ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.

Syllabus (Effective from 2023-24)

School/ Department: School of Electronic Sciences

Course: M. Tech. (SSP, Part Time), Programme: Instrumentation and Control Engineering (ICE), Duration: 3 years (Six Semesters)

Abbreviation used:

AC	Audit course	LC	Lab Course	PA	Practical Assessment
PC	Professional Core	PR	Project/ Practical/ Internship	L	Lecture
PE	Professional Elective	SE	Seminar/ Expert Lecture/ Etc.	T	Tutorial
OE	Open Elective	IA*	Internal Assessment	P	Practical
MC	Mandatory/ Common Course	EA	End-Semester Assessment		

Subject Code Format:

A1 / A2	B3	C4	C5 / C6
School/ Dept. (Offering)	**Level**	**0:** AC	**Serial Number (01 to 99)**
BH: Basic Sciences and Humanities	**1:** UG/ Int. Msc. (1st Year)	**1:** PC	01/ 03/…/ 19: Odd Sem. (ECE)
CS: Computer Sciences	**2:** UG/ Int. Msc. (2nd Year)	**2:** PE	21/ 23/…/ 39: Odd Sem. (ICE)
EE: Electrical Sciences	**3:** UG/ Int. Msc. (3rd Year)	**3:** OE	41/ 43/…/ 59: Odd Sem. (VLSI)
EI: Electronic Sciences	**4:** UG/ Int. Msc. (4th Year)	**4:** MC	61/ 63/…/ 79: Odd Sem. (Prog-4)
IP: Infrastructure and Planning	**5:** UG/ Int. Msc. (5th Year)	**5:** LC	81/ 83/…/ 99: Odd Sem. (Prog-5)
MS: Mechanical Sciences	**6:** PG (1st Year)	**6:** PR	02/ 04/…/ 20: Even Sem. (ECE)
BT: Biotechnology	**7:** PG (2nd Year)	**7:** SE	22/ 24/…/ 40: Even Sem. (ICE)
TE: Textile Engineering	**8:** Ph.D.	**8:**	42/ 44/…/ 60: Even Sem. (VLSI)
		9:	62/ 64/…/ 80: Even Sem. (Prog-4)
			82/ 84/…/ 98: Even Sem. (Prog-5)

1st Semester

Sl. No.	Subject Type	Subject Code	Subject Name	Teaching Hours L	T	P	Credit	Maximum Marks IA	EA	PA	Total
1	PC 1	EI6121	Instrumentation Devices and Systems	3	0	0	3	40	60	-	100
2	MC 1	BH6401	Mathematical Methods in Engineering	3	0	0	3	40	60	-	100
3	MC 2	MS6403	Research Methodology and IPR	2	0	0	2	40	60	-	100
4	LC 1	EI6521	Instrumentation System Design Lab	0	0	4	2	-	-	100	100
5	AC 1	Any One from the List of AC 1 (Appendix-I)		2	0	0	0	40	60	-	100
			Total	**10**	**0**	**4**	**10**	**160**	**240**	**100**	**500**

2nd Semester

Sl. No.	Subject Type	Subject Code	Subject Name	Teaching Hours L	T	P	Credit	Maximum Marks IA	EA	PA	Total
1	PC 2	EI6123	Advanced Control System	3	0	0	3	40	60	-	100
2	PE 1 (Any One)	EI6221	Micro Electro Mechanical System (MEMS)	3	0	0	3	40	60	-	100
		EI6223	Biomedical Instrumentation								
		EI6225	Process Dynamics and Control								
3	PE 2 (Any One)	EI6222	Embedded System Design	3	0	0	3	40	60	-	100
		EI6224	SCADA System and Applications								
		EI6226	Industrial Automation								
4	LC 2	EI6523	Advanced Control System Lab	0	0	4	2	-	-	100	100
5	AC 2	Any One from the List of AC 2 (Appendix-I)		2	0	0	0	40	60	-	100
			Total	**11**	**0**	**4**	**11**	**160**	**240**	**100**	**500**

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3rd Semester

Sl. No.	Subject Type	Subject Code	Subject Name	Teaching Hours L	T	P	Credit	Maximum Marks IA	EA	PA	Total
1	PC 3	EI6122	Industrial Instrumentation	3	0	0	3	40	60	-	100
2	PE 3 (Any One)	EI6228	Adaptive Control	3	0	0	3	40	60	-	100
		EI6230	Renewable Power and Control								
		EI6232	Analog Instrumentation								
3	OE 1	Any One from the List of OE 1 (Appendix-I)		3	0	0	3	40	60	-	100
4	PR 1	EI6622	Project (Specialization Related)	0	0	4	2	-	-	100	100
			Total	**9**	**0**	**4**	**11**	**120**	**180**	**100**	**400**

