifts, sensitivity drifts, sensitivity to acceleration – Inertial mass elements: sensing and transduction elements of flowmeters, electromagnetic flowmeters, nanoelectrode electromagnetic flowmeters -ultrasonic elements – Acoustical elements: acoustical filters.

**UNIT IV OPTICAL MICROSTRUCTURE SENSORS 9**

Photo detectors: Thermal detectors, pneumatic detectors, pyroelectric detectors, photoemissive devices, photo conductive detectors, photo diodes, avalanche photo diodes, schottky photo diodes, photo transistors – Fiber optic sensors: Fibers as light guides, reflection sensors, Intrinsic multimode sensor, temperature sensor, phase modulated sensor, fiber optic gyroscopes and other fiber sensors

**UNIT V MISCELLANEOUS MINIATURE SENSORS 9**

Magnetic sensors: Hall Effect sensors, magnetoresistors and other sensors – Solid state chemical sensors: Silicon based sensors, metal oxide sensors, solid electrolyte sensors, membranes – Electromechanical micro sensors and basic factors of design

**L=45, T=15 TOTAL : 60 PERIODS**

**REFERENCES:**


1. Alexander D Khazan, "Transducers and their elements – Design and application", PTR Prentice Hall, 1994.
2. Pavel Ripka and Alois Tipek,"Modern sensors hand book", Instrumentation and measurement series, ISTE Ltd., 2007.
3. David Fraden. , PHI, 2004 " Hand book of Modern Sensors, Physics,Design and Applications", Third Edition, Springer India Pvt.Ltd, 2006.


**CL7103 SYSTEM THEORY L T P C**
**3 0 0 3**

**OBJECTIVES**

- To educate on modeling and representing systems in state variable form
- To educate on solving linear and non-linear state equations
- To illustrate the role of controllability and observability
- To educate on stability analysis of systems usig Lyapunov's theory
- To educate on modal concepts and design of state and output feedback controllers and estimators

**UNIT I STATE VARIABLE REPRESENTATION 9**

Introduction-Concept of State-State equation for Dynamic Systems -Time invariance and linearity- Non uniqueness of state model-State Diagrams - Physical System and State Assignment.

**UNIT II SOLUTION OF STATE EQUATIONS 9**

Existence and uniqueness of solutions to Continuous-time state equations-Solution of Nonlinear and Linear Time Varying State equations-Evaluation of matrix exponential-System modes- Role of Eigenvalues and Eigenvectors.

**UNIT III CONTROLLABILITY AND OBSERVABILITY 9**

Controllability and Observability-Stabilizability and Detectability-Test for Continuous time Systems- Time varying and Time invariant case-Output Controllability-Reducibility-System Realizations.

**UNIT IV STABILTY 9**

Introduction-Equilibrium Points-Stability in the sense of Lyapunov-BIBO Stability-Stability of LTI Systems-Equilibrium Stability of Nonlinear Continuous Time Autonomous Systems-The Direct Method of Lyapunov and the Linear Continuous-Time Autonomous Systems-Finding Lyapunov Functions for Nonlinear Continuous Time Autonomous Systems-Krasovskii and Variable-Gradiant Method.

**UNIT V MODAL CONTROL 9**

Introduction-Controllable and Observable Companion Forms-SISO and MIMO Systems-The Effect of State Feedback on Controllability and Observability-Pole Placement by State Feedback for both SISO and MIMO Systems-Full Order and Reduced Order Observers.

**TOTAL : 45 PERIODS**

**REFERENCES:**


1. M. Gopal, "Modern Control System Theory", New Age International, 2005.
2. K. Ogatta, "Modern Control Engineering", PHI, 2002.
3. John S. Bay, "Fundamentals of Linear State Space Systems", McGraw-Hill, 1999.
4. D. Roy Choudhury, "Modern Control Systems", New Age International, 2005.
5. John J. D'Azzo, C. H. Houpis and S. N. Sheldon, "Linear Control System Analysis and Design with MATLAB", Taylor Francis, 2003.
6. Z. Bubnicki, "Modern Control Theory", Springer, 2005.


**ET7102 MICROCONTROLLER BASED SYSTEM DESIGN LT P C**
**3 0 0 3**

**OBJECTIVES**

- To expose the students to the fundamentals of microcontroller based system design.
- To teach I/O and RTOS role on microcontroller.
- To impart knowledge on PIC Microcontroller based system design.
- To introduce Microchip PIC 8 bit peripheral system Design
- To give case study experiences for microcontroller based applications.

**UNIT I 8051 ARCHITECTURE 9**

Architecture – memory organization – addressing modes – instruction set – Timers - Interrupts - I/O ports, Interfacing I/O Devices – Serial Communication.

**UNIT II 8051 PROGRAMMING 9**

Assembly language programming – Arithmetic Instructions – Logical Instructions –Single bit Instructions – Timer Counter Programming – Serial Communication Programming Interrupt Programming – RTOS for 8051 – RTOSLite – FullRTOS – Task creation and run – LCD digital clock/thermometer using FullRTOS.

**UNIT III PIC MICROCONTROLLER 9**

Architecture – memory organization – addressing modes – instruction set – PIC progrmming in Assembly & C –I/O port, Data Conversion, RAM & ROM Allocation, Timer programming, MP-LAB.

**UNIT IV PERIPHERAL OF PIC MICROCONTROLLER 9**

Timers – Interrupts, I/O ports- I2C bus-A/D converter-UART- CCP modules -ADC, DAC and Sensor Interfacing –Flash and EEPROM memories.

**UNIT V SYSTEM DESIGN – CASE STUDY 9**

Interfacing LCD Display – Keypad Interfacing - Generation of Gate signals for converters and Inverters - Motor Control – Controlling DC/ AC appliances – Measurement of frequency - Stand alone Data Acquisition System.

**TOTAL : 45 PERIODS**

**REFERENCES:**

1. Muhammad Ali Mazidi, Rolin D. Mckinlay, Danny Causey ‘ PIC Microcontroller and Embedded Systems using Assembly and C for PIC18’, Pearson Education 2008
2. John Iovine, ‘PIC Microcontroller Project Book ’, McGraw Hill 2000
3. Myke Predko, “Programming and customizing the 8051 microcontroller”, Tata McGraw Hill 2001.
4. Muhammad Ali Mazidi, Janice G. Mazidi and Rolin D. McKinlay, ‘The 8051 Microcontroller and Embedded Systems’ Prentice Hall, 2005.
5. Rajkamal,”.Microcontrollers-Architecture,Programming,Interfacing & System Design”,2ed,Pearson,2012.
6. I Scott Mackenzie and Raphael C.W. Phan, “The Micro controller”, Pearson, Fourth edition 2012

**CL7201 PROCESS DYNAMICS AND CONTROL** **L T P C**
**3 0 0 3**

**OBJECTIVES**

- To give an overview of the features associated with Industrial Type PID Controller such as reset windup, bumpless auto-manual transfer, proportional kick and derivative kick.
- To make the students understand the various PID tuning methods
- To elaborate different types of control schemes such as cascade control, feed-forward control etc.
- To educate on multivariable systems and multi-loop control
- To educate on various industrial processes

**UNIT I PROCESS DYNAMICS & CONTROL ACTIONS** **9**

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

**UNIT II PID CONTROLLER TUNING – SINGLE LOOP REGULATORY CONTROL** **9**

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

**UNIT III ENHANCEMENT TO SINGLE LOOP REGULATORY CONTROL & MODEL BASED CONTROL SCHEMES** **9**

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

**UNIT IV MULTIVARIABLE SYSTEMS & MULTI-LOOP REGULATORY CONTROL** **9**

Multivariable Systems – Transfer Matrix Representation – Poles and Zeros of MIMO System -Multi-loop Control - Introduction – Process Interaction – Pairing of Inputs and Outputs -The Relative Gain Array (RGA) – Properties and Application of RGA - Multi-loop PID Controller - Decoupling Control

**UNIT V CASE –STUDIES** **9**

Introduction to Multivariable control – Multivariable PID Controller –Predictive PID Control - Control Schemes for Distillation Column, CSTR, Four-tank system and pH .

