M. TECH. – CONTROL AND INSTRUMENTATION ENGINEERING

Department of Electrical and Electronics Engineering

Control and Instrumentation has wide range of applications starting from day to day life to space exploration. In today's information age, many businesses are placing increasing demands on real time accessibility in order to improve business planning and decision making, and to access information that can demonstrate their economic and environmental performance. Rapid advancement in technologies also provides challenges as businesses need assurance that their control system investments will deliver efficient operational performance of their plants and economic returns, with minimal risk of technological obsolescence. Hence control and instrumentation systems not only play important roles in plant operation, but also in reducing the cost of production while maintaining and/or enhancing safety. Therefore, it is extremely important that control and instrumentation systems are managed efficiently and economically. With the increasing use of digital technologies, new methods are needed to solve problems associated with various aspects of digital control systems.

M. Tech. program in Control and Instrumentation Engineering is intended to explore the above mentioned challenges and also initiate research activities. This program provides necessary theoretical background with a good blend of applied mathematics along with in-depth coverage in analysis of various control and instrumentation systems. The core courses include automatic, economic, efficient and reliable control and instrumentation with a wide range of electives in robotics, flight dynamics, electric drives, power system, micro controllers etc.

CURRICULUM

First Semester

Course Code	Type	Course	L - T - P	Credits
16MA607	FC	Numerical Methods and Optimization	4 - 0 - 0	4
16CI611	FC	Linear Control Systems	3 - 1 - 0	4
16CI612	FC	Digital Signal Processors	3 - 0 - 1	4
16CI621	SC	Instrumentation Systems	3 - 0 - 0	3
16CI622	SC	Digital Control Systems	3 - 0 - 0	3
16CI625	SC	Control and Instrumentation Laboratory I	0 - 0 - 1	1
16HU601	HU	Cultural Education*		P/F
			Credits	19

***** Non-credit course

Second Semester

Course Code	Type	Course	L – T - P	Credits
16CI613	FC	Optimal and Adaptive Control	3 – 1 – 0	4
16CI623	SC	Nonlinear System Analysis	3 – 1 – 0	4
16CI624	SC	Process Control and Instrumentation	3 – 0 – 0	3
	E	Elective – I	3 – 0 – 0	3
	E	Elective – II	3 – 0 – 0	3
16CI626	SC	Control and Instrumentation Laboratory II	0 – 0 – 1	1
16CI601	FC	Open Laboratory	0 – 0 – 1	1
16EN600	HU	Technical Writing*		P/F
			Credits	19

* Non-credit course

Third Semester

Course Code	Type	Course	L - T - P	Credits
	E	Elective – III	3 - 0 - 0	3
	E	Elective – IV - Open Elective*	3 - 0 - 0	3
16CI798	P	Dissertation		6
			Credits	12

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

Fourth Semester

Course Code	Type	Course	L - T - P	Credits
16CI799	P	Dissertation		16
			Credits	16

Total Credits: 66

LIST OF COURSES

Foundation Core

Course Code	Course	L - T - P	Credit
16MA607	Numerical Methods and Optimization	4 - 0 - 0	4
16CI611	Linear Control Systems	3 - 1 - 0	4
16CI612	Digital Signal Processors	3 - 0 - 1	4
16CI613	Optimal and Adaptive Control	3 - 1 - 0	4
16CI601	Open Laboratory	0 - 0 - 1	1

Subject Core

Course Code	Course	L - T - P	Credit
16CI621	Instrumentation Systems	3 - 0 - 0	3
16CI622	Digital Control Systems	3 - 0 - 0	3
16CI623	Nonlinear System Analysis	3 - 1 - 0	4
16CI624	Process Control and Instrumentation	3 -0- 0	3
16CI625	Control and Instrumentation Laboratory I	0 - 0 – 1	1
16CI626	Control and Instrumentation Laboratory II	0 - 0 - 1	1

Electives

Course Code		L - T - P	Credit
Elective I			
16CI710	Introduction to Flight	3 - 0 - 0	3
16CI711	Smart Grid	3 - 0 - 0	3
16CI712	Intelligent Control	3 - 0 - 0	3
16CI713	Virtual Instrumentation	2 - 0 - 1	3

Elective II

16CI720	Robotics Control	3 - 0 - 0	3
16CI721	System Identification and Parameter Estimation	3 - 0 - 0	3
16CI722	Modeling and Simulation	2 - 0 - 1	3
16CI723	Power Plant Instrumentation	3 - 0 - 0	3
Elective III			
16CI730	Intelligent Communication Systems	3 - 0 - 0	3
16CI731	Flight Dynamics and Control	3 - 0 - 0	3
16CI732	Operation and Control of Power Systems	3 - 0 - 0	3
16CI733	Biomedical Instrumentation	3 - 0 - 0	3
Elective IV*			
16CI740	Electrical Drives and Control	3 - 0 - 0	3
16CI741	Control of Power Converters	3 - 0 - 0	3
16CI742	Robust Control	3 - 0 - 0	3
16CI743	Embedded Control Systems	3 - 0 - 0	3

Project Work

Course Code	Course	L - T - P	Credit
16CI798	Dissertation		6
16CI799	Dissertation		16

