August, 2019

M. TECH. – EMBEDDED CONTROL AND AUTOMATION (2019)

Embedded Control and Automation is a diverse and rapidly expanding discipline which has become increasingly important in a wide range of industries. The use of multiple disciplines and the heterogeneity of applied technologies are the important factors in making the embedded control and automation special. This M. Tech. programme has wide range of applications starting from day to day life to space exploration. With increased use of digital technologies, new methods, algorithms and techniques are neededto solve problems associated with various aspects of embedded and digital control systems. This programme provides necessary theoretical and practical background with a good blend of applied mathematics along with indepthcoverage of various aspects of embedded systems, control systems and automation entities. Study of state-of-the-art technologies with focus in industrial R/D requirements includinglocomotion, robotics, biomedical, aeronautics, biological systems and defence & spaceindustries also comes under the programme.

All the courses are lab oriented to provide insight into finding solutions forreal time engineering problems. The core courses include automatic, economic,efficient and reliable control and automation techniques with a wide range of electivesin Advanced control systems, Instrumentation, Robotics,Guidance and Control, Automotive Systems, Biological systems etc. This M.Tech. course in Embedded Control and Automation ensures students to get employed in all production relatedindustries, Aerospace and Aeronautical industries, research institutes, oil and gas industries,Petrochemical industries, Automotive companies, Telecommunication sector, Power andDefence, Biomedical industries, Hospitals etc.

CURRICULUM

FIRST SEMESTER

Course Code	Type	Course	L – T – P	Credits
19MA605	FC	Computational Linear Algebra, Differential Equations and Probability Theory	3 – 1 – 0	4
19EM601	FC	Digital Signal Controllers	3 – 0 – 2	4
19EM602	FC	Dynamics of Linear & Nonlinear Systems	2 – 0 – 2	3
19EM611	SC	Modelling and Identification of Dynamic Systems	3 – 0 – 2	4
19EM612	SC	Embedded Control System	3 – 0 – 2	4
19EM613	SC	Process Control and Automation	3 – 0 – 2	4
19HU601	HU	Amrita Values Program*		P/F
19HU602	HU	Career Competency I *		P/F
			Credits	**23**

* Non-credit course

SECOND SEMESTER

Course Code	Type	Course	L – T – P	Credits
19EM614	SC	Digital Control for Automation	3 – 0 – 2	4
19EM615	SC	Optimal and Adaptive Control	3 – 0 – 2	4
19EM616	SC	Smart Sensing and Signal Processing	3 – 0 – 2	4
	E	Elective -I	3 – 0 –0	3
	E	Elective -II	3 – 0 – 0	3
19EM603	FC	Application Development Lab	1 – 0 – 2	2
19HU603	HU	Career Competency II	0-0-1	1
19RM600	SC	Research Methodology	2-0-0	2
			Credits	**23**

THIRD SEMESTER

Course Code	Type	Course	L – T – P	Credits
19RM798	P	Dissertation		10
			Credits	**10**

FOURTH SEMESTER

Course Code	Type	Course	L – T – P	Credits
19RM799	P	Dissertation		10
			Credits	**10**

Total credits: 66

LIST OF COURSES
Foundation Core (FC)

Course Code	Course	L – T – P	Credits
19MA605	Computational Linear Algebra, Differential Equations and Probability Theory	3 – 1 – 0	4
19EM601	Dynamics of Linear and Nonlinear Systems	2 – 0 – 2	3
19EM602	Digital Signal Controllers	3 – 0 – 2	4
19EM603	Application Development Lab	1 – 0 – 2	2

Subject Core (SC)

Course Code	Course	L – T – P	Credits
19EM611	Modelling and Identification of Dynamic Systems	3 – 0 – 2	4
19EM612	Embedded Control System	3 – 0 – 2	4
19EM613	Process Control and Automation	3 – 0 – 2	4
19EM614	Digital Control for Automation	3 – 0 – 2	4
19EM615	Optimal and Adaptive Control	3 – 0 – 2	4
19EM616	Smart Sensing and Signal Processing	3 – 0 – 2	4

Electives
(Subjects from areas including Advanced Control Systems, Embedded Systems, Automation, Instrumentation, Robotics, Guidance and Control)

Course Code	Course	L – T – P	Credits
19EM701	Intelligent Control Systems	3 – 0 – 0	3
19EM702	Robotics and Control	3 – 0 – 0	3
19EM703	Flight Dynamics and Control	3 – 0 – 0	3
19EM704	Virtual Instrumentation	3 – 0 – 0	3
19EM705	Logic and Distributed Control Systems	3 – 0 – 0	3
19EM706	Robust Control	3 – 0 – 0	3
19EM707	Advanced Digital Signal Controllers and Applications	3 – 0 – 0	3
19EM708	Estimation Theory and Stochastic Control	3 – 0 – 0	3
19EM709	Multi Agent Systems	3 – 0 – 0	3
19EM710	Power Plant Instrumentation	3 – 0 – 0	3
19EM711	Electrical Drives and Control	3 – 0 – 0	3
19EM712	Modern Optimization Techniques	3 – 0 – 0	3
19EM713	Guidance and Control of Autonomous Systems	3 – 0 – 0	3
19EM714	Biomedical Instrumentation	3 – 0 – 0	3
19EM715	Smart Electrical Network & Intelligent Communication Systems	3 – 0 – 0	3
19EM716	Variable Structure and Sliding Mode Control	3 – 0 – 0	3
19EM717	Cloud Computing	3 – 0 – 0	3
19EM718	Cyber Physical Systems	3 – 0 – 0	3

19EM719	Automotive Control System Design	3 – 0 – 0	3
19EM720	Biological Control Systems	3 – 0 – 0	3
19EM721	Nonlinear System Analysis and Control	3 – 0 – 0	3
19EM722	Advanced Digital Signal Processing	3 – 0 – 0	3
19EM723	Robotics for Industrial Automation	3 – 0 – 0	3
19EM724	Artificial Intelligence in Automation	3 – 0 – 0	3

*Any of the elective subjects offered in any semester in any department may also be permitted with the concurrence of the department.

Project Work

Course Code	Course	L – T – P	Credits
19EM798	Dissertation		10
19EM799	Dissertation		10

19MA605   COMPUTATIONAL LINEAR ALGEBRA, DIFFERENTIAL EQUATIONS ANDPROBABILITY THEORY 3-1-0-4

Linear Algebra: Matrix, Geometry of linear equations, Vector spaces and subspaces, linear independence, basis and dimensions, linear transformations, applications of linear transformations, inner product space, Orthogonality, projections and least square applications, Eigen values and Eigen vectors. Ordinary Differential Equations and applications of integration: Separable first order differential equations, exact first order differential equations, applications of differential equations, Linear homogeneous differential equations with constant coefficients, method of undetermined coefficients, Variation of Parameters, techniques and applications of integration. Probability: Random Variables, Mass and Density Functions, Conditional Probability, Conditional Expectation, Independence, Correlation, Special Distributions and their Generating Functions, Binomial, Poisson, Normal, Linear Combinations of Normal Variables, Limit Theorems, Types of Convergence, Continuity Theorem, Central Limit Theorem. Laboratory Practice: Case studies and simulation experiments in system modelling, path planning, estimation and detection and so on.

TEXT BOOKS/REFERENCES

1. Erwin Kreyszig, "Advanced Engineering Mathematics", 10th Edition, Wiley, 2013.
2. Howard Anton, "Elementary Linear Algebra with Applications", 11th Edition, Wiley, 2005.
3. Douglas C. Montgomery and George C.Runger, "Applied Statistics and Probability for Engineers", 6th Edition, John Wiley & Sons, 2014.
4. Bernard Kolman and David R. Hill, "Introductory Linear Algebra withApplications", 8th Edition, Pearson Education 2005.
5. E. A. Coddington and N. Levinson, "Theory of ordinary Differential Equations", Tata-McGraw Hill, 1984.
6. E. L. Ince, "Ordinary Differential Equations", Dover, 1956.
7. Hoel, P. G., Port, S. C. and Stone, C. J, "Introduction to Probability Theory", Reprint 2003.
8. Chung, K. L., "A Course in Probability Theory", Academic Press, San Diego, USA, 2001.
9. Fausett L.V, "Applied Numerical Analysis Using MATLAB", 2nd Edition, PearsonEducation 2007.

19EM602   DIGITAL SIGNAL CONTROLLERS   3-0-2-4

Digital Signal controllers: Introduction, file registers, memory organization, interrupts, electrical characteristics, peripherals: Ports, Timer, ADC, USART, PWM Channels. Signal generation: PWM, SPWM and servo signals. Filtering algorithms: FIR filters, IIR filters, Control Algorithms: P, PI, PID controllers, Fourier Transforms: DFT, FFT, DCT algorithms. Simulation/hardware experiments with latest digital signal controllers. Lab Practice: Interfacing power electronic switches, voltage and current measurement techniques, digital ammeter and voltmeter, PWM generation for Servo Motor control, harmonics analysis in DSC using FFT.