**TOTAL 45 PERIODS**

**REFERENCES**


1. B.Wayne Bequette, “Process Control: Modeling, Design, and Simulation”, Prentice Hall of India, 2004.
2. George Stephanopolus, "Chemical Process Control", Prentice Hall India, 2006.
3. Dale E. Seborg , Duncan A. Mellichamp , Thomas F. Edgar, and Francis J. Doyle, III “Process Dynamics and Control”, John Wiley and Sons, 3rd Edition, 2010.
4. Jose A. Romagnoli and Ahmet Palazoglu , "Introduction to Process Control", CRC Press, Taylor and Francis Group, Second Edition, First Indian Reprint, 2010.
5. Coleman Brosilow and Babu Joseph, "Techniques of Model-based Control", Prentice Hall International Series, PTR, New Jersey, 2001.
6. Pertrezeulla, “Programmable Controllers”, McGraw-Hill, 1989
7. Chidambarm. M, “Computer control of processes”, Narosa Publications, 2002.


| CL7202 | INDUSTRIAL AUTOMATION | L T P C |
|---|---|---|
| | | 3 0 0 3 |

**OBJECTIVES**

- To educate on design of signal conditioning circuits for various applications
- To educate on signal transmission techniques and their design
- Study of components used in data acquisition systems interface techniques
- To educate on the components used in distributed control systems
- To introduce the communication buses namely field bus and profibus.

**UNIT I DESIGN OF SIGNAL CONDITIONING AND TRANSMISSION 9**

Design of V/I Converter and I/V Converter- Analog and Digital filter design and Adaptive filter design – Signal conditioning circuit for pH measurement, Level Measurement –Temperature measurement: Thermocouple, RTD and Thermistor - Cold Junction Compensation and Linearization – software and Hardware approaches **-** Electrical, Pneumatic and fibre optic transmissions-Digital transmission protocols-Study of 2 wire and 4 wire transmitters – Design of RTD based Temperature Transmitter, Thermocouple based Temperature Transmitter, Capacitance based Level Transmitter and Smart Flow Transmitters-smart sensors.

**UNIT II DATA ACQUISITION AND INSTRUMENT INTERFACE 9**

Programming and simulation of Building block of instrument Automation system – Signal analysis, I/O port configuration with instrument bus protocols - ADC, DAC, DIO, counters & timers, PC hardware structure, timing, interrupts, DMA, software and hardware installation, current loop, RS 232/RS485, GPIB, USB protocols,

**UNIT III PLC AND SCADA 9**

Evolution of PLC – Sequential and Programmable controllers – Architecture – Programming of PLC – Relay logic and Ladder logic – Functional blocks – Communication Networks for PLC. PLC based control of processes – Computer control of liquid level system – heat exchanger – Smart sensors and Field bus.
SCADA:- Remote terminal units, Master station, Communication architectures and Open SCADA protocols.

**UNIT IV DISTRIBUTED CONTROL SYSTEM 9**

Evolution - Different architectures - Local control unit - Operator Interface – Displays - Engineering interface- Study of any one DCS available in market - Factors to be considered in selecting DCS.

**UNIT V COMMUNICATION PROTOCOLS 9**

Introduction- Evolution of signal standard – HART communication protocol – Communication modes – HART Networks – HART commands –HART and OSI models-HART applications Fieldbus:- Introduction, General Fieldbus architecture, Basic requirements of Fieldbus standard, Fieldbus topology, Interoperability and Interchangeability Profibus:- Introduction, Profibus protocol stack, Profibus communication model, Communication objects, System operation and Troubleshooting – Foundation fieldbus versus Profibus.

**TOTAL=45 PERIODS**

**REFERENCES**


1. Alan s morris “measurement and instrumentation principles”, elsevier , 2006
2. C.j.chesmond, p.a.wilson & m.r.le pla “advanced control system technology” , viva books private limited, 1998
3. Patrick h.garrett “high performance instrumentation and automation” crc press, taylor & francis group, 2005


**CL7203 NON-LINEAR CONTROL L T P C**
**3 0 0 3**

**Program Objectives**

- To impart knowledge on phase plane analysis of non-linear systems.
- To impart knowledge on Describing function based approach to non-linear systems.
- To educate on stability analysis of systems using Lyapunov’s theory.
- To educate on stability analysis of systems using Lyapunov’s theory.
- To introduce the concept of sliding mode control.

**UNIT I PHASE PLANE ANALYSIS 9**

Concepts of phase plane analysis- Phase portraits- singular points- Symmetry in phase plane portraits-Constructing Phase Portraits- Phase plane Analysis of Linear and Nonlinear Systems-. simulation of phase portraits in matlab

**UNIT II DESCRIBING FUNCTION 9**

Describing Function Fundamentals-Definitions-Assumptions-Computing Describing Functions-Common Nonlinearities and its Describing Functions-Nyquist Criterion and its Extension-Existence of Limit Cycles-Stability of limit Cycles. simulation of limit cycles in matlab

**UNIT III LYAPUNOV THEORY 9**

Nonlinear Systems and Equilibrium Points-Concepts of Stability-Linearization and Local Stability-Lyapunov’s Direct Method-Positive definite Functions and Lyapunov Functions-Equilibrium Point Theorems-Invariant Set Theorems-LTI System Analysis based on

Lyapunov's Direct Method-Krasovski's Method-Variable Gradient Method-Physically – Control Design based on Lyapunov's Direct Method.

**UNIT IV FEEDBACK LINEARIZATION 9**

Feedback Linearization and the Canonical Form-Mathematical Tools-Input-State Linearization of SISO Systems- input-Output Linearization of SISO Systems-Generating a Linear Input-Output Relation-Normal Forms-The Zero-Dynamics-Stabilization and Tracking-Inverse Dynamics and Non-Minimum-Phase Systems-Feedback Linearization of MIMO Systems Zero-Dynamics and Control Design. Simulation of tracking problems in matlab

**UNIT V SLIDING MODE CONTROL 9**

Sliding Surfaces- Continuous approximations of Switching Control laws-The Modeling/Performance Trade-Offs- MIMO Systems. simulation of sliding mode controller in matlab

**TOTAL :45 PERIODS**

**REFERENCES**


1. J A E Slotine and W Li, Applied Nonlinear control, PHI, 1991.
2. Hasan Khalil, "Nonlinear systems and control", Prentice Hall.
3. S H Zak, "Systems and control", Oxford University Press, 2003.
4. Torkel Glad and Lennart Ljung, "Control Theory – Multivariable and Nonlinear Methods", Taylor & Francis, 2002.
5. G. J. Thaler, "Automatic control systems", Jaico publishers, 1993.
6. Felix L. Chernousko, Igor M.Ananievski, Sergey A.Reshmin, "Control of Nonlinear Dynamical Systems Methods and Applications, Springer, First Indian Reprint 2013.

**CL7204 SOFT COMPUTING TECHNIQUES** **L T P C**
**3 0 0 3**

## OBJECTIVES

- To expose the concepts of feed forward neural networks.
- To provide adequate knowledge about feed back neural networks.
- To teach about the concept of fuzziness involved in various systems.
- To expose the ideas about genetic algorithm
- To provide adequate knowledge about of FLC and NN toolbox

**UNIT I INTRODUCTION AND ARTIFICIAL NEURAL NETWORKS 9**

Introduction of soft computing - soft computing vs. hard computing- various types of soft computing techniques- applications of soft computing-Neuron- Nerve structure and synapse- Artificial Neuron and its model- activation functions- Neural network architecture- single layer and multilayer feed forward networks- Mc Culloch Pitts neuron model- perceptron model- Adaline and Madaline- multilayer perception model- back propogation learning methods- effect of learning rule coefficient -back propagation algorithm- factors affecting back propagation training- applications.

**UNIT II ARTIFICIAL NEURAL NETWORKS 9**

Counter propagation network- architecture- functioning & characteristics of counter-Propagation network-Hopfield/ Recurrent network- configuration- stability constraints-associative memory- and characteristics- limitations and applications- Hopfield v/s Boltzman machine- Adaptive Resonance Theory- Architecture- classifications-Implementation and training-Associative Memory.