16MA607 NUMERICAL METHODS AND OPTIMIZATION 4 - 0 - 0 - 4

Solution of equations and eigen value problems: linear interpolation methods, method of false position, Newton's method, statement of fixed point theorem, fixed point iteration, solution of linear system by Gaussian elimination, Gauss-Jordon methods and iterative methods, inverse of a matrix by Gauss Jordon method, eigen value of a matrix by power method. Initial value problems for ordinary differential equations: single step methods, Taylor series method, Euler and modified Euler methods, fourth order Runge - Kutta method for solving first and second order equations. Multistep methods: Milne's and Adam's predictor and corrector methods. Linear programming: formulation, graphical and simplex methods, Big-M method, two phase method, dual simplex method, primal dual problems. Unconstrained one dimensional optimization techniques: necessary and sufficient conditions. Unrestricted search methods: Fibonacci and golden section method, quadratic interpolation methods, cubic interpolation and direct root methods. Unconstrained n- dimensional optimization techniques: direct search methods, random search, pattern search and Rosen Brooch's hill claiming method, descent methods, steepest descent, conjugate gradient, quasi-Newton method. Constrained optimization techniques: necessary and sufficient conditions, equality and inequality constraints, Kuhn-Tucker conditions, gradient projection method, cutting plane method, penalty function method. Dynamic programming, principle of optimality, recursive equation approach, application to shortest route, cargo-loading, allocation and production schedule problems.

TEXT BOOKS/ REFERENCES:

1. S. S. Rao, "Energy Optimisation Theory and Practice", John Wiley and Sons, 2009.
2. Taha H. A., "Operations Research – An Introduction", Eighth Edition, Prentice Hall of India, 2008.
3. Gerald C. F. and Wheatley P. O, "Applied Numerical Analysis", Sixth Edition, Pearson Education Asia, New Delhi, 2002.
4. Balagurusamy. E., "Numerical Methods", Tata McGraw-Hill, New Delhi, 2000.
5. Kandasamy. P., Thilagavathy K. and Gunavathy K., "Numerical Methods", S.Chand Co. Ltd., New Delhi, 2003.
6. Burden R. L. and Faires T. D., "Numerical Analysis", Seventh Edition, Thomson Asia Pvt. Ltd., Singapore, 2002.
7. Fox R. L., "Optimization Methods for Engineering Design", Addition Wesley, 1971.

16CI611 LINEAR CONTROL SYSTEMS 3 - 1 - 0 - 4

Overview: Linear and nonlinear control system. Introduction to control system design. Time domain and frequency domain techniques: Lag, lead, lag-lead compensators. Concept of state: State variables of a dynamic system, state differential equation. State space representation of multivariable systems: Phase variable form, canonical forms. State equation from transfer function, diagonalization. State transition matrix: Forced response, methods for evaluation of state transition matrix (STM), power series method, Cayley-Hamilton theorem, Stability based on Eigen values. 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.

TEXT BOOKS/ REFERENCES:

1. M. Gopal, "Modern Control System Theory", Third Edition, New Age International, 2014.
2. Norman S. Nise, "Control Systems Engineering", John Wiley and Sons PTE Ltd, 2013.
3. Katsuhiko Ogata, "Modern Control Engineering", Prentice Hall of India Pvt. Ltd., New Delhi, 2010.
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",Prentice- Hall,1980.

16CI612 DIGITAL SIGNAL PROCESSORS 3 - 0 – 1- 4

Introduction to microcontrollers: Role of microcontrollers and its comparison with microprocessors. Embedded systems and their characteristics, overview of available microcontrollers. PIC16F877A: Architecture, file registers, memory organization, interrupts, electrical characteristics. MPLAB IDE, ADC. AVR/ATMEGA: Introduction, architecture, specifications, ARDIUNO IDE. Signal generation: PWM, SPWM and servo signals. Filtering algorithms. Control Algorithms: P, PI. dSPIC: Introduction, signal analysis-DFT and filtering algorithms.

Practice sessions: LCD display, Interfacing power electronic switches, design of optical encoders, servo motors, voltage and current measurement techniques, wireless communication -Xbee radio modules.

TEXTBOOKS/ REFERENCES:

1. PICmicro^{TM} Mid-Range MCU Family Reference Manual,1997 Microchip Technology Inc., December 1997 /DS33023A.
2. Atmel-8271J-AVR- ATmega-Datasheet_11/2015.
3. PICmicro^{TM} PIC16F87XA Data Sheet 28/40/44-Pin Enhanced Flash Microcontrollers, 2003 Microchip Technology Inc., DS39582B.
4. dsPIC30F Family Reference Manual, 2006 Microchip Technology Inc., DS70046E.
5. Richard C Dorf, "The Engineering Handbook", Second Edition, CRC Press, 2005.
6. Katsuhiko Ogata, "Discrete-time Control Systems", Second Edition, Prentice Hall International Editions, 1995.

16CI621 INSTRUMENTATION SYSTEMS 3 - 0 - 0 - 3

General concepts of measurement systems: Transfer function, error, resolution, output impedance, excitation, dynamic characteristics, and reliability. Transducers: Classifications, working principle, construction and design of various active and passive transducers. Voltage and current transducers, tap position transducers, Hall effect transducers and optical transducers. Semiconductor traducers for physical and chemical parameter measurements. Sensors and Actuators: Temperature sensor, displacement sensors, pressure sensors, flow sensors and actuators. Principles of data acquisition and interfacing: sampling concepts, D/A converter, A/D converters, data acquisition configurations, applications and signal conditioning. Design of detection electronics and signal conditioning circuits for various resistive, capacitive and inductive transducers. Active filters, impedance matching, loading effect. Introduction to electromagnetic coupling, interference coupling, shielding. Applications, Computer aided control and case study.