TEXT BOOKS/ REFERENCES:

1. *dsPIC30F Family Reference Manual, 2017 Microchip Technology Inc., DS70046E.*
2. *dsPIC30F Programmer's Reference manual, Microchip, 2008*
3. *PICmicroTM Mid-Range MCU Family Reference Manual, 2017 Microchip Technology Inc., December 1997 /DS33023A.*
4. *Atmel-8271J-AVR- ATmega-Datasheet_11/2018.*
5. *PICmicrocontroller, PIC16F87XA Data Sheet 28/40/44-Pin Enhanced Flash Microcontrollers, 2003 Microchip Technology Inc., DS39582B.*
6. *Richard C Dorf, "The Engineering Handbook," Second edition, CRC press, 2005.*
7. *Katsuhiko Ogata, "Discrete-time Control Systems," Pearson India, 2ndediton, 2015.*

19EM601DYNAMICS OF LINEAR AND NONLINEAR SYSTEMS   2-0-2-3

Overview: Introduction to control system design. Time domain and frequency domain techniques: compensators, controllers, Concept of controllability and Observability: Kalman's and Gilbert's tests. Design of control system in state space: Pole placement controller, control law design for full state feedback, design of servo systems. Observer design: Reduced order observer, design of regulator systems with observers. Case study: Computer aided designs.Introduction to nonlinear and time-varying systems. Mathematical background: norms, Lipschitz continuity, Lp norms for signals and Lp spaces, induced norms for systems. Existence and uniqueness of solutions to nonlinear differential equations. Linearization through Taylors series, Hartman-Grobmann Theorem. Characteristics of nonlinear systems. Second order systems, Phase plane techniques, Describing Functions, Lyapunov based Design.Lab Practice: Simulation/hardware experiments in design of compensators, controllers, observers, linearization, nonlinear system analysis with the help of an example from industries.

TEXTBOOKS/ REFERENCES:

1. *Katsuhiko Ogata, "Modern Control Engineering", Prentice Hall of India Pvt. Ltd., New Delhi, 2010.*
2. *M. Gopal, "Modern Control System Theory", New Age International, 3rd edition 2014.*
3. *Norman S. Nise, "Control Systems Engineering", John Wiley & Sons PTE Ltd, 2013.*
4. *Richard C. Dorf and Robert H. Bishop, "Modern Control Systems", Pearson, 2011.*
5. *Graham C. Goodwin, Stefan F. Graebe and Mario E. Salgado, "Control System Design", PHI Learning, 2003.*
6. *Thomas Kailath, "Linear Systems", Princeton University Press, 2009.*
7. *Hassan K Khalil, "Nonlinear Systems", Prentice – Hall PTR, 2013.*
8. *Jean-Jacques Slotine, Weiping Li, "Applied Nonlinear Control", Prentice Hall, 2005*
9. *S. Sastry, "Nonlinear Systems: Analysis, Stability, and Control", Springer 2013*
10. *AIsidori, "Nonlinear Control Systems", Springer, 2013.*
11. *K. Ogata, "System Dynamics", Pearson, 2006.*

19EM611 MODELLING AND IDENTIFICATION OF DYNAMICSYSTEMS3-0-2-4

Modelling by first principle approach of simple mechanical, electrical, thermal, chemicalsystems. Modelling by energy approach using Lagrangian and Hamiltonian, bond graphmodelling of dynamical systems. Classical methods of system identification:

Identificationof system transfer function, Fourier analysis and spectral analysis. Sampling, Discretedomain to continuous domain conversion techniques. Offline methods of parameterestimation: least squares method, Generalized Least squares method, Instrumental Variablemethod (IV), Maximum Likely hood estimation. Stochastic modelling: Regression methods,Linear regression model, Polynomial Models. Online Identification methods: RecursiveLeast squares (RLS). Identification of multivariable systems and closed loop systems, orderreduction of higher order systems, aggregation method. Lab Practice: Hardware/simulationof system identification case study using classical methods, least square estimates,stochastic modelling and so on.

TEXT BOOKS/ REFERENCES:

1. *Sinha N K, Kuztsa, "Modeling and Identification of Dynamic Systems", VanNostrand Reinhold Company, 1983.*
2. *K. Ogata, "System Dynamics", Pearson Prentice-Hall, 4th Edition, 2004.*
3. *E.O. Doeblin, "System Dynamics: Modeling, Analysis, Simulation, Design", Marcel Dekker, 1998.*
4. *LennartLjung, "System Identification Theory for the User", Prentice Hall Inc, 1999.*
5. *Harold W Sorensen, "Parameter Estimation: Principles and Problems", Marcel Dekker Inc, New York, 1980.*
6. *Thomas Kailath, Ali H. Sayed, BabakHassibi, "Linear Estimation", Pearson, 2000*

19EM612   EMBEDDED CONTROL SYSTEM   3-0-2-4

Review of control system design: closed loop control, analysis of control loops, time and frequency domain specifications, stability. Approaches for controller design. Practical realization of a control loop. Controller Implementation: architecture of embedded controllers and description of various components. Design and implementation of control loops, choice of embedded computing platforms- Real-time Operating Systems, Tiny Operating systems, I/O and communication, scheduling algorithms and their performance analysis, real-time issues in co-design implementation. Validation techniques for embedded control systems. Model Based Control System Design: discrete systems, notion of state, Finite State Machines, Extended State Machines, Model based design, code generation, verification and validation, HIL, MIL, SIL, PIL. Performance assessment of control algorithms on the target implementation architectures. Case studies from automotive, aerospace, process control and other application domains.

TEXT BOOKS/ REFERENCES:

1. *Edward Ashford Lee and Sanjit Arunkumarr Seshia, "Introduction to Embedded Systems A Cyber-Physical Systems Approach", 2011.*
2. *Karl Johan Astrom, Bjorn Wittenmark, "Computer Controlled Systems", Dover Publications, 2011.*
3. *Dimitrios Hristu-Varsakelis, William S. Levine, "Handbook of Networked and Embedded Control Systems", Birkhäuser Boston,2005.*
4. *J. W. Valavano, "Embedded Microcomputer Systems: Real-time Interfacing", Thompson Asia, 2011.*
5. *Wayne Wolf, "Computers as components: Principles of Embedded Computing Systems Design", Academic Press, 2005.*

6. *H. Hanselmann, "Implementation of Digital Controllers- A Survey", Automatica (journal), Volume 23, Issue 1, Pages 7-32, January 1987.*

19EM613   **PROCESS CONTROL AND AUTOMATION**   **3-0-2-4**

Process Modelling: hierarchies. Theoretical models: transfer function, state space models, and time series models. Development of empirical models from process data, chemical reactor modelling. Feedback & feed forward control, cascade control, selective control loops, ratio control, feed forward and ratio, split range, selective, override, auctioneering, adaptive and inferential controls. Multi-loop and multivariable control: process interactions, Singular value decomposition, Relative gain array, I/O pairing. Decoupling and design of non-interactive control loops. Statistical process control, supervisory control, direct digital control, distributed control, Introduction to Automatic Control: PC based automation. SCADA in process automation. Time Delay Systems and Inverse Response Systems, Special Control Structures, Introduction to Sequence Control, PLC, RLL, Sequence Control. Scan Cycle, Simple RLL Programs, Sequence Control. RLL Elements, RLL Syntax, Lab practice: Implementation of RLL, sequence control etc. using PLC Hardware Environment

TEXT BOOKS/ REFERENCES:

1. *Dale E. Seborg, Duncan A. Mellichamp, Thomas F. Edgar, Francis J. Doyle "Process Dynamics and Control", John Wiley & Sons, 2010.*
2. *Karl Johan Astrom, Bjorn Wittenmark, "Computer Controlled Systems", Dover Publications, 2011.*
3. *Johnson D Curtis, "Process Control Instrumentation Technology", Prentice Hall India, 2013.*
4. *Bob Connel, "Process Instrumentation Applications Manual", McGraw Hill, 1996.*
5. *Coughanowr, D. R. and L. B. Koppel, "Process systems Analysis and Control ", Mc-Graw-Hill, 2nd. edition., 1991.*
6. *Luyben, W. L., "Process Modelling Simulation and Control for Chemical Engineers", McGraw Hill, 1990.*
7. *H. Hanselmann, "Implementation of Digital Controllers – A Survey", Automatica (journal), Volume 23, Issue 1, Pages 7-32, January 1987.*

19EM614   **DIGITAL CONTROL FOR AUTOMATION**   **3-0-2-4**

Review of Z-transforms. Pulse transfer function. Digital control system: sampling, quantization, data reconstruction and filtering of sampled signals. Mathematical modelling of sampling process. Simulation examples- effect of sampling rate. Analysis of filters in discrete domain. Z-transform analysis of closed loop and open loop systems, multirate Z - transform. Stability analysis of closed loop systems in the z- plane: root loci, frequency domain analysis, Stability tests. Discrete equivalents. Digital controller design for SISO systems: design based on root locus method in the z-plane, design based on frequency response method, design of lag compensator, lead compensator, lag lead compensator, design of PID Controller based on frequency response method, direct design, method of Ragazzini. 2DOF discrete PID controller- software approach. State space representation in discrete system. Controllability, observability, control law design, decoupling by state variable feedback, effect of sampling period. Estimator/ Observer Design: full order observers, reduced order observers, regulator design. Discrete LQR design. Introduction to event

triggered systems: examples using state flow technique. Real-Time Applications of Computer-Aided Design. Case Study: Simulation/hardware experiments in controller, observer/estimator, design for automation. Use of IOT based systems for process control and automation.

TEXT BOOKS/ REFERENCES:

1. Gene F. Franklin, J. David Powell, Michael Workman, "Digital Control of Dynamic Systems", Pearson, 3rd Edition, 2006.
2. M. Sami Fadali, Antonio Visioli, "Digital Control Engineering: Analysis and Design", Elsevier, 2013.
3. IoanDoré Landau, GianlucaZito, "Digital Control Systems: Design, Identification and Implementation", Springer, 2006.
4. Cheng Siong Chin, "Computer-Aided Control Systems Design" CRC Press, 2013.
5. HemchandraMadhusudanShertukde, "Digital Control Applications-Illustrated with MATLAB" CRC Press Inc., 2015.
6. C. L. Philips, Troy Nagle, AranyaChakrabortty, "Digital Control System Analysis and Design", Prentice-Hall, 2014.
7. K. Ogata, "Discrete-Time Control Systems", Pearson Education, 2011.
8. M. Gopal, "Digital Control and State Variable Methods", Tata McGraw-Hill, 2012.

19EM615   **OPTIMAL AND ADAPTIVE CONTROL3-0-2-4**

Optimal control problem: fundamental concepts and theorems of calculus of variations.Euler - Lagrange equation and extremal of functional, the variational approach to solvingoptimal control problems, Hamiltonian and different boundary conditions for optimalcontrol problem. Linear regulator problem: LQR/LQG controller design, applications topractical systems. Multi objective optimization techniques, genetic algorithm. Introduction to Model Predictive Control (MPC): State space MPC,prediction model, Objective function, constraints and optimization. Pontryagin'sminimumprinciple, dynamic programming, principle of optimality and its application to optimalcontrol problem, Hamilton-Jacobi-Bellman equation. Discrete time optimal ControlSystems. Adaptive control: Closed loop and open loop adaptive control. Self-tuningcontroller, parameter estimation using least square and recursive least square techniques,gain scheduling, model reference adaptive systems (MRAS), self-tuning regulators. VariableStructure Control.

TEXT BOOKS/ REFERENCES:

1. Donald E. Kirk, "Optimal Control Theory, An Introduction", Prentice Hall Inc., 2004.
2. S. Boyd, and L. Vandenberghe, "Convex Optimization", Cambridge, 2006.
3. J. A. Rossiter, "Model-Based Predictive Control: A Practical Approach", CRCPress,2003.
4. Gang Tao, "Adaptive Control Design and Analysis", John Wiley & Sons, 2003.
5. Hans Butler, "Model Reference Adaptive Control: From Theory to Practice", Prentice Hall, 1992.
6. A.P. Sage, "Optimum Systems Control", Prentice Hall, 1977.
7. M. Krstic, I. Kanellakopoulos, and P. V. Kokotovic, "Nonlinear and AdaptiveControl Design", Wiley, 1995.
8. Karl J Astrom, Bjorn Wittenmark, "Adaptive Control", Addison –Wesley series,1995

9. Diederik M Roijers,ShimonWhiteson, "Multi Objective Decision Making",Morgan and Claypool Publishers,2017.

19EM616   **SMART SENSING AND SIGNAL PROCESSING 3-0-2-4**

Sensors Fundamentals: Sensor classification, Thermal sensors, Humidity sensors, Capacitive sensors, Electromagnetic sensors, Light sensing technology, Moisture sensing technology, Carbon dioxide (CO2) sensing technology, Sensors parameters, Selection of sensors.Interfacing of Sensors and Signal Conditioning: Change of bios and level of signals, Loading effects on Sensor's output, Potential divider, Low-Pass RC filter, High-Pass RC filter, practical issues of designing passive filters. Op-amp circuits in Instrumentation: Instrumentation amplifier, Isolation Amplifier, current to voltage and voltage to current converter. Active Filters: Transfer function, First order active filters, Standard second order responses, KRC filters, Multiple feedback filters, Sensitivity, Filter approximations, Cascade design, Direct design, Switched capacitor, Switched capacitor filter. Wireless sensors and sensors network: Introduction, Frequency of wireless communication, Development of wireless sensor network based project, Wireless sensor network based on only Zigbee. Use of Arduino for Signal conditioning and signal processing: Study of ADC, Using maths operations and filter operations in Arduino. Smart Transducers: Smart Sensors, Components of Smart Sensors, General Architecture of Smart Sensors, Evolution of Smart Sensors, Advantages, Application area of Smart Sensors. Introduction to Embedded Web servers, IOT cloud based data storage and processing. Lab experiments: Simulation/hardware experiments in filters, amplifiers, signal processing using Arduino, wireless sensor networks.

TEXT BOOK/REFERENCES:

1. *Smart Sensors, Measurement and Instrumentation by Subhas Chandra Mukhopadhyay, Springer Book Series.*
2. *Measurement and Instrumentation: Theory and ApplicationsBy Alan S Morris, Reza Langari, Academic Press, Elsevier, 2016*
3. *Franco S. , Operational Amplifiers and Analog Integrated Circuits , Fourth Edition, McGraw Hill International Edition, 2014.*
4. *Randy Frank , Understanding Smart Sensors , Second Edition, Artech House sensors library, 2000.*
5. *NikolayKirianaki, Sergey Yurish, Nestor Shpak, VadimDeynega, Data Acquisition and Signal Processing for Smart Sensors, John Wiley & Sons Ltd, 2002.*

19EM603   **APPLICATION DEVELOPMENT LABORATORY 1-0-2-2**

The student in consultation with the faculty advisor has to select a topic related to Control and Instrumentation area, write a paper and present it. Lab training sessions in commonly used ICs and kits (Microcontrollers, FPGA kits etc) to prepare students for project phase.

19RM600   **RESEARCH METHODOLOGY**   **2-0-0-2**

Unit I:
Meaning of Research, Types of Research, Research Process, Problem definition, Objectives of Research,Research Questions, Research design, Approaches to Research, Quantitative vs. Qualitative Approach,Understanding Theory, Building and Validating Theoretical Models,

Exploratory vs. ConfirmatoryResearch, Experimental vs Theoretical Research, Importance of reasoning in research.

Unit II:

Problem Formulation, Understanding Modeling& Simulation, Conducting Literature Review,Referencing, Information Sources, Information Retrieval, Role of libraries in Information Retrieval,Tools for identifying literatures, Indexing and abstracting services, Citation indexes

Unit III:

Experimental Research: Cause effect relationship, Development of Hypothesis, Measurement SystemsAnalysis, Error Propagation, Validity of experiments, Statistical Design of Experiments, FieldExperiments, Data/Variable Types & Classification, Data collection, Numerical and Graphical DataAnalysis: Sampling, Observation, Surveys, Inferential Statistics, and Interpretation of Results

Unit IV:

Preparation of Dissertation and Research Papers, Tables and illustrations, Guidelines for writing the abstract,introduction, methodology, results and discussion, conclusion sections of a manuscript. References,Citation and listing system of documents

Unit V:

Intellectual property rights (IPR) - patents-copyrights-Trademarks-Industrial design geographical indication. Ethics of Research- Scientific Misconduct- Forms of Scientific Misconduct.Plagiarism, Unscientific practices in thesis work, Ethics in science

TEXT BOOKS/ REFERENCES:

1. Bordens, K. S. and Abbott, B. B., "Research Design and Methods – A Process Approach", 8thEdition, McGraw-Hill, 2011
2. C. R. Kothari, "Research Methodology – Methods and Techniques", 2nd Edition, New Age International Publishers
3. Davis, M., Davis K., and Dunagan M., "Scientific Papers and Presentations", 3rd Edition, Elsevier Inc.
4. Michael P. Marder," Research Methods for Science", Cambridge University Press, 2011
5. T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008
6. Robert P. Merges, Peter S. Menell, Mark A. Lemley, "Intellectual Property in New Technological Age". Aspen Law & Business; 6th Edition July 2012

19EM701   INTELLIGENT CONTROL SYSTEMS3-0-0-3

Introduction to Neural Networks, Artificial Neural Network (ANN) based control: ANNArchitectures, Classification Taxonomy of ANN-Connectivity, Learning Strategy:Supervised, Unsupervised, Reinforcement, Learning Rules. Feed Forward Neural Networks,Perceptron Models: Discrete, Continuous and Multi-Category, Training Algorithms: Backpropagation (BP) algorithm, Competitive Learning, Vector Quantization, SelfOrganizedLearning Networks, Kohonen Networks, Radial Basis function (RBF). Artificial NeuralNetwork application: inverse model approach, direct model reference control, modelpredictive control, indirect adaptive controller design using neural network. Fuzzy logicbased control: fuzzy controllers, preliminaries, Mamdani and Sugeno inference methods,fuzzy sets in commercial products, defuzzification, basic construction of fuzzy controller,fuzzy PI, PD and PID control, T-S fuzzy model, Neural and fuzzy-neural networks.

Geneticalgorithm: basics of Genetic Algorithms, design issues in Genetic Algorithm, geneticmodelling, hybrid approach, GA based fuzzy model identification, Particle SwarmOptimization: concept, algorithm, PSO variations and applications. Ant colonyoptimization. Mathematical modelling of intelligent robotic systems. Lab Practice:Simulation/ Hardware experiments in Neural control, Fuzzy logic control and Comparisonof optimization algorithms in a selected case study.

TEXT BOOKS/ REFERENCES:

1. *Klir G. J. and Folger T. A., "Fuzzy Sets, Uncertainty and Information", PrenticeHall of India, 2006.*
2. *Bose N. K. and Liang P., "Neural Network Fundamentals with Graphs, Algorithmsand Applications", Tata McGraw-Hill, 2006.*
3. *Robert Fuller, "Advances in Soft Computing, Introduction to Neuro Fuzzy Systems",Springer, 2000.*
4. *Astrom K., "Adaptive Control", Second Edition, Pearson Education Asia Pvt. Ltd,2002.*
5. *Gang Tao, "Adaptive Control, Design and Analysis", John Wiley and Sons, 2003.*

6. *Zi-Xing Cai, "Intelligent control: Principle, Techniques and Applications", World Scientific Publishing Co. Ptc. Ltd, 1997*
7. *LaxmidharBehera, IndraniKar, "Intelligent Systems and Control",OxfordUniversity press,2009.*

19EM702   **ROBOTICS AND CONTROL**   **3-0-0-3**

Mathematical representations of rigid bodies in 3D space, the concept of a 4 x 4 homogeneous transformations and elementary screw theory. Lab: Different kinds of actuators and their mathematical models: stepper, DC servo and AC motors, model of a DC servo motor, sensors: internal and external sensors, common sensors, encoders, tachometers, strain gauge based force-torque sensors, proximity and distance measuring sensors and vision.Symbolic representation of robots: representation of joints, link representation using D-H parameters, kinematics of serial robot. Direct Kinematics: forward solutions for Stanford and PUMA robots, Inverse Kinematics: inverse (back) solution by Geometric approach with co-ordinate transformation and manipulation of symbolic T and A matrices. Lab: Software simulation of manipulators. Wheeled mobile robots: Kinematic models of holonomic and non-holonomic mobile robots, modelling of slip. Introduction to ROS. Lab: Application of modern control systems on wheeled mobile robots: Navigation of differential drive mobile robots Software simulation and hardware demonstration. Laboratory Experiments: Simulation/Hardware experiments on the topics as mentioned above.

TEXT BOOKS/ REFERENCES:

1. R. K. Mittal and I. J. Nagrath, "Robotics and Control", Tata McGraw-Hill, 2006.
2. John J. Craig, "Introduction to Robotics: Mechanics and Control", Pearson Education, 2008.
3. Kozlowski and Krzysztof, "Robot Motion and Control", Springer, 2012.
4. Peter Corke, "Robotics, Vision and Control: Fundamental Algorithms In MATLAB", Springer, 2nd edition, 2017
5. www.wiki.ros.org

19EM703   FLIGHT DYNAMICS AND CONTROL   3-0-0-3

Aerodynamic forces: lift, drag and moment coefficients-variation with angle of attack aerodynamic center, Aircraft Performance: drag polar of vehicles from low speed to hypersonic speed. Six DOF Equations of motion of aircraft. Aircraft Stability and Control: longitudinal and lateral dynamics stability, conditions for longitudinal static stability. Modes of motion: Short period, phugoid, spiral divergence, Dutch roll, stability derivatives, roll coupling. Aircraft transfer functions, control surface actuator, longitudinal autopilots, displacement autopilot, pitch autopilot, lateral,autopilots, yaw and roll autopilots, attitude control systems stability augmentation, numerical problems. Dynamics and control of Launch Vehicles (SLV). Inertial sensors: Gyros, accelerometers, MEMS devices for aerospace navigation, IMU. Navigational aids: Instrument landing system, radar, GPS. Lab practice: simulation/case study of SLV, autopilot.

TEXT BOOKS / REFERENCES:

1. John D Anderson Jr, "Introduction to Flight", McGraw Hill International, 8th edition, 2015
2. John D. Anderson Jr, "Fundamentals of Aerodynamics", McGraw HillInternational, 5th edition, 2010.
3. Thomas R. Yechout, "Introduction to Aircraft Flight Mechanics", AIAA EducationSeries, 2003.
4. Robert C. Nelson, "Flight Stability and Automatic Control", WCB McGraw-Hill, 2nd edition, 1998.
5. David Titteron and John Weston, "Strapdown Inertial Navigation Technology"Second Edition IEE Radar, Sonar, Navigation and Avionics Series, 2005.
6. Arthur l Greensite, "Control Theory Vol II, Launch vehicle control and analysis,1970

19EM704   VIRTUAL INSTRUMENTATION3-0-0-3

Virtual Instrumentation: Historical perspective, advantages, block diagram and architectureof a virtual instrument, data flow techniques, graphical programming in data flow,comparison with conventional programming. Development of Virtual Instrument usingGUI, Real–time systems, Embedded Controller, OPC, HMI / SCADA software, Active Xprogramming.VI programming techniques: VIS and sub - VIS, loops and charts, arrays,clusters and graphs, case and sequence structures, formula nodes, local and global variables,string and file I/O, Instrument Drivers, Publishing measurement data in the web. Dataacquisition basics: Introduction to data acquisition on PC, Sampling fundamentals,Input/output techniques and buses. ADC, DAC, Digital I/O, counters and timers, DMA,Software and hardware installation, Calibration, Resolution, Data acquisition interfacerequirements.VI Chassis

requirements. Common Instrument Interfaces: Current loop, RS232C/ RS485, GPIB. Bus Interfaces: USB, PCMCIA, VXI, SCSI, PCI, PXI, Fire wire. PXIsystem controllers, Ethernet control of PXI. Networking basics for office & Industrialapplications, VISA and IVI. VI toolsets, distributed I/O modules. Application of VirtualInstrumentation: Instrument Control, Development of Process database management system,Simulation of systems using VI, Development of Control system, IndustrialCommunication, Image acquisition and processing, Motion Control. Lab Practice:Simulation Experiments in Instrument control, Image acquisition and processing and so on.

TEXTBOOKS/ REFERENCES:

1. *Gary Johnson, "LabVIEW Graphical Programming", Fourth edition, McGraw Hill,Newyork, 2007*
2. *Lisa K. wells & Jeffrey Travis, "LabVIEW for everyone", Third Edition, PrenticeHall, New Jersey, 2007.*
3. *Kevin James, "PC interfacing and Data Acquisition: Techniques for measurement,Instrumentation and Control", First Edition, Newnes, 2004.*
4. *www.ni.com*

19EM705   LOGIC AND DISTRIBUTED CONTROL SYSTEMS 3-0-0-3

Data loggers, Data Acquisition Systems (DAS), Direct Digital Control (DDC). SupervisoryControl and Data Acquisition Systems (SCADA), sampling considerations. Functionalblock diagram of computer control systems, alarms, interrupts. Characteristics of digitaldata, controller software, linearization. Digital controller modes: Error, proportional,derivative and composite controller modes. PLC: Evolution, Components, advantages overrelay logic, Architecture, Programming devices, Discrete and Analog I/O modules.Programming languages, Ladder diagrams, timers and counters. Instructions in PLC:Program control instructions, math instructions, sequencer instructions. Use of PC as PLC,Case studies using PLC. DCS Architectures, Comparison, Local control unit. Processinterfacing issues. Communication facilities, configuration of DCS, displays, redundancyconcept. Lab Practice: Simulation/hardware experiments in DAS, digital controllers,programming in PLC and so on.

TEXT BOOKS/ REFERENCES:

1. John. W. Webb, Ronald A Reis, "Programmable Logic Controllers - Principles andApplications", 5th Edition, Prentice Hall Inc., New Jersey, 2003.
2. M.P Lukcas, "Distributed Control Systems", Van Nostrand Reinhold Co., New York,1986.
3. Frank D. Petruzella, "Programmable Logic Controllers", 5th Edition, McGraw Hill,New York, 2016.
4. P.B.Deshpande and R.H Ash, "Elements of Process Control Applications", ISAPress, New York, 1995.
5. Curtis D. Johnson, "Process Control Instrumentation Technology, 8th Edition,Prentice Hall", New Delhi, 2006
6. Krishna Kant, "Computer-based Industrial Control", 2nd Edition, Prentice Hall,New Delhi, 2010.

19EM706 **ROBUST CONTROL3-0-0-3**

Norms for signals and systems, input output relationships, internal stability, asymptotictracking, performance. Uncertainty and robustness: plant uncertainty, robust stability, robustperformance. Stabilization: controller parameterization for stable plant, co-primefactorization, controller parameterization for general plant, asymptotic properties, strong andsimultaneous stabilization. Design constraints: algebraic constraints, analytic constraints.Design for performance: unstable, design example, 2-norm minimization. Stability MarginOptimization: optimal robust stability, gain margin optimization, phase margin optimization.Loop Shaping, Sliding mode control and H∞ control. Applications in control design. LabPractice: Simulation experiments in loop shaping, H∞ control and so on.

TEXT BOOKS/ REFERENCES:

1. S.P. Bhattacharyya, H. Chapellat, L.H. Keel, "Robust Control: The ParametricApproach", Prentice Hall, 2007.
2. Chandrasekharan, P.C., "Robust Control of Linear Dynamical Systems", AcademicPress, 1996.
3. Kemin Zhou, John Comstock Doyle, "Essentials of Robust Control", Prentice HallInternational, 1998.
4. Sinha, "Linear Systems: Optimal and Robust Control", Taylor & FrancisGroup,2007.

5. U. Mackenroth, "Robust Control Systems Theory and Case studies", Springer, 2013.

19EM707   ADVANCED DIGITAL SIGNAL CONTROLLERS AND APPLICATIONS

3-0-0-3

Pre-requisite: General background of microprocessors and microcontrollers.Overview of Digital signal controllers: C2000 modules, Piccolo based controllers,Delfino based controllers, MAC units, hardware divide support, floating point signal processing support. dsPIC30F series DSC- CPU, data memory, program Memory, instruction set. Programming using XC16 compiler and C- Interrupt Structure. Peripherals of dsPIC30F: I/O Ports, timers, input capture, output compare, motor control PWM, 10 bit A/D converter, UART.

Applications using dsPIC30F: Generating SPWM, generating PWM's for power converters, PID based control loops, signal processing based on FIR and IIR filter structures, developing single and multi-point communications with dsPIC and other IC's. Lab Practice: FIR/IIR Filters, FFT, PID control loops and communication systems using dsPIC30F2010.

TEXT BOOKS/ REFERENCES:

1. *dsPIC30F Family Reference manual, Microchip, 2008*
2. *dsPIC30F Programmer's Reference manual, Microchip, 2008*
3. *Chris Nagy, "Embedded System Design using the TI MSP 430 series," First Edition. Newnes, 2003.*
4. *John G Proakis, G Manolakis, "Digital Signal Processing Principles, Algorithms, Applications," Fourth Edition, Prentice Hall India Private Limited, 2007.*
5. *Byron Francis, "Raspberry PI3: The Complete Beginner's Guide,"Create Space Independent Publishing Platform, 2016*

19EM708   ESTIMATION THEORY AND STOCHASTIC CONTROL   3-0-0-3

Estimation Theory: Cramer Rao Lower Bound. Linear Modeling. Estimation Techniques: Least Squares Estimation, Recursive Least Squares Estimation, Best Linear Unbiased Estimation, Likelihood and Maximum Likelihood Estimation. Bayesian Philosophy: Maximum Aposteriori Estimation, Wiener Filter, Kalman Filter. Dynamic programming: basic problem, min-max control, set membership function. Stochastic Control: stochastic integrals, analysis of dynamical systems with stochastic inputs. Lab Practice: Simulation experiments in Wiener Filter, Kalman Filter, Least square estimation, Cramer Rao bound and soon.**TEXT BOOKS/ REFERENCES:**

1. *Steven M. Kay, "Statistical Signal Processing: Estimation Theory", Vol. 1, Prentice Hall Inc., 1998.*
2. *Steven M. Kay, "Statistical Signal Processing: Detection Theory", Vol. 2, Prentice Hall Inc., 1998.*
3. *Harry L. Van Trees, "Detection, Estimation and Modulation Theory", Part 1, John Wiley and Sons Inc. 2004.*
4. *Monson H. Hayes, "Statistical Digital Signal Processing and Modelling", John Wiley and Sons Inc., 2009.*
5. *H.Vincent Poor, "An Introduction to Signal Detection and Estimation", Second Edition, Springer, 2013.*

6. *Dimitri P Bertsektas, "Dynamic Programming and Optimal Control", Athens Scientific, 2012.*

19EM709   MULTI AGENT SYSTEMS   3-0-0-3

Introduction to Multi Agent Systems, Intelligent Agents: the design of intelligent agents,reasoning agents (eg:AgentO), agents as reactive systems (eg: subsumption architecture),hybrid agents (eg:PRS), layered agents (eg:Interrap) a contemporary (Java-based)framework for programming agents (eg:JADE Java Agent Development Environment).Multi-Agent Systems: Classifying multi-agent interactions ,cooperative versus noncompetitive,zero-sum and other interactions, cooperation, the Prisoner's dilemma andAxelrod's experiments. Interactions between self-interested agents: auctions &votingsystems, negotiation. Interactions between benevolent agents: cooperative

distributedproblem solving (CDPS), partial global planning, coherence and coordination. Interactionlanguages and protocols: speech acts, KQML/KIF, the FIPA framework. Application tomulti-UAV systems: Formation control with time-varying topology, Formation control withconnectivity maintenance, Steady-state behaviours, Bearing-based formation control,formation of autonomous vehicles and consensus. Application to multi-UGV systems:Cooperative Mobile Manipulations, Cooperative exploration of unknown environments,Mutual localization with anonymous measurements, Target localization and encircling.

TEXT BOOKS / REFERENCES:

1. *Michael Woodbridge, "Introduction to Multi agent systems" Wiley, 2009.F. Bullo, J. Cort´es, and S. Mart´ınez.,"Distributed Control of Robotic Networks.*
2. *Applied Mathematics Series", Princeton University Press, 2010.*
3. *M. Mesbahi and M. Egerstedt, "Graph Theoretic Methods in Multiagent Networks.*
4. *W. Ren and R. W. Beard. , "Distributed Consensus in Multi-vehicle CooperativeControl. Communications and Control Engineering", Springer, 2008.*
5. *Rafael H. Bordini, Jomi Fred Hubner and Michael Wooldridge, "ProgrammingMulti-agent Systems in AgentSpeak Using Jason". Wiley 2007.*
6. *S. Russell and P. Norvig,"Artificial Intelligence – A Modern Approach", PrenticeHall, 2010.*

19EM710   **POWER PLANT INSTRUMENTATION3-0-0-3**

Introduction: Importance of Instrumentation and control in power generation, piping andinstrumentation diagrams. Instrumentation and control in water circuit: boiler feed watercirculation, measurements, controls, impurities in water and steam. Instrumentation andcontrol in air-fuel circuit: measurements, controls, analytical measurements. Turbinemonitoring and control: classification of turbines, instrumentation and control points ofview, principal parts of turbines, turbine steam inlet system, turbine measurements, turbinecontrol system, lubrication for turbo-alternator, turbo alternator cooling system. Basicprinciples of a nuclear plant. Nuclear power plant training simulator project. Designconcepts of instrumentation and control of CWR, PWR and BWR reactors (differentexamples). Operator/Plant communication systems, main control systems, safety and safetyrelated systems. Role of Instrumentation in hydroelectric power plant. Regulation andmonitoring of voltage and frequency of output power. Pollution and effluent monitoring andcontrol. Energy management. Electrical substation controls. Plant safety and redundanciesof non-conventional power plants. Diesel generator controls. Laboratory Practice:Simulation of intelligent control strategies in instrumentation, SCADA and soon.

TEXT BOOKS/ REFERENCES:

1. *K. Krishnaswamy, M. PonniBala, "Power Plant Instrumentation", PHI LearningPrivate limited, New Delhi, 2011.*
2. *David Lindsley, "Power Plant Control and Instrumentation, The Control of Boilersand HRSG systems", IEE Control Engineering Series 2000.*
3. *Philip Kiameh, "Power Plant Instrumentation and Controls", McGraw HillEducation, 2014.*
4. *Singh S K, "Industrial Instrumentation and control" Tata- McGraw-Hill PublishingCompany, 2009.*
5. *"Nuclear power plant instrumentation and control", A guidebook, Internationalatomic energy agency Vienna, 1984(online resource).*
6. *David Linsley, "Power plant control and instrumentation: The control of boilers andHRSG system", Institution of Electrical Engineers,2000.*

19EM711   **ELECTRIC DRIVES AND CONTROL 3-0-0-3**

Fundamentals of electric drives, dynamics of electric drives, multi quadrant operation,closed loop control of drives. Review of DC and AC Motor Drives: Primitive machine:unified approach to the analysis of electrical machine, basic two pole model of rotatingmachines, Kron's primitive machine: voltage, power and torque equation, lineartransformation from 3 phase to 2 phase and from rotating axes to stationary axes, invarianceof power. Principle of vector Control: vectorcontrolled induction motor drive, basicprinciple, direct rotor flux oriented vector control, estimation of rotor flux and torque,implementation with current source and voltage source inverters. Stator flux oriented vectorcontrol, indirect rotor flux oriented vector control scheme, implementation, tuning (includelab practice). Vector control strategies for synchronous motor. Introduction to sensor-lesscontrol, basic principle of direct torque control, MRAS, PLC based control.

TEXT BOOKS/REFERENCES:

1. *R. Krishnan, "Electric Drives: Modeling, Analysis and Control", PHI, 2007.*
2. *VedamSubramaniam, "Electric Drives: Concepts and Applications", Tata McGraw Hill,2011.*
3. *Bose B. K, "Modern Power Electronics and AC Drives", Pearson Education Asia, 2002.*
4. *N. K. De and P. K. Sen, "Electric Drives", PHI, New Delhi 2001.*
5. *M. D. Singh and K. B. Khanchandani, "Power Electronics", Tata McGraw Hill, 2008.*
6. *Joseph Vithayathil, " Power Electronics, Principles and Applications", McGraw HillSeries, 6 th. Reprint, 2013.*

19EM712   **MODERN OPTIMIZATION TECHNIQUES3-0-0-3**

Historical   Development,   Engineering   applications   of   Optimization.   Art   of Modelling:Objective function, Constraints and Constraint surface, Formulation of design problems asmathematical programming problems. Classification of optimization problems:Optimization techniques, classical and advanced techniques, Functions of single and twovariables, Stationary points, Global Optimum, Convexity and concavity of functions of oneand two variables, optimization of function of one variable and multiple variables,

Gradientvectors, Examples. Optimization of function of multiple variables subject to equalityconstraints: Lagrangian Function, Hessian matrix formulation, Kuhn-Tucker Conditions,Examples. Advanced Topics in optimization: Piecewise linear approximation of a nonlinearfunction, Direct and indirect search methods. Evolutionary algorithms for optimization:Working Principles of Genetic Algorithm, genetic Operators, Selection, Crossover andMutation, Issues in GA implementation. Particle Swarm Optimization: Fundamentalprinciple, Velocity Updating, Advanced operators, Parameter selection. Simulated annealingalgorithm, Tabu search algorithm, Ant colony optimization, Bacteria Foraging optimization.Multi objective optimization: Weighted and constrained methods, Multi level optimization,Concept of pareto optimality. Lab Practice: simulationbased experiments /Case studies inpath planning, Trajectory optimization, Drive Control and so on.

TEXT BOOKS/ REFERENCES:

1. *D. P. Kothari and J. S. Dhillon, "Power System Optimization", 2ndEdition, PHIlearning private limited, 2010.*
2. *Kalyanmoy Deb, "Multi objective optimization using Evolutionary Algorithms", JohnWiley and Sons, 2008.*
3. *Kalyanmoy Deb, "Optimization for Engineering Design", Prentice hall of India firstedition, 1988.*
4. *Carlos A. CoelloCoello, Gary B. Lamont, David A. Van Veldhuizen, "EvolutionaryAlgorithms for solving Multi Objective Problems", 2nd Edition, Springer, 2007.*
5. *Kwang Y. Lee, Mohammed A. E L Sharkawi, "Modern heuristic optimizationtechniques", John Wiley and Sons, 2008.*

19EM713   GUIDANCE AND CONTROL OF AUTONOMOUS SYSTEMS3-0-0-3

Introduction to the concepts of navigation, guidance and control. General principles of earlyconventional navigation systems, Geometric concepts of navigation, Reference frames.Inertial navigation: Gyros and Accelerometers, Inertial platforms: stabilised platforms,gimballed and strap down INS. Stabilization and Control of spacecrafts, Missile controlsystems and Autopilots, Launch vehicle flight control systems. Longitudinal and lateralautopilots for aircraft, Radar systems, Command and Homing guidance systems.Introduction to Manipulators and Mobile Robots: Direct Kinematics, Co-Ordinate Frames,Rotations, Homogeneous Coordinates, the Arm Equation. Kinematic Navigation andGuidance of Mobile Robots: Path Planning, Single Axis PID Control, PD Gravity Control,Computed Torque Control, Variable Structure Control, Impedance Control.

TEXT BOOKS/ REFERENCES:

1. *Marshall H Kaplan, "Modern Spacecrafts Dynamics and Control", John Wiley &Sons, 1976*
2. *Edward V B Stearns, "Navigation and Guidance in Space", Prentice-Hall Inc*
3. *John J. Craig, "Introduction to Robotics Mechanics and Control"',PearsonEducation Asia. 2009*

4. *AshitavaGhosal, "Robotics Fundamental Concepts and Analysis", OxfordUniversity Press. 2006*

19EM714   **BIOMEDICAL INSTRUMENTATION3-0-0-3**

Basics of biomedical instrumentation: Terminology, medical measurements, constraints,Classification of biomedical instruments. Introduction to biological system modelling:electrical and ionic properties of cellular membranes, sources and theories of bioelectricpotentials. Biomedical Transducers: types of transducers used in bio-instrumentation.Recording electrodes: electrodes theory, biopotential Electrodes, biochemical electrodesBiomedical signal measurement Basics: Bio amplifiers, Measurement of Ph, Oxygen andTherapeutic and prosthetic devices: cardiac pacemakers, defibrillators, hemodynamic &haemodialysis, ventilators, infant incubators, surgical instruments. Therapeutic Applicationsof Laser. Cardiovascular measurements: blood flow, pressure, cardiac output and impedancemeasurements, plethysmography. Measurement of heart sounds: introduction toElectrocardiography (ECG), elements of intensive care. Monitoring: heartrate Monitors,Arrhythmia Monitors. EEG & EMG: anatomy and functions of brain, bioelectric potentialsfrom brain, resting rhythms, clinical EEG. Instrumentation techniques ofElectroencephalography, Electromyography. Medical imaging systems: radiography, MRI,Computed Tomography, Ultrasonography. Non-invasive Instrumentation: t measurements,principles of Ultrasonic measurements, ultrasonic and its applications in medicine.Biotelemetry: introduction to biotelemetry, physiological parameters adaptable tobiotelemetry, biotelemetry system components, implantable units and applications oftelemetry in patient care. Lab Practice: Simulation Experiments in EEG, ECG, EMG,Defibrillator,Pacemaker and so on.

TEXTBOOKS/ REFERENCES:

1. *L.A.Geddes and L.E. Baker,"Principles of Biomedical Instrumentation",2nd edition,John Wiley & Sons Inc., 1989.*
2. *L.Cromwell, "Biomedical Instrumentation and Measurements", 2nd edition, PrenticeHall, 1980.*
3. *John G.Webster (Ed.), "Medical Instrumentation – Application and Design", 4th Edition, John Wiley & Sons Inc., 2009.*
4. *R. S. Khandpur, "Handbook of Biomedical Instrumentation",3rdedition, TataMcGraw Hill, New Delhi, 2014.*

19EM715   SMART ELECTRICAL NETWORKS AND INTELLIGENT

COMMUNICATIONSYSTEMS 3-0-0-3

Data communication, Communication channels: Wireless and Wired communication.Layered architecture and protocols: ISO/OSI, TCP/IP models. Communication technologies:IEEE 802, Multi- protocol label switching, Power line communication. Protocols andstandards for information exchange-Standards for smart metering, Modbus, DNP3 , IEC61850, Ethernet, Power line carrier communication, CAN Bus, I2C, LIN Bus protocol,Modbus protocol structure: Profibus protocol stack, Profibus communication model,Bluetooth, ZigBee, IEEE 801.11-a,b,g,n, Z-Wave, Cellular networks, WiMAX .Sensingmeasurement control and automation technologies. Communications infrastructure andprotocols for smart metering: Home area network, Neighbourhood area network, Dataconcentrator, Meter data

management system. Demand side integration, Services providedby DSI, Hardware support to DSI implementations, system support. Distribution automationequipment: Substation automation, IED, Remote terminal units. Distribution managementsystems, SCADA, Modelling and analysis tools. Application: System monitoring, operationand management, Interactions in autonomy-stability, Inference and predictions, hierarchicalcontrol, decentralized control, swarm robotics. Networked control systems: Time driven,Event driven feedback schemes.

TEXT BOOKS / REFERENCES:

1. *J. Ekanayake, et al, "SMART GRID, Technology and Applications", Wiley, 2012.*
2. *Bernard Sklar., "Digital Communications", Second Edition, Pearson Education, 2001.*
3. *John G. Proakis., "Digital Communication", Fourth Edition, McGraw HillPublication,2001.*
4. *Theodore S. Rappaport., "Wireless Communications", Second edition, PearsonEducation, 2002.*
5. *Stephen G. Wilson, "Digital Modulation and Coding", First Indian Reprint PearsonEducation,2003.*
6. *Clint Smith. P.E., and Daniel Collins, "3G Wireless Networks", Second Edition, TataMcGraw Hill, 2007.*
7. *Vijay. K. Garg, "Wireless Communication and Networking", Morgan KaufmannPublishers, http://books.elsevier.com/9780123735805:,2007.*
8. *KavethPahlavan. K. and Prashanth Krishnamurthy, "Principles of WirelessNetworks", Prentice Hall of India, 2006.*
9. *LubomirBakule, "Decentralized control: An overview" Annual Reviews in Control,vol.32, pp. 87-98, 2008.*
10. *SokratisKartakis, Anqi Fu, Manuel Mazo, Julie A. McCann, "Communication Schemesfor Centralized and Decentralized Event-Triggered Control Systems" IEEE*
11. *Transactions on Control Systems Technology, pp. 1-14, 2017.*

19EM716   VARIABLE STRUCTURE AND SLIDING MODE CONTROL3-0-0-3

Notion of variable structure systems and sliding mode control, Existence conditions ofsliding mode, sliding surface, Design of continuous sliding mode control, chatteringreduction methods, Discrete sliding mode control, sliding mode observer, uncertaintyestimation using sliding mode, Discrete output feedback SMC using multiratesampling,Introduction to higher order sliding mode control, twisting and super twisting algorithms.Lab Practice: Simulation experiments in sliding mode control, continuous sliding modecontrol and so on.

TEXTBOOKS/ REFERENCES:

1. *Spurgeaon and Edwards, "Sliding Mode Control Theory and Applications"Taylor&Francis, 1998.*
2. *B. Bandyopadhyay and S. Janardhanan,"Discrete-time Sliding Mode Control : AMultirateOutput Feedback Approach", Ser. Lecture Notes in Control andInformation Sciences, Vol. 323, Springer-Verlag, Oct. 2005.*
3. *Yuri Shtessel, Christopher Edwards, Leonid Fridman,Arie Levant "Sliding ModeControl and Observation", Birkhauser, 2013.*

4. S. Kurode, B. Bandyopadhyay and P.S. Gandhi, "Output feedback Control for Sloshfree Motion using Sliding modes", Lambert Publications 2012.

19EM717   **CLOUD COMPUTING   3-0-0-3**

The Cloud -Hype cycle-metaphorical interpretation-cloud architecture standards and interoperability- Cloud types; IaaS, PaaS, SaaS. Benefits and challenges of cloud computing, public, private clouds community cloud, role of virtualization in enabling the cloud. Requirement analysis: strategic alignment and architecture development cycle-strategic impact-Risk impact-financial impact-Business criteria technical criteria-cloud opportunities – evaluation criteria and weight-End to end design-content delivery networks-capacity planning-security architecture and design, Development environments for service development; Amazon, Azure, Google App-cloud platform in industry. Web Application Design- Machine Image Design-privacy design –Database management. Workload distribution architecture-Dynamic scalability-Cloud burstinghypervisor clustering-service quality metrics & SLA.

TEXTBOOKS/ REFERENCES:

1. Reese, G. "Cloud Application Architectures: Building Applications and Infrastructure in the Cloud." O'Reilly Media, Inc. (2009).
2. John Rhoton,Cloud Computing Explained: Handbook for Enterprise Implementation 2013 edition, 2013, recursive press
3. RajkumarBuyya, Christian Vecchiola, S.ThamaraiSelvi, "Mastering Cloud Computing: Foundations and Applications",Elsevier publication, 2013
4. Thomas Erl, ZaighamMahmood, and Ricardo Puttini "Cloud Computing Concepts, Technology & Architecture," Prentice Hall, 2013

19EM718   **CYBER PHYSICAL SYSTEMS3-0-0-3**

Cyber-Physical Systems (CPS) in the real world , Basic principles of design and validationof CPS, CPS HW platforms : Processors, Sensors, Actuators , CPS Network, CPS Sw stackRTOS , Scheduling Real Time control tasks, Principles of Automated Control Design :Dynamical Systems and Stability , Controller Design Techniques, Stability Analysis: CLFs,MLFs, stability under slow switching , Performance under Packet drop and Noise, CPS:From features to software components, Mapping software components to ECUs, CPSPerformance Analysis: effect of scheduling, bus latency, sense and actuation faults oncontrol performance, network congestion, Formal Methods for Safety Assurance of Cyber-Physical Systems: Advanced Automata based modelling and analysis: Basic introductionand examples ,Timed and Hybrid Automata, Definition of trajectories, zenoness, FormalAnalysis: Flow pipe construction, reachability analysis, Analysis of CPS Software, WeakestPre-conditions, Bounded Model checking, Hybrid Automata Modeling : Flowpipeconstruction using Flowstar, SpaceX and Phaver tools, CPS SW Verification: Frama-C,CBMC, Secure Deployment of CPS : Attack models, Secure Task mapping and Partitioning,State estimation for attack detection, Automotive Case study : Vehicle ABS hacking, PowerDistribution Case study : Attacks on Smartgrid.

TEXTBOOKS/ REFERENCES:

1. *E. A. Lee and S. A. Seshia, "Introduction to Embedded Systems: A Cyber-PhysicalSystems Approach", 2011.*
2. *R. Alur, "Principles of Cyber-Physical Systems," MIT Press, 2015.*
3. *T. D. Lewis "Network Science: Theory and Applications", Wiley, 2009.*
4. *P. Tabuada, "Verification and control of hybrid systems: a symbolic approach",Springer-Verlag 2009.*
5. *C. Cassandras, S. Lafortune, "Introduction to Discrete Event Systems", Springer 2007.*
6. *Constance Heitmeyer and Dino Mandrioli, "Formal methods for real-time computing",Wiley publisher, 1996.*

19EM719   AUTOMOTIVE CONTROL SYSTEM DESIGN 3-0-0-3

Automotive Systems Overview: Automotive Vehicle Technology, Overview of Vehicle Categories, Various Vehicle Sub Systems.Future Trends in Automotive Embedded Systems: Hybrid Vehicles, Electric Vehicles. Automotive Sensory System:Automotive Sensors and Transducers: Proximity Distance Sensors, Engine Speed sensor, Throttle Position Sensor, Pressure Sensors, Knock Sensor & Mass Flow Sensor. Automotive Control System Design : Digital Engine Control, Features, Control Modes for Fuel Control, Discrete Time Idle Speed Control, EGR Control, Variable Valve Timing Control, Electronic Ignition Control, Integrated Engine Control System, Summary of Control Modes, Cruise Control System, adaptive cruise control, Cruise Control Electronics, Anti-locking Braking System, Electronic Suspension System, Electronic Steering Control, Four-Wheel Steering, drive by wire system, ESP, Traction Control System, Active Suspension System, HVAC, vehicle immobilization and deactivation system, parking system, body electronics and central locking system. Automotive Protocols: LIN, CAN, FlexRay, Test, Calibration and Diagnostics tools for networking of electronic systems like ECU Software and Testing Tools, ECU Calibration Tools, AUTOSAR Architecture. Trends in Automotive Electronics: Intelligent Transportation System, V2V, V2I communication, Vehicle Network Simulation, autonomous vehicles architecture, control methods in autonomous vehicle navigation, vehicle platoon.

TEXT BOOKS/ REFERENCES:

1. *William B. Ribbens, "Understanding Automotive Electronics-An Engineering Perspective", Seventh edition, Butterworth-Heinemann Publications.*
2. *Ronald K. Jurgen, "Automotive Electronics Handbook", Mc -Graw Hill.*
3. *Kiencke, Uwe, Nielsen&Lars, "Automotive Control Systems for Engine, Drivelineand Vehicle", Second edition, Springer Publication.*
4. *Tao Zhang, Luca Delgrossi, "Vehicle Safety Communications: Protocols, Securityand Privacy", Wiley Publication.*
5. *Robert Bosch," Automotive Hand Book", Fifth edition, SAE Publications.*

19EM720   BIOLOGICAL CONTROL SYSTEMS3-0-0-3

Biological Control Systems Analysis. Comparison of Engineering and Biological ControlSystem. Mathematical modelling of Biological (Physiological) Systems: Transfer functionand State-Space Analysis, Computer Analysis and Simulation. Static Analysis of BiologicalSystems: Regulation of Cardiac Output, Regulation of Glucose, Chemical

Regulation ofVentilation. Time-Domain Analysis: Linearized Respiratory Mechanics, Dynamics ofNeuromuscular Reflex Motion. Frequency-Domain Analysis of Biological systems:Frequency Response of a Model of Circulatory Control, Frequency Response of Glucose-Insulin Regulation. Stability Analysis: Stability Analysis of the Pupillary Light ReflexModel of Cheyne-Stokes Breathing. Identification of Biological Control Systems:Identification of Closed-Loop Systems, Case studies. Optimization in Biological Control:Adaptive Control of Biological Variables. Nonlinear Analysis of Biological ControlSystems: Models of Neuronal Dynamics

TEXT BOOKS/ REFERENCES:

1. *Michael C.K. Khoo, "Physiological Control Systems: Analysis, Simulation andEstimation". John Wiley & Sons, Inc., 2012.*
2. *Schlick, T., " Molecular Modeling and Simulation: An Interdisciplinary Guide". NewYork, NY: Springer, 2002.*
3. *Katsuhiko Ogata, "Modern Control Engineering", Prentice Hall of India Pvt. Ltd.,New Delhi, 2010.*
4. *Barry R. Dworkin, "Learning and Physiological Regulation (Hardcover)",Universityof Chicago Press, March 1993.*
5. *E. Carson, E. Salzsieder, "Modelling and Control in Biomedical Systems ", 2000(including Biological Systems) (IFAC Proceedings Volumes) (Paperback),Pergamon Publishing.*

19EM721　　　　　NONLINEAR SYSTEM ANALYSIS AND CONTROL 3-0-0-3

Introduction to nonlinear and time-varying systems. Mathematical background: norms, Lipschitz continuity, Lp norms for signals and Lp spaces, induced norms for systems. Existence and uniqueness of solutions to nonlinear differential equations. Linearization through Taylors series, Hartman-Grobmann Theorem. Characteristics of nonlinear systems. Second order systems, Phase plane techniques, Poincare-Bendixson Theorem, periodic orbits, stability of periodic solutions, slow and fast manifolds. Input-output analysis and stability-Small gain theorem, passivity, describing functions. Stability of nonlinear systems: Lyapunov stability, local linearization and stability in the small, direct method of Lyapunov, La Salles's invariance principle and singular perturbation. Lyapunov function for linear and nonlinear systems, variable gradient method, centre manifold theorem, input-output stability, stability of state models, L2 stability. Lyapunov based design, back stepping, sliding mode control, Analysis of feedback systems, circle criterion, Popov criterion, simultaneous Lyapunov functions. Feedback linearization, input state linearization, input output linearization, full state linearization, harmonic linearization, filter hypothesis, stabilization, regulation via integral control, tracking. Gain scheduling. Zero dynamics, MIMO systems, non-minimum phase systems, singularities. Introduction to variable structure control. Laboratory Practice: Simulation / hardware experiments in controller design, linearization, tracking and so on.

TEXT BOOKS/ REFERENCES:

1. *Hassan K Khalil, "Nonlinear Systems", Prentice – Hall PTR, 2013.*
2. *Jean-Jacques Slotine, Weiping Li, "Applied Nonlinear Control", Prentice Hall, 2005*
3. *S. Sastry, "Nonlinear Systems: Analysis, Stability, and Control", Springer 2013*
A. *Isidori, "Nonlinear Control Systems", Springer, 2013.*
4. *K. Ogata, "System Dynamics", Pearson, 2006.*

5. Stephen Wiggins, "Introduction to Applied Nonlinear Dynamical Systems and Chaos", Springer, 2013.
6. H. Nijmeijer, A. J. Van der Schaft, "Nonlinear Dynamic Control Systems", Springer 2013.
7. M.Vidyasagar, "Nonlinear System Analysis", Prentice – Hall PTR, second edition 2002.

19EM722 **ADVANCED DIGITAL SIGNAL PROCESSING** **3-0-0-3**

Discrete and random signal processing: Wide sense stationary process – Ergodic process – Mean – Variance - Auto-correlation and Autocorrelation matrix - Properties - Weiner Khitchine relation - Power spectral density – filtering random process, Spectral Factorization Theorem–Finite Data records, Simulation of uniformly distributed/Gaussian distributed white noise – Simulation of Sine wave mixed with Additive White Gaussian Noise. Spectrum Estimation: Bias and Consistency of estimators - Non-Parametric methods - Correlation method - Co-variance estimator - Performance analysis of estimators – Unbiased consistent estimators - Periodogram estimator - Barlett spectrum estimation - Welch estimation. Linear Estimation and Prediction Model based approach - AR, MA, ARMA Signal modeling - Parameter estimation using Yule-Walker method - Maximum likelihood criterion - Efficiency of estimator - Least mean squared error criterion – Wiener filter - Discrete Wiener Hoff equations – Mean square error. Adaptive filters: Recursive estimators - Kalman filter - Linear prediction – Forward prediction and Backward prediction, Prediction error - Whitening filter, Inverse filter - Levinson recursion, Lattice realization, Levinson recursion algorithm for solving Toeplitz system of equations. Mutltirate DSP: FIR Adaptive filters - Newton's steepest descent method - Adaptive filters based on steepest descent method - Widrow Hoff LMS Adaptive algorithm - Adaptive channel equalization - Adaptive echo canceller - Adaptive noise cancellation - RLS Adaptive filters - Exponentially weighted RLS – Sliding window RLS - Simplified IIR LMS Adaptive filter.

TEXT BOOKS/ REFERENCES

1. Proakis J G and Manolakis DG Digital Signal Processing Principles, Algorithms and Application, PHI.
2. Openheim AV & Schafer RW, Discrete Time Signal Processing PHI.
3. Samuel D Stearns, "Digital Signal Processing with examples in MATLAB," CRC Press.
4. ES Gopi. "Algorithm collections for Digital Signal Processing Applications using Matlab," Springer.
5. TaanS.Elali, "Discrete Systems and Digital Signal Processing with MATLAB" CRC Press,2005

19EM723 **ROBOTICS FOR INDUSTRIAL AUTOMATION** **3-0-0-3**

Prerequisite: Mathematics -Vector Algebra, Introduction: Automation   and   Robotics, Historical Development, Definitions, Basic Structure of Robots, Robot   Anatomy, Classification of Robots, Fundamentals about Robot Technology, Factors related to   use Robots, Robot Performance, Basic Robot Configuration. Kinematics of Robot Manipulator: Introduction, General Mathematical Preliminaries on Vectors & Matrices, Direct Kinematics problem, Geometry Based Direct kinematics problem, Robotic Manipulator Joint Co-ordinate System, Euler Angle & Euler Transformations, Roll Pitch-Yaw (RPY) Transformation. DH

Representation & Displacement Matrices for Standard Configurations, Jacobian Transformation in Robotic Manipulation. Dynamics of Robotic Manipulators: Introduction, Preliminary Definitions, Generalized Robotic Coordinates, Jacobian for a Two link Manipulator, Euler Equations, Lagrangian Equations of motion. Application of Lagrange–Euler (LE) for Dynamic Modeling of Robotic Manipulators.

TEXT BOOKS/REFERENCES:

1. *Robotics, control vision and intelligence-Fu, Lee and Gonzalez. McGraw Hill International, 2nd edition, 2007.*
2. *Introduction to Robotics- John J. Craig, Addison Wesley Publishing, 3rd edition, 2010. Robotics for Engineers -YoramKoren, McGraw Hill International, 1st edition, 1985.*
3. *Industrial Robotics-Groover, Weiss, Nagel, McGraw Hill International, 2nd edition, 2012.*
4. *Robotic Engineering - An Integrated approach, Klafter, Chmielewski and Negin, PHI, 1st edition, 2009.*

19EM724   ARTIFICIAL INTELLIGENCE IN AUTOMATION 3-0-0-3

Artificial Intelligence: Foundations of Artificial Intelligence, History of Artificial Intelligence, Intelligent Agents: Agents and Environments, Problem-solving: Problem-Solving Agents. Informed (Heuristic) Search Strategies, Greedy best-first search, A* search, Heuristic Functions, The effect of heuristic accuracy on performance; Classical Search: Local Search Algorithms and Optimization Problems, Hill climbing search, Simulated annealing, Local beam search, Genetic algorithms, Local Search in Continuous Spaces, Searching with Nondeterministic Actions, Searching with Partial Observations, Online Search Agents and Unknown Environments. Knowledge Representation: Ontological Engineering, Categories and Objects, Events, Mental Events and Mental Objects, Reasoning Systems for Categories, Semantic networks, Description logics, Reasoning with Default Information, Truth maintenance systems, Uncertain knowledge and reasoning: Basic Probability Notation, Inference Using Full Joint Distributions, Bayes' Rule and Its Use, Probabilistic Reasoning, Representing Knowledge in an Uncertain Domain, Probabilistic Reasoning over Time: Hidden Markov Models, Kalman Filters, Dynamic Bayesian Networks, Keeping Track of Many Objects, Combining Beliefs and Desires under Uncertainty, Basis of Utility Theory, Utility Functions, Multi attribute Utility Functions, Decision Networks, The Value of Information. Expert system architecture.

TEXT BOOKS/ REFERENCES:

1. *Artificial Intelligence: A Modern Approach by Stuart Russell and Peter Nowig, PEARSON 3rd ed.*
2. *A Guide to Expert Systems - Donald A Waterman, Addison Wesley,2nd edition,1986.*
3. *Introduction to Artificial Intelligence and Expert Systems – DAN.W.Patterson, PHI, 2nd edition, 2009.*
4. *Artificial Intelligence- George.F.Luger, Pearson Education, Asia, 3rd Edition,2009.*
5. *Artificial Intelligence: An Engineering Approach- Robert J. Schalkeff, PHI, Second edition, 1990.*