SARDAR VALLABHBHAI NATIONAL INSTITUTE OF TECHNOLOGY, SURAT

DEPARTMENT OF ELECTRICAL ENGINEERING

M. Tech. Programme
In
Instrumentation and Control
Course Structure and Scheme of Evaluation (Semester-wise)

SEMESTER – I

Sr. No.	Course Code	Course	L	T	P	Credits	Examination Scheme			
			Hrs	Hrs	Hrs		Theory Marks	Tutorial Marks	Practical Marks	Total Marks
1	ELIC1C01	**Process Control**	3	0	0	03	100	-	-	100
2	ELIC1C02	**Modern Instrumentation**	3	0	2	04	100	-	50	150
3	ELIC1C03	**Industrial Automation**	3	0	2	04	100	-	50	150
4	ELIC1C04	**System Theory**	4	0	0	04	100	-	-	100
5	ELIC1C05	**Advanced Instrumentation Laboratory**	0	0	4	02	-	-	100	100
6	ELIC1EXX	**Elective I**	3	0	0	03	100	-	-	100
		TOTAL	**16**	**0**	**8**	**20**	**500**	**-**	**200**	**700**
	TOTAL		**24**			**20**				

SEMESTER - II

Sr. No.	Course Code	Course	L	T	P	Credits	Examination scheme			
			Hrs	Hrs	Hrs		Theory Marks	Tutorial Marks	Practical Marks	Total MARKS
1	ELIC2C01	**Advanced Process Control**	3	0	0	03	100	-	-	100
2	ELIC2C02	**Advanced Embedded Controllers**	3	0	2	04	100	-	50	150
3	ELIC2C03	**Industrial Drives and Control**	3	0	2	04	100	-	50	150
4	ELIC2C04	**Modern Control Theory**	4	0	0	04	100	-	-	100
5	ELIC2C05	**Advanced Control Laboratory**	0	0	4	02			100	100
6	ELIC2EXX	**Elective II**	3	0	0	03	100	-	-	100
		TOTAL	**16**	**0**	**8**	**20**	**500**	**-**	**200**	**700**
	TOTAL		**24**			**20**				

SEMESTER – III

Sr. No.	Course Code	Course	L	T	P	Credits	Examination scheme				
			Hrs	Hrs	Hrs		Theory Marks	Tutorial Marks	Term work Marks	Practical Marks	Total Marks
1	ELIC3D01	**Mid Semester Seminar on Dissertation**	-	-	-	04	-	-			
2	ELIC3D02	**End Semester Seminar on Dissertation**	-	-	-	06	-	-			
		TOTAL	**-**	**-**	**-**	**10**	**-**	**-**			
	TOTAL		**-**			**10**					

SEMESTER – IV

Sr. No.	Course Code	Course	L	T	P	Credits	Examination scheme				
			Hrs	Hrs	Hrs		Theory Marks	Tutorial Marks	Term work Marks	Practical Marks	Total Marks
1	ELIC4D01	**Mid Semester Seminar on Dissertation**	**-**	**-**	**-**	**04**	**-**	**-**			
2	ELIC4D02	**End Semester Seminar on Dissertation**	-	-	-	**08**	-	-			
		TOTAL	**-**	**-**	**-**	**12**	**-**	**-**			
	TOTAL		**-**			**12**					

Total : 62 credits

Elective I

(From amongst the following electives, one subject will be offered to each group of students)

ELIC1E01	Digital Signal Processing
ELIC1E02	Bio-medical Instrumentation
ELIC1E03	Robust Control
ELIC1E04	Optimal and Adaptive Control

Elective II

(From amongst the following electives, one subject will be offered to each group of students)

ELIC2E01	Process Instrumentation
ELIC2E02	Industrial Robotics
ELIC2E03	Intelligent Control
ELIC2E04	Parameter Estimation and Control

Note: Throughout this scheme structure, the notations L, T, P, C denote lecture, tutorial, practical and credit respectively for the related subject.

Programme Education Objectives (PEOs):

1. To prepare graduates, who will be successful professionals in industry, government, academia, research and consulting firms.
2. To prepare the graduates, who have the ability to identify and address current problems in technology and society using the domain of control engineering.
3. To augment research and contribution to technological development in the fields of Process Control and Instrumentation.
4. To be life-long independent and reflective learning skills in their career.
5. To prepare graduates, who will achieve peer-recognition as an individual or in a team, through demonstration of good analytical, research, design and implementation skills.

Program Outcomes (POs):

1. Ability to apply knowledge of mathematics, science and engineering in practice.
2. To identify, critically analyze, formulate and solve engineering problems with comprehensive knowledge in the area of specialization.
3. An ability to address the societal problems by using control for society.
4. To understand the impact of engineering solutions in a contemporary, environmental and societal context for sustainable development.
5. To demonstrate the ability to use the Instrumentation techniques for societal implications.
6. Analyzing ability for abstracting information for preparation of the system models and ability to critically analyze the system models.
7. To demonstrate implementation skills using advanced software and embedded tools.
8. To function professionally with ethical responsibility as an individual as well as in multidisciplinary teams with positive attitude
9. To effectively communicate with the engineering community and with the society at large and capable of presenting reports and design documentation by adhering to appropriate standards.
10. To appreciate the importance of goal-setting and recognize the need for life-long reflective learning.

SEMESTER I

M. Tech. (Electrical)(I&C), Semester – 1	**L**	**T**	**P**	**C**
ELIC1C01: Process Control	**3**	**0**	**0**	**3**

Introduction to process control **(08 Hours)**
Terms and objectives, piping and instrumentation diagram, instrument terms and symbols. Regulator and servo control, classification of variables. Process characteristics: process equation, degrees of freedom, modelling of simple systems, i.e. thermal gas, liquid systems. Process lag, load disturbance and their effect on processes. Self-regulating processes, interacting and non- interacting processes, Anti surge control of compressors, Introduction to Statistical Process Control.

Controller modes **(10 Hours)**
Basic control action, two position, multi-position, floating control modes. Continuous controller modes: proportional, integral, derivative. Composite controller modes: P-I, P-D, P-I-D, integral wind-up and prevention. Auto/ Manual transfer, Bump less transfer. Electronic controllers, their implementation and design. Response of controllers for different test inputs. Selection of control modes for processes like level, pressure, temperature and flow.