4th Semester

Sl. No.	Subject Type	Subject Code	Subject Name	Teaching Hours L	T	P	Credit	Maximum Marks IA	EA	PA	Total
1	PC 4	EI6124	Digital Control System	3	0	0	3	40	60	-	100
2	PE 4* (Any One)	EI7221	IoT and its Applications	3	0	0	3	40	60	-	100
		EI7223	Soft Computing								
		EI7225	Analytical Instrumentation								
3	LC 3	EI6522	Industrial Instrumentation Lab	0	0	4	2	-	-	100	100
			Total	**6**	**0**	**0**	**08**	**80**	**120**	**100**	**300**

* Virtual/Online Course either offered by OUTR or available in MOOCs platform (No physical class)

5th Semester

Sl. No.	Subject Type	Subject Code	Subject Name	Teaching Hours L	T	P	Credit	Maximum Marks IA	EA	PA	Total
1	PR 2	EI7621	Dissertation (Phase-I)	0	0	24	12	-	-	100	100
			Total	**0**	**0**	**20**	**12**	-	-	**100**	**100**

6th Semester

Sl. No.	Subject Type	Subject Code	Subject Name	Teaching Hours L	T	P	Credit	Maximum Marks IA	EA	PA	Total
1	PR 3	EI7622	Dissertation (Phase-II)	0	0	32	16	-	-	100	100
			Total	**0**	**0**	**32**	**16**	-	-	**100**	**100**

Credits and Maximum Marks

Sl. No.	Semester	Credits	Maximum Marks
1	1st	10	500
2	2nd	11	500
3	3rd	11	400
4	4th	08	300
5	5th	12	100
6	6th	16	100
	Total	**68**	**1900**

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

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1st Semester

PC 1	EI6121	Instrumentation Devices and Systems	3	0	0	3

Prerequisites: Electrical and Electronics measurements

Course Outcomes: At the end of this course students will be able to

1. Identify a sensor based on required characteristics.
2. Select a suitable sensor for measurement.
3. Choose sensor among Mechanical Sensors, Passive and Active Electrical sensors.

Module I

Fundamentals of Measurement, Instrumentation & Calibration: Instrument Classification, Performance Characteristics, Errors in measurement, Computation of Precise Values.

Mechanical Transducers: Sensors for measurement of Temperature, Pressure, Force, Torque and Flow.

(Project, Design, Modelling and Simulation on topics covered in Module – I)

(Measurement, Instrumentation & Calibration: Instrument Classification, Performance Characteristics, Static Characteristics, Dynamic Characteristics, Errors in measurement, Gross Error, Systematic Error, Estimation of Systematic Error, Computation of Precise Values.

Mechanical Transducers: Bimetallic Element, Manometers, Ring-Balance Manometer, Bell type Manometer, Thin Plate Diaphragms, Membranes, Corrugated Diaphragms and Capsules, Bellows Element, Bourdon Tube Element, Helical Springs, Cantilever Beams, Beams held at both ends, Diaphragm Elements, Column type Load Cells, Proving Ring type Load Cells, Torsion Bar, Flat-Spiral Spring, Pitot-Static Tube, Flow-Obstruction Elements, Centrifugal Force Element, Static Vane Elements, Rotating Vane Systems, Rotameter Float System.)

Module II

Passive Electrical Transducers: Fundamentals of Resistive, Inductive and Capacitive sensors.

(Project, Design, Modelling and Simulation on topics covered in Module – II)

(**Passive Electrical Transducers: Resistive Transducers:** Fundamentals of Resistive Sensors, RTD (Metallic, Semiconductor), Errors in measurement, Thermistor, Linearization, Strain Gauge (Bonded, Unbonded, Semiconductor), Sources of error, Temperature Compensation, Circuitry for Strain Gauge, Hot Wire Resistance Transducers, Resistive Sensor for Pressure measurement, Thermal Conductivity Gauge.

Inductive Transducers: Fundamentals of Inductive Sensors, Induction Potentiometer, Inductive Thickness Transducers, Linear Variable Differential Transformer, Phase Sensitive Demodulator. **Capacitive Transducers:** Fundamentals of Capacitive Sensor, Capacitive Microphone, Capacitive Pressure Transducers, Capacitive Thickness Transducer.)

Module III

Active Electrical Transducers: Thermoelectric, Piezoelectric, Ferroelectric, Magnetostrictive, Hall Effect, Photoelectric, Electrode Potentials, Digital Transducers.

(Project, Design, Modelling and Simulation on topics covered in Module – III)

Active Electrical Transducers: Thermoelectric Transducers: Thermoelectric Phenomena, Common Thermocouple Systems; Piezoelectric Transducers: Piezoelectric Materials, Ferroelectric Materials, Piezoelectric Semiconductors; Magnetostrictive Transducers: Magnetostriction Phenomenon;

Hall Effect Transducers: Application of Hall Transducer. Photoelectric Transducers: Photoelectric Phenomenon, Photoconductive Transducers, Photovoltaic Transducers, Photo emissive Transducers, Phototransistor, Photomultiplier, Photo counter, Thermal Radiation Detectors. Electrochemical Transducer: Basics of Electrode Potentials, Reference Electrode, Indicator Electrode.)

