I SEMESTER

15UC01 SYSTEMS ENGINEERING MATHEMATICS

2 2 0 3

CALCULUS OF VARIATIONS: Introduction **-** Variational problems of fixed boundaries: Variations and its properties - simplest variational problems – Euler equation – Brachistochrone problem – Variational problems involving several unknown functions – Functional involving first and second order derivatives. (6+6)

VECTOR SPACES: Real vector spaces, subspaces, linear independence – basis and dimension of a vector space – row space, column space and null space - inner product space, orthonormal bases, Gram-Schmidt process. Best approximation: Least squares. (7+7)

LINEAR TRANSFORMATION: Introduction to linear transformations – linear transformations, kernel and range – matrices of linear transformations. (2+2)

STOCHASTIC PROCESSES: Introduction – classification of Stochastic processes. Markov chain: Introduction - transition probability matrices – Chapman Kolmogorov equations - classification of states, limiting probabilities, Poisson process - continuous time Markov chains, Chapman Kolmogorov equations. (6+6)

GRAPH THEORY: Basic concepts**:** Graphs - directed and undirected, subgraphs, graph models, degree of a vertex, degree sequence, Hand-shaking lemma. Walk, trail, path, connectedness, distance, diameter - common classes of graphs, regular, complete, petersen, cycle, path, tree, k-partite, planar, hypercube, mesh - Isomorphic graphs - representation of graphs, adjacency list, incidence list , adjacency matrix and incidence matrix, Spanning trees – Matrix tree theorem (statement only) – Minimum spanning tree using Prim's and Kruskal's algorithms. (6+6)

FINITE ELEMENT METHOD: The Rayleigh-Ritz method, the Collocation and Galerkin method - Finite element method - ordinary differential equations. (3+3)

Total L: 30 + T: 30 = 60

REFERENCES:

1. Elsgolts .L, "Differential Equation and Calculus of Variation", MIR Publication, Moscow, 1977.
2. Howard Anton and Chris Rorres, "Elementary Linear Algebra : Applications Version", Wiley India, New Delhi, 2010.
3. Saeed Ghahramani, "Fundamentals of Probability with Stochastic processes", Pearson, Prentice Hall, New Jersey, 2012.
4. Curtis F, Gerald & Patrick O Wheatly, "Applied Numerical Analysis", Pearson Education, New Delhi, 2011.
5. Narsingh Deo, "Graph Theory with Applications to Engineering and Computer Science", Prentice Hall, New Delhi, 2005.
6. Yellen J and Gross J, "Graph Theory and its Applications", Chapman & Hall, Boca Raton, 2006

15UC02 MEASUREMENT SYSTEMS

3 0 0 3

SCIENCE OF MEASUREMENT: Units and Standards - General concepts and terminology of measurement system - General Input - Output Configuration, Classification of transducers - Static and dynamic characteristics – Calibration techniques –Statistic analysis of measurement data (9)

TRANSDUCERS: Introduction, principle, construction and characteristics of resistive, inductive, capacitive, piezoelectric transducers, seismic instruments and accelerometers, thermocouple, design of signal conditioning circuits for the above transducers. (10)

MICRO AND SMART SENSOR: MEMS sensors and actuators, principle and application. Smart sensor: Introduction, construction, advantages and applications. (8)

SMART FIELDS DEVICES: Introduction to conventional transmitters, types and design - Smart transmitters - primary and secondary sensors - compensation methods. Standards for smart transmitter interface - Handheld communicator, smart valves and positioners. (9)

ELECTRICAL INTERFERENCE AND SAFETY: Effects of noise and interference on measurement circuits, noise sources and coupling mechanisms, methods of reducing effects of noise and interferences. Safety: Introduction, electrical hazards, hazards areas and classification, non hazards areas, enclosures- NEMA types, fuses and circuit breakers. Protection methods – Purging, explosion proofing and intrinsic safety. (9)

Total L:45

REFERENCES:

1. John P Bentley, "Principles of Measurement Systems", Pearson Education, 2009.
2. Doebelin E O, "Measurement Systems - Application and Design", Tata McGraw-Hill, 2010.
3. Srinivasan A V, Michael D and McFarland, "Smart Structures Analysis and Design", Cambridge University Press, 2001.
4. Gondi Ananthasuresh, Vinoy K J, Gopalakrishnan S, Bhat K N and Vasudev Aatre V, "Micro and Smart Systems", Wiley Publishers, 2010.
5. Bela G Liptak, "Instrument Engineers Handbook: Process Measurement and Analysis", CRC Press, 2003.

15UC03 LINEAR SYSTEMS THEORY AND DESIGN

4 0 0 4

MATHEMATICAL DESCRIPTION OF SYSTEM: Causality – Lumpedness – Linearity – Linearization- Concept of state, state variables and state model - State space representation using physical, phase and canonical variables - Comparison of input-output description and state variable description- MIMO systems- Discretization of a continuous time model. (12)

SOLUTION OF STATE EQUATIONS: State transition matrix – Significance – Properties – Computation, impulse response matrix - Simulation of state space model- Solution of discrete time state equation- Solution of linear time variant systems – Discrete time case. Transfer function from state space model- similarity transformation- decomposition of transfer functions: direct, cascade and parallel decomposition techniques. (12)

CONCEPT OF CONTROLLABILITY: Kalman`s and Gilbert`s test – Pole assignment by state feedback using Ackermann's formula – Controllable canonical form and numerically stable method based on controllable Hessenberg form. Kalman Canonical form – Controller design using output feedback – Controllability of Discrete LTI systems – Controllability of linear time variant systems. (12)

CONCEPT OF OBSERVABILITY: Kalman`s and Gilbert`s test- Design of full order observer using Ackermann's formula – Observable canonical form – Observable Hessenberg canonical form – Duality – Observer based controller design – Reduced order observer design – Observability of Discrete LTI Systems – Observability of linear time variant systems (12)

STABILITY: Stability in the sense of Lyapunov, asymptotic stability of linear time invariant continuous and discrete systems – Solution of Lyapunov equation – Disturbance rejection, sensitivity and complementary sensitivity functions, internal stability, stability of linear time variant system. (12)

Total L: 60

REFERENCES:

1. Chen CT, "Linear System Theory and Design", Oxford University Press, 1999.
2. Gopal M, "Modern Control System Theory", New Age International, 2003.
3. Katsuhiko Ogata, "Modern Control Engineering", Prentice Hall of India Pvt. Ltd., 2010.
4. Benjamin C Kuo, "Automatic Control Systems", Prentice Hall of India, 2003.
5. William L Brogan, "Modern Control Theory", Dorling Kindersley (India) Pvt. Ltd., 2011.