Process loop tuning **(8 Hours)**
Evaluation criteria, 1/4th decay ratio, IAE, ISE, ITAE. Process reaction curve method, continuous oscillation method, damped oscillation method. Auto tuning feature. Closed loop response of I & II order systems with and without valve measuring element dynamics.

Final control elements **(8 Hours)**
Pneumatic control valves, construction details, types, various plug characteristics. Valve sizing. Selection of control valves. Inherent and installed valve characteristics. Cavitation and flashing in control valves. Valve actuators and positioners. Instrument air supply. Other final control elements like stepper motors and drives, PCVs, pneumatic like SOVs, pilot valves etc.

Case study on appealing process control problem **(8 Hours)**
Cascade control, ratio control, feed forward control. Over-ride, split range and selective control.
Examples: distillation column, boiler drum level control and chemical reactor control problems.

Total Hours:42

COURSE OUTCOMES

- To determine the advanced features supported by the Industrial Type PID Controller.
- To design, tune and implement SISO P/PI/PID Controllers to achieve desired performance for various processes.
- To identify, formulate, and solve problems in the process control domain

BOOKS RECOMMENDED:

1. Thomas E. Marlin, "Process Control", McGraw Hill, 2015. (ISBN13: 9781259025594)
2. Stephanopoulos, Chemical Process Control: An introduction to Theory and Practice, Prentice Hall, New Delhi, 1999.
3. Curtis D. Johnson, Process Control Instrumentation Technology, Seventh edition, Prentice Hall, New Delhi, 2002.
4. B. G Liptak, Process Control, Third edition, Chilton Book Company, Pennsylvania, 1995.

M. Tech. (Electrical)(I&C), Semester – 1
ELIC1C02: Modern instrumentation

L	T	P	C
3	0	2	4

Concepts and features of intelligent instrumentation **(05 Hours)**
Drawbacks of conventional sensors, definitions of sensors, transducers, intelligent transducers and transmitters, integrated systems and sensors, features of intelligent transducers, self-calibration, diagnostics computation, communications, multi-sensing. Compensation: temperature compensation, non-linear compensation, cross axis sensitivity, noise and limited frequency response, interfacing of sensors with microcontrollers.

Signal conditioning **(13 Hours)**
Signal modification and conditioning, analog amplifiers, instrumentation amplifiers, effect of noise, signal conversion methods-modulator theorem, side frequencies and side bands, A to D convertor (SAR, sigma delta, flash), D to A convertor, active and passive filters, bridge circuits, 4-20mA current loop and concept of transmitters (2 wire, 3 wire etc.), single ended and differential analog signals.

Industrial data communications **(14 Hours)**
Open system interconnection (OSI model), Data communication methodology, overview of EIA RS 485 interface standard, Modbus protocol, Introduction to HART protocol and smart instrumentation, Profibus protocol stack, Foundation fieldbus, overview of Industrial Ethernet & TCP/IP.

Recent transducers **(10 Hours)**
Optical sensors, positioning sensors, distance and thickness sensors, micro-miniaturized sensing devices (MEMS), ultrasonic sensors, IR temperature detection, distributed fiber optic sensors, radio frequency tagging (RFID), intelligent sensors standard and protocols, introduction to wireless sensor network and protocols.

Total Hours:42

Course Outcomes:

- To understand the constructional details, principle of operation, and performance of different unit operations and their Instrumentation.
- To analyze the application of different transducers, calculation of errors in measurement,
- To determine experimentally and evaluate transfer functions of the sensors or systems.

BOOKS RECOMMENDED:

1. M Bhuyan, Intelligent Instrumentation: Principles and Applications, CRC Press, 2010.
2. Steve Mackay, "Practical Industrial Data Networks: Design, Installation and Troubleshooting", IDC Technologies British Library Cataloguing, Elsevier, 2004.
3. Clarence W. de Silva, "Sensors Systems- Fundamentals and Applications", CRC Press Taylor & Francis Group, New York, 2016.

M. Tech. (Electrical)(I&C), Semester – 1	L	T	P	C
ELIC1C03 INDUSTRIAL AUTOMATION	3	0	2	4

Review of computers in process control **(8 Hours)**

Data loggers, Data Acquisition Systems (DAS), Direct Digital Control (DDC). Supervisory Control and Data Acquisition Systems (SCADA), sampling considerations. Functional block diagram of computer control systems. Alarms, interrupts. Characteristics of digital data, controller software, linearization. Digital controller modes: Error, proportional, derivative and composite controller modes.

Programmable Logic Controller (PLC) basics **(10 Hours)**

Definition, overview of PLC systems, input/output modules, power supplies and isolators. General PLC programming procedures, programming on-off inputs/ outputs. Auxiliary commands and functions, PLC Basic Functions, register basics, timer functions, counter functions.

PLC intermediate functions **(12 Hours)**

Arithmetic functions, number comparison functions, Skip and MCR functions, data move systems. PLC Advanced intermediate functions: utilising digital bits, sequencer functions, matrix functions. PLC advanced functions: alternate programming languages, analog PLC operation, networking of PLC, PLC-PID functions, PLC installation, troubleshooting and maintenance. Design of interlocks and alarms using PLC, creating ladder diagrams from process control descriptions.

Distributed Control Systems (DCS): **(12 Hours)**

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

Total Hours:42

Course Outcomes:

After successful completion of the course, students will be able

(i) To understand fundamental principles of Programmable Logic Controllers, I/O modules and IEC standard architecture.

(ii) To design programs using IEC standards programming software.

(iii)To develop and design an application orientated project using PLC.

BOOKS RECOMMENDED:

1. John W. Webb and Ronald A. Reis, Programmable Logic Controllers - Principles and Applications, Fourth edition, Prentice Hall Inc., New Jersey, 1998.
2. Frank D. Petruzella, Programmable Logic Controllers, Second edition, McGraw Hill, New York, 1997.
3. Stuart A. Boyer, SCADA: Supervisory control and data acquisition system, ISA Publication, 2009.