**UNIT III FUZZY LOGIC SYSTEM 9**

Introduction to crisp sets and fuzzy sets- basic fuzzy set operation and approximate reasoning. Introduction to fuzzy logic modeling and control- Fuzzification-inferencingand defuzzification-Fuzzy knowledge and rule bases-Fuzzy modeling and control schemes for nonlinear systems. Self organizing fuzzy logic control- Fuzzy logic control for nonlinear time delay system.

**UNIT IV GENETIC ALGORITHM 9**

Basic concept of Genetic algorithm and detail algorithmic steps-adjustment of free Parameters- Solution of typical control problems using genetic algorithm- Concept on some other search techniques like tabu search and ant colony search techniques for solving optimization problems.

**UNIT V APPLICATIONS 9**

GA application to power system optimization problem- Case studies: Identification and control of linear and nonlinear dynamic systems using Matlab-Neural Network toolbox. Stability analysis of Neural Network interconnection systems- Implementation of fuzzy logic controller using Matlab fuzzy logic toolbox-Stability analysis of fuzzy control systems.

**TOTAL : 45 PERIODS**

**REFERENCES**

1. Laurene V. Fausett, Fundamentals of Neural Networks: Architectures, Algorithms And Applications, Pearson Education,
2. Timothy J. Ross, “Fuzzy Logic with Engineering Applications” Wiley India.
3. Zimmermann H.J. "Fuzzy set theory and its Applications" Springer international edition, 2011.
4. David E.Goldberg, “Genetic Algorithms in Search, Optimization, and Machine Learning”, Pearson Education, 2009.
5. W.T.Miller, R.S.Sutton and P.J.Webrose, “Neural Networks for Control”, MIT Press, 1996.


**CL7211 DIGITAL CONTROL AND INSTRUMENTATION LABORATORY** **L T P C 0 0 3 2**

1. Simulation of Converters
2. Simulation of Machines
3. Simulation of Power System
4. Simulation of Process Loop
5. Design of analog and digital interfaces
   (i) Digital input,
   (ii) Analog input,
   (iii) Digital output ,
   (iv) Analog output,
6. Design of analog and digital interfaces
   interrupts,
   timer handling.
7. Design of controllers for linear systems
8. Design of controllers for non linear systems
9. Hardware in loop simulation of system.
   (i) Microcontroller
   (ii) PC based Data acquisition and control
10. Hardware simulation of closed loop control system.

**TOTAL: 45 PERIODS**

**For a Batch of 25 students**
Branch: ME Control & Instrumentation
Course Title: Digital Control & Instrumentation Lab
Faculty: Electrical

| Sl No | Description of Equipment | Quantity required |
|---|---|---|
| 1 | Control system Simulation Software package (e.g. MATLAB/ Labview/ PSIM or other equivalent ) | 25 user license |
| 2 | Computer Pentium IV or better configuration | 25 |
| 3 | Data Acquisition interfaces with PC Analog input/ Analog Output/ Timer/ Digital input-output | Minimum 10 sets |
| 4 | Micro-controller based interface of DAQ with PC | Minimum 5 sets |
| 5 | Closed loop control system set up | Minimum one |

**CL7311 PROJECT WORK (PHASE I)**

| | L | T | P | C |
|---|---|---|---|---|
| | 0 | 0 | 12 | 6 |

**CL7411 PROJECT WORK (PHASE II)**

| | L | T | P | C |
|---|---|---|---|---|
| | 0 | 0 | 24 | 12 |

**ET7101 ADVANCED DIGITAL SYSTEM DESIGN**

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**OBJECTIVES**

- To expose the students to the fundamentals of sequential system design, modelling
- To teach the fundamentals of Asynchronous circuits, switching errors
- To study on Fault identification in digital switching circuits
- To introduce logics for design of Programmable Devices
- To comparatively study the classification of commercial family of Programmable Devices

**UNIT I SEQUENTIAL CIRCUIT DESIGN 9**

Analysis of Clocked Synchronous Sequential Networks (CSSN) Modelling of CSSN – State Stable Assignment and Reduction – Design of CSSN – Design of Iterative Circuits – ASM Chart – ASM Realization.

**UNIT II ASYNCHRONOUS SEQUENTIAL CIRCUIT DESIGN 9**

Analysis of Asynchronous Sequential Circuit (ASC) – Flow Table Reduction – Races in ASC – State Assignment Problem and the Transition Table – Design of ASC – Static and Dynamic Hazards – Essential Hazards – Data Synchronizers – Designing Vending Machine Controller – Mixed Operating Mode Asynchronous Circuits.

**UNIT III FAULT DIAGNOSIS AND TESTABILITY ALGORITHMS 9**

Fault Table Method – Path Sensitization Method – Boolean Difference Method – Kohavi Algorithm – Tolerance Techniques – The Compact Algorithm – Practical PLA's – Fault in PLA – Test Generation – Masking Cycle – DFT Schemes – Built-in Self Test.

**UNIT IV SYNCHRONOUS DESIGN USING PROGRAMMABLE DEVICES 9**

Programming Techniques -Re-Programmable Devices Architecture- Function blocks, I/Oblocks, Interconnects, Realize combinational, Arithmetic, Sequential Circuit with Programmable Array Logic; Architecture and application of Field Programmable Logic Sequence.

**UNIT V ARCHITECTURES AND PROGRAMMING PROGRAMMABLE LOGIC DEVICES 9**

Architecture with EPLD, PEEL – Realization State machine using PLD – FPGA-Aptix Field Programmable Interconnect – Xilinx FPGA – Xilinx 2000 - Xilinx 4000 family.VHDL based Designing with PLD-ROM,PAL,PLA,Sequential PLDs,Case study –Keypad Scanner.

**TOTAL : 45 PERIODS**

**REFERENCES:**


1. Donald G. Givone, "Digital principles and Design", Tata McGraw Hill 2002.
2. Stephen Brown and Zvonk Vranesic, "Fundamentals of Digital Logic with VHDL Deisgn", Tata McGraw Hill, 2002
3. Charles H. Roth Jr., "Digital Systems design using VHDL", Cengage Learning, 2010.
4. Mark Zwolinski, "Digital System Design with VHDL", Pearson Education, 2004
5. Parag K Lala, "Digital System design using PLD", BS Publications, 2003
6. John M Yarbrough, "Digital Logic applications and Design", Thomson Learning,2001
7. Nripendra N Biswas, "Logic Design Theory", Prentice Hall of India, 2001
8. Charles H. Roth Jr., "Fundamentals of Logic design", Thomson Learning, 2004.
9. John V.Oldfeild,Richard C.Dorf,"Field Programmable Gate Arrays",Wiley India Edition,2008


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| **ET7104** | **DESIGN OF EMBEDDED SYSTEMS** | **L T P C** |
| | | **3 0 0 3** |

**OBJECTIVES**

- To provide a clear understanding on the basic concepts, Building Blocks for Embedded System
- To teach the fundamentals of System design with Partioning
- To introduce on Embedded Process development Environment
- To study on Basic tool features for target configuration
- To introduce different EDLC Phases &Testing of embedded system

**UNIT I EMBEDDED DESIGN WITH MICROCONTROLLERS 9**

Product specification – Hardware / Software partitioning – Detailed hardware and software design – Integration – Product testing – Microprocessor Vs Micro Controller – Performance tools – Bench marking – RTOS Micro Controller -issues in selection of processors.

**UNIT II PARTITIONING DECISION 9**

Hardware / Software duality – Hardware-Software portioning- coding for Hardware-software development – ASIC revolution – Managing the Risk – Co-verification – execution environment – memory organization –memory enhancement – Firmware-speed and code density -System startup

**UNIT III FUNCTIONALITIES FOR SYSTEM DESIGN 9**

Timers,Watch dog timers – RAM, Flash Memory basic toolset – Integration of Hardware & Firmware- InSystem Programming, InApplication Programming,,IDE-Target Configuration- Host based debugging – Remote debugging – ROM emulators – Logic analyser

**UNIT IV IN CIRCUIT EMULATORS 9**

Buller proof run control – Real time trace – Hardware break points – Overlay memory – Timing constraints – Usage issues – Triggers.