15UC04 PRINCIPLES OF FEEDBACK CONTROL

3 0 0 3

INTRODUCTION TO FEEDBACK SYSTEMS: Motivation for Control Engineering. Historical Periods of Control theory- types of control system design- System integration. Principal goal of control- Prototype solution to the control problem via inversion. High gain feedback and inversion- From open to closed loop architectures. Trade-offs Involved in choosing the feedback gain. Measurements- Modeling Errors for Linear Systems- Bounds for modeling errors. Discrete time sensitivity functions. Zeros of sample data systems - Dedicated digital theory- Approximate continuous designs. Fundamental performance limitations. (9)

SISO FEEDBACK CONTROL: Feedback structures. Nominal sensitivity functions. Stability and polynomial analysis. Nominal stability using frequency response- Relative stability: Stability margins and sensitivity peaks. Synthesis of SISO controllers: polynomial approach. PI and PID synthesis revisited using pole assignment. (9)

LIMITATIONS IN SISO FEEDBACK CONTROL: Sensors- actuators- disturbances- model error limitations. Structural limitations- delays, Interpolation constraints, effect of open loop integrators, effect of imaginary axis poles and zeros. Frequency-domain design limitations**:** Bode's integral constraints on sensitivity. Integral constraints on complementary sensitivity. Poisson integral constraint on sensitivity. Poisson integral constraint on complementary sensitivity. (9)

MIMO FEEDBACK CONTROL: Motivational examples. Models for multivariable systems. The basic MIMO control loop- Closed loop stability. Frequency domain analysis. Exploiting SISO techniques in MIMO control: Completely decentralized control. Pairing of inputs and outputs. Converting MIMO problems to SISO problems. (9)

LIMITATIONS IN MIMO CONTROL.: Closed loop transfer function. MIMO Internal Model principle. The cost of the internal model principle- RHP poles and zeros- Time domain constraints- Poisson integral constraints on MIMO complementary sensitivity. Poisson integral constraints on MIMO sensitivity. Non square systems. (9)

Total L:45

REFERENCES:

1. Graham C Goodwin, Stefan F Graebe and Mario E Salgado, "Control System Design", Prentice Hall of India Pvt. Ltd., 2001.
2. Gene F Franklin, David Powell J and Abbas Emami- Naeini, "Feedback Control of Dynamic Systems", Pearson Education, 2004.
3. Mackenroth U, "Robust Control Systems Theory and Case Studies", Springer, 2010.
4. Skogestad S and Postlethwaite I, "Multivariable Feedback Control, Analysis and Design", New York: Wiley, 2005.
5. Maceijowski J M, "Multi Variable Feedback Design", Addision Wesely Pub., 1989.

15UC05 ADVANCED VIRTUAL INSTRUMENTATION

4 0 0 4

INTRODUCTION: Graphical system design model, virtual instrumentation model, design flow with graphical system design, virtual instruments and traditional instruments, graphical programming and textual programming, software environment, data flow programming. (12)

PROGRAMMING TECHNIQUES: Modular programming, repetition and loops, arrays, clusters, plotting data, structures, strings, state machines -file I/O- creating LabVIEW executables and projects, .NET and ActiveX. (12)

INSTRUMENT CONTROL: Virtual Instrumentation Software Architecture (VISA), instrument drivers, serial and parallel interfaces: RS232, USB, firewire, controller area network (CAN), GPIB, Industrial Ethernet. OLE for Process Control (OPC) (12)

DATA ACQUISITION: DAQ hardware configuration, DAQ hardware– Sampling and grounding techniques- analog I/O, digital I/O, counter/timer, DAQ software architecture, network data acquisition. Application design using Real Time Targets: PXI, cRIO. (12)

CONTROL APPLICATIONS: Control design and simulation – system identification, control design, simulation interface, data logging and supervisory control, case studies on machine vision, motion control, GSD applications. (12)

Total L: 60

REFERENCES:

1. Jovitha Jerome, “Virtual Instrumentation using LabVIEW”, PHI Learning Pvt. Ltd, New Delhi, 2010.
2. Steve Mackay, Edwin Wright, John Park and Deon Reynders, “Industrial Data Networks”, Elsevier, 2004.
3. Gary Johnson and Richard Jennings, “LabVIEW Graphical Programming”, McGraw Hill Inc., 2006.
4. Kevin James, “PC Interfacing and Data Acquisition: Techniques for Measurement, Instrumentation and Control”, Newnes Publishers, 2000
5. Mathivanan, N. “PC-Based Instrumentation”, PHI Learning Pvt. Ltd, New Delhi, 2009.

15UC51 OBJECT COMPUTING AND DATA STRUCTURES LABORATORY

0 0 4 2

LABORATORY COMPONENT:

Object Computing (Using C++):

Implementation of the following problems:

1. Creation of class and objects.
2. Implementation of array of objects and dynamic objects.
3. Simple Arithmetic operations.
4. Implementation of Static members.
5. Implementation of different types of functions.
6. Creation of derived class and implementation of different visibilities and access specifiers.
7. Implementation of virtual classes and virtual functions
8. Overloading operators.
9. Overloading stream operators and creation of user manipulators.
10. Usage of file stream.

Data Structures (Using C or C++):

1. Program using arrays.
2. Representation of Sparse & dense Matrix using arrays.
3. Implementation of Stacks using array.
4. Application of Stack: Conversion of infix to postfix expression
5. Implementation of queue using array.
6. Implementation of Linked Lists: Singly linked, doubly linked and Circular lists and applications.
7. Implementation of various sorting algorithms.

Total P: 60

REFERENCES:

1. Harvey M Deitel,and Paul J Deitel, “C++ How to Program”, Prentice Hall, New Delhi, 2010.
2. Herbert Schildt, “C++ - The Complete Reference", Tata McGraw Hill, New Delhi, 2012.
3. Sahni Sartaj, "Data Structures, Algorithms and Applications in C++", Universities Press, Hyderabad, 2005.
4. Aaron M Tanenbaum, Moshe J Augenstein and Yedidyah Langsam, "Data structures using C and C++", Pearson Education, New Delhi, 2009.
5. Mark Allen Weiss, “Data Structures and Algorithm Analysis in C”, Pearson Education, New Delhi, 2007.
6. Robert L Kruse, Bruce P Leung and Clovin L Tondo, “Data Structures and Program Design in C”, Pearson Education, New Delhi, 2009.

15UC61 INDUSTRIAL VISIT & TECHNICAL SEMINAR

0 0 2 1

The student will make at least two technical presentations on current topics related to the specialization. The same will be assessed by a committee appointed by the department. The students are expected to submit a report at the end of the semester covering the various aspects of his/her presentation together with the observation in industry visits.