M. Tech. (Electrical)(I&C), Semester – 1 **ELIC1C04 SYSTEM THEORY**

	L	T	P	C
	4	0	0	4

Linear algebra **(14 Hours)**

Vector spaces, basis, operator, range of the linear operator, null space, rank, nullity, rank-nullity theorem, matrix representation of the linear operator in the bases, orthogonal bases, Inner product spaces, Holder inequality, Cauchy-Schwartz inequality, triangular inequality, Minkowski inequality, best approximation theorem , orthogonal projection lemma, Gram- Schmidt orthogonalization, Characteristics polynomial, minimal polynomial, eigen value and eigen vector, Diagonal form, Triangular form, Caley- Hamilton Theorem.

Dynamical system theory **(14 Hours)**

Axiomatic definition of a dynamical system, Lagrange equation of motion, state plane analysis, numerical technique, Solving Discrete LTI system using Z transformation, pulse transfer function, phase space analysis of the discrete LTI system, Jury Stability criterion, Schur-Cohn test, bilinear transformation applied with Routh's stability criterion. Conservative system, controllability, observability, observer Design, Diophantine equation, Full order, reduced order, minimum order observer.

Non-Linear system theory **(14 Hours)**

Homogenous nonlinear systems, polynomial and Volterra systems, interconnections of nonlinear systems, the Carleman linearization approach, the vibrational equation approach.

Total Hours: 42

Course Outcomes:

1. To understand the vector spaces and then develop the knowledge of matrices from the vector space viewpoint.
2. To apply the method and techniques for developing control algorithmic procedures.
3. To evaluate the qualitative characteristics of dynamical systems using system theory.

BOOKS RECOMMENDED:

1. Kenneth Hoffmann and Ray Kunze**, "**Linear Algebra**",** PHI India limited, 1971.
2. Stanislaw H. Zak, "Systems & Control", Oxford University Press, New York, 2003.
3. Wilson J. Rugh, "Nonlinear System Theory", The Johns Hopkins University Press, 2002.

M. Tech. (Electrical)(I&C), Semester – 1	L	T	P	C
ELIC1C05 Advanced Instrumentation Laboratory	0	0	4	2

Lab View based simulations will be carried out on following topics: Introduction to Virtual Instrumentation, data flow techniques, graphical programming. Programming Techniques, VIS & Sub VIS, loops & charts, arrays, clusters, graphs, case & sequence structures, formula modes, local and global variable, string & file input. Data Acquisition basics, ADC, DAC, DIO, Counters & timers, PC Hardware structure, timing, interrupts, DMA, Software and Hardware Installation.

Common Instrument Interfaces for Current loop, RS 485 MODBUS, interface basics: USB, PCI bus etc. Introduction to CIP 51 MCU architecture. Programing of peripherals like GPIO, Timer, on chip ADC, DAC, UART, SPI and I2C ports. Interfacing of MEMS (3 axis accelerometer, 3 axis gyroscope) with MCU. Motion Control and servo drives. Use of Analysis Tools, Fourier transforms, Power spectrum, Correlation methods, filtering.

Application of VI in Process Control, Development of instruments like oscilloscope, Digital Millimeter using Lab View, Study of Data Acquisition & control using Lab view.

Course Outcomes:

1. To understand basics, programming techniques, data acquisition and interfacing techniques of virtual instrumentation.
2. To configure data acquisition hardware in LabVIEW.
3. To create VI for different practical applications.

Text / References:

1. Virtual Instrumentation Using LabVIEW by Sanjay Gupta and Joseph John, Tata McGraw-Hill
2. Virtual Instrumentation using LabVIEW by Jovitha Jerome, PHI

ELECTIVE-I

M. Tech. (Electrical)(I&C), Semester – 1
ELIC1E01: Digital signal processing

L	T	P	C
3	0	0	3

Introduction **(08 Hours)**
Signals, systems and signal processing, classification of signal concepts of discrete-time signals, sampling of analog signal and sampling Theorem, anatomy of digital filters.

Discrete-time signals and systems **(10 Hours)**
Classification, analysis of discrete-time signals and systems, implementation of discrete-time systems, correlation of discrete-time signals, z-transform and its application to the analysis of linear time-invariant systems.

Discrete and fast Fourier transforms **(10 Hours)**
Frequency domain sampling, proportion of DFT, efficient computation of DFT: FFT algorithms, Quantization effects in the computation of the DFT.

Digital filters **(08 Hours)**
Structures of FIR and IIR filters, design of FIR filters using windows, optimum approximations of FIR filters using Parks-McClellan algorithm, Design of IIR filters from analog filters by bilinear transformations; impulse invariance method.

Applications of DSP **(06 Hours)**
Applications of DSP to Instrumentation and control engineering

Total Hours:42

Course Outcomes CO(s):

By the end of the course, students will be able

(i) To understand the meaning and implications of the properties of systems and signals.
(ii) To apply the transform domain and its significance and problems related to computational complexity.
(iii)To design and evaluate any digital filters using MATLAB.

BOOKS RECOMMENDED:

1. Sanjit K. Mitra, *Digital Signal Processing:* a computer based approach, McGraw-Hill Education, 2010, ISBN-13: 978-0077366766.
2. A. V. Oppenheim, R W Schafer, J. R. Buck, *Discrete-Time Signal Processing*, Prentice Hall, New Jersey, 1998.
3. John G Proakis, Dimitris G. Manolikis, *Digital Signal Processing, Principles, Algorithms and Applications,* Prentice Hall, Inc. New Jersey, 1996.

M. Tech. (Electrical)(I&C), Semester – 1

ELIC1E02 Bio-Medical Instrumentation

L	T	P	C
3	0	0	3

Physiology and transducers **8 Hours**

Cell and its structure, Resting and Action Potential, Nervous system: Functional organization of the nervous system, structure of nervous systems, neurons, synapse, transmitters and neural communication, cardiovascular system, respiratory system, Basic components of a biomedical system, transducers selection criteria, piezo electric, ultrasonic transducers, temperature measurements, fiber optic temperature sensors.