TEXT BOOKS/ REFERENCES:

1. Ernest O. Doebelin, "Measurement Systems Application and Design", McGraw Hill International Editions, 2006.
2. Jacob Fraden, "Hand book of Modern Sensors: Physics, Design and Applications, Publication by Springer.
3. John P. Bentley, "Principle of Measurement Systems", Third Edition, Addition Wesley Longman Ltd.
4. Sanjit K. Mitra, "Digital Signal Processing", Fourth Edition, English-Tata McGraw Hill Education Private Limited, 2013.

16CI622 DIGITAL CONTROL SYSTEMS 3 - 0 - 0 - 3

Review of Z-transforms. Pulse transfer function. Digital control system: sampling, quantization, data reconstruction and filtering of sampled signals. 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. 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.

TEXT BOOKS/ REFERENCES:

1. Gene F. Franklin, J. David Powell and Michael Workman, "Digital Control of Dynamic Systems", Pearson, 2000.
2. IoanDoré Landau and GianlucaZito, "Digital Control Systems: Design, Identification and Implementation", Springer, 2006.
3. K. Ogata, "Discrete-Time Control Systems", Pearson Education, 2011.
4. M. Sami Fadali and Antonio Visioli, "Digital Control Engineering: Analysis and Design", Elsevier, 2013.
5. M. Gopal, "Digital Control and State Variable Methods", Tata McGraw-Hill, 2006.
6. C. L. Philips, Troy Nagle and Aranya Chakrabortty, "Digital Control System Analysis and Design", Prentice-Hall, 2014.

16CI625 CONTROL AND INSTRUMENTATION LABORATORY I 0 - 0 - 1 - 1

This course includes analysis, modeling, designing and simulation of various control systems carried out in a practical laboratory setup. Topics to be dealt with are transient and steady state analysis of systems, compensator design, study of disturbances and internal model control, PID tuning, simulations with MATLAB, LabView etc.

16CI613 OPTIMAL AND ADAPTIVE CONTROL 3 - 1 - 0 - 4

Optimal control problem: fundamental concepts and theorems of calculus of variations. Euler - Lagrange equation and extremal of functional, the variational approach to solving optimal control problems, Hamiltonian and different boundary conditions for optimal control problem. Linear regulator problem: LQR/LQG controller design, applications to practical systems. Pontryagin's minimum principle, dynamic programming, principle of optimality and its application to optimal control problem, Hamilton-Jacobi-Bellman equation. Adaptive control: Closed loop and open loop adaptive control. Self-tuning controller, parameter estimation using least square and recursive least square techniques, gain scheduling, model reference adaptive systems (MRAS), self-tuning regulators. Adaptive smith predictor control: auto tuning and self-tuning smith predictor. Variable Structure 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. Gang Tao, "Adaptive Control Design and Analysis", John Wiley and Sons, 2003.
4. Hans Butler, "Model Reference Adaptive Control: From Theory to Practice", Prentice Hall, 1992.
5. A.P. Sage, "Optimum Systems Control", Prentice Hall, 1977.
6. M. Krstic, I. Kanellakopoulos and P. V. Kokotovic, "Nonlinear and Adaptive Control Design", Wiley, 1995.
7. Karl J Astrom and Bjorn Wittenmark, "Adaptive Control", Addison –Wesley Series,1995

16CI623 NONLINEAR SYSTEM ANALYSIS 3 - 1 - 0 - 4

Characteristics of nonlinear systems: Describing function: study of limit cycles (amplitude and frequency), study of sub-harmonic oscillations. Phase plane analysis, periodic orbits, stability of periodic solutions, slow and fast manifolds. Stability of nonlinear systems: Lyapunov stability, local linearization and stability in the small, direct method of Lyapunov, Lyapunov function for linear and nonlinear systems, variable gradient method, centre manifold theorem, input output stability, stability of state models, L_2 stability. Lyapunov based design, Robust stabilization: nonlinear damping, back stepping, sliding mode control, adaptive control, harmonic linearization, filter hypothesis. Analysis of feedback systems, circle criterion, Popov criterion, simultaneous Lyapunov functions, feedback linearization, stabilization, regulation via integral control, gain scheduling, input state linearization, input output linearization, integral control. Introduction to robotics control: Mathematical modeling, Variable structure control, Computed torque control.

TEXT BOOKS/ REFERENCES:

1. Hassan K Khalil, "Nonlinear Systems", Prentice – Hall PTR, 2002.
2. Jean-Jacques Slotine, Weiping Li, "Applied Nonlinear Control", Prentice Hall, 1991.
3. K. Ogata, "System Dynamics", Pearson, 2006.
4. A. Isidori, "Nonlinear Control Systems", Springer, 1995.
5. Stephen Wiggins, "Introduction to Applied Nonlinear Dynamical Systems and Chaos", Springer, 2003.
6. H. Nijmeijer and A. J. Van der Schaft, "Nonlinear Dynamic Control Systems", Springer 1990.
7. M.Vidyasagar, "Nonlinear System Analysis", Prentice – Hall PTR, Second Edition 2002.

16CI624 PROCESS CONTROL AND INSTRUMENTATION 3 - 0 - 0 - 3

Process Modeling: hierarchies. Theoretical models: transfer function, state space models, and time series models. Development of empirical models from process data- chemical reactor modeling. Feedback & feed forward control, cascade control, selective control loops, ratio control, feed forward and ratio control. Multi-loop and multivariable control: process interactions, singular value analysis. PID design, tuning, trouble shooting, tuning of multiloop PID control systems. Decoupling control: strategies for reducing control loop interactions. Instrumentation for process monitoring: codes and standards, preparation of P&I diagrams. Model predictive control. Statistical process control, supervisory control, direct digital control, distributed control, PC based automation. Programmable logic controllers: organization, programming aspects, ladder programming, final control elements. SCADA in process automation. Case studies.