Total P: 30

II SEMESTER

15UC06 SYSTEM IDENTIFICATION

3 0 0 3

INTRODUCTION TO IDENTIFICATION AND MODELS: Historical developments- System Identification- Systematic identification- Identifiability- Signal-to-Noise ratio- Over fitting- A modeling example: liquid level system- Models: Definition of a model, Classification of models, Models for Discrete-Time LTI Systems: Convolution model, Response models, Difference equation form, State-space descriptions, Transform-Domain Models for Linear Time-Invariant Systems- Frequency response function- Transfer function form- Empirical transfer function (ETF)- Models for Linear Stationary Processes: Moving average models, Auto-regressive models, Auto-regressive moving average models, Auto-regressive integrated moving average models . (9)

ESTIMATION METHODS: Types of estimation problems- Estimation methods- Historical notes- Goodness of Estimators: Fisher information, Bias, Variance, Efficiency, Sufficiency, Cramer-Rao's inequality, Asymptotic bias, Mean square error, Consistency, Distribution of estimates- Hypothesis testing and confidence intervals- Empirical methods for hypothesis testing- Method of moments estimators- Least squares estimators- Non-linear least squares- Maximum likelihood estimators- Bayesian estimators. (9)

IDENTIFICATION OF DYNAMIC MODELS: Non-Parametric and Parametric Models for Identification: The overall model- Quasi-stationary- Non-parametric descriptions parametric descriptions- Predictions: Conditional expectation and linear predictors- One-step ahead prediction and innovations- Multi-step and infinite-step ahead predictions- Predictor model: An alternative LTI description- Identification of Parametric Time-Series Models: Estimation of AR models- Estimation of MA models- Estimation of ARMA models. (9)

IDENTIFICATION OF NON-PARAMETRIC INPUT-OUTPUT MODELS: Identification of Non-Parametric Input-Output Models: Impulse response estimation- Step response estimation- Estimation of frequency response function- Estimating the disturbance spectrum- Identification of Parametric Input-Output Models: Prediction-error minimization (PEM) methods. Properties of the PEM estimator- Variance and distribution of PEM-QC estimators- Accuracy of parameterized FRF estimates using PEM- Algorithms for estimating specific parametric models- Correlation methods. (9)

STATISTICAL ELEMENTS OF MODEL AND STATE SPACE MODEL IDENTIFICATION: Informative Data- Input design for identification- Data pre-processing- Time-delay estimation- Model development- Identification of State-Space Models:-Kalman filter- Foundations for subspace identification- Preliminaries for subspace identification methods- Subspace identification algorithms- Structured state-space models. (9)

Total L: 45

REFERENCES:

1. Ljung L, "System Identification: Theory for the User", Prentice Hall, Englewood Cliffs, 1987.
2. Arun K Tangirala, "Principles of System Identification: Theory and practice", CRC Press, 2014.
3 Thomas Kailath, Ali H Sayed and Babak Hassibi, "Linear Estimation", Prentice Hall, 2000.
4. Brian Rofel and Ben Betlem, "Advanced Practical Process Control", Springer, 2004.
5. Jer Nan Juang, "Applied System Identification", Pearson Education, 1994.

15UC07 ADVANCED DIGITAL SIGNAL PROCESSING

3 0 0 3

DISCRETE RANDOM PROCESS: Random variable – Random process – Ensemble average- Stationary process- Autocorrelation- Ergodicity - Filtering random process – Spectral Factorization - Types of Random process-ARMA, AR, MA – Yule Walker equations. (9)

SPECTRAL ESTIMATION: Nonparametric methods – The periodiogram – Performance of the periodiogram – The Modified Periodiogram – Bartlett's method –Welch Method – Blackman-Tukey method- Performance comparisons – Parametric methods. (9)

ADAPTIVE FILTERS: FIR adaptive filters – adaptive filters based on steepest descent method – LMS algorithm – Variants of LMS algorithm – adaptive channel equalization – adaptive echo cancellation – RLS adaptive algorithm (9)

MULTIRATE SIGNAL PROCESSING: Downsampling- Upsampling – Commutativity of upsampling and down sampling- Multirate identities – Polyphase representation – Fracational sampling rate conversion - Multistage implementation of decimation and interpolation. (9)

DESIGN OF FILTER BANK: Two channel filter bank – M channel filter bank - Perfect reconstruction criterion –– polyphase implementation of two channel filter bank – paraunitary filter bank – Uniform DFT filter bank - Cosine modulated filter bank - Transmultiplexer- Application of filter bank in speech and image coding. (9)

Total L: 45

REFERENCES:

1. Monson H Hayes, "Statistical Digital Signal Processing and Modeling," John Wiley and Sons, 2012.
2. Bernard Widrow and Samuel D Stearns, "Adaptive Signal Processing," Prentice Hall, 2009.
3. Behrouz Farhang-Boroujeny, "Adaptive Filters:Theory and Applications" Wiley, 2013.

4. Vaidyanathan P P, “Multirate Systems and Filter Banks”, Pearson Education, 2008.
5. Fliege N J, “Multirate Digital Signal Processing”, Wiley-Blackwell, 1999.

15UC08 NONLINEAR CONTROL

3 0 0 3

INTRODUCTION: Nonlinear system behavior- Common Nonlinearities in control systems- Autonomy - Analysis and design methods of Nonlinear control systems. (5)

DESCRIBING FUNCTION: Describing Function Fundamentals -Describing functions of common nonlinearities – Describing function analysis of nonlinear systems: Existence and stability of limit cycles - Dual input describing function for typical nonlinearities: Relay, hysteresis and polynomial type nonlinearity. (10)

PHASE PLANE ANALYSIS: Singular points - Construction of phase plane using Isocline, delta and Lienard’s methods - Existence of Limit cycles: Poincare index and Bendixon theorems - Stability. (10)

LYAPUNOV STABILITY THEORY: Concepts of Stability-Linearization and Local Stability-Lyapunov’s Direct Method –Generation of Lyapunov functions: Krasovski’s, Lure’s and Variable Gradient Method- Popov’s stability criterion. Concepts of stability for non autonomous systems. Concepts of passivity formalism in linear systems (10)

NONLINEAR CONTROL SYSTEMS DESIGN: Method of feedback linearization-Mathematical tools- Input-state linearization of SISO systems- Input-output linearization of SISO Systems- Basic concepts of variable structure systems - Sliding surfaces-Filippov’s construction of equivalent dynamics- Conditions for existence of sliding regions – Case Study- Back stepping method for non-feedback linearizable systems . (10)

Total L: 45

REFERENCES:

1. Jean Jacques Slotine and Weiping Li, “Applied Nonlinear Control”, Prentice Hall Inc., 1991.
2. Zoran Vukic, Ljubomir Kuljaca, Dali Donlagic and Sejid Tesnjak, “Nonlinear Control Systems”, Marcel Dekker Inc, 2003.
3. Horacio J Marquez, “Nonlinear Control Systems: Analysis and Design”, John Wiley & Sons Inc, 2003.
4. Wilfrid Peruquetti and Jean Pierre Barabot, “Sliding Mode Control in Engineering”, Marcel Dekker Inc, 2002.
5. Gopal M “Digital Control and State Variable Methods”, Tata McGraw- Hill Ltd, New Delhi, 2003.