Electro –physiological measurements **10 Hours**

Electrodes Limb electrodes, floating electrodes, propelled disposable electrodes, surface electrodes Amplifiers: preamplifiers, differential amplifiers, chopper amplifiers, Isolation amplifier. ECG, EEG, EMG, ERG, Lead systems and recording method typical waveforms Electrical safety in medical environment: shock hazards, leakage current-Instruments for checking safety parameters of biomedical equipment's.

Non-electrical parameter measurements **10 Hours**

Measurement of blood pressure, cardiac output, heart rate, heart sound, pulmonary function measurements, spirometer, photo plethysmography, body plethysmography, blood gas analyzers: pH of blood, measurement of blood pCO_2, pO_2, finger-tip oximeter, ESR, GSR measurements

Medical imaging **8 Hours**

Radio graphic and fluoroscopic techniques, computer tomography, MRI, Ultrasonography, Endoscopy, Gamma camera, Thermography, Different types of biotelemetry systems and patient monitoring, Introduction to Biometric systems

Assisting and therapeutic equipments **6 Hours**

Pacemakers, Defibrillators, Ventilators, Nerve and muscle stimulators, Diathermy, Heart Lung machine, Audio meters, Dialyzers , Lithotripsy

Total Hours:42

Course Outcomes:

1. To learn several signals that can be measured from the human body. Specific examples include temperature, electrical, and pressure signals.
2. To understand how noise from the environment, instruments and other physiologic systems can create artifacts in instrumentation and be able to design components to condition the signals.
3. To analyse the cardiac, respiratory and muscular physiological systems. Study the designs of several instruments used to acquire signals from living systems.

BOOKS RECOMMENDED:

1. R.S. Khandpur, 'Hand Book of Bio-Medical instrumentation, McGraw Hill Publishing Co Ltd. 2003.
2. Leslie Cromwell, Fred J. Weibull, Erich A. Pfeiffer, Bio-Medical Instrumentation and Measurements', II edition, Pearson Education, 2002.
3. J. Webster, 'Medical Instrumentation', John Wiley & Sons, 1995.

M. Tech. (Electrical)(I&C), Semester – 1

	L	T	P	C
ELIC1E02 Robust control	**3**	**0**	**0**	**3**

Introduction **(06 Hours)**

Concept of sensitivity, review of LQR and state feedback designs, Kharlamov's Theorem, Barmish's Theorem, Wei-Yedavailli 's Theorem, edges Theorem and element of H_∞ control , LQC-LTR design.

Robustness **(18 Hours)**

Introduction, graph topology, conditions, requirement and genericity, instability phenomenon, parameter drift, high gain, high frequency, specifications, feedback properties, uncertainty modeling, modifications for robustness, leakage parameter projection, dynamic normalization, dead zone, Ricatti equation and Hamiltonian matrix, KYP Lemma.

Model realizations **(18 Hours)**

Lyapunov equations and inequalities, observability operator and inequalities, balanced equalizations, Hankel operators, Kalman controllability decomposition Theorem, Kalman observability decomposition Theorem, stabilizing controllers, system stability, parametrization of stabilizing controllers.

Total Hours:42

Course Outcomes:

1. To understand the concept of robustness, uncertainty.
2. To apply the robust control that practical feedback systems can handle uncertainty.
3. To analyze the case studies involving robust control.

Books recommended:

1. Geir E. Dullerud, Fernando Paganini, A Course in Robust Control Theory, Springer, 2010.
2. Petros Ioannou & Jing Sun, Robust Adaptive Control, Dover Publications, 2012.
3. Kemin Zou and John Doyle, Essentials of Robust Control, Prentice Hall, 1998.

M. Tech. (Electrical)(I&C), Semester – 1

ELIC1E04 Optimal and Adaptive Control

L	T	P	C
3	0	0	3

(16 Hours)

Optimal control

Calculus of variation, fixed-end-point problem, free-end-point problem and constrained variation problem, optimal control Problems, the Hamiltonian formulation, HJB equation a linear regulator problem, Pontryagin's, Minimum time problems.

Introduction to adaptive control **(12 Hours)**

Relevance of adaptive control in the real world, gain scheduling, model reference and self-tuning techniques, self tuning control, the minimum variance controller, stability considerations, input tracking, self tuning control with weighted input and output variables.

Model Reference Adaptive Systems (MRAS) **(8 Hours)**

Adaptation by gradient methods, Mayer-Kalman-Yalubovich Lemma, stable adaption based on hyper stability concepts, relationship between self-tuning controller and MRAS based on hyper stability theory applications, control of non-linear adaptive dynamic controllers

Applications of optimal and adaptive control **(6 Hours)**

Aircraft control, satellite control, surface to air missile control, missile control, chemical process control, underwater satellite, underwater missiles.

Total Hours: 42

Course Outcomes:

(i) To learn about optimal control methods and how optimal and adaptive control are superior to the classical control.
(ii) To apply MRAC (Model Reference Adaptive Control) and LQR (Linear Quadratic Regulator) for the state space control.
(iii) To apply optimal-adaptive control for autonomous systems.

BOOKS RECOMMENDED:

1. I D Landau, R. Lozano, M. M'Saad, A. Karimi, Adaptive Control (Algorithms, Analysis and Applications), Springer, 2011.
2. V V Chalam, Adaptive Control Systems: Techniques and Applications (Electrical and Computer Engineering), Marcel Dekker, 1987.
3. Donald E. Kirk, Optimal Control: an introduction, Dover Publications, 2006.

SEMESTER II

M.Tech. (Electrical)(I&C), Semester – 2	L	T	P	C
ELIC2C01 ADVANCED PROCESS CONTROL	3	0	0	3

Enhancement to single loop regulatory control & Model based control schemes **10 Hours**
Cascade control, Split-range, Feed-forward control, Ratio control, Inferential control, override control, Smith predictor control scheme, Internal Model Controller, IMC PID controller, single loop dynamic matrix control, generalized predictive control.

Multivariable systems & multi-loop regulatory control **10 Hours**
Multivariable systems, transfer matrix representation, poles and zeros of MIMO System, multivariable frequency response analysis, directions in multivariable systems, singular value decomposition, multi-loop control, introduction, process interaction, pairing of inputs and outputs, the Relative Gain Array (RGA), properties and application of RGA, multi-loop PID Controller, biggest log modulus tuning method, decoupling control.