TEXT BOOKS/ REFERENCES:

1. Dale E. Seborg, Duncan A. Mellichamp, Thomas F. Edgar and Francis J. Doyle "Process Dynamics and Control", John Wiley and Sons, 2010.
2. Ernest O. Doebelin, "Measurement Systems Application and Design", McGraw Hill International Editions, 2006.
3. Johnson D Curtis, "Process Control Instrumentation Technology", Prentice Hall India, 2013.
4. Bob Connel, "Process Instrumentation Applications Manual", McGraw Hill, 1996.

16CI626 CONTROL AND INSTRUMENTATION LABORATORY II 0 - 0 - 1- 1

This course includes analysis, modeling, designing and testing of various control and instrumentation systems carried out in a practical laboratory setup. Topics to be dealt with are temperature control system, level control system, Programmable Logic Controllers (PLC), motor control. Inverted Pendulum, MATLAB/ LabVIEW interfaced hardware experiments.

16CI601 OPEN LABORATORY 0- 0 - 1 - 1

The student in consultation with the faculty advisor has to select a topic related to control systems and Instrumentation, 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.

16EN600 TECHNICAL WRITING P/F

(Non-credit Course)

Technical terms – Definitions – extended definitions – grammar checks – error detection – punctuation – spelling and number rules – tone and style – pre-writing techniques – Online and offline library resources – citing references – plagiarism – Graphical representation – documentation styles – instruction manuals – information brochures – research papers – proposals – reports (dissertation, project reports etc.)

TEXTBOOKS/REFERENCES:

1. H.L. Hirsch, *Essential Communication Strategies for Scientists, Engineers and Technology Professionals*, Second Edition, New York: IEEE Press, 2002.
2. P.V. Anderson, *Technical Communication: A Reader-Centered Approach*, Sixth Edition, Cengage Learning India Pvt. Ltd., New Delhi, 2008, (Reprint 2010).
3. W.Jr. Strunk and E.B.White, *The Elements of Style*, New York. Alliyan & Bacon, 1999.

16CI710 INTRODUCTION TO FLIGHT 3 - 0 - 0 - 3

Course Objective: To give basic ideas of aerodynamics and principles of flight of aerospace vehicles. Fundamentals of Aerodynamics: aerodynamic variables, definition of standard atmosphere, definition of altitudes, layers of atmosphere, stability of atmosphere, lapse rate, pressure, density and temperature altitudes. Aerodynamic flow: types of flow, inviscid and viscous flow, incompressible and compressible flow, subsonic, transonic, supersonic and hypersonic flow regimes, boundary layer, laminar and turbulent flow, Buckingham PI theorem, aerodynamic forces and moments, Mach number, critical Mach number, drag-divergence Mach number, wind tunnels-open, closed and variable density tunnel, critical shock stall, drag polar, shock polar, numerical problems. Air foils and Generation of Lift **:**Symmetric and cambered air foil, pressure distribution over air foil, air foil nomenclature, NACA aerofoils, modern low speed air foils, chord line, angle of attack, aerodynamic forces-lift, drag, force and moment coefficients: C_l,C_d,and C_m, stalling of aerofoils, characteristics of ideal aerofoil, control surfaces: elevator, aileron, rudder, canard, tail plane, loads on tail plane, dihedral angle, dihedral effect, flaps and slots, spoilers, numerical problems. Classification of aerospace vehicles: aircrafts, helicopters, launch vehicles, missiles, unmanned aerial vehicles and spacecraft. UAV**:** system architecture, coordinate frames kinematics and dynamics, forces and moments.

TEXT BOOKS/ REFERENCES

1. John D Anderson Jr, "Introduction to Flight" Fifth Edition, McGraw Hill International, 2005
2. John D Anderson Jr, "Fundamentals of Aerodynamics", Fourth Edition, McGraw Hill International, 2007.
3. A. C. Kermode, "Mechanics of Flight", Tenth Edition, Pearson Education, 2005.
4. Thomas R. Yechout, 'Introduction to Aircraft Flight Mechanics', A1AA Education Series, 2003
5. Richard S. Shevell, "Fundamentals of Flight", Second Edition, Pearson Education Inc., 2004.

16CI711 SMART GRID 3–0- 0- 3

Review of conventional grid,. EMS/SCADA: Structure and operation. Micro-grids: Need for micro grids, structure of micro grids, AC, DC and hybrid micro grids Operation & Control: Synchronous and asynchronous operation, load flow control, fault studies. Islanded and grid connected modes of operation. Smart Grids: Need for smart power grid systems, basic concepts, smart grid architectural designs, multi-agent system (MAS) technology. Smart grid components: RTU, phasor measurement units (PMU), smart meters, smart sensors & relays, WAMS, AMI, energy storage systems, HEMS. Smart grid communication: – Power line carrier communication, Wireless communication techniques, Network structures (HAN, LAN, NAN, WAN),GIS, google mapping tools. Smart grid operation and control: Load flow, fault & stability analyses, control strategies. Demand side energy management: demand response, role of smart grid technology in demand response, building automation systems, dynamic energy management system. Renewable Energy integration, HEV integration, smart parks.