15UC09 ADVANCED PROCESS CONTROL

4 0 0 4

PROCESS DYNAMICS : Need for Process Control –PI Diagrams - Degrees of freedom - Linearization of nonlinear systems-Mathematical model of liquid level and thermal processes – Gas processes- Higher order process: Process with dead time, process with inverse response – Interacting and non-interacting systems. Continuous and batch process – Servo and regulator operation - Self regulation (12)

CONTROL ACTIONS & FINAL CONTROL ELEMENT: Characteristic of ON-OFF, P, P+I, P+D and P+I+D control modes – Electronic PID controller –Digital PID algorithm – Auto/manual transfer - Reset windup. Selection of control modes . I/P converter Pneumatic and electric actuators –– types of Control Valves – Construction-Characteristic of Control Valves: Inherent and Installed characteristics- control valve sizing – Cavitations and flashing – selection criteria. (12)

CONTROLLER TUNING –SINGLE LOOP REGULATORY CONTROL : Evaluation criteria – IAE, ISE, ITAE and ¼ decay ratio – Tuning: Process reaction curve method, Continuous cycling method and Damped oscillation method – Auto tuning - Determination of optimum PID settings using time response and frequency response approaches. (12)

ADVANCED CONTROL SYSTEMS: Control systems with multiple loops: Cascade control – Selective Control Systems –Split Range Control – Feedforward control and Ratio Control - Adaptive and Inferential Control. Model based control: – Dead Time Compensation - Smith predictor control - Internal Model Control- Introduction of Model predictive control. (12)

MULTIVARIABLE CONTROL: Interaction of control loop - general pairing problem- Relative gain array(RGA)- properties and application of RGA- Decoupling of control loops Case study: Control schemes for – Evaporator – Dryer – Distillation process – binary distillation column. (12)

Total L: 60

REFERENCES:

1. Stephanopoulos G, “Chemical Process Control”, Prentice Hall of India, New Delhi, 2008.
2. Donald R Coughanowr, “Process Systems Analysis and Control”, Tata McGraw Hill Inc., 2006.
3. Wayne Bequette B. “Process Dynamics Modeling, Analysis and Simulation”, Prentice Hall, 2003.
4. Liptak B G, “Process Control”, Chilton Book Company, 2005.
5. Curtis D Johnson, “Process Control Instrumentation Technology”, Pearson Education, New Delhi, 2008.

15UC10 OPTIMAL CONTROL

3 0 0 3

CALCULUS OF VARIATIONS AND OPTIMAL CONTROL: Introduction- State variable representation of systems- Performance measures for optimal control problems - Selection of performance measures – Calculus of variations – Function, Functional, Increment, Differential and variation and optimum of function and functional – The basic variational problem Extrema of functions and functional with conditions – Variational approach to optimal control system. (9)

LINEAR QUADRATIC OPTIMAL CONTROL SYSTEM: Problem formulation – Finite time Linear Quadratic regulator – Infinite time LQR system: Time Varying case- Time-invariant case – Stability issues of Time-invariant regulator – Linear Quadratic Tracking system: Fine time case and Infinite time case. (9)

DISCRETE TIME OPTIMAL CONTROL SYSTEMS: Variational calculus for Discrete time systems – Discrete time optimal control systems:- Fixed final state and open-loop optimal control and Free-final state and open-loop optimal control - Discrete time linear state regulator system – Steady state regulator system. (9)

PONTRYAGIN MINIMUM PRINCIPLE: Pontryagin Minimum Principle – Dynamic Programming:- Principle of optimality, optimal control using Dynamic Programming – Optimal Control of Continuous time and Discrete-time systems – Hamilton-Jacobi-Bellman Equation – LQR system using H-J-B equation. (9)

CONSTRAINED OPTIMAL CONTROL SYSTEMS: Time optimal control systems – Fuel Optimal Control Systems- Energy Optimal Control Systems – Optimal Control Systems with State Constraints. (9)

Total L: 45

REFERENCES:

1. Kirk D E, “Optimal Control Theory: An Introduction”, Prentice Hall, New Jersey, 2008.
2. Desineni Subbaram Naidu, “Optimal Control Systems”, CRC Press, 2009.
3. Jeffrey B Burl, “Linear Optimal Control”, Addison-Wesley, California, 1999.
4. Frank L Lewis, “Optimal Control”, John Wiley & Sons, New York, 1986.
5. Gopal M, “Modern Control System Theory”, Wiley Eastern, New Delhi, 1993.

15UC52 INDUSTRIAL AUTOMATION LABORATORY

0 0 4 2

In this course, students will be provided an introduction regarding the hardware and software facilities and features available in the department. Each student is expected to formulate and complete industry related problems with the help of the above facilities. The student is expected to submit a detailed report with relevant references from literature comprising of the idea of the solution, source code (if any), results and its analysis followed by conclusion.

Experimental Facilities Available
1. Programmable Logic Controller
2. Distributed Control Systems

Total P: 60

III SEMESTER

15UC53 ADVANCED CONTROL LABORATORY

0 0 4 2

In this course, students will be provided an introduction for the design and implementation of the following problems using software and available hardware in the department. After the introduction each student is expected to formulate and complete a work related to the problem discussed by the faculty. The student is expected to submit a detailed report with relevant references from literature comprising of the idea of the solution, source code (if any), results and its analysis followed by conclusion.

Scope of the Problems:
1. Mathematical modeling of systems.
2. Design and implementation of multivariable PID control on the simulated model.
3. Implementation of state estimator on the simulated model.
4. Design and implementation of state feedback controller for regulatory and tracking applications.
5. Design and implementation of adaptive controller on the simulated model.
6. Control of one degree of freedom and two degree of freedom systems
7. Control of system using Model Predictive Controller.
8. Control of system using non linear controller.

Total P: 60

15UC71 PROJECT WORK - I

0 0 6 3

- Identification of a real life problem in thrust areas
- Developing a mathematical model for solving the above problem
- Finalisation of system requirements and specification
- Proposing different solutions for the problem based on literature survey
- Future trends in providing alternate solutions

- Consolidated report preparation of the above

Total P: 90

IV SEMESTER

15UC72 PROJECT WORK – II

0 0 28 14

The project involves the following:

- **Preparing a project - brief proposal including**
  - Problem Identification
  - A statement of system / process specifications proposed to be developed (Block Diagram / Concept tree)
  - List of possible solutions including alternatives and constraints
  - Cost benefit analysis
  - Time Line of activities
- **A report highlighting the design finalization [based on functional requirements & standards (if any)]**
- **A presentation including the following:**
  - Implementation Phase (Hardware / Software / both)
  - Testing & Validation of the developed system
  - Learning in the Project
- **Consolidated report preparation**

Total P: 420

ELECTIVE THEORY COURSES

15UC21 LOGIC AND DISTRIBUTED CONTROL SYSTEM

3 0 0 3

SUPERVISORY CONTROL AND DATA ACQUISITION SYSTEMS (SCADA): Elements of SCADA – Functionality of SCADA - Master Terminal unit (MTU) – Remote Terminal unit (RTU) – SCADA Master – Communication system components – Applications – Sampling considerations. (9)

PROGRAMMABLE LOGIC CONTROLLER (PLC) BASICS: Definition - overview of PLC systems - input/output modules – power supplies and isolators - General PLC programming procedures - programming on-off inputs/ outputs - Auxiliary commands and functions - PLC Basic Functions - register basics - timer functions - counter functions. (9)

PLC INTERMEDIATE FUNCTIONS: Arithmetic functions - comparison functions - Skip and MCR functions - data move systems - PLC Advanced intermediate functions - sequencer functions - matrix functions - PLC Advanced functions: Alternate programming languages - analog PLC operation - networking of PLC - PLC-PID functions - Design of interlocks and alarms using PLC. (9)