Multivariable regulatory control & case studies **12 Hours**
Introduction to multivariable control, multivariable PID Controller, multivariable IMC multivariable dynamic matrix controller, multiple model based predictive controller, predictive PID Control, control schemes for distillation column, CSTR, bioreactor, four-tank system, pH, and polymerization reactor

Control of time-varying and nonlinear systems **10Hours**
Models for time varying and nonlinear systems, input signal design for Identification, real time parameter estimation, model validation, types of adaptive control, gain scheduling, adaptive control, deterministic self-tuning controller and model reference adaptive controller, control of Hammerstein and Wiener Systems.

Total Hours: 42

Course Outcomes

(i) To design, tune and implement SISO P/PI/PID controllers to achieve desired Performance for various processes.
(ii) To analyze multivariable systems and design multi-variable and multi-loop control schemes for various processes namely four-tank system, pH process, bio-reactor, distillation column.
(iii) To evaluate the different controllers for the chemical processes and check their sensitivity.

BOOKS RECOMMENDED:

1. Wayne Bequette, Process Control: Modeling, Design, and Simulations", Prentice Hall of India, 2004.
2. Dale E. Seborg, Duncan A. Mellichamp, Thomas F. Edgar, and Francis J. Doyle, III, Process Dynamics and Control", John Wiley and Sons, 3rd Edition, 2010.
3. Jose A. Romagnoli and Ahmet Palazoglu, "Introduction to Process Control", CRC Press, Taylor and Francis Group, Second Edition, First Indian Reprint, 2010.

M. Tech. (Electrical)(I&C), Semester – 2
ELIC2C02 Advanced Embedded Controllers

L	T	P	C
3	0	2	4

Introduction to ARM Cortex M architecture **(06 Hours)**
RISC and CISC architecture, Harvard and Von Neumann architecture, Cortex M0, M4, M7 architecture, assembly instructions set, Core buses, on chip peripherals, Memory systems and registers, interrupt processing, bit banding.

Embedded C programming **(08 Hours)**
Embedded 'C' programming for 32-bit controllers, Introduction to IDE, Registers and variables, Pointers, structures and union, pointer to structure enumeration, conditional compilation directives, pointers to functions, addressing scheme for memory mapped registers, bit filled structure addressing, Interrupt functions in 'C'.

Introduction to STM 32 (MCU) architecture **(20 Hours)**
ARM Cortex M core, bus matrix, AHB and APB buses, different clock domains on MCU, Architecture and Programming of peripherals like GPIO, Timers, PWM Timers, UART, DAC/ADC, SPI, I2C Ports, Hardware debugging techniques.

Applications **(08 Hours)**
Introduction to STM 32 H7 MCU architecture. Application of 32-bit controllers in instrumentation, control and power electronics and control.

Total Hours: 42

Course Outcome:

- To understand the fundamentals of different architectures of micro controllers
- To design programs for the 32-bit processor using assembly language and C language
- To implement algorithms on processors for on-board estimation and control

BOOKS RECOMMENDED:

1. Trevor Martin, "The Insider's Guide to The STM 32", Published by Hitex (UK) Ltd., April 2005
2. Joseph, Yiu, The Definite Guide to cortex –M3/M4", Elsevier publication, 2007.
3. Datasheet and user manual of STM F4 series MCU, www.st.com, 2015.

M. Tech. (Electrical)(I&C), Semester – 2
ELIC2C03 Industrial Drives and Control

L	T	P	C
3	0	2	4

Introduction to Electric Drives: **(8 Hours)**
Electric drive and electric drive system, Motor Load system dynamics, Load characteristics, multi quadrant operation of drives. Types & characteristics of DC motors, Characteristics of induction motor.

Induction motor drives **(12) hours)**
Introduction, Review of three phase I.M. analysis and performance, Analysis of I.M. fed from Non-sinusoidal supply voltage, Stator voltage control, V/f controlled induction motors, Slip power recovery, field oriented control, direct torque and flux control, CSI fed induction motor drives, Applications.

Synchronous motor drives **(12 hours)**
Introduction, Sinusoidal SPM machine drives, synchronous reluctance machine drives, Trapezoidal SPM machine drive, wound field synchronous motor drive, Load-commutated Synchronous Motor Drives, Model of PMSM, Vector controlled PMSM drive, UPF control, torque angle control, optimum torque per ampere control.

Total Hours:42

Course Outcomes:

1. To understand the operation of various power converters and electric drives.
2. To design control of machines using the knowledge of power electronic circuits Design and develop a power converter like inverter and chopper.
3. To select and implement appropriate method of speed control of electric drive.

BOOKS RECOMMENDED:

1. R. Krishnan, Electric motor drives Modeling, Analysis and Control” PHI-India, 2005.
2. B. K. Bose, Modern Power Electronics and AC drives” Pearson Education Asia, 2003.
3. V. V. Athani, Stepper motor principle and applications, New Age International

M.Tech. (Electrical)(I&C), Semester – 2
ELIC2C04 Modern Control Theory

L	T	P	C
4	0	0	4

Linear control systems **10 Hours**

State space descriptions: canonical Realizations, state equations in time and frequency domain, controllability and observability, solution of state model. Linear state-variable feedback: analysis of stabilization by output feedback, State-feed-back and model controllability, quadratic regulator theory for continuous-time systems, discrete-time systems. Asymptotic observer and compensator design, state feedback and Compensator design.

Nonlinear control systems **10 Hours**

Introduction to nonlinear systems, describing function analysis, stability of the equilibrium point in Lyapunov sense, asymptotic stability of the equilibrium point, and limit cycles, qualitative analysis of the non-linear autonomous and non-autonomous systems, phase-plane analysis of linear control systems, phase-plane analysis of' non-linear control systems, minimum time trajectory, optimum switching curve, IMC Volterra controllers.