TEXT BOOKS / REFERENCES:

1. Ali Keyhani, "Design of Smart Power Grid Renewable Energy Systems", John Wiley and Sons, IEEE Press 2011.
2. James Momoh, "Smart Grid - Fundamentals of Design and Analysis", John Wiley and Sons, IEEE Press 2012.
3. Clark W. and Gellings, P.E., "The Smart Grid: Enabling Energy Efficiency and Demand Response", The Fairmont Press, Taylor and Francis, 2009.
4. Francis Vanek, Louis Albright and Largus Angenent, "Energy Systems Engineering Evaluation and Implementation", McGraw Hill, 2008.
5. Andres Carvello and John Cooper, "The Advanced Smart Grid", ARTECH House, 2011.
6. Prabha Kundur, "Power System Stability and Control", McGraw-Hill Education, 2011.
7. IEEE Power and Energy magazine.

16CI712 INTELLIGENT CONTROL 3 - 0 - 0 - 3

Artificial Neural Network (ANN) based control: introduction to ANN, model reference control, internal model control, predictive control, indirect and direct adaptive controller design using neural network. Fuzzy logic based control: fuzzy controllers, preliminaries, Mamdani and Sugeno inference methods, fuzzy sets in commercial products, basic construction of fuzzy controller, fuzzy PI, PD and PID control, analysis of static properties of fuzzy controller, analysis of dynamic properties of fuzzy controller,. Stability issues in fuzzy control. Direct and indirect and model predictive control schemes using T-S fuzzy model.Neural and fuzzy-neural networks.Simulation studies and case studies. Genetic algorithm: basics of Genetic Algorithms, design issues in Genetic Algorithm, genetic modeling, hybrid approach, GA based fuzzy model identification. Fuzzy logic controlled Genetic Algorithm, neuro-genetic hybrids & fuzzy, Genetic hybrids. Particle Swarm Optimization: concept, algorithm, PSO variations and applications. Ant colony optimization. Evolutionary controller, Learning Control systems, Imitation learning. Mathematical modeling of intelligent robotic systems. Case studies.

TEXT BOOKS/ REFERENCES:

1. Klir G. J. and Folger T. A., "Fuzzy Sets, Uncertainty and Information", Prentice Hall of India, 2006.
2. Bose N. K. and Liang P., "Neural Network Fundamentals with Graphs, Algorithms and 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. Laxmidhar Behera and Indrani Kar, "Intelligent Systems and Control", Oxford University Press, 2009.
8. Recent Publications from Reputed Journals.

16CI713 VIRTUAL INSTRUMENTATION 2 - 0 - 1 – 3

Virtual Instrumentation: review of virtual instrumentation, block diagram and architecture of virtual instrument, conventional instruments versus traditional instruments, data-flow techniques, graphical programming in data flow. Programming techniques (include laboratory practice): VIs and sub-VIs, loops and charts, arrays, clusters and graphs, case and sequence structures, formula nodes, local and global variables, state machine, string and file I/O, instrument drivers, publishing measurement data in the web. Data acquisition: sampling fundamentals, input/output techniques and buses. Modern ADCs, DACs, digital I/O, counters and timers, DMA, software and hardware installation, calibration, resolution, data acquisition interface requirements, issues involved in selection of data acquisition cards, data acquisition cards with serial communication, VI chassis requirements. SCSI, PCI, PXI system controllers, ethernet control of PXI. VI tool sets: use of analysis tools. Application of VI in process control designing of equipments like oscilloscope, digital multimeter, design of digital voltmeters with transducer input virtual laboratory, web based laboratory distributed I/O modules. Application of virtual instrumentation: instrument control, development of process database management system, simulation of systems using VI, development of control system, industrial communication, image acquisition and processing, motion control. Development of virtual instrument using GUI, real-time systems.

TEXT BOOKS/ REFERENCES:

1. Gary Johnson and Richard Jennings, “LabVIEW Graphical Programming”, McGraw Hill Education, 2006.
2. Jeffrey Travis and Jim Kring, “LabVIEW for Everyone”, Prentice Hall, 2007.
3. Kevin James, “PC Interfacing and Data Acquisition: Techniques for Measurement, Instrumentation and Control”, Newnes, 2000.
4. Jovitha Jerome, “Virtual Instrumentation Using LabVIEW”, Prentice Hall, 2010.
5. LabVIEW Core 1 Exercises – Manual from National Instruments.
6. LabVIEW Core 1 Course Manual from National Instruments.

16CI720 ROBOTICS CONTROL 3 - 0 - 0 - 3

Robot arm dynamics and transformation: Newton Euler equations, kinetic and potential energy, Lagrangian analysis for a single prismatic joint working against gravity and single revolute joint. Joint vector, homogeneous co-ordinates. Matrix operators for translation and rotation. Homogeneous transformation matrix. Concept of "Hand Matrix". Effect of pre and post multiplication of a hand matrix by basic matrix operators. Kinematics: Denavit-Hartenberg (D-H) representation of kinematics chains. Rules for establishing link co-ordinate frames. D-H matrix. Forward solution of robotic manipulator. Examples of forward solutions for Stanford and PUMA robots. Inverse Kinematics: inverse (back) solution by i) direct approach, ii) Geometric approach, iii) Geometric approach with co-ordinate transformation and iv) manipulation of symbolic T and A matrices. Robot Control**,** Manipulator Jacobian, Jacobian for prismatic and revolute joint. Jacobian inverse, singularities. Control of robot manipulator: joint position controls (JPC), resolved motion position controls (RMPC) and resolved motion rate control (RMRC).Intelligent Control of Robots. Bio mimetic robots.

TEXT BOOKS/ REFERENCES:

1. Richard D. Klafter, Thomas A. Chemielewski and Michael Neign, “Robotic Engineering – An Integral Approach”, Prentice Hall of India, 2006.
2. R. K. Mittal and I. J. Nagrath, “Robotics and Control”, Tata McGraw-Hill, 2006.
3. John J. Craig, “Introduction to Robotics: Mechanics and Control”, Pearson Education, 2008.
4. Kozlowski and Krzysztof, “Robot Motion and Control”, Springer, 2012.
5. Peter Corke, “Robotics, Vision and Control”, Springer, 2011.