DISTRIBUTED CONTROL SYSTEM (DCS): Definition – Generalized Architecture- Local Control Unit (LCU) architecture - LCU languages - LCU - Process interfacing issues - communication facilities - HART Protocol, Foundation Field bus, Profibus, Ethernet, Ethernet IP, TCP/IP-redundancy concept. (12)

CASE STUDIES: Power plant Industry, Petroleum Industry. (6)

Total L: 45

REFERENCES:

1. Stuart A Boyer, “SCADA: Supervisory Control and Data Acquisition Systems”, ISA Press, 2010.
2. Frank D Petruzella, “Programmable Logic Controllers”, McGraw Hill, New York, 2010.
3. Lukcas M P, “Distributed Control Systems”, Van Nostrand Reinhold Co., New York, 1986.
4. Bela G Liptak, “Instrument Engineers' Handbook: Process Software and Digital Networks”, Third Volume, CRC Press, 2011.
5. John Park, Steve Mackay, Edwin Wright, “Practical Data Communications for Instrumentation and Control”, Elsevier, 2003

15UC22 VLSI SYSTEM DESIGN

3 0 0 3

BASIC DEVICE CHARACTERISTICS: NMOS, PMOS, enhancement and depletion mode transistor, MOSFET threshold voltage, linear and saturated operation, standard CMOS inverter, transit time and switching speed of NMOS and CMOS inverters, transistor sizing and power dissipation, CMOS device fabrication principles. (9)

DESIGN RULES AND LAYOUT: Purpose of design rules, NMOS and CMOS design rules and layout, Design of NMOS and CMOS inverters, NAND and NOR gates. Interlayer contacts, butting and buried contacts, stick diagrams - examples. (9)

LOGIC DESIGN: Pass transistors, transmission gates, pseudo NMOS logic, dynamic CMOS logic, clocked CMOS logic, Design examples – adder, multiplexer, decoder, priority encoder, multiplier, flip flops, shift registers and accumulator. (9)

FPGAs AND CPLDs: Introduction. FPGA Architectures. SRAM-Based FPGAs. Permanently Programmed FPGAs. Chip I/O, Introduction to CPLDs Comparison of FPGAs and CPLDs from Xilinx, Altera and Actel. Introduction to ASIC. (9)

PRINCIPLES OF HDL: VHDL design Entity- Signal and Variable – Using Subcircuits - Concurrent Assignment Statements – Sequential Assignment Statements – Combinational and Sequential circuits. Realizing PID controller in VHDL. (9)

Total L: 45

REFERENCES:

1. Jan M Rabaey, Anantha Chandrakasan and Borivoje Nikolic, "Digital Integrated Circuits – A Design Perspective", Prentice Hall of India, 2004.
2. Bhasker J, "VHDL Primer", Pearson Education, New Delhi, 2002.
3. Stephen Brown and Zvonko Vranesic, "Fundamentals of Digital Logic with VHDL design", McGraw Hill, 2004.
4. Wayne Wolf, "FPGA – Based System Design", Prentice Hall, 2004.
5. Kamran Eshraghian, Douglas A Pucknell and Sholeh Eshraghian, "Essentials of VLSI Circuits and Systems", Prentice Hall of India, New Delhi, 2005.
6. Neil H E West and Kamran Eshranghian, "Principles of CMOS VLSI Design: A system Perspective", Addision - Wesley, 2004.

15UC23 ADAPTIVE CONTROL SYSTEM

3 0 0 3

INTRODUCTION: Development of adaptive control problem-The role of Index performance (IP) in adaptive systems-Parametric models of dynamical systems - Adaptive Schemes- The adaptive Control Problem- Applications. Gain scheduling: The principle - Design of gain scheduling controllers- Nonlinear transformations -application of gain scheduling - Auto-tuning techniques- Methods based on Relay feedback. (9)

DETERMINISTIC SELF-TUNING REGULATORS : Pole Placement design - Indirect Self-tuning regulators - Continuous time self tuners direct self-tuning regulators – Disturbances with known characteristics (9)

STOCHASTIC AND PREDICTIVE SELF-TUNING REGULATORS: Design of minimum variance controller - Design of moving average controller - stochastic self-tuning regulators - Unification of direct self tuning regulators - Linear Quadratic STR - Adaptive Predictive Control. (9)

MODEL – REFERENCE ADAPTIVE SYSTEM: MIT rule – Determination of adaptation gain - Lyapunov theory –Design of MRAS using Lyapunov theory – Relations between MRAS and STR- Case Study. (9)

PROPERTIES OF ADAPTIVE SYSTEMS: Nonlinear dynamics, Analysis of Indirect discrete time self-tuners, Stability of direct discrete time algorithms , Averaging, Application of averaging techniques , Averaging in stochastic systems, Robust adaptive controllers. (9)

Total L: 45

REFERENCES:

1. Karl J Astrom and Bjorn Wittenmark, "Adaptive Control", Pearson Education Inc., New Delhi, 2008.
2. Ioannou P A and Sun J, "Robust Adaptive Control", Prentice Hall, 1996.
3. Krstic M, Kanellakopoulos I and Kokotovic P, "Nonlinear and Adaptive Control Design", Wiley -Interscience , 1995.
4. Chalam V V, "Adaptive Control Systems – Techniques and Applications", Marcel Dekkar Inc., NewJersey, 1987.
5. Shankar Sastry and Marc Bodson, "Adaptive Control – Stability, Convergence and Robustness", Prentice Hall Englewood Cliffs, New Jersey, 1989.

15UC24 ROBUST CONTROL

3 0 0 3

INTRODUCTION: Concepts of model uncertainty, including both parametric and dynamic uncertainty - Fundamental concept of robustness and the relationship between physical systems and mathematical models - Mathematical background including norms for vectors, matrices, signals, and systems - Co prime Factorization and stabilizing controllers, singular value decomposition and its application to perturbation analysis. (10)

MODELLING OF UNCERTAIN SYSTEMS: Unstructured Uncertainties - Parametric Uncertainty - Linear fractional transformations and canonical forms - Structured Uncertainty - Robust stability and performance problems. (8)

ROBUST DESIGN SPECIFICATIONS: Small gain theorem and Robust Stabilization, Performance Consideration, Structured Singular Values. H – infinity design: Mixed Sensitivity H-infinity Optimization. H-infinity suboptimal solutions, Discrete time case(10)

H-INFINITY LOOP SHAPING DESIGN: Robust Stabilization against normalised Coprime Factor Perturbations, Loop Shaping Design, Discrete time case. Mixed Optimization Design Method with LSDP. µ- Analysis and Synthesis: Consideration of Robust performance, µ-synthesis- D-K Iteration method, µ-K Iteration method. (10)

LOWER ORDER CONTROLLERS: Absolute-error Approximation Methods, Reduction via Fractional Factors, Relative-error Approximation Methods, Frequency Weighted Approximation Methods. (7)

Total L: 45

REFERENCES:
1. Skogestad and Postlethwaite, “Multivariable Feedback Control: Analysis and Design”, John-Wiley & Sons, 2005.
2. Mackenroth U “Robust Control Systems, Theory and Case Studies”, Springer India Pvt. Ltd, New Delhi, 2010.
3. Gu D W, Petkov and Konstantinov M M, “Robust Control with MATLAB”, Springer, 2005.
4. Kemin Zhou and John Doyle, “Essentials of Robust Control”, Prentice-Hall Inc., 1998.
5. Zhou K, Doyle J C and Glover K, “Robust and Optimal Control”, Prentice-Hall Inc., 1996.

15UC25 INDUSTRIAL DRIVES AND CONTROL

3 0 0 3

CONVERTER FED DC DRIVES: Introduction to Electrical drives, Fundamental torque equations, Speed torque conventions and multiquadrant operation, Components of load torques, Nature and classification of load torques, State space model of DC motor drive, Single-phase and Three-phase drives: Half converter, Semi converter, Full converter and Dual converter fed drives (9)

CHOPPER FED DC DRIVES: Introduction, Chopper control of separately excited and series motor drives - Two quadrant and four quadrant chopper controlled drives – Closed loop control of dc drives. (9)

INDUCTION MOTOR DRIVES: Performance characteristics, Stator Control: Stator voltage control, Rotor voltage control, Frequency control, Voltage and frequency control, Current control, Voltage, current and frequency control - Rotor resistance control: Conventional methods, Static rotor resistance control - Slip power recovery: Static Kramer drive, Static Scherbius drive. (9)

VECTOR CONTROL OF INDUCTION MOTOR DRIVES: Principle of vector control – Direct vector control - Flux vector estimation – Indirect vector control – Vector control of line-side PWM rectifier – Stator flux oriented vector control – Vector control of current fed inverter drive. (9)

SYNCHRONOUS AND SPECIAL DRIVES: Synchronous Motor Drives: Open loop volts/hertz control, Self control model Permanent magnet ac motor drives, Brushless dc motor drives, Sensorless control - Stepper motor and Switched reluctance motor drives. (9)

Total L: 45

REFERENCES:
1. Gopal K Dubey, “Fundamentals of Electric Drives”, Narosa Publishing House, New Delhi, 2005.
2. Bimal K Bose, “Power Electronics and Variable Frequency Drives - Technology and Application”, IEEE Press, NewYork, 1997.
3. Ion Boldea and Nasar S A, “Electric Drives”, CRC Press LLC, New York, 1999.
4. Krishnan R, “Electric Motor Drives: Modelling, Analysis and Control”, Prentice Hall of India, New Delhi, 2002.
5. Muhammad H Rashid, “Power Electronics Handbook”, Academic Press, 2001.

15UC26 APPLIED SOFT COMPUTING

3 0 0 3

ARTIFICIAL NEURAL NETWORKS (ANN) : Review of basic concepts of Artificial Neural Nets – Architecture of learning algorithm – MLP Architecture: Back Propagation Algorithm – Radial Basis Function Nets(RBF) – Kohonen Self-Organizing Nets – support vector machines and reinforcement learning. (9)

NEURAL NETWORKS BASED CONTROL : Non Linear optimization - Representation of nonlinear Systems – Nonlinear system identification and monitoring with Artificial Neural Networks – Modeling and control of nonlinear system using ANN - Adaptive neuro controller – case studies. (9)

FUZZY LOGIC : Basics of Fuzzy sets - Fuzzy operations- Fuzzy Relations – Fuzzification – Defuzzification -Linguistic Hedges – Model based fuzzy control : Fuzzy rule for modeling and control-Mamdani fuzzy rule systems - Takagi-Sugeno-Kang fuzzy rule systems – rule extraction from neural networks. (9)

FUZZY LOGIC BASED CONTROL : Development of membership functions – Modeling of fuzzy nonlinear systems using fuzzy models (Mamdani and Sugeno) - Design of fuzzy logic controller – Adaptive fuzzy systems – case studies. (9)

NEURO-FUZZY BASED CONTROL: Adaptive Neuro-Fuzzy systems - Neuro-Fuzzy control for nonlinear systems- Neuro-Fuzzy identification of sub systems - optimization of membership function and rule base using genetic algorithm and particle swarm optimization – adaptive backthrough control -case studies. (9)

Total L: 45

REFERENCES:
1. Laurene V Fausett, “Fundamentals of Neural Networks, Architecture, Algorithms and Applications”, Pearson Education, 2011.
2. Timothy J Ross, “Fuzzy Logic with Engineering Applications”, Wiley India Pvt. Ltd, 2011.
3. Kecman V, “Learning and Soft Computing, Support Vector Machines, Neural Networks and Fuzzy Logic Models”, Pearson Education, New Delhi, 2004.
4. Yen J and Langari R, “Fuzzy logic intelligence control and information”, Pearson Education, New Delhi, 2003.
5. Jin Y, “Advanced Fuzzy systems Design & Applications “Springer, New Delhi, 2010.

15UC27 ROBOTIC SYSTEMS

3 0 0 3

INTRODUCTION TO ROBOTICS: History of Robots – Classifications –Elements of Robotics: Joints, Actuators and Sensors –End effectors – Applications – Social issues. (7)

ROBOT KINEMATICS: Matrix representation – Homogeneous transformation – DH representation of standard robots – Inverse kinematics. (8)

ROBOT DYNAMICS: Velocity kinematics – Jacobian and inverse Jacobian – Lagrangian formulation – Eulers Lagrangian formulation – Robot equation of motion-Trajectory planning. (10)

ROBOTIC VISION: Introduction to robotic vision-Image formation -Image processing and analysis- Vision applications: Detection, Recognition and Tracking- Camera geometry and calibration- Simulation using OpenCV. (10)

JOINT CONTROL: Linear control of robot manipulation – Second-order systems –Modeling and control of single joint – Performance of feedback control system-Implementation issues- Architecture of industrial robotic controllers – Robot Programming- Simulation and experimental case studies of robot manipulators. (10)

Total L: 45

REFERENCES:

1. Saeed B Niku, "Introduction to Robotics Analysis, Systems, Applications", Prentice Hall of India, 2001.
2. Craig, "Introduction to Robotics Mechanics and Control", Pearson Education, Asia, 2004.
3. Mikell P. Groover, Mitchell Weiss, Roger N Nagel and Nicholas G Odrey, "Industrial Robotics: Technology, Programming and Applications", Mc-Graw Hill Publisher, 2011.
4. Ashitava Ghosal, "Robotics: Fundamental Concepts and Analysis", Oxford University Press, 2006.
5. Davis E R, "Machine Vision: Theory, Algorithms and Practicalities", Morgan Kaufmann Publishers, 2005.

15UC28 BUILDING AUTOMATION SYSTEMS

3 0 0 3

INTRODUCTION TO BUILDING AUTOMATION SYSTEMS: Historical perspective- Definitions of intelligent building- Intelligent architecture and structure- Facilities management and intelligent building- Technology systems and evolution of intelligent buildings- Comfort in buildings: thermal comfort, visual comfort and indoor air quality indices- Comfort analysis (9)

SYSTEMS OF BUILDING AUTOMATION: The progress of BAS- Programming and monitoring platforms and environment- Building management functions- Lighting control systems- Security and safety control systems- Fire protection systems- Applications in energy management and design (9)

COMMUNICATION NETWORKS FOR BAS: Background and problems- Features of BACnet, LonWorks and EIB and its features- Compatibility of different open protocol standards- Integration at management level- Overview of internet technologies in BAS- Use of internet technologies: automation and management level- Convergence networks and total integration. (9)

CONTROL AND OPTIMIZATION OF THERMAL SYSTEMS: Typical control loops of the air conditioning systems- Control of CAV and VAV systems- Outdoor air ventilation control and optimization- An overview of optimal control methods used for HVAC systems- Optimal control of air side systems- Chiller capacity control and safety interlocks- Chillers and central chilling system configurations- Chiller performance and optimal control- Optimal control of heat rejection systems- Optimal set point reset of chilled water supply temperature- Sequence control of multiple chiller plants- Pump seed and sequence control of chilled water system (9)

CONTROL STRATEGIES FOR BAS: Approaches using linear controllers for user's thermal comfort: Hierarchical predictive control strategy- Classical predictive control system approach- Comparison of linear controllers. Non linear controller for user's thermal comfort: Optimization layer- Nonlinear model predictive controller- control layer- Fancoil MISO controller. Multivariable non linear controller for user's thermal comfort and indoor air quality: Formulation of multivariable PNMPC approach. Centralized comfort control for a building: Controller and optimization method. (9)

Total L: 45

REFERENCES:

1. Maria del Mar Castilla , Jose Domingo Alvarez, Francisco Rodriguez Diaz and Manuel Berenguel, "Comfort Control in Buildings", Springer-Verlag, 2014
2. Hermann Merz, James Backer and Viktoriya Moser, "Building Automation: Communication systems with EIB/KNX, LON and BACnet (Signals and Communication Technology)", Springer-Verlag, 2014.
3. Shengwei Wang "Intelligent Buildings and Building Automation", Spon Press, 2010.
4. Albert Ting-pat So and Wai Lok Chan, "Intelligent Buildings systems", Kluwer Academic publishers.
5. Reinhold A Carlson and Robert A Di Giandomenico, "Understanding Building Automation Systems: Direct Digital Control, Energy Management, Life Safety, Security Access Control, Lighting, Building", R.S. Means Company Ltd., 1991.

15UC29 MACHINE VISION

3 0 0 3

IMAGE FORMATION AND TRANSFORM: Digital image – image sensor- image model – perspective geometry - image file formats - neighbours of a pixel - Fourier transform- Discrete Cosine Transform- KL transform- Singular Vale Decomposition-Hough transform-Affine transform-scale invariant feature transform. (9)

IMAGE ENHANCEMENT AND RESTORATION: Spatial domain enhancement: gray level transformations - histogram processing-edge detection - Frequency domain enhancement: filtering in frequency domain- smoothing frequency domain filters-sharpening frequency domain filters- homomorphic filtering- Noise models- Restoration by order statistics filter - Inverse filtering - Wiener filtering. (9)

IMAGE REPRESENTATION AND SEGMENTATION: Chain code – Fourier descriptor- Bspline representation- Convex hull- Detection of discontinuities: point, line and edge detection-Edge linking and boundary detection-Thresholding: global thresholding- optimal thresholding- local thresholding- thresholds based on several variables- Region based segmentation: basic formulation- region growing- region splitting and merging. (9)

PATTERN RECOGNITION AND CLASSIFICATION: Feature –Feature vector – Feature extraction – Principal Component Analysis – Linear Discriminant Analysis – transform based feature extraction - Stastical pattern recognition – Bayes classifier- k-nearest Neighbor classifier - Syntactic Pattern Recognition– Support Vector Machine. (9)

APPLICATIONS: Optical Character Recognition – Robot vision – Inspection of materials – Biometric based visual identification of persons - Tracking of moving objects. (9)

Total L: 45

REFERENCES:

1. Sonka, Hlavac and Boyle, "Image Processing, Analysis, and Machine Vision", Thomson Learning, 2012.
2. Forsyth and Ponce, "Computer Vision: A Modern Approach", Prentice Hall, 2010.
3. Rafael C Gonzalez and Richard E Woods, "Digital Image Processing", Pearson Education, New Delhi, 2009.
4. Anil K Jain, "Fundamentals of Digital Image Processing" Prentice Hall of India, New Delhi, 2010.
5. Duda R, Hart P and Stork D, "Pattern Classification", Wiley, 2010.

15UC30 STATE ESTIMATION

3 0 0 3

INTRODUCTION TO STATE ESTIMATION AND KALMAN FILTER: Review of state observers for deterministic System- Least Square Estimation - Discrete Kalman Filter- Kalman filter generalization – correlated process and measurement noise- limitations of Kalman filter – Case Studies. (9)

EXTENDED KALMAN FILTER: Linearized Kalman filter – Extended Kalman filter – The iterated Extended Kalman filter – The Second order Extended Kalman filter – Constrained Extended Kalman filter - Case Studies. (9)

UNSCENTED KALMAN FILTER: Mean and Covariance of non-linear transformations – Unscented transformation –Unscented Kalman filtering - The simplex Unscented transformation – Spherical Unscented transformation - Constrained Unscented Kalman filter – Case Studies. (9)

PARTICLE FILTER : Bayesian state Estimation - Particle filtering - Implementation issues:- Sample Impoverishment - Particle filter with EKF as proposal - Unscented Particle filter-Case Studies. (9)

DECENTRALIZED ESTIMATION FOR MULTISENSOR SYSTEMS: Introduction- Multisensor systems - Decentralized systems - Information Filter - Decentralized Estimators - Decentralized information filter - Decentralized Kalman filter - Limitations of fully connected Decentralization. (9)

Total L:45

REFERENCES:

1. Dan Simon, "Optimal State Estimation Kalman, H-infinity and Non-linear Approaches", John Wiley and Sons, 2006.
2. Arthur G O Mutambara, "Decentralized Estimation and Control for Multisensor Systems", CRC Press, 1998.
3. Thomas Kailath, Ali H Sayed and Babak Hassibi, "Linear Estimation", Prientice Hall, 2000.
4. Arthur Gelb, "Applied Optimal Estimation", MIT Press, 1974.
5. Eli Brookner, "Tracking and Kalman Filtering Made Easy", Wiley Publishers, 1998.

15UC31 OPTIMIZATION TECHNIQUES

3 0 0 3

INTRODUCTION TO OPTIMIZATION: Statement of Optimization problems - Classical optimization techniques - Single variable and multi variable optimization - Method of direct substitution constraint variation - Lagrange multipliers multivariable optimization with equality constraints - Kuhn Tucker conditions. (7)

LINEAR PROGRAMMING: Linear programming definition - Pivotal reduction of general system of equations - Simplex algorithms - Two phases of the simplex method - Revised simplex method - Duality in linear programming. (8)

UNCONSTRAINED OPTIMIZATION: Optimality conditions-Direct search methods - Univariate method, Pattern search methods - Rosenbrock's method – The simplex method - Descent method - Conjucate gradient method - Quasi Newton methods-Least squares problem. (10)

CONSTRAINED OPTIMIZATION: Theory of constrained optimization – Direct methods - Complex method - Cutting plane method - Methods of feasible directions and determination of step length-Termination criteria, determination of step length-Penalty and Barrier methods, Interior point methods. (10)

DYNAMIC PROGRAMMING: Multistage decision process - Computational procedure - Final value problem to initial value problem -Continuous dynamic programming - Discrete dynamic programming. (10)

Total L: 45

REFERENCES:
1. Singiresu S Rao, "Engineering Optimization Theory and Practice", John Wiley and Sons Pvt. Ltd, 2009.
2. Kalyanmoy Deb, “Optimization for Engineering Design, Algorithms and Examples", Prentice Hall, 2004.
3. Chong E K P and Zak S, “An Introduction to Optimization”, John Wiley and Sons Pvt. Ltd., Singapore, 2004.
4. David Luenberger and Yinyu Ye, "Linear and Nonlinear Programming", Springer, 2008.
5. Fletcher R, “Practical Methods of Optimization”, John Wiley, 2000.

15UC32 EMBEDDED SYSTEMS

3 0 0 3

INTRODUCTION: Overview of embedded systems, Hard and soft real-time systems – Hardware Software components- Embedded system development lifecycle-Challenges in embedded computing system design – Autonomous Control Applications: Unmanned Aerial Vehicles. (6)

EMBEDDED PROCESSORS: RISC and CISC architectures - CPU - Memory organization- On chip peripherals- Timers- ADC-PWM-Interrupt Controller-DMA-Communication protocols- Microcontrollers- ARM Processor- Pipelined architecture- Instruction level parallelism. (10)

DIGITAL CONTROLLERS: Digital control system- Sensors and Actuators- Signal conditioning and Driver circuits- - Discretization - Digital realization of controllers- Proportional-Integral-Derivative (PID) Controller-Hardware implementation considerations-. Fixed and Floating point number representation-IEEE 754-Floating point emulation-Fixed point implementation of control algorithms (9)

EMBEDDED SOFTWARE DEVELOPMENT: Assembler- Compiler -Cross compiler- Embedded Programming in Assembly and C-Datatypes- -Peripheral programming- Debugging- JTAG - Interfacing- Motor control: Position control of DC motor. (10)

REAL TIME SYSTEMS: Real-time issues in controller implementation-algorithmic and code optimization- Performance assessment of control algorithms on the target implementation architecture. Multitasking- Constraints of the operating systems. Real-time operating systems – Tasks-Task States-Task data- Memory management - Context switching- Scheduling algorithms and their performance analysis-Inter task communication. Task runtime behavior analysis using traces (10)

Total L: 45

REFERENCES:
1. Raj Kamal, “Embedded Systems: Architecture, Programming and Design”, Tata-McGraw Hill, 2008.
2. David E Simon, “An Embedded Software Primer”, Prentice Hall, 2007.
3. Jonathan W Valvano, “Embedded Microcomputer Systems: Real Time Interfacing”, Cengage Learning, 2012.
4. Alexandru Forrai, “Embedded Control System Design: A Model Based Approach”, Springer, 2013.
5. Andrew N Sloss, Dominic Symes and Chris Wright, “ARM System Developer’s Guide: Designing and Optimizing System Software”, Margan Kaufmann Publishers, 2004.

15UC33 WAVELETS AND APPLICATIONS

3 0 0 3

SIGNAL DECOMPOSITION: Vector space and inner product – orthogonal basis - Hilbert space- Fourier basis and Fourier Transform – Limitations of Fourier Transform – Need for Time-Frequency Analysis - Heisenberg’s Uncertainty principle – Wigner Ville distribution - Short time Fourier transform (STFT) Analysis - short comings of STFT- Need for wavelets. (10)

CONTINUOUS WAVELET TRANSFORM: Wavelet basis – concept of scale and its relation with frequency, Continuous time Wavelet Transform equation – series expansion using wavelets – CWT – Admissibility condition – Multi Resolution Analysis (MRA) (8)

DISCRETE WAVELET TRANSFORM: Series expansion of discrete-time signals- design and analysis of filter banks - Perfect Reconstruction condition – orthogonal and biorthogonal filter banks – tree structured filter bank - relationship between wavelets and filter banks – lifting scheme. (12)

BEYOND WAVELET TRANSFORM: Need for wavelet packet transform – best basis selection – dual tree complex wavelet transform - Multiwavelet transform – Contourlet transform. (10)
APPLICATIONS OF WAVELETS: Power signal analysis - Signal Denoising - Sub-band coding of speech and music– Image Compression (5)

Total L:45

REFERENCES:
1. Vetterli M and Kovacevic J, "Wavelets and Subband Coding," Prentice Hall, 2008.
2. Vaidyanathan P P, “Multirate Systems and Filter Banks”, Prentice Hall, 2010.
3. Stephane G Mallat, “A Wavelet Tour of Signal Processing”, Academic Press, 1999.
4. Sidney Burrus C, Ramesh A. Gopinath and Haitao Guo, “Introduction to Wavelets and Wavelet Transforms: A Primer”, Prentice Hall, 2008.
5. Grant Welland, “Beyond Wavelets”, Academic Press, 2010.

15UC34 SLIDING MODE CONTROL

3 0 0 3

INTRODUCTION TO SLIDING MODE CONTROL: Properties of sliding motion, different controller designs, pseudo-sliding with a smooth control action, state space approach. Sliding mode control problem statement, existence of solution and equivalent control, properties of sliding motion. Reachability problem, single input and multivariable case. Unit vector approach, continuous approximations. (9)

DESIGN APPROACHES: Regular form based approach, robust eigen structure assignment, quadratic minimisation, direct eigen structure assignment. Incorporation of tracking requirement, model reference approach , integral action approach. (9)

CONTROLLER DESIGN USING OUTPUT INFORMATION: Problem formulation, special case square plants. General frame work, hyperplane design, control law synthesis. Dynamic compensation, model reference system using only outputs. (9)

HIGHER ORDER SLIDING MODES: Definitions, higher order sliding modes in control systems, sliding order and dynamic actuators, 2-sliding controllers, arbitrary order sliding controllers. (9)

SLIDING MODE OBSERVERS: Utkin observer, Walcott–Zak observer, synthesis of discontinuous observer. Observer based output tracking controllers. (9)

Total L: 45

REFERENCES:

1. Christopher Edwards and Sarah K. Spurgeon, "Sliding Mode Control: Theory and Applications", Taylor and Francis Ltd., 1998.
2. Wilfrid Perruquetti and Jean Pierre Barbot, "Sliding Mode Control in Engineering", Marcel Dekker, Inc, 2002.
3. Zinober A. S. I.and Dorling C. M., "Deterministic Control of Uncertain Systems", Peter Peregrinus, 1990.
4. Utkin V. I., "Sliding Modes in Control Optimization", Springer – Verlag, 1992.

ONE CREDIT COURSES

For the detailed syllabi of the electives and one credit courses offered by other departments refer to the syllabi of M.E- Automotive Engineering offered by Automobile Engineering Department.