**UNIT V EMBEDDED DESIGN LIFE CYCLE & TESTING 9**

Objective, Need, different Phases & Modelling of the EDLC.choice of Target Architectures for Embedded Application Development-for Control Dominated-Data Dominated Systems- Software &Hardware Design,PCB Design, Manufacturing & PCB Assembly-Bug tracking – reduction of risks & costs – Performance – Unit testing – Regression testing – Choosing test cases – Functional tests – Coverage tests – Testing embedded software – Performance testing – Maintenance.

**TOTAL : 45 PERIODS**

**REFERENCES**


1. James K.Peckol, “Embedded system Design”,JohnWiley&Sons,2010
2. Elicia White,”Making Embedded Systems”,O’Reilly Series,SPD,2011
3. Rajkamal,”Embedded Systems”,TMH,2009.
4. Lyla B Das,” Embedded Systems-An Integrated Approach”,Pearson2013
5. Arnold S. Berger – “Embedded System Design”, CMP books, USA 2002.
6. ARKIN, R.C., Behaviour-based Robotics, The MIT Press, 1998.


**PX7102 ANALYSIS OF POWER CONVERTERS L T P C**
**3 0 0 3**

**OBJECTIVES :**

- To provide the electrical circuit concepts behind the different working modes of power converters so as to enable deep understanding of their operation.
- To equip with required skills to derive the criteria for the design of power converters starting from basic fundamentals.
- To analyze and comprehend the various operating modes of different configurations of power converters.
- To design different power converters namely AC to DC, DC to DC and AC to AC converters.

**UNIT I SINGLE PHASE AC-DC CONVERTER 9**

Static Characteristics of power diode, SCR and GTO, half controlled and fully controlled converters with R-L, R-L-E loads and free wheeling diodes – continuous and discontinuous modes of operation - inverter operation –Sequence control of converters – performance parameters: harmonics, ripple, distortion, power factor – effect of source impedance and overlap-reactive power and power balance in converter circuits

**UNIT II THREE PHASE AC-DC CONVERTER 9**

Semi and fully controlled converter with R, R-L, R-L-E - loads and free wheeling diodes – inverter operation and its limit – performance parameters – effect of source impedance and over lap – 12 pulse converter.

**UNIT III DC-DC CONVERTERS 9**

Principles of step-down and step-up converters – Analysis of buck, boost, buck-boost and Cuk converters – time ratio and current limit control – Full bridge converter – Resonant and quasi – resonant converters.

**UNIT IV AC VOLTAGE CONTROLLERS 9**

Static Characteristics of TRIAC- Principle of phase control: single phase and three phase controllers – various configurations – analysis with R and R-L loads.

**UNIT V CYCLOCONVERTERS 9**

Principle of operation – Single phase and Three-phase Dual converters - Single phase and three phase cyclo-converters – power factor Control – Introduction to matrix converters.

**TOTAL : 45 PERIODS**

**REFERENCES**


1. Ned Mohan,T.M Undeland and W.P Robbin, "Power Electronics: converters, Application and design" John Wiley and sons.Wiley India edition, 2006.
2. Rashid M.H., "Power Electronics Circuits, Devices and Applications ", Pierson Prentice Hall India, New Delhi, 2004.
3. Cyril W.Lander, "power electronics", Third Edition McGraw hill-1993
4. P.C Sen.," Modern Power Electronics ", Wheeler publishing Co, First Edition, New Delhi-1998.
5. P.S.Bimbra, "Power Electronics", Khanna Publishers, Eleventh Edition, 2003.
6. Power Electronics by Vedam Subramanyam, New Age International publishers, New Delhi Second Edition, 2006


**PX7203 SPECIAL ELECTRICAL MACHINES L T P C**
**3 0 0 3**

**OBJECTIVES**

- To review the fundamental concepts of permanent magnets and the operation of permanent magnet brushless DC motors.
- To introduce the concepts of permanent magnet brushless synchronous motors and synchronous reluctance motors.
- To develop the control methods and operating principles of switched reluctance motors.
- To introduce the concepts of stepper motors and its applications.
- To understand the basic concepts of other special machines.

**UNIT I PERMANENT MAGNET BRUSHLESS DC MOTORS 9**

Fundamentals of Permanent Magnets- Types- Principle of operation- Magnetic circuit analysis-EMF and Torque equations- Characteristics and control

**UNIT II PERMANENT MAGNET SYNCHROUNOUS MOTORS 9**

Principle of operation – EMF and Torque equations - Phasor diagram - Power controllers – Torque speed characteristics – Digital controllers – Constructional features, operating principle and characteristics of synchronous reluctance motor.

**UNIT III SWITCHED RELUCTANCE MOTORS 9**

Constructional features –Principle of operation- Torque prediction–CharacteristicsPower controllers – Control of SRM drive- Sensorless operation of SRM – Applications.

**UNIT IV STEPPER MOTORS 9**

Constructional features –Principle of operation –Types – Torque predictions – Linear and Non-linear analysis – Characteristics – Drive circuits – Closed loop control – Applications.

**UNIT V OTHER SPECIAL MACHINES 9**

Principle of operation and characteristics of Hysteresis motor – AC series motors – Linear motor – Applications.

**TOTAL: 45 PERIODS**

**REFERENCES:**


1. T.J.E. Miller, 'Brushless magnet and Reluctance motor drives', Claredon press, London, 1989.
2. R.Krishnan, ' Switched Reluctance motor drives' , CRC press, 2001.
3. T.Kenjo, ' Stepping motors and their microprocessor controls', Oxford University press, New Delhi, 2000.
4. T.Kenjo and S.Nagamori, 'Permanent magnet and Brushless DC motors', Clarendon press, London, 1988.
5. R.Krishnan, ' Electric motor drives' , Prentice hall of India,2002.
6. D.P.Kothari and I.J.Nagrath, ' Electric machines', Tata Mc Graw hill publishing company, New Delhi, Third Edition, 2004.
7. Irving L.Kosow, "Electric Machinery and Transformers" Pearson Education, Second Edition, 2007.


**ET7006 ADVANCED DIGITAL SIGNAL PROCESSING L T P C**
**3 0 0 3**

**OBJECTIVES**

- To expose the students to the fundamentals of digital signal processing i domain & its application
- To teach the fundamentals of digital signal processing in time-frequency application
- To compare Architectures & features of Programmable DSprocessors
- To discuss on Application development with commercial family of DS Processo
- To design & develop logical functions of DSProcessors with Re-Programma Devices

**UNIT I INTRODUCTION TO DIGITAL SIGNAL PROCESSING 12**

Introduction, A Digital Signal-Processing System, The Sampling Process, Discrete Time Sequences, Discrete Fourier Transform (DFT) and Fast Fourier Transform (FFT), Linear Time-Invariant Systems, Decimation and Interpolation, Digital Filters, FIR Filters, IIR Filters.

**UNIT II WAVELET TRANSFORM 6**

Introduction to continuous wavelet transform- discrete wavelet transform -orthogonal wavelet decomposition- Multiresolution Analysis-Wavelet function-DWT,bases,orthogonal Basis-Scaling function, Wavelet coefficients- ortho normal wavelets and their relationship to filter banks- Digital filtering interpolation (i) Decomposition filters, (ii) reconstruction, the signal- Example MRA- Haar & Daubechies wavelet.

**UNIT III ARCHITECTURES OF COMMERCIAL DIGITAL SIGNAL PROCESSORS 12**

Introduction, catogorisation of DSP Processors, Fixed Point (Blackfin),Floating Point (SHARC),TI TMS 320c6xxx & OMAP processors TMS320C54X & 54xx on Basic Architecture – comparison : of functional variations of Computational building blocks, MAC, Bus Architecture and memory, Data Addressing, Parallelism and pipelining, Parallel I/O interface,Memory Interface, Interrupt, DMA (one example Architecture in each of these case studies).