16CI721 SYSTEM IDENTIFICATION AND PARAMETER ESTIMATION 3-0-0-3

Principles of modeling and identification of transfer function, system identification and stochastic modeling, state space models, distributed parameter models, model structures, identifiability of model structures, transfer function from frequency response. Fourier analysis and spectral analysis, pseudo random binary signals, maximum length sequences. Parameter estimation methods: linear regression and least squares methods, recursive methods, RLS algorithm, recursive IV method, recursive prediction error method. Identification of multivariable systems and closed loop systems, reduction of higher order systems aggregation method. Experiment design and choice of identification criterion, optimal input design. Persistently exciting condition, choices of identification criterion, choice of norm – variance, optimal instruments.

TEXT BOOKS/ REFERENCES:

1. James Vere Beck and Kenneth J. Arnold, "Parameter Estimation in Engineering and Science", Springer, 2001.
2. Lennart Ljung, "System Identification Theory for the User", Prentice Hall Inc, 1999.
3. Harold W Sorensen, "Parameter Estimation", Marcel Dekker Inc, New York, 1980.
4. Sinha N K and Kuztsa, "Modeling and Identification of Dynamic Systems", Van Nostrand Reinhold Company, 1983.
5. Thomas Kailath , Ali H. Sayed and Babak Hassibi, "Linear Estimation", Pearson, 2000.

16CI722 MODELING AND SIMULATION 2 - 0 - 1 - 3

Optimal filtering and prediction: estimation of continuous linear systems, continuous Kalman filter, estimation of discrete system, Kalman filter, information filter, extended Kalman filter, extended information filter, unscented Kalman filter, particle filter, decentralized estimation for multi-sensor systems. Simulation languages: simulation using C++/ MATLAB/ LabVIEW-control design tool suit. Case studies (include lab practice) related to process control, automation and power systems.

TEXT BOOKS/ REFERENCES:

1. Richard C. Dorf and Robert H. Bishop, "Modern Control Systems", Pearson, 2011.
2. Averill M. Law and W. David Kelton, "Simulation, Modeling and Analysis", Tata McGraw Hill, 2003.
3. Gottfried B. S., "Elements of Stochastic Process Simulation", Prentice Hall, London, 1984.
4. NarasinghDeo, "System Simulation Using Digital Computer", Prentice Hall of India, 2003.
5. Wayne Bequette W., "Process Control: Modeling, Design and Simulation", Prentice Hall of India, 2003.

16CI723 POWER PLANT INSTRUMENTATION 3 - 0 - 0 - 3

Overview of power generation, various sources of electrical energy, importance of Instrumentation and control in power generation, piping and instrumentation diagrams. Instrumentation and control in water circuit: water circuit, boiler feed water circulation, measurements in water circuit, controls in water circuit, impurities in water and steam. Instrumentation and control in air-fuel circuit: air-fuel circuit, measurements in air fuel circuit, controls in air-fuel circuit, analytical measurements. Turbine monitoring and control-classification of turbines, instrumentation control points of view, principal parts of turbines, turbine steam inlet system, turbine measurements, turbine control system, lubrication for turbo-alternator, turbo alternator cooling system.

TEXT BOOKS/ REFERENCES:

1. K. Krishnaswamy and M. Ponni Bala, "Power Plant Instrumentation", PHI Learning Private limited, New Delhi, 2011.

2. David Lindsley, “Power Plant Control and Instrumentation, The Control of Boilers and HRSG Systems”, IEE Control Engineering Series 2000.
3. Philip Kiameh, “Power Plant Instrumentation and Controls”, McGraw Hill Education, 2014.

16CI730 INTELLIGENT COMMUNICATION SYSTEMS 3 - 0 - 0 - 3

Introduction to communication systems, block diagram description of analog and digital systems, review of Fourier representations, modulation techniques, analog communication mechanisms, amplitude modulation, frequency modulation, phase modulation, frequency spectrum. Digital modulation schemes, ASK, PSK, FSK, QAM, min-PSK, QPSK, MSK, wireless communication schemes, overview on computer networks, wireless networks .Communication protocols and standards, 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. Introduction to Smart Grid based communication: Home area network, wide area network, Neighbourhood area network, Wireless Mesh networks, networking issues in smart grid,recent literatures in the area of smart grid communication.

TEXT BOOKS/ REFERENCES:

1. Bernard Sklar., ‘Digital Communications’, Second Edition, Pearson Education, 2001.
2. John G. Proakis., ‘Digital Communication’, Fourth Edition, McGraw Hill Publication, 2001.
3. Theodore S. Rappaport, ‘Wireless Communications’, Second Edition, Pearson Education, 2002.
4. Stephen G. Wilson., ‘Digital Modulation and Coding’, First Indian Reprint Pearson Education, 2003.
5. Clint Smith. P.E. and Daniel Collins, “3G Wireless Networks”, Second Edition, Tata McGraw Hill, 2007.
6. Vijay. K. Garg, “Wireless Communication and Networking”, Morgan Kaufmann Publishers, http://books.elsevier.com/9780123735805:, 2007.
7. KavethPahlavan. K. And Prashanth Krishnamurthy, "Principles of Wireless Networks", Prentice Hall of India, 2006.
8. William Stallings, "Wireless Communications and Networks" Second Edition, Pearson / Prentice Hall of India, 2007.
9. Dharma Prakash Agrawal and Qing-An Zeng, “Introduction to Wireless and Mobile Systems”, Second Edition, Thomson India Edition, 2007.