Estimation theory with applications to control **12 Hours**

Random variables, conditional probability density, conditional expectation, auto correlation, cross correlation Power spectrum density, stochastic resonance, linear minimum variance estimators, Wiener-Hopf equation, orthogonal projection, Wiener filter, Kalman filter, stationary Kalman filters, extended Kalman filter, Ricatti equation, Degenerate Ricatti equation ()

Total Hours: 42 Hours

Course Outcome:

1. To design control of autonomous systems using state space approach
2. To design control of non-linear systems using their state space as well as non-linear transfer function.
3. To analyze linear and non-linear systems using Lyapunov function-based control

BOOKS RECOMMENDED:

1. E D Sontag, Mathematical Control Theory: deterministic finite dimensional systems, Springer-Verlag, New York, 1998.
2. A. P. sage and P. L. Melsa, Estimation Theory with Applications to Communications and Control", McGraw Hill: New York, 1971.
3. A. Papoulis, Probability, Random Variables, and Stochastic Processes, McGraw-Hill, 3rd edition, 1991.

M. Tech. (Electrical)(I&C), Semester – 2	**L**	**T**	**P**	**C**
ELIC2C05 Advanced Control Laboratory	**0**	**0**	**4**	**2**

MATLAB based simulations will be carried out on following topics:
Control System Toolbox
Design of controller: SISO Tool and State Space Design
System Identification Toolbox: Use of *ident*
Optimal controller design.
Robust controller design

Laboratory work:
This shall consist of at least 10 laboratory experiments / assignments based on the above syllabus.

Course Outcomes:

(i) To analyze simulation results and effective documentation
(ii) To acquire expertise in usage of modern tools
(iii) To develop the ability of techniques, skills and modern engineering tools necessary for engineering practices.

Text / References:

1. R V Dukkipati, "Analysis and Design of Control Systems using MATLAB".
2. Ashish Tewari, "Modern Control Design".
3. D. Xue, Y. Q. Chen, D. P. Atherton, "Linear Feedback Control Analysis and Design with MATLAB, Advances in Design and Control", Society for Industrial and Applied Mathematics, 2007.

ELECTIVE-II

M. Tech. (Electrical)(I&C), Semester – 2	**L**	**T**	**P**	**C**
ELIC2E01 **Process Instrumentation**	**3**	**0**	**0**	**3**

General concepts of process instrumentation **(12 Hours)**
Components and process monitoring, predictive monitoring and process equipments, the vibration diagnostics, value conditioning, measurements and measuring devices of temperature, pressure, liquid density, displacement, flow.

Sampled data instrumentation **(18 Hours)**
Analog to digital conversion, special purpose amplifiers and data conversion for instrumentation, phase-locked techniques, computer data logging and digital control techniques, repeatability and reliability index, microprocessor-based intelligent temperature transmitters, Coriolis mass flow meters, electromagnetic flow meters.

Sensor instrumentation **(12 Hours)**
Fiber optics in sensor instrumentation, sensor classifications, modulation parameters, performance criteria, interferometric sensing approach, Doppler anemometry, nanotechnology for pressure transmitters, Microelectromechanical systems (MEMS), MEMS sensors.

Total Hours: 42

Course Outcomes

1. To selects measurement method for a process parameter by process instruments for temperature level, vibration, force and torque in a process plant.
2. To specify instrumentation for temperature level, vibration, force and torque application.
3. To Identify, describe and Calibrate major instruments for temperature, level, vibration, force and torque in a process plant.

Books Recommended

1. Terry, L. M., Instrumentation and Process Control**,** Cengage Learning, 2006.
2. Franklyn, W. Kirk, Thomas A. Weedon and Phillip Kirk, Amer Technical Publications, 2010.
3. William, D., Fundamentals of Industrial Instrumentation and Process Control, McGraw-Hill, 2005.

M. Tech. (Electrical)(I&C), Semester – 2	L	T	P	C
ELIC2E02 Industrial Robotics	3	0	0	3

Introduction and robot kinematics **(8 Hours)**
Definition, need and scope of Industrial robots, robot anatomy, work volume, precision movement, end effectors, sensors. robot kinematics, direct and inverse kinematics, robot trajectories, control of robot manipulators, robot dynamics, methods for orientation and location of objects.

Robot drives and control **(9 Hours)**
Controlling the robot motion, position and velocity sensing devices, design of drive systems, hydraulic and Pneumatic drives, linear and rotary actuators and control valves, electro hydraulic servo valves, electric drives, Motors, designing of end effectors, vacuum, magnetic and air operated grippers.

Robot sensors **(9 Hours)**
Transducers and sensors, sensors in robot, tactile sensor, proximity and range sensors, sensing joint forces, robotic vision system, Image grabbing, image processing and analysis, image segmentation, pattern recognition, training of vision system.

Robot cell design and application **(7 Hours)**
Robot work cell design and control, safety in robotics, robot cell layouts, multiple robots and machine interference, robots cycle time analysis, industrial application of robots.

Robot programming and artificial intelligence **(9 hours)**
Methods of robot programming, characteristics of task level languages lead through programming methods, motion interpolation, artificial intelligence, basics, goals of artificial intelligence, AI techniques, problem representation in AI, problem reduction and solution techniques, application of AI and ES in Robots.

(Total Hours: 42)

Course Outcomes:
1. To analyze the manipulator design, including actuator, drive and sensor issues.
2. To apply the forward kinematics, inverse kinematics and Jacobian for serial and parallel robots.
3. To design the robots that addresses the human limitations and meets societal requirements.

Books Recommended:

1. Fu K. S., Gonzalez, R. C. and Lee, C. S. G., Robotics: Control, Sensing, Vision and Intelligence, McGraw Hill, 1987.
2. Richard, D, Klafter, Thomas, A, Chmielowski, Michael Negin, Robotics Engineering: an Integrated approach, PHI, 1987.

M.Tech. II (Electrical)(I&C), Semester – 2

	L	T	P	C
ELIC2E03 Intelligent Control	**3**	**0**	**0**	**3**

Motivation for intelligent control **08 Hours**

The role of neural networks in engineering, Artificial neural nets (ANNs), fuzzy logic, knowledge representation and inference mechanism, genetic algorithm and fuzzy neural networks.