**UNIT IV INTERFACING I/O PERIPHERALS FOR DSP BASED APPLICATIONS 6**

Introduction, External Bus Interfacing Signals, Memory Interface, Parallel I/O Interface, Programmed I/O, Interrupts and I / O Direct Memory Access (DMA).**-**Introduction, Design of Decimation and Interpolation Filter, FFT Algorithm, PID Controller ,Application for Serial Interfacing, DSP based Power Meter, Position control , CODEC Interface .

**UNIT V VLSI IMPLEMENTATION 9**

Low power Design-need for Low power VLSI chips-Basics of DSP system architecture design using VHDL programming, Mapping of DSP algorithm onto hardware, Realisation of MAC & Filter structure.

**TOTAL : 45 PERIODS**

**REFERENCES**


1. John G. Proaks, Dimitris G. Manolakis, “Digital Signal Processing”, Pearson Education 2002.
2. Avatar Sing, S. Srinivasan, “Digital Signal Processing- Implementation using DSP Microprocessors with Examples from TMS320C54xx”, Thomson India,2004.
3. Lars Wanhammer, “DSP Integrated Circuits”, Academic press, 1999,NewYork.
4. Lyla B Das,” Embedded Systems-An Integrated Approach”,Pearson2013
5. Ashok Ambardar,”Digital Signal Processing: A Modern Introduction”, Thomson India edition, 2007.
6. Raghuveer M.Rao and Ajit S. Bapardikar, Wavelet transforms- Introduction to theory and applications, Pearson Education, 2000.
7. K.P. Soman and K.L. Ramchandran,Insight into WAVELETS from theory to practice, Eastern Economy Edition, 2008
8. Ifeachor E. C., Jervis B. W ,”Digital Signal Processing: A practical approach, Pearson-Education, PHI/ 2002
9. B Venkataramani and M Bhaskar **“**Digital Signal Processors**”**, TMH, 2nd, 2010
10. Peter Pirsch **“**Architectures for Digital Signal Processing”, John Weily, 2007
11. Vinay K.Ingle,John G.Proakis,”DSP-A Matlab Based Approach”,Cengage Learning,2010

12. Taan S.Elali,"Discrete Systems and Digital Signal Processing with Matlab",CRC Press2009.

**ET7004 PROGRAMMING WITH VHDL LT P C**
**3 0 0 3**

**OBJECTIVES**

- To give an insight to the students about the significance of VHDL Programming
- To teach the importance and architectural modelling of programmable logic devices.
- To introduce the construction and design programming
- To teach the basic VLSI design configurations
- To study the Logic synthesis and simulation of digital system with PLD.

**UNIT I VHDL FUNDAMENTALS 9**

Fundamental concepts- Modeling digital system-Domain and levels of modeling-modeling languages-VHDL modeling concepts-Scalar Data types and operations-constants and Variable-Scalar Types- Type Classification-Attributes and scalar types-expression and operators-Sequential statements.

**UNIT II DATA TYPES AND BASIC MODELING CONSTRUCTS 9**

Arrays- unconstrained array types-array operations and referencing- records - Access Types- Abstract Date types- -basic modeling constructs-entity declarations-Architecture bodies-behavioral description-structural descriptions- design Processing, case study: A pipelined Multiplier accumulator.

**UNIT III SUBPROGRAMS , PACKAGES AND FILES 9**

Procedures-Procedure parameters- Concurrent procedure call statements –Functions –Overloading –visibility of Declarations-packages and use clauses- Package declarations-package bodies-use clauses-Predefined aliases-Aliases for Data objects-Aliases for Non-Data items-Files- I/O-Files. Case study: A bit vector arithmetic Package.

**UNIT IV SIGNALS, COMPONENTS, CONFIGURATIONS 9**

Basic Resolved Signals-IEEE std_Logic_1164 resolved subtypes- resolved Signal Parameters - Generic Constants- Parameterizing behavior- Parameterizing structure-components and configurations-Generate Statements-Generating Iterative structure-Conditionally generating structure-Configuration of generate statements-case study: DLX computer Systems.

**UNIT V DESIGN WITH PROGRAMMABLE LOGIC DEVICES 9**

Realization of -Micro controller CPU.- Memories- I/O devices-MAC- Design, synthesis, simulation and testing.

**TOTAL : 45 PERIODS**

**REFERENCES**

1. Peter J.Ashenden, "The Designer's guide to VHDL", Morgan Kaufmann publishers,San Francisco,Second Edition, May 2001.
2. Zainalabedin navabi, "VHDL Analysis ans modeling of Digital Systems", McGraw Hill international Editions, Second Editions, 1998.
3. Charles H Roth, Jr. "Digital system Design using VHDL", Thomson ,2006.

4. Douglas Perry, “VHDL Programming by Example”, Tata McGraw Hill,4th Edition 2002.
5. Navabi.Z., “VHDL Analysis and Modeling of Digital Systems”, McGraw International, 1998.
6. Peter J Ashendem, “The Designers Guide to VHDL”, Harcourt India Pvt Ltd, 2002
7. Skahill. K, “VHDL for Programmable Logic”, Pearson education, 1996.

**PS7001 OPTIMIZATION TECHNIQUES L T P C**
**3 0 0 3**

**OBJECTIVES**

- To introduce the different optimization problems and techniques
- To study the fundamentals of the linear and non-linear programming problem.
- To understand the concept of dynamic programming and genetic algorithm technique

**UNIT I INTRODUCTION 9**

Definition, Classification of optimization problems, Classical Optimization Techniques, Single and Multiple Optimization with and without inequality constraints.

**UNIT II LINEAR PROGRAMMING (LP) 9**

Simplex method of solving LPP, revised simplex method, duality, Constrained optimization, Theorems and procedure, Linear programming, mathematical model, solution technique, duality.

**UNIT III NON LINEAR PROGRAMMING 9**

Steepest descent method, conjugates gradient method, Newton’s Method, Sequential quadratic programming, Penalty function method, augmented Lagrange multiplier method.,

**UNIT IV DYNAMIC PROGRAMMING (DP) 9**

Multistage decision processes, concept of sub-optimization and principle of optimality, Recursive relations, Integer Linear programming, Branch and bound algorithm

**UNIT V GENETIC ALGORITHM 9**

Introduction to genetic Algorithm, working principle, coding of variables, fitness function, GA operators; Similarities and differences between Gas and traditional methods; Unconstrained and constrained optimization using genetic Algorithm, real coded gas, Advanced Gas, global optimization using GA, Applications to power system.

**TOTAL : 45 PERIODS**

**REFERENCES**:

1. Computational methods in Optimization, Polak , Academic Press,1971.
2. Optimization Theory with applications, Pierre D.A., Wiley Publications,1969.
3. Taha, H. A., Operations Research: An Introduction, Seventh Edition, Pearson Education Edition, Asia, New Delhi ,2002.
4. S.S. Rao,”Optimization – Theory and Applications”, Wiley-Eastern Limited, 1984.

5. G.Luenberger," Introduction of Linear and Non-Linear Programming" , Wesley Publishing Company, 2011

**EB7202 CONTROL OF ELECTRIC DRIVES L T P C**
**3 0 0 3**

**OBJECTIVES**

- To introduce the PWM converters and their analysis
- To educate on modeling of dc motor, drives and control techniques
- To educate on dynamic modeling of Induction motor drive
- To educate on the V/f and vector control of Induction motor
- To educate on generation of firing pulses and control algorithms in embedded platforms

**UNIT I POWER ELECTRONIC CONVERTERS FOR DRIVES 9**

Power electronic switches-state space representation of switching converters-Fixed frequency PWM-variable frequency PWM- space vector PWM- Hysteresis current control-dynamic analysis of switching converters-PWM modulator model

**UNIT II CONTROL OF DC DRIVES 9**

Modelling of DC machines-block diagram/transfer function-phase control-1phase/3phase converter fed DC drives- Chopper fed DC drives-four quadrant chopper circuit-closed loop control-speed control-current control-cascade control –constant torque/power operation-comparison of chopper/converter fed drives- techniques-merits/demits

**UNIT III ANALYSIS AND MODELLING OF INDUCTION MOTOR DRIVE 9**

Basics of induction motor drive-classification – equivalent circuit- torque Vs slip characteristics-steady state performance- Dynamic modeling of induction motor, Three phase to two phase transformation-stator, rotor, synchronously rotating reference frame model

**UNIT IV CONTROL OF INDUCTION MOTOR DRIVE 9**

VSI fed induction motor drives- waveforms for 1-phase, 3-phase Non-PWM and PWM VSI fed induction motor drives -principles of V/F control- principle of vector control-direct vector control- space vector modulation- indirect vector control .