Text Books:

1. D.V.S. Murty, Transducers & Instrumentation, PHI Learning Pvt. Ltd., New Delhi, 2009.
2. Ernest O. Doebelin, Measurement Systems Application & Design, Tata McGraw Hill Publishing Co. Ltd., New Delhi, 5th Edition.

Reference Books:

1. C.S. Rangan, G.R. Sarma and V.S.V. Mani, Instrumentation Devices & Systems, Tata McGraw Hill Publishing Co. Ltd., New Delhi.
2. B.C. Nakra and K.K. Chaudhry, Instrumentation Measurement and Analysis, McGraw Hill Education (India) Pvt. Ltd.
3. Alan S. Morris, Measurement and Instrumentation Principles, Elsevier – a Division of Reed Elsevier India Pvt. Ltd.

School/ Department: School of Electronic Sciences
Course: M. Tech. (SSP, Part Time), Programme: Instrumentation and Control Engineering (ICE), Duration: 3 years (Six Semesters)

MC 1	BH6401	Mathematical Methods in Engineering	3	0	0	3

Refer Appendix-I for detailed Syllabus.

MC 2	MS6403	Research Methodology and IPR	2	0	0	2

Refer Appendix-I for detailed Syllabus.

School/ Department: School of Electronic Sciences
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LC 1	EI6521	Instrumentation System Design Lab	0	0	4	2

Prerequisites:
Software tools Multisim and MATLAB.

Course Outcomes:
The students will be able to:
1. Design of Signal Conditioning Circuit.
2. Design of filters.
3. Design of Charge Amplifier and Voltage Regulated Power Supply.
4. Modelling and simulation of instrumentation system.

LIST OF EXPERIMENTS:
1. Design of Instrumentation amplifier using Multisim and hardware implementation.
2. Design of Signal conditioning circuit of LVDT
3. Design of Active and Passive filters using Multisim.
4. Design of I/V and V/I converter using Multisim.
5. Design of Charge Amplifier using Multisim.
6. Design of Voltage Regulated power supply using Multisim.
7. Design of Signal conditioning circuit for Strain Gauge.
8. Design of D/A and A/D Converter using Multisim.
9. Design of lead, lag, lead-lag compensator using Multisim.
10. Design of Thermistor linearization circuit.

School/ Department: School of Electronic Sciences
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Duration: 3 years (Six Semesters)

AC 1	Any One from the List of AC 1 (Appendix-I)	2	0	0	0

Refer Appendix-I for detailed Syllabus.

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2nd Semester

PC 2	EI6123	Advanced Control System	3	0	0	3

Pre-requisites: Control System Engineering-I.

Course Outcomes: At the end of this course students will be able to

1. Analyze mathematical models in both time and frequency domain using transfer functions using S-transform). Develop state-space models
2. Design pole-assignment controller and the specific design procedures
3. Design state feedback controller using Pole Placement techniques and state observer
4. Design compensation network and acquire knowledge of Control System components
5. Acquire knowledge of state space and state feedback in modern control systems, pole placement, design of state observers and output feedback controllers, Control system components.
6. Analyze the stability of non-linear systems and the uncertainty of the system using Fuzzy controller.

Module I

Concept of State, State variables and State models; State Models for SISO, SIMO, MISO, and MIMO linear systems. Mathematical model of a system through State Space Representation using Physical variables and Canonical variables. Solution of state space equations, Eigen Values, Eigen Vectors, Matrix Diagonalisation.

Cayley-Hamilton Theorem and its utility, Controllability and Observability tests for Linear Systems and their importance. Pole placement design, Full order observers and reduced order observer.

Module II

Compensation Network: Lead compensation, Lag Compensation, Lag -Lead Compensation, Parallel Compensation, Comparison between Lag and Lead Compensation.

Control System Components: DC Servomotors, AC Servomotors, Stepper Motors, Potentiometer, Optical Encoders, Synchros, Hydraulic Linear Actuator, Pneumatic Systems.

Pneumatic System: Pneumatic proportional controllers (Force-Distance type), Pneumatic Actuating valves, Basic principles for obtaining derivative control action, Pneumatic PI Control action, Pneumatic PID control.

Hydraulic System: Advantages and Disadvantages of Hydraulic system. Hydraulic Servo Systems, Hydraulic proportional control, Hydraulic I-control, Hydraulic P-I-D control action.

Thermal System: Thermal resistance & capacitance, Mathematical modeling of fluid and thermal system.

Module III

Non-linear Systems, Limit Cycles, Various methods of non-linear stability analysis and their shortcomings, Basic concepts of Lyapunov’s stability Analysis., Lyapunov’s first and second methods Stability definitions, Stability theorems, Lyapunov functions for linear and non-linear systems.