Introduction to neural networks **09 Hours**

Introduction, biological neurons, artificial neurons, activation function, learning rules, feed forward, linear filters, networks, supervised learning, perceptron Architecture adaline, madaline, back propagation networks, learning factors, linear reparability, Hopfield network - discrete Hopfield networks.

Introduction to fuzzy sets and systems **09 Hours**

Introduction, conventional control system design, fuzzy control system design, fuzzy control: the basics, general fuzzy systems, simulation of fuzzy control Systems, real-Time implementation Issues, defuzzification.

Nonlinear analysis and fuzzy identification and estimation **08Hours**

Parameterized fuzzy controllers, Lyapunov stability analysis, fuzzy identification and estimation, fitting functions to Data, least squares methods, gradient Methods, clustering methods.

Hybrid control schemes **08Hours**

Fuzzification and rule base using ANN–Neuro fuzzy systems-ANFIS –optimization of membership function and rule base using genetic algorithm particle swarm optimization - case study–introduction to support vector regression – familiarization of ANFIS tool box. introduction to reinforcement learning based control. Genetic algorithm, simulated annealing, ant-colony.

Total Hours: 42

Course Outcomes

(i) To understand the basic ANN architectures, algorithms and their limitations.
(ii) To design ANN based models and control schemes for non-linear systems.
(iii)To apply Fuzzy logic for modeling and control of non-linear systems.

BOOKS RECOMMENDED:

1. Timothy, J. Ross, Fuzzy Logic with Engineering Applications", McGraw Hill International Edition, USA, 1997.
2. Kevin M. Passino, Stephen Yurkovich, Fuzzy Control, Addison Wesley, Longman, 1998.
3. Lawrence, Fausatt, Fundamentals of Neural Networks", Prentice Hall of India, New Delhi, 1994.

M.Tech. II (Electrical)(I&C), Semester – 2 **L T P C**

ELIC2E04 Parameter Estimation and Control **3 0 0 3**

14 Hours

Estimations

Introduction, development of parameter estimators, estimation of stochastic processes, applications.

Least–square estimation. Linear least squares problem, generalized least square problem. Sequential least squares, non-linear least squares theory, Estimation and the Maximum Likely hood method- Instrument Variable method, Recursive and Weighted Least square method, State estimation using Kalman Filtering.

Review of stochastic processes **14 Hours**

Models and model classification, the identification problem, some fields of applications, classical methods of identification of impulse response and transfer function models, models learning techniques, linear least square estimator, Generalized and weighted least squares and instrumental variable method.

Filtering and Control **14 Hours**

Wiener's theory of optimization, application of Wiener's theory in the compensator design for feedback control systems, Gauss-Markov models for vector random processes, Kalman filtering and prediction for discrete-time and continuous time systems, minimum variance control, Kushner theory of filtering, stochastic stability, asymptotic stability in probability, stochastic Lyapunov functions, non-linear dynamic controllers for noise perturbed dynamical systems.

Total Hours: 42

COURSE OUTCOMES

1. To develop estimators for different types of linear and nonlinear systems.
2. To apply the knowledge of signal estimations, parameter estimations and state estimations of the linear and non linear system.
3. To analyse and decide the usefulness of filters for the trajectory estimation and control of autonomous systems.

BOOKS RECOMMENDED

1. P. G. Stoica and T. S. Soderstrom, System Identifications, Prentice Hall, 1989.
2. A. H. Jazwinski, Stochastic Processes and Filtering Theory, New York and London: Academic Press, 1970.
3. H. J. Kushner, Stochastic Stability and Control, New York: Academic Press, 1967.

SEMESTER III

1. Mid- Semester seminar on dissertation (ELIC3D01)

The mid semester seminar on dissertation would be based on emerging as well as established topics of Instrumentation and Control. The seminar topic would be linked to dissertation topic of students. The connection between the seminar title and dissertation title is preferred. The seminar content will encompass new developments in the area of Instrumentation and Control and related available results. *One conference paper submitted or presented in the conference is recommended for the better score.*

Recommended references:

(i) M. Vidyasagar, V. V. Patel, G. S. Deodhare, Control India Education, *IEEE Control Systems Magazine*, Publication, 30 – 33, 1996.

(ii) S. Poznyak, V. I. Utkin, A. S. Vostrikov, Control Russia Education, *IEEE Control Systems Magazine,* Publication, 37 – 40, 1996.

(iii) *IEEE Control Systems Magazines.*

(iv) *IEEE Transactions on Education*

(v) Bode Lectures, *IEEE Control Conference on Decision and Control* (CDC)

(vi) IFAC newsletter

Rubrics for evaluation of the mid-semester seminar on dissertation (ELIC3D01)

Seminar Title (abbrev.): ____

Enter scores of 1, 2, 3, 4, or 5. If you cannot rate an area, use NA. Comments can be written below.

Characteristics	Unacceptable (1, 2)	Acceptable (3, 4)	Commendable (5)	Score
Presentation quality	Presentation is either dull (did not capture attention), overly creative (hard to follow), or poorly organized. Writing is often poor.	Presentation holds viewer's attention and includes acceptable graphics and tables. Writing is mostly clear.	Presentation captures viewer's attention and includes interesting, appropriate tables and professional graphics. Organization flows, and writing is crisp and clear.	
Background information and project goals (Literature survey)	Insufficient background information is given; project goals and benefits are poorly stated or missing.	Sufficient background information is given; the purpose and goals of the project are adequately explained.	Thorough and relevant background information is given; project goals are clear and easy to identify.	
Information conveyed about design/ development and results	Information is missing or difficult to understand; further explanation is often needed.	Information is present but at times is difficult to understand.	Information is thorough and relevant and at times enriches viewer's knowledge and interest.	
Oral quality	Unprepared. Misunderstood questions and did not respond appropriately. Poor verbal skills.	Adequately prepared. Understood questions but sometimes had difficulty responding. Adequate verbal skills.	Fully prepared. Anticipated questions and responded with more information than required. Excellent verbal skills.	
Total Marks				
Overall Grade				

2. End Semester Seminar on Dissertation (ELIC3D02)

Rubrics for evaluation of the end-semester seminar on dissertation

Seminar Title (abbrev.): ____

Enter scores of 1, 2, 3, 4, or 5. If you cannot rate an area, use NA. Comments can be written below.