**UNIT V EMBEDDED CONTROL OF DRIVES 9**

Generation of firing pulses- generation of PWM pulses using embedded processors-IC control of DC drives- fixed frequency/variable frequency/current control- V/F control using PIC microcontroller- vector control using embedded processors

**TOTAL : 45 PERIODS**

**REFERENCES**

1. R.Krishnan, "Electric Motor Drives, Modeling, Analysis and Control" Prentice Hall of India, 2002.
2. Thyristor control of Electric drives, Vedam Subrahmanyam, Tata McGraw Hill, 1988
3. Ion Boldea & S.A.Nasar "ELECTRIC DRIVES", CRC Press, 2006

4. Simon Ang, Alejandro Oliva "POWER SWITCHING CONVERTERS", CRC Press, 2005
5. Buxbaum, A. Schierau, and K.Staughen, "A design of control systems for DC drives", Springer- Verlag, Berlin,1990.

**CL7001 APPLIED INDUSTRIAL INSTRUMENTATION L T P C**
**3 0 0 3**

**OBJECTIVES**

- To enable students acquire knowledge about the various techniques used for the measurement of primary industrial parameters like flow, level, temperature and pressure.
- To understand the important parameters to be monitored and analyzed in Thermal power Plant
- To get an exposure on the important parameters to be monitored and analyzed in Petrochemical Industry
- To learn about the hazardous zone classification and intrinsic safety techniques to the adapted in industries.
- Learn about other special purpose instruments like Nuclear radiation detection
- techniques, fibre optic sensors, Instrumentation for NDT applications etc

**UNIT I REVIEW OF INDUSTRIAL INSTRUMENTATION 9**
Overview of Measurement of Flow, level, Temperature and Pressure.

**UNIT II MEASUREMENT IN THERMAL POWER PLANT (BOILERS) 9**
Selection and Installation of instruments used for the Measurement of fuel flow, Air flow, Drum level, Steam pressure, Steam temperature – Feed water quality measurement-Flue gas Oxygen Analyzers- Coal Analyzer.

**UNIT III MEASUREMENT IN PETROLEUM REFINERY 9**
Parameters to be measured in petroleum industry:-Flow, Level, Temperature and Pressure measurement in Distillation, Pyrolysis, catalytic cracking and reforming process-Hydrocarbon analyzers-oil in or on water- sulphur in oil Analyzer.

**UNIT IV INSTRUMENTATION FOR INDUSTRIAL SAFETY 9**
Electrical and Intrinsic Safety - Explosion Suppression and Deluge systems -Conservation and emergency vents - Flame, fire and smoke detectors - Leak Detectors - Metal Detectors.

**UNIT V SPECIAL PURPOSE INSTRUMENTATION 9**
Detection of Nuclear Radiation – Corrosion monitoring – Fibre optic sensors-Instrumentation in weather stations – Instrumentation for NDT applications-Image processing Technique for measurements.

**TOTAL : 45 PERIODS**

**REFERENCES**

1. B.G.Liptak, "Instrumentation Engineers Handbook (Process Measurement & Analysis)", Fourth Edition, Chilton Book Co, 2003.
2. K.Krishnaswamy and M.Ponnibala, "Power Plant Instrumentation", PHI Learning Pvt Ltd, 2011.

3. John G Webster, “The Measurement, Instrumentation, and Sensors Handbook”, CRC and IEEE Press, 1999.
4. Håvard Devold, “Oil and Gas Production Handbook - An Introduction to Oil and Gas Production”, ABB ATPA oil and gas, 2006.
5. M.Arumugam, “Optical Fibre Communication and Sensors”, Anuradha Agencies, 2002.
6. Paul E. Mix, “Introduction to Nondestructive Testing”, John Wiley and Sons, 2005.

**CL7002 ROBUST CONTROL L T P C**
**3 0 0 3**

**OBJECTIVES**

- To introduce norms, random spaces and robustness measures
- To educate on H2 optimal control and estimation techniques
- To educate on Hinfinity optimal control techniques
- To educate on the LMI approach of Hinfinity control
- To educate on synthesis techniques for robust controllers and illustrate through case studies

**UNIT I INTRODUCTION 9**

Norms of vectors and Matrices – Norms of Systems – Calculation of operator Norms – vector Random spaces- Specification for feedback systems – Co-prime factorization and Inner functions –structured and unstructured uncertainty- robustness

**UNIT II $H_2$ OPTIMAL CONTROL 9**

Linear Quadratic Controllers – Characterization of $H_2$ optimal controllers – H2 optimal estimation-Kalman Bucy Filter – LQG Controller

**UNIT III H-INFINITY OPTIMAL CONTROL-RICCATI APPROACH 9**

Formulation – Characterization of H-infinity sub-optimal controllers by means of Riccati equations – H-infinity control with full information – Hinfinity estimation

**UNIT IV H-INFINITY OPTIMAL CONTROL- LMI APPROACH 9**

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

**UNIT V SYNTHESIS OF ROBUST CONTROLLERS & CASE STUDIES 9**

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

**TOTAL : 45PERIODS**

**REFERENCES**

1. U. Mackenroth “Robust Control Systems: Theory and Case Studies”, Springer International Edition, 2010.
2. J. B. Burl, “ Linear optimal control H2 and H-infinity methods”, Addison W Wesley, 1998
3. D. Xue, Y.Q. Chen, D. P. Atherton, "Linear Feedback Control Analysis and Design

with MATLAB, Advances In Design and Control", Society for Industrial and Applied Mathematics, 2007.
4. I. R. Petersen, V.A. Ugrinovskii and A. V. Savkin, "Robust Control Design using H-infinity Methods", Springer, 2000.
5. M. J. Grimble, "Robust Industrial Control Systems: Optimal Design Approach for Polynomial Systems", John Wiley and Sons Ltd., Publication, 2006.

**CL7003 WIRELESS SENSOR NETWORKS LT P C**
**3 0 0 3**

**OBJECTIVES**

- To introduce the technologies and applications for the emerging domain of wireless sensor networks,
- To impart knowledge on the design and development of the various layers in the WSN protocol stack
- To elaborate the various issues related to WSN implementations
- To familiarize the students with the hardware and software platforms used in the design of WSN

**COURSE OUTCOMES**

- Ability to analyze WSN with respect to various performance parameters in the protocol stack
- Ability to understand MAC algorithms and Network protocols used for specific WSN applications
- Design and develop a WSN for a given application

**UNIT I INTRODUCTION 9**

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

**UNIT II PHYSICAL LAYER 9**

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

**UNIT II DATA LINK LAYER 9**

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

**UNIT IV NETWORK LAYER 9**

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

**UNIT V CASE STUDIES 9**

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

**TOTAL : 45PERIODS**

**REFERENCES**


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


| **ET7014** | **APPLICATION OF MEMS TECHNOLOGY** | **L T P C** |
|---|---|---|
| | | **3 0 0 3** |

Pre-requisites: Basic Instrumentation ,Material Science,Programming

**OBJECTIVES**

- To teach the students properties of materials ,microstructure and fabrication methods.
- To teach the design and modeling of Electrostatic sensors and actuators.
- To teach the characterizing thermal sensors and actuators through design and modeling
- To teach the fundamentals of piezoelectric sensors and actuators
- To give exposure to different MEMS and NEMS devices.

**UNIT I MEMS:MICRO-FABRICATION, MATERIALS AND ELECTRO-MECHANICAL CONEPTS 9**

Overview of micro fabrication – Silicon and other material based fabrication processes – Concepts: Conductivity of semiconductors-Crystal planes and orientation-stress and strain-flexural beam bending analysis-torsional deflections-Intrinsic stress- resonant frequency and quality factor.