16CI731 FLIGHT DYNAMICS AND CONTROL 3 - 0 - 0 - 3

Aircraft Performance: drag polar, 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 and simulations. Dynamics and control of Launch Vehicles (SLV). Inertial sensors: Gyros, accelerometers, MEMS devices for aerospace navigation, IMU. Navigational aids: Instrument landing system, radar, GPS.

TEXT BOOKS/ REFERENCES:

1. John D Anderson Jr, "Introduction to Flight", Fifth Edition, McGraw Hill International, 2005.
2. John D. Anderson Jr, "Fundamentals of Aerodynamics", Fourth Edition, McGraw Hill International, 2007.
3. Thomas R. Yechout, "Introduction to Aircraft Flight Mechanics", AIAA Education Series, 2003.
4. Robert C. Nelson, "Flight Stability and Automatic Control", Second Edition, WCB McGraw-Hill, 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", Spartan Books, 1970.

16CI732 OPERATION AND CONTROL OF POWER SYSTEMS 3 - 0 - 0 - 3

Review of thermal units, the Lambda iteration method, and first order gradient method base point and participation factors. Generation with limited supply, take or pay fuel contract, composite generation production cost function, solution of gradient search techniques. Hard limits and slack variables. Hydro-thermal coordination, long range and short range scheduling, hydro-electric plant models, scheduling problems, types of scheduling problems. Scheduling energy-short-term hydrothermal scheduling problem, pumped storage hydro plants, pumped storage hydro scheduling λ-γ iteration. Inter change evaluation and power pools, economy interchange evaluation with unit commitments. Types of interchange. Energy banking. State Estimation, introduction to advanced topics, detection and identification of bad measurements. Estimation of quantities not being measured, network observability and pseudo-measurements. Power system security, system monitoring, contingency analysis, security constrained optimal power flow. Factors affecting power system security. Load frequency control, automatic voltage and frequency control, basic concepts of governor mechanism, block diagram representation and mathematical models of speed governing system. State space model of a single area system and two area systems. Voltage control, AGC including excitation system. MVAR control, application of voltage regulator, synchronous condenser, transformer taps, static VAR compensators. SCADA in power systems.

TEXT BOOKS/ REFERENCES:

1. Allen J. Wood and Wollenberg B. F., "Power Generation Operation and Control", Wiley Student Edition, 2008.
2. Nagrath, I. J. and Kothari D. P., "Modern Power System Analysis", Tata McGraw Hill, New Delhi, 2011.

3. A. Monticelli, “Electric Power System State Estimation”, Proc. IEEE, Vol. 88, No.2, 2000.
4. Olle I. Elgerd, “Electric Energy and System Theory – An Introduction”, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2004.
5. N. V. Ramana, “Power System Operation and Control”, Pearson, 2012.
6. Hassan Bevarani, Masayuki Watanabe and Yasunori Mitani, “Power System Monitoring and Control”, Wiley-IEEE Press, 2014.
7. Prabha Kundur, “Power System Stability and Control”, McGraw-Hill Education, 2011.

16CI733 BIOMEDICAL INSTRUMENTATION 3-0-0-3

Fundamental of biomedical instrumentation, bio-transducers, transduction principles, resistive transistor strain gauge, types, construction, selection materials, gauge factor, bridge circuit, temperature compensation. Strain gauge type blood pressure transducers. Thermo resistive transducer, RTD and thermistor, thermoemf transducer, thermocouples, non-contact type infrared thermometry, optical pyrometer. Thermistor used for cardiac output measurement, nasal air flow measurement. Biomedical applications of inductive transducer, LVDT, construction variable inductance method, capacitive transducer, diaphragm type capacitive pressure transducer, piezoelectric transducer, output equation, mode of operation. Body surface recording electrodes for ECG, EEG, EMG. Internal electrodes, needle and wire electrodes. Electrodes for electric simulation of tissue, methods of use of electrodes. Cardiac measurement, cardiovascular system, heart structure, cardiac cycle, ECG electrodes, electrocardiograph, indicator dilution methods, measurement of continuous cardiac output derived from aortic pressure waveforms, phonocardiogram, blood pressure measurement techniques, foetal heart rate measurements, plethysmography. Cardiac pacemakers, defibrillators, Heart- Lung Machine (HLM). Patient monitoring systems: different Types of ECG monitors, ambulatory monitoring instruments. Measurement of heart rate, blood pressure, temperature, respiration rate, apnea detectors; computerized patient monitoring system. Sensory instrumentation: mechanism of hearing, sound conduction system, basic audiometer; pure tone audiometer; Bekesy audiometer system, evoked response audiometer system, hearing aids, anatomy of eye, errors in vision, ophthalmoscope, tonometer. Tomographic systems.

TEXT BOOKS/ REFERENCES:

1. Harry N. Norton, “Biomedical Sensors- Fundamentals and Applications”, William Andrew Publications, 1982.
2. Richard S. C. Cobbold, “Transducers for Biomedical Measurements”, Krieger Publishing Company, 1992.
3. John G. Webster, “Medical Instrumentation Application and Design”, Wiley, 2009.
4. E. A. H. Hall, “Biosensors”, Prentice Hall, Advanced Reference Series, Engineering, New Jersey, 1991.
5. Tatsuo Togawa, Toshiyo Tamura and P. Ake Oberg, “Biomedical Transducers and Instruments”, CRC Press, 1997.

6. R. S. Khandpur, “Handbook of Biomedical Instrumentation”, Tata McGraw Hill, New Delhi, 2003.
7. S. K. Venkata Ram, “Biomedical Electronics and Instrumentation”, Galgotia Publication Pvt. Ltd., New Delhi, 2003.
8. Leslie Cromwell, Fred J. Weibell and Erich A. Pfeiffer, “Biomedical Instrumentation and Measurements”, Second Edition, Prentice-Hall India, 1997.

16CI740 ELECTRICAL DRIVES AND CONTROL 3 - 0 - 0 - 3

Fundamentals of electric drives, dynamics of electric drives, multi quadrant operation, closed loop control of drives. DC motors: methods of speed control, dual converter fed DC motor drives, chopper fed drives, single, two and four quadrant chopper drives. Speed control of 3 Phase induction motors, stator voltage control, principle, operation and applications. Slip power recovery scheme, principle, static Kramer’s drive, static Scherbius’ drive and applications. V/f control, constant torque and constant power control. Speed control of synchronous motors, principles of synchronous motor control, self-controlled synchronous motor with electronic commutation, self-controlled synchronous motor drive using load commutated thyristor inverter. Primitive machine: unified approach to the analysis of electrical machine, basic two pole model of rotating machines, Kron’s primitive machine, voltage, power and torque equation, linear transformation from 3 phase to 2 phase and from rotating axes to stationary axes, invariance of power. Principle of vector Control: vector controlled induction motor drive, basic principle, direct rotor flux oriented vector control, estimation of rotor flux and torque, implementation with current source and voltage source inverters. Stator flux oriented vector control, indirect rotor flux oriented vector control scheme, implementation, tuning (include lab practice). Vector control strategies for synchronous motor. sensorless control, basic principle of direct torque 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, 1998.
6. G. K. Dubey, “Power Semiconductor Controlled Drives”, Prentice Hall, 1989.
7. P.S. Bimbhra, “Generalized Theory of Electrical Machines”, Khanna Publications,1987.

16CI741 CONTROL OF POWER CONVERTERS 3 - 0 - 0 - 3

Basics of converter modeling:Introduction, converter circuits: Buck, Boost, Buck-boost and Cuk converters- continuous and discontinuous conduction mode. Principles of steady-state converter analysis: Inductor volt-sec balance and capacitor charge balance, steady-state equivalent circuit, and modeling.Converter dynamics and control: AC and DC equivalent circuit modeling of the continuous and discontinuous conduction mode operations, averaging, perturbation and linearization, small signal equivalent circuit model, State space average model , modeling of pulse width modulator. Converter Transfer Functions: Review of Bode plots, analysis of converter transfer functions, construction and measurement of transfer functions.Controller design: Feedback and effects, Stability: Transient response, regulator design, controller with compensators, voltage and current injection, current programmed control, oscillation and stabilization. Current programmed controller model. MATLAB based simulation.

TEXT BOOKS/ REFERENCES:

1. Erickson, R W., Maksimovic, D, "Fundamentals of Power Electronics", Second Edition, Springer Science - 2001.
2. Christophe P. Basso, "Designing Control Loops for Linear and Switching Power Supplies", Kindle Edition, 2012.
3. Luca Corradini, Dragan Maksimovic, Paolo Mattavelli and Regan Zane, "Digital Control of High-Frequency Switched-Mode Power Converters, IEEE Press Series on Power Engineering, 2015.
4. Ned Mohan, Tore M. Undeland and William P. Robbins, "Power Electronics: Converters, Applications, and Design", Third Edition, John Wiley & Sons, 2003.

16CI742 ROBUST CONTROL 3 - 0 - 0 - 3

Norms for signals and systems, input output relationships, internal stability, asymptotic tracking, performance. Uncertainty and robustness: plant uncertainty, robust stability, robust performance. Stabilization: controller parameterization for stable plant, co-prime factorization, controller parameterization for general plant, asymptotic properties, strong and simultaneous stabilization. Design constraints: algebraic constraints, analytic constraints. Design for performance: unstable, design example, 2-norm minimization. Stability Margin Optimization: optimal robust stability, gain margin optimization, phase margin optimization. Sliding mode control and $H\infty$ control. Design for robust performance. Applications in control design.

TEXT BOOKS/ REFERENCES:

1. S.P. Bhattacharyya, H. Chapellat and L.H. Keel, "Robust Control: The Parametric Approach", Prentice Hall, 1995.
2. Chandrasekharan, P.C., "Robust Control of Linear Dynamical Systems", Academic Press, 1996.
3. Kemin Zhou and John Comstock Doyle, "Essentials of Robust Control", Prentice Hall International, 1998.
4. A. Sinha, "Linear Systems: Optimal and Robust Control", Taylor and Francis Group, 2007.
5. U. Mackenroth, "Robust Control Systems Theory and Case studies", Springer, 2010.

16CI743 EMBEDDED CONTROL SYSTEMS 3- 0 - 0 - 3

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, and 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. 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. Karl Johan Astrom and Bjorn Wittenmark, “Computer Controlled Systems”, Dover Publications, 2011.
2. DimitriosHristu-Varsakelis and William S. Levine, “Handbook of Networked and Embedded Control Systems”, Birkhäuser Boston,2005.
3. J. W. Valavano, “Embedded Microcomputer Systems: Real-time Interfacing”, Thompson Asia, 2011.
4. Wayne Wolf, “Computers as Components: Principles of Embedded Computing Systems Design”, Academic Press, 2005.
5. H. Hanselmann, “Implementation of Digital Controllers - A Survey”, Automatica (journal), Volume 23, Issue 1, Pages 7-32, January 1987.