Characteristics	Unacceptable (1, 2)	Acceptable (3, 4)	Commendable (5)	Score
Presentation Quality	Presentation is either dull (did not capture attention), overly creative (hard to follow), or poorly organized. Writing is often poor.	Presentation holds viewer's attention and includes acceptable graphics and tables. Writing is mostly clear.	Presentation captures viewer's attention and includes interesting, appropriate tables and professional graphics. Organization flows, and writing is crisp and clear.	
Design approach, testing, and results	Approach to the problem is weak or flawed. Tests are inconclusive. Results are disappointing or incomplete.	Approach to the problem is adequate. Testing is good. Results are acceptable and complete.	Approach to the problem is innovative. Testing is thorough, and results are robust and usable.	
Information conveyed about design process and results	Information is missing or difficult to understand; further explanation is often needed.	Information is present but at times is difficult to understand.	Information is thorough and relevant and at times enriches viewer's knowledge and interest.	
Oral quality	Unprepared. Misunderstood questions and did not respond appropriately. Poor verbal skills.	Adequately prepared. Understood questions but sometimes had difficulty responding. Adequate verbal skills.	Fully prepared. Anticipated questions and responded with more information than required. Excellent verbal skills.	
Progress made in achieving goals	No progress made or goals does not suffice for proper evaluation	Few goals are achieved but needs improvement and proper proof.	Adequate goals are achieved towards the final goal of dissertation.	
Total Marks				
Overall Grade				
Cumulative Grade (Mid sem + End sem)				

SEMESTER IV

3. DISSERTATION PRELIMINARY SEMINAR (Mid-Sem) (ELIC4D01)

Rubrics for evaluation of the mid-semester seminar on dissertation (ELIC4D01)

Seminar Title (abbrev.): ____

Enter scores of 1, 2, 3, 4, or 5. If you cannot rate an area, use NA. Comments can be written below.

Characteristics	Unacceptable (1, 2)	Acceptable (3, 4)	Commendable (5)	Score
Presentation Quality	Presentation is either dull (did not capture attention), overly creative (hard to follow), or poorly organized. Writing is often poor.	Presentation holds viewer's attention and includes acceptable graphics and tables. Writing is mostly clear.	Presentation captures viewer's attention and includes interesting, appropriate tables and professional graphics. Organization flows, and writing is crisp and clear.	
Design approach, testing, and results	Approach to the problem is weak or flawed. Tests are inconclusive. Results are disappointing or incomplete.	Approach to the problem is adequate. Testing is good. Results are acceptable and complete.	Approach to the problem is innovative. Testing is thorough, and results are robust and usable.	
Information conveyed about design process and results	Information is missing or difficult to understand; further explanation is often needed.	Information is present but at times is difficult to understand.	Information is thorough and relevant and at times enriches viewer's knowledge and interest.	
Oral quality	Unprepared. Misunderstood questions and did not respond appropriately. Poor verbal skills.	Adequately prepared. Understood questions but sometimes had difficulty responding. Adequate verbal skills.	Fully prepared. Anticipated questions and responded with more information than required. Excellent verbal skills.	
Progress made in achieving goals (since last seminar)	No progress made or goals does not suffice for proper evaluation	Few goals are achieved but needs improvement and proper proof.	Adequate goals are achieved towards the final goal of dissertation.	
Total Marks				
Overall Grade				

4. DISSERTATION (End-sem) (ELIC4D02)

Dissertation work will be on the basis of new developments in the area of Instrumentation and Control and related fields. The new results must be the main contribution of the dissertation in addition to understanding the available results in literature on the dissertation topic. One conference paper accepted in the known conference would be treated as the good contribution to the area of the dissertation research.

Recommended Sources:
(i) *IEEE Control Systems Magzines*
(iii) *IEEE Transactions on Automatic Control*
(iv) *Automatica*, a Journal of International Federation of Automatic Control

(V) *International Journal of Control*
(vi) *European Journal of Control*
(vii) *Journal of Franklin Institute*
(viii) *Journal of Process Control*
(ix) *IEEE Transactions on Instrumentation and Measurements*

Rubrics for evaluation of the end-semester seminar on dissertation
(ELIC4D02)

Dissertation Title (abbrev.): ____

Enter scores of 1, 2, 3, 4, or 5. If you cannot rate an area, use NA. Comments can be written below.

Characteristics	Unacceptable (1, 2)	Acceptable (3, 4)	Commendable (5)	Score
Presentation Quality	Presentation is either dull (did not capture attention), overly creative (hard to follow), or poorly organized. Writing is often poor.	Presentation holds viewer's attention and includes acceptable graphics and tables. Writing is mostly clear.	Presentation captures viewer's attention and includes interesting, appropriate tables and professional graphics. Organization flows, and writing is crisp and clear.	
Design approach, testing, and results	Approach to the problem is weak or flawed. Tests are inconclusive. Results are disappointing or incomplete.	Approach to the problem is adequate. Testing is good. Results are acceptable and complete.	Approach to the problem is innovative. Testing is thorough, and results are robust and usable.	
Information conveyed about design process and results	Information is missing or difficult to understand; further explanation is often needed.	Information is present but at times is difficult to understand.	Information is thorough and relevant and at times enriches viewer's knowledge and interest.	
Oral quality	Unprepared. Misunderstood questions and did not respond appropriately. Poor verbal skills.	Adequately prepared. Understood questions but sometimes had difficulty responding. Adequate verbal skills.	Fully prepared. Anticipated questions and responded with more information than required. Excellent verbal skills.	
Progress made in achieving goals (since last seminar)	No progress made or goals does not suffice for proper evaluation	Few goals are achieved but needs improvement and proper proof.	Complete goals are achieved towards the final goal of dissertation.	
Research paper	No attempt for research paper	1 paper in renowned International\ National conference **(acceptance/ rejection awaited cases are to be evaluated accordingly)**	1 paper in renowned International Journal (preferably SCI or SCOPUS)	
Total Marks				
Overall Grade				
Cumulative Grade (3rd semester seminar + 4th semester seminar)				

Comments: ____

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