**UNIT II ELECTROSTATIC SENSORS AND ACTUATION 9**

Principle, material, design and fabrication of parallel plate capacitors as electrostatic sensors and actuators-Applications

**UNIT III THERMAL SENSING AND ACTUATION 9**

Principle, material, design and fabrication of thermal couples, thermal bimorph sensors, thermal resistor sensors-Applications.

**UNIT IV PIEZOELECTRIC SENSING AND ACTUATION 9**

Piezoelectric effect-cantilever piezo electric actuator model-properties of piezoelectric materials-Applications.

**UNIT V CASE STUDIES 9**

Piezoresistive sensors, Magnetic actuation, Micro fluidics applications, Medical applications, Optical MEMS.-NEMS Devices

**TOTAL : 45 PERIODS**

**REFERENCES**


1. Chang Liu, “Foundations of MEMS”, Pearson International Edition, 2006.
2. Marc Madou , “Fundamentals of microfabrication”,CRC Press, 1997.
3. Boston , “Micromachined Transducers Sourcebook”,WCB McGraw Hill, 1998.
4. M.H.Bao “Micromechanical transducers :Pressure sensors, accelerometers and gyroscopes”, Elsevier, Newyork, 2000.
5. P. RaiChoudry“ MEMS and MOEMS Technology and Applications”, PHI, 2012.
6. Stephen D. Senturia, “ Microsystem Design”, Springer International Edition, 2011.


**CL7004 ROBOTICS AND CONTROL LT P C**
**3 0 0 3**

**OBJECTIVES**

- To introduce robot terminologies and robotic sensors
- To educate direct and inverse kinematic relations
- To educate on formulation of manipulator Jacobians and introduce path planning techniques
- To educate on robot dynamics
- To introduce robot control techniques

**UNIT I INTRODUCTION AND TERMINOLOGIES 9**

Definition-Classification-History- Robots components-Degrees of freedom-Robot joints-coordinates- Reference frames-workspace-Robot languages-actuators-sensors-Position, velocity and acceleration sensors-Torque sensors-tactile and touch sensors-proximity and range sensors- vision system-social issues

**UNIT II KINEMATICS 9**

Mechanism-matrix representation-homogenous transformation-DH representation-Inverse kinematics-solution and programming-degeneracy and dexterity

**UNIT III DIFFERENTIAL MOTION AND PATH PLANNING 9**

Jacobian-differential motion of frames-Interpretation-calculation of Jacobian-Inverse Jacobian- Robot Path planning

**UNIT IV DYNAMIC MODELLING** 9

Lagrangian mechanics- Two-DOF manipulator- Lagrange-Euler formulation – Newton-Euler formulation – Inverse dynamics

**UNIT V ROBOT CONTROL SYSTEM 9**

Linear contol schemes- joint actuators- decentalised PID control- computed torque control – force control- hybrid position force control- Impedance/ Torque control

**TOTAL : 45 PERIODS**

**REFERENCES**


1. R.K. Mittal and I J Nagrath, " Robotics and Control", Tata MacGrawHill, Fourth Reprint 2003.
2. Saeed B. Niku ,"Introduction to Robotics ", Pearson Education, 2002
3. Fu, Gonzalez and Lee Mcgrahill ,"Robotics ", international
4. R.D. Klafter, TA Chmielewski and Michael Negin, "Robotic Engineering, An Integrated approach", Prentice Hall of India, 2003.
5. Reza N.Jazar, Theory of Applied Robotics Kinematics, Dynamics and Control, Springer, Fist Indian Reprint 2010.


**CL7005 OPTIMAL CONTROL AND FILTERING L T P C**
**3 0 0 3**

**OBJECTIVES**

- To educate on formulation of optimal control problems and introduce the minimum principle
- To educate on Linear Quadratic tracking problems- in continuous and discrete domain
- To introduce the numerical techniques used for solving optimal control problems
- To educate on the concepts of filtering in the presence of noise
- To educate on the theory and design of Kalman filter

**UNIT I INTRODUCTION 9**

Statement of optimal control problem – Problem formulation and forms of optimal Control – Selection of performance measures. Necessary conditions for optimal control – Pontryagin's minimum principle – State inequality constraints – Minimum time problem.

**UNIT II LINEAR QUADRATIC TRACKING PROBLEMS 9**

Linear tracking problem – LQG problem – Computational procedure for solving optimal control problems – Characteristics of dynamic programming solution – Dynamic programming application to discrete and continuous systems – Hamilton Jacobi Bellman equation.

**UNIT III NUMERICAL TECHNIQUES FOR OPTIMAL CONTROL 9**

Numerical solution of 2-point boundary value problem by steepest descent and Fletcher Powell method solution of Ricatti equation by negative exponential and interactive Methods

**UNIT IV FILTERING AND ESTIMATION 9**

Filtering – Linear system and estimation – System noise smoothing and prediction – Gauss Markov discrete time model – Estimation criteria – Minimum variance estimation

– Least square estimation – Recursive estimation.

**UNIT V KALMAN FILTER AND PROPERTIES 9**

Filter problem and properties – Linear estimator property of Kalman Filter – Time invariance and asymptotic stability of filters – Time filtered estimates and signal to noise ratio improvement – Extended Kalman filter.

**TOTAL : 45 PERIODS**

**REFERENCES**:

1. KiRk D.E., 'Optimal Control Theory – An introduction', Prentice hall, N.J., 1970.
2. Sage, A.P., 'Optimum System Control', Prentice Hall N.H., 1968.
3. Anderson, BD.O. and Moore J.B., 'Optimal Filtering', Prentice hall Inc., N.J., 1979.
4. S.M. Bozic, "Digital and Kalman Filtering", Edward Arnould, London, 1979.
5. Astrom, K.J., "Introduction to Stochastic Control Theory", Academic Press, Inc, N.Y., 1970.
6. Alok Sinha, Linear Systems Optimal and Robust Control, CRC Press, First Indian Reprint,2009.

**CL7006 ADVANCED TOPICS IN NONLINEAR CONTROL L T P C**
**3 0 0 3**

**OBJECTIVES**

- To educate on the theory of perturbation
- To educate on stability analysis and theory of singular perturbation
- To educate on gain scheduling and feedback linearization techniques
- To educate on the concepts input-output stability and passivity
- To educate on the theory and design of back stepping controllers

**UNIT I PERTURBATION THEORY` 9**

Vanishing and Non vanishing Perturbations – Continuity of solutions on the infinite interval – Interconnected systems – Slowly varying systems – Perturbation method – Averaging - Weakly nonlinear second-order oscillators – Exercises

**UNIT II SINGULAR PERTURBATIONS 9**

Standard singular perturbation model – Time scale properties – Singular perturbation on the infinite interval – Slow and fast manifolds – stability analysis – exercises

**UNIT III GAIN SCHEDULING AND FEEDBACK LINEARIZATION 9**

Control problem – stabilization via linearization – integral control via linearization – gain scheduling – Input output linearization – Full state linearization – state feedback control – tracking- exercises

**UNIT IV INPUT-OUTPUT STABILITY 9**

L stability – L stability of state models – $L_2$ gain – feedback system: small gain theorem – exercises – Passivity – State models - $L_2$ and Lyapunov stability

**UNIT V BAKSTEPPING CONTROL ALGORITHMS 9**

Passivity based control – High gain observers – stabilization – Regulation via integral control - exercises

**TOTAL : 45 PERIODS**

**REFERENCES**


1. Hasan Khalil," Nonlinear systems and control", 3rd ed, PHI,
2. Slotine, J A E Slotine and W Li, "Applied Nonlinear control",1991, PHI
3. S.H. Zak," Systems and control", Oxford University Press


**CL7007 SYSTEM IDENTIFICATION AND ADAPTIVE CONTROL L T P C**
**3 0 0 3**

**OBJECTIVES**

- To introduce various model structures for system identification
- To impart knowledge on parametric and non-parametric identification
- To introduce non-linear identification techniques
- To introduce the concept of adaptation techniques and control

  To illustrate the identification and adaptive control techniques through case studies

**UNIT I MODELS FOR INDENTIFICATION 9**

Models of LTI systems: Linear Models-State space Models-OE model- Model sets, Structures and Identifiability-Models for Time-varying and Non-linear systems: Models with Nonlinearities – Non-linear state-space models-Black box models, Fuzzy models'.

**UNIT II NON-PARAMETRIC AND PARAMETRIC IDENTIFICATON 9**

Transient response and Correlation Analysis – Frequency response analysis – Spectral Analysis – Least Square – Recursive Least Square –Forgetting factor- Maximum Likelihood – Instrumental Variable methods.

**UNIT III NON-LINEAR IDENTIFICATION 9**

Open and closed loop identification: Approaches – Direct and indirect identification – Joint input-output identification – Non-linear system identification – Wiener models – Power series expansions - State estimation techniques – Non linear identification using Neural Network and Fuzzy Logic.

**UNIT IV ADAPTIVE COTROL AND ADAPTATION TECHNIQUES 9**

Introduction – Uses – Auto tuning – Self Tuning Regulators (STR) – Model Reference Adaptive Control (MRAC) – Types of STR and MRAC – Different approaches to self-tuning regulators – Stochastic Adaptive control – Gain Scheduling.

**UNIT V CASE STUDIES 9**

Inverted Pendulum, Robot arm, process control application: heat exchanger, Distillation column, application to power system, Ship steering control.

**TOTAL : 45 PERIODS**

**REFERENCES**

1. Ljung,” System Identification Theory for the User”, PHI, 1987.
2. Torsten Soderstrom, Petre Stoica, “System Identification”, prentice Hall International (UK) Ltd,1989.
3. Astrom and Wittenmark,” Adaptive Control ”, PHI
4. William S. Levine, “ Control Hand Book”. Narendra and Annasamy,” Stable Adaptive Control Systems, Prentice Hall, 1989.

| **CL7008** | **FAULT TOLERANT CONTROL** | **L T P C** |
|---|---|---|
| | | **3 0 0 3** |

**OBJECTIVES**

- To give an overview of different Fault Detection and Diagnosis methods
- To impart knowledge and skills needed to design and detect sensor and actuators faults using structured residual approach as well as directional structured residual approach
- To impart knowledge and skills needed design and detect faults in sensor and actuators using GLR and MLR based Approaches
- To present an overview of various types of fault tolerant control schemes such as Passive and active approaches
- To impart knowledge and skills needed to detect and quantify and compensate stiction in Control valves

**COURSE OUTCOMES**

- Ability to Explain different approaches to Fault Detection and Diagnosis
- Ability to design and detect sensor and actuators faults using structured residual approach as well as directional structured residual approach
- Ability to design and detect faults in sensor and actuators using GLR and MLR based Approaches
- Ability to explain various types of fault tolerant control schemes such as Passive and active approaches
- Ability to Design fault-tolerant control scheme in the presence of actuator failures

  Ability to detect and quantify and compensate stiction in Control valves

**UNIT I INTRODUCTION & ANALYTICAL REDUNDANCY CONCEPTS** 9

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

**UNIT II DESIGN OF STRUCTURED RESIDUALS & DIRECTIONAL STRUCTURED RESIDUALS** **9**

Introduction- Residual structure of single fault Isolation: Structural and Canonical structures- Residual structure of multiple fault Isolation: Diagonal and Full Row canonical concepts – Introduction to parity equation implementation and alternative representation

- Directional Specifications: Directional specification with and without disturbances – Parity Equation Implementation

**UNIT III FAULT DIAGNOSIS USING STATE ESTIMATORS 9**

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

**UNIT IV FAULT TOLERANT CONTROL 9**

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

**UNIT V CASE STUDIES 9**

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

**TOTAL: 45PERIODS**

**REFERENCE BOOKS**


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

**ET7011 SMART METER AND SMART GRID COMMUNICATION** **LT P C**
**3 0 0 3**

**Pre-requisites:** Basics in Instrumentation, Power system and communication

**OBJECTIVES**

- To teach the fundamentals of automated meters and Grids.
- To teach on functional components of Smart meters
- To discuss on need of smart grid for power systems
- To teach the significance of microgrid and its needs
- To teach the communication and protocols for power system

**UNIT I INTRODUCTION** **9**

Introduction to Smart grid and metering technology- Smart energy management technical architecture-Functions of Smart Grid and smart meters, Opportunities and challenges-Difference between conventional and smart grid-meters, Concept of Resilient and Self Healing Grid, recent developments and International policies in Smart Grid. IEC 61850 protocol standards.

**UNIT II SMART METERS** **9**

Smart metering**-**Smart Meters types- hardware architecture- software architecture- requirements- communication protocols- Real Time Prizing, Smart Appliances, Automatic Meter Reading- MEMS, Smart Sensors- Smart actuators- Advanced metering infrastructure- spectrum analyzer.

**UNIT III SMART GRID AND APPLICATIONS** **9**

Outage Management System, Plug in Hybrid Electric Vehicles, Vehicle to Grid, Home and Building Automation- Smart Substations, Substation Automation, Feeder Automation- Geographic Information System(GIS), Intelligent Electronic Devices and their application for monitoring and protection- -Smart city- Wide Area Measurement System, Phase Measurement Unit- Power Quality and EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid, Web based Power Quality monitoring and Power Quality Audit.

**UNIT IV MICROGRIDS** **9**

Concept of microgrid, need and applications of microgrid, formation of microgrid, Issues of interconnection, protection and control of microgrid. Plastic and Organic solar cells, Thin film solar cells, Variable speed wind generators, fuelcells, microturbines, Captive power plants, Integration of renewable energy sources.

**UNIT V INFORMATION AND COMMUNICATION TECHNOLOGY FOR SMART GRID AND METERS** **9**

Home Area Networks for smart grid - IEEE802.15.4- ITU G.hn-IEEE 802.11, Field Area Networks -power-line communications- IEEE P1901 /HomePlug, RF mesh, Wide-area Networks for Smart Grid- Fiber Optics, WiMAX, sensor networks, Information Management in Smart Grid - SCADA, CIM. Networking Issues in Smart Grid -Wireless Mesh Network- CLOUD Computing - Security and Privacy in Smart Grid and smart meters -Broadband over Power line.

**TOTAL: 45PERIODS**

**TEXT BOOKS:**


1. Ali Keyhani, Mohammad N. Marwali, Min Dai “Integration of Green and Renewable Energy in Electric Power Systems”, Wiley
2. Stuart Borlase, “ Smart Grid: infrastructure, technology and Solutions”.2012 CRC Press
3. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, “Smart Grid: Technology and Applications”, Wiley
4. Jean Claude Sabonnadière, Nouredine Hadjsaïd, “Smart Grids”, Wiley Blackwell
5. Peter S. Fox Penner, “Smart Power: Climate Changes, the Smart Grid, and the Future of Electric Utilities”, Island Press; 1 edition 8 Jun 2010
6. S. Chowdhury, S. P. Chowdhury, P. Crossley, “Microgrids and Active Distribution Networks.” Institution of Engineering and Technology, 30 Jun 2009
7. Stuart Borlase, “Smart Grids (Power Engineering)”, CRC Press


**REFERENCES:**


1. Andres Carvallo, John Cooper, “The Advanced Smart Grid: Edge Power Driving Sustainability: 1”, Artech House Publishers July 2011
2. James Northcote, Green, Robert G. Wilson “Control and Automation of Electric Power Distribution Systems (Power Engineering)”, CRC Press
3. Mladen Kezunovic, Mark G. Adamiak, Alexander P. Apostolov, Jeffrey George Gilbert “Substation Automation (Power Electronics and Power Systems)”, Springer
4. R. C. Dugan, Mark F. McGranghan, Surya Santoso, H. Wayne Beaty, “Electrical Power System Quality”, 2nd Edition, McGraw Hill Publication
5. Yang Xiao, “Communication and Networking in Smart Grids”, CRC Press.