Introduction to Fuzzy control: Fuzzy sets and linguistic variables, The fuzzy control scheme, Fuzzification and defuzzification methods, Examples, Comparison between conventional and fuzzy control.

Text Books: -

1. Control Systems Engineering, I. J. Nagrath, M. Gopal, New Age International (3rd Edition).
2. Modern Control Engineering, K.Ogata, PHI India , 22nd Edition.
3. Automatic Control System, B.C.Kuo.

Reference Books

1. M. Gopal, "Modern Control System Theory", Wiley Eastern Ltd., New Delhi.

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PE 1	EI6221	Micro Electro Mechanical System (MEMS)	3	0	0	3

At the end of the course, the student will be able to:
1. Understand the purpose of MEMS and their application areas.
2. Choose appropriate microfabrication technology for a specific application.
3. Choose appropriate nanofabrication technology for a specific application.
4. Select one or more suitable MEMS integration and packaging approaches for a given application.

Module I

Intrinsic Characteristics of MEMS: Miniaturization, Microelectronics Integration, Mass Fabrication with Precision, Microelectronics Fabrication Process, Silicon based MEMS processes.

Electrostatic Sensing and Actuation: Introduction to Electrostatic Sensors and Actuators, Parallel-Plate Capacitors, Applications of Parallel Plate Capacitors, Thermal Sensing and Actuation: Introduction, Sensors and Actuators Based on Thermal Expansion, Thermal Couples, Thermal Resistors, Applications. Magnetic Actuation.

Module II

Piezoresistive Sensors: Piezoresistive Sensor Materials, Stress Analysis of Mechanical Elements, Applications of Piezoresistive Sensors. Piezoelectric Sensing and Actuation: Introduction, Properties of Piezoelectric Materials, Applications.

Bulk Micromachining and Silicon Anisotropic Etching: Introduction, Anisotropic Wet Etching, Dry Etching of Silicon-Plasma Etching, Deep Reactive Ion Etching (DRIE), Isotropic Wet Etching, Gas-Phase Etchants, Native Oxide, Wafer Bonding.

Surface Micromachining: Basic Surface Micromachining Processes, Structural and Sacrificial Materials, Acceleration of Sacrificial Etch, Stiction and Anti-Stiction Methods, Assembly of 3D MEMS, Foundry Process.

Module III

Optical MEMS: Passive MEMS Optical Components-Lenses, Mirrors, Actuators for Active Optical MEMS Actuators for Small Out-of-Plane Translation, Actuators for Large In Plane Translation Motion, Actuators for Out-of-Plane Rotation.

Polymer MEMS: Introduction, Polymers in MEMS- Polyimide, SU-8, Liquid Crystal Polymer (LCP), PDMS, PMMA.

Text Books:

1. Chang Liu, Foundations of MEMS, Pearson Education Inc., 2012.
2. Stephen D Senturia, Microsystem Design, Springer Publication, 2000.

Reference Books:

1. Tai Ran Hsu, MEMS & Micro systems Design and Manufacture, TMH, New Delhi, 2002.

School/ Department: School of Electronic Sciences
Course: M. Tech. (SSP, Part Time), Programme: Instrumentation and Control Engineering (ICE), Duration: 3 years (Six Semesters)

PE 1	EI6223	Biomedical Instrumentation	3	0	0	3

Prerequisites:
Physiological system of the human, various sensors to measure temperature, flow, pressure, Dynamical and statistical properties of Instrument.

Course Outcomes:
At the end of this course students will be able to:
1. Understand the application of Instrumentation and measurement in biomedical domain for better healthcare technologies
2. Learn about various bioelectric signals, cardiovascular measurements, respiratory measurements, patient monitoring system, instrumentation for clinical lab.
3. Apply various Electronics circuits in the field of biomedical instrumentation.
4. Design analog circuits to reduce noises in biomedical systems.

Module I
Fundamentals of Biomedical Instrumentation: Generalized Medical Instrumentation System, Roles of Engineering in Healthcare facilities, Problems encountered during measurement of physiological parameters.
Biometrics Physiological Transducers: Different types of transducers for measurement of physiological parameters and their selection for medical applications, Bio-Electric Signals: Origin of bio-electric signals, Various types of Bioelectric potential signal and their features, Biopotential electrodes.
Brief description of the physiological systems: Like Cardiovascular, Respiratory and Nervous systems and their analogy to electrical circuits.

Module II
Cardiovascular Measurement: Electrocardiograph, Measurement of ECG, ECG electrodes, ECG Amplifiers, Driven Right leg circuit, Cardiac pacemaker, Phonocardiograph, Measurement of heart rate, Plethysmography, Blood pressure measurement.
Blood Flow Meters: Electromagnetic blood flow meter, Ultrasonic blood flow meter, Doppler flow meter
Measurement of Electrical Activities in Muscles and Brain: Electroencephalograph, Electromyograph and their interpretations and applications Measurement of body temperature, GSR measurement.

Module III
Respiratory System Measurement: Respiration rate measurement, Lung Volume and Lung Capacity, Spirometer, Ventilators.
Instrumentation for Clinical laboratory: Blood Gas Analyzers, Blood pH Measurement, Pulse oximeter.
Noise fundamental: Noise description, Low and high frequency noise, Noise Bandwidth, noise calculation, Noise in biomedical circuits and components.

Text Books:

1. L. Cromwell, F. J. Weibell, E. A. Pfeiffer, Biomedical Instrumentation and Measurements, Pearson Education.
2. R. S. Khandpur, Handbook of Biomedical Instrumentation, 3rd Edition, TMH Publication, 2003.

Reference Books:

1. J. G. Webster, Medical Instrumentation: Application and Design, Wiley.
2. Rangaraj M. Rangayyan, Biomedical Signal analysis, A case –Study approach, John Wiley,2014.

School/ Department: School of Electronic Sciences
Course: M. Tech. (SSP, Part Time), Programme: Instrumentation and Control Engineering (ICE), Duration: 3 years (Six Semesters)

PE 1	EI6225	Process Dynamics and Control	3	0	0	3

Prerequisites:
Control System Engineering, Hydraulics and fluid machines, Thermodynamics.

Course Outcomes:
At the end of this course students will be able to:
1. Design the parameters of various controller and tuning.
2. Model and simulate the processing plant.
3. Analyze the utility of actuators and valves in processing plants.

Module I
Mathematical Modelling of Processes:
Introduction to Process control:
Evolution of process control, Concept, definition and types of processes, Benefits, difficulties and requirements of process control implementation, classification of process variables, open loop Vs closed loop systems, Servo Vs regulatory control, Feedback and feed forward control configuration, Step in synthesis of a control system. Need for process control –Hardware elements of a process control system – Need of Mathematical modelling –Mathematical model of level, pressure, thermal processes.

Module II
Various Controllers and its Characteristics:
Classification of Controllers- Continuous Controller-P- Controller, I-Controller, D-Controller, I-Controllers, PD-Controllers, ID-Controllers- Discontinuous controllers- ON-OFF Controllers-Two Position-Three Position –Multi position Controllers-Design of Various Controllers (P, I, D, PI, PD, PID Controllers), Sliding Mode Controller, Model Predictive Control. Closed loop response- PI- Controllers, PD- Controllers, PID-Controllers in closed loop.

Module III
Introduction to Final Control Elements- Final Control Operation-Signal Conversion-Actuators-Pneumatic Actuators-Types of control valves - Valve positioner and its importance –Characteristics of Control Valve-Control valve sizing - Cavitation and flashing-Valve characteristics and types-Selection Criteria for control valves, Electrical and Hydraulic Actuators.
Controller Design and Final Control Elements:
Need for controller tuning -Tuning of PID controllers using Process reaction curve method, and Z-N tuning method. – IAE, ISE and ITAE– Optimum controller tuning using Evaluation criteria

Text Books:

1. Johnson C. D, “Process Control Instrument Technology”, Prentice Hall Inc., 2004.
2. Surekha Bhanot, “Process Control – Principles and applications” Oxford University Press.

Reference Books:

1. Bequette. B.W, “Process Control Modeling, Design and Simulation”, Prentice Hall of India, 2004.
2. Seborg. D.E, Edgar. T.F and Mellichamp. D.A, “Process Dynamics and Control”, Wiley John and Sons, 2nd Edition, 2003.

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Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.

Syllabus (Effective from 2023-24)

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PE 2	EI6222	Embedded System Design	3	0	0	3

Prerequisite:

- Familiarity with microcontrollers/microprocessors.
- Basic coding skills.

Course Outcomes:

1. Understand the concept of embedded systems, including their characteristics and applications, challenges.
2. Apply common design metrics to evaluate the performance and quality of embedded systems and Utilize specification techniques to describe an embedded system behavior.
3. Apply the understanding of ARM to embedded system design and create and execute sample programs using ARM assembly language instructions.
4. Understand various communication protocols and task scheduling algorithms commonly used in embedded systems.

Module I

Introduction to Embedded Systems:

Embedded systems Overview, Characteristics of embedded computing applications. Design Challenges, Common Design Metrics, Embedded systems Design flow.

Specification Techniques:

State charts, Specification Description Language (SDL), Petri Nets, Unified Modeling Language (UML).

Module II

Introduction to ARM Processors:

Background of ARM and ARM Architecture, ARM Pipeline.

ARM Cortex programming:

Assembly basics, Instruction set, Data transfer, Data processing, conditional and branch instructions, Thumb2 instructions, Sample data transfer, arithmetic, and logical assembly language programs.

Module III

Embedded Systems Interfacing:

Serial Peripheral Interface (SPI), Inter Integrated Circuit (I2C), RS-232, Universal Serial Bus (USB), CAN, IrDA, Bluetooth, PCI and AMBA bus protocols.

RTOS and Scheduling:

RTOS and its requirements, Task Scheduling, Scheduling Algorithms- Clock Driven and Event Driven Algorithms.

Text Books:

1. Joseph Yiu, The Definitive Guide to ARM Cortex-M3 and Cortex-M4 Processors, Newnes Publications; 3rd edition, 2013.
2. Peter Marwedel, Embedded System Design, Springer, ISBN 978-3-319-56043-4
3. Santanu Chattopadhya, Embedded System Design‖, PHI, 2nd Edition.
4. Frank Vahid and Tony Givargis, ―Embedded System Design‖, John Wiley & sons Inc.3rd Edition.

Reference Books:

1. Raj Kamal, Embedded Systems- Architecture, Programming and Design, 3rd Edition, 2017.
2. Lyla B. Das, Architecture, Programming, and Interfacing of Low-power processors- ARM7, Cortex, 2017, Cengage, ISBN 978-81-315-3401-4.

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.

Syllabus (Effective from 2023-24)

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PE 2	EI6224	SCADA System and Applications	3	0	0	3

Prerequisite: Electrical and Instrumentation principles, understanding of Control system types, basics of programming.

Course Outcomes: Upon completion of the course, students will be able to:

1. Describe the basic tasks of Supervisory Control Systems (SCADA) as well as their typical applications.
2. Define SCADA system components: remote terminal units, PLCs, intelligent electronic devices, HMI systems, SCADA server.
3. Develop concept of SCADA architecture, various advantages, and disadvantages of each system.
4. Define single unified standard architecture IEC61850.
5. Implement SCADA in transmission and distribution sector, industries, etc.

Module I

Introduction to SCADA at an acquisition system, Evolution of SCADA, Communication technologies. Monitoring and supervisory functions-SCADA applications in Utility Automation, Industries.

SCADA System Components: Schemes- Remote Terminal Unit (RTU), Intelligent Electronic Devices (IED), Communication Network, SCADA Server, SCADA/HMI Systems.

Module II

SCADA Architecture: Various SCADA architectures, advantages, and disadvantages of each system - single unified standard architecture -IEC 61850-SCADA.

Communication: Various industrial communication technologies -wired and wireless methods and fiber Optics-Open standard communication protocols.

Module III

SCADA Applications: Utility applications- Transmission and Distribution sector - operations, monitoring, analysis and improvement. Industries - oil, gas and water. Case studies, Implementation. Simulation Exercises.

Text Books:

1. Stuart A Boyer. SCADA-Supervisory Control and Data Acquisition', Instrument Society of America Publications, USA.1999.
2. Gordan Clarke, Deon Rzyn Azvs, Practical Modern SCADA Protocols: DNP3, 60870J and Related Systems', Newnes Publications, Oxford, UK, 2004.

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.

Syllabus (Effective from 2023-24)

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PE 2	EI6226	Industrial Automation	3	0	0	3

Prerequisite:

1. Operation of different types of sensors and their characteristics.
2. Knowledge of control system.

Course Outcomes:

Upon successful completion of this course, a student will be able to:

1. Understand the fundamental principles and concepts of automation in industry.
2. Comprehend the functioning of data acquisition system using GPIB and serial interface.
3. Evaluate and judge the implementation of DCS and PLC in industry.
4. Apply basic knowledge and skill to design automatic systems using relay and ladder logic.

Module I

Generalized instrumentation system, PC-Based instrumentation system, Principles of data acquisition, generalized data acquisition system, S/H circuits, multi-channel data acquisition systems.

Principles of PC based Data Acquisition: Interpolation, PC-bus based data acquisition system, Analog and digital isolation, Types of sampling, Data transfer methods, Data acquisition configurations, Expansion buses and I/O ports, Local data acquisition: Plug-in data acquisition, Parallel port data acquisition.

Module-II

Data Acquisition using GPIB: GPIB system, Pins and signals, Handshake protocol, GPIB commands: Primary commands, Secondary commands, Expanding GPIB, Sharing GPIB device.

Data Acquisition using Serial Interfaces: Features of Serial communication, Serial communication formats, Serial communication modes, Serial interface standards, USB, IEEE1394, Remote I/O modules.

Networked Data Acquisition

Hierarchy model for industrial automation, Network data communication: Analog communication, Hybrid communication, Digital communication, Local area networks, OSI model, LAN characteristics, LAN types, Internet protocol, Network devices, HART communication, Network connection, Communication modes, Protocol layers Field buses – MODBUS, PROFIBUS.

Module III

Programmable Logic Controller: Software Programmable Logic Controllers, Parts of PLC, Operation of PLC, Symbols used in PLC realization, Difference between PLC, Hardwired System and Computer, Relay Logic and ladder logic, Ladder commands, PLC timers and counters, Recent developments.

DCS system: DCS hardware and software, DCS structure, Representative DCS.

Text Books:

1. PC-Based Instrumentation: Concepts and Practice, N. Mathivanan, Prentice-Hall of India, New Delhi, 2016
2. Process Control: Principles and Applications, Surekha Bhanot, Oxford University Press, 2010.
3. Computer-Based Industrial Control, Krishna Kant, PHI, 2009.

Reference Books:

1. Electronic Instrumentation, P H.S. Kalsi, Tata-McGraw Hill Education, 2017.
2. D. Bailey, E. Wright, *Practical SCADA for Industry*, Newnes.

School/ Department: School of Electronic Sciences
Course: M. Tech. (SSP, Part Time), Programme: Instrumentation and Control Engineering (ICE), Duration: 3 years (Six Semesters)

LC 2	EI6523	Advanced Control System Lab	0	0	4	2

Prerequisites:
Control Systems, MATLAB.

Course Outcomes:
The students will be able to:
1. Analyze the linear and non-linear systems using Lyapunov method.
2. Determine P, PI, PID responses of closed loop system.
3. Design lead, lag and lead-lag compensator using frequency domain method.
4. Test Controllability and observability of continuous and discrete control system.

List of Experiments:
1. Design and analyze PID control system using 2nd and 3rd order system.
2. Stabilize PID control system using Ziegler-Nichol’s method.
3. Design of level controller using PI Controller.
4. Design lead compensator network using MATLAB and analyze the network using MATLAB / Simulink.
5. Design lag compensator network using MATLAB and analyze the network using MATLAB / Simulink.
6. Design of lead –lag compensator to stabilize an unstable system.
7. Controllability & Observability test of a continuous control system using MATLAB / Simulink Software.
8. Controllability & Observability test of a discrete control system using MATLAB / Simulink Software.
9. Study and analyze stepper motor using PLC.
10. Study of synchro transmitter and receiver.
11. Design Boost convertor using Fuzzy logic controller.
12. Stability test of state space analysis by Lyapunov’s theorem.
13. Design Digital Kalman filter using MATLAB.
14. Study and analyze 2nd order transfer function using control system simulator.

School/ Department: School of Electronic Sciences
Course: M. Tech. (SSP, Part Time), Programme: Instrumentation and Control Engineering (ICE), Duration: 3 years (Six Semesters)

AC 2	Any One from the List of AC 2 (Appendix-I)	2	0	0	0

Refer Appendix-I for detailed Syllabus.

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.

Syllabus (Effective from 2023-24)

School/ Department: School of Electronic Sciences

Course: M. Tech. (SSP, Part Time), Programme: Instrumentation and Control Engineering (ICE), Duration: 3 years (Six Semesters)

3rd Semester

PC 3	EI6122	Industrial Instrumentation	3	0	0	3

Prerequisite: Basics of Instrumentation Devices.

Course outcomes: After successful completion of the course, student will be able to

1. Choose suitable sensor for measurement of displacement, level, density, viscosity, concentration of electrolyte, moisture, dew point, gas analysis etc.
2. Choose advanced sensors like Semiconductor sensor, Smart sensor, Micro sensor, Ultrasonic sensor, Chemical sensor and Bio sensor.
3. Apply feedback techniques in measurements for industrial automation.

Module I

Displacement sensors:

Potentiometer and its linearization, Inductive & Capacitive Type Displacement sensors, Proximity sensor, Displacement to Pressure Transducer, Seismic Displacement Transducer.

Level Measurement:

Capacitive Level Transducer, Hot Wire Level Transducer, Float Element, Electrical Level Transducer, Radiation methods, Ultrasonic level Transducer, Level to Pressure Converter, Level to Force Converter.

Density Measurement: Hydrometer System, Air Bubbler System, U-Tube Weighing System.

Viscosity Measurement: Viscosity to Pressure Converter, Viscosity to Torque Converter, Viscosity to Displacement Converter.

Miscellaneous measurements:

Concentration of Electrolytic Solution, Humidity measurement, Measurement of dew point, Gas Analysis for composition, Fibre Optic Sensors.

Module II

Development in Sensor Technology: Introduction; **Semiconductor Sensors:** Basics, Materials and Techniques, IC Temperature sensor **Smart Sensors:** Definition of Smart Sensor, Configuration of Smart Sensor; **Micro sensors:** Introduction, A Micro size Microphone, Inertial Sensors, **Ultrasonic sensors:** Introduction, Basics of Ultrasonics, Sonar, Ultrasonic Sensing System, Ultrasonic Flow Meters, Doppler Flow Meter, Cross Correlation Flow Meter, Surface Acoustic Wave (SAW) Sensors, Coriolis type Flowmeter; **Chemical Sensors:** Introduction, Semiconductor Gas Detectors, Ion Selective Electrodes; **Bio Sensors:** Introduction, Biosensor Structure, Biomedical Sensors.

(Project, Design, Modelling and Simulation on topics covered in Module – II)

Module III

Feedback Transducer Systems: Introduction, Feedback Fundamentals, Inverse Transducers, Temperature Balance System, Self-Balancing Potentiometers, Self-Balancing Bridges, Heat Flow Balance Systems, Beam Balance Systems, Servo Operated Manometer, Feedback Accelerometer System, Automated Measurement of Dew Point, Non-Contact Position Measurement, Other Applications of Feedback.

(Project, Design, Modelling and Simulation on topics covered in Module – III)

Text Books:

1. D.V.S. Murty, Transducers & Instrumentation, PHI Learning Pvt. Ltd., New Delhi, 2009.
2. Ernest O. Doebelin, Measurement Systems Application & Design, Tata McGraw Hill Publishing Co. Ltd., New Delhi, 5th Edition.

Reference Books:

1. C.S. Rangan, G.R. Sarma and V.S.V. Mani, Instrumentation Devices & Systems, Tata McGraw Hill Publishing Co. Ltd., New Delhi.
2. B.C. Nakra and K.K. Chaudhry, Instrumentation Measurement and Analysis, McGraw Hill Education (India) Pvt. Ltd.
3. Alan S. Morris, Measurement and Instrumentation Principles, Elsevier – a Division of Reed Elsevier India Pvt. Ltd.

School/ Department: School of Electronic Sciences
Course: M. Tech. (SSP, Part Time), Programme: Instrumentation and Control Engineering (ICE), Duration: 3 years (Six Semesters)

PE 3	EI6228	Adaptive Control	3	0	0	3

Prerequisites:
Knowledge of feedback control systems and linear system theory.

Course Outcomes:
At the end of this course students will be able to:
1. Understand different on-line parameter estimation methods.
2. Explain adaptive control systems and their properties.
3. Identify different methods and tools for stability analysis of adaptive and learning systems.
4. Apply methods for on-line parameter estimation.
5. Develop adaptive control systems.

Module I
Introduction: Parametric models of dynamical systems, Adaptive control problem
Real time parameter estimation: Least squares and regression models, Estimating parameters in Dynamical Systems, Experimental conditions, Prior information, MLE, RLS, Instrument variable method.

Module II
Deterministic Self tuning regulators (STR): Pole placement design, Indirect self-tuning regulators, Continuous time self-tuners, Direct self-tuning regulators, disturbances with known characteristics.
Stochastic and Predictive Self tuning regulators: Design of Minimum variance and Moving average controllers, Stochastic self-tuning regulators, Unification of direct self-tuning regulators. Linear quadratic STR, adaptive predictive control.

Module III
Model reference adaptive control (MRAS): The MIT Rule, Determination of adaptation gain,
Lyapunov theory, Design of MRAS using Lyapunov theory, BIBO stability, Output feedback, Relations between MRAS and STR.
Properties of Adaptive systems: Nonlinear dynamics, Analysis of Indirect discrete time self-tuners, Stability of direct discrete time algorithms, Averaging, Application of averaging techniques, Averaging in stochastic systems, Robust adaptive controllers.

Text Books:

1. K.J. Astrom and B. Wittenmark, Adaptive Control, 2nd ed., Pearson Education, 1995.
2. Sankar Sastry and Marc Bodson, Adaptive Control- Stability, Convergence and Robustness, Springer, 2011.

Reference Books:

1. Petros Ioannou and Baris Fidan, Adaptive Control Tutorial, SIAM, 2006.
2. P.A. Ioannou and J. Sun, Robust Adaptive Control, Prentice Hall, 1995.
3. M. Krstic, I. Kanellakopoulos and P. Kokotovic, Nonlinear and Adaptive Control Design, Wiley-Interscience, 1995.

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.

Syllabus (Effective from 2023-24)

School/ Department: School of Electronic Sciences

Course: M. Tech. (SSP, Part Time), Programme: Instrumentation and Control Engineering (ICE), Duration: 3 years (Six Semesters)

PE 3	EI6230	Renewable Power and Control	3	0	0	3

Prerequisite:
Knowledge of Control system.

Course Outcomes:
1. Express the idea about energy scenario.
2. Define different types of solar energy systems.
3. Design and control wind energy systems.
4. Design and control of energy storage and hybrid systems.
5. Design grid integration of renewable energy system and demonstrate concept of microgrids.

Module I
Energy Scenario: Classification of Energy Sources, Energy resources (Conventional and Nonconventional), Energy needs of India, and Energy Consumption Patterns. Worldwide Potentials of these sources. Energy efficiency and Energy security. Energy and its environmental impacts, Distributed generation. Solar Radiation and its Measurement: Introduction, Solar Constant, Solar Radiation at the Earth's Surface, Solar Radiation Geometry, Solar Radiation Measurements, Solar Radiation Data, Estimation of Average Solar Radiation, Solar Radiation on Tilted Surfaces.

Module II
Solar Energy: Solar thermal Systems: Types of collectors, Collection systems, efficiency calculations, applications. Photo voltaic (PV) technology: Present status, solar cells, cell technologies, characteristics of PV systems, equivalent circuit, array design, building integrated PV system, its components, sizing, and economics. Peak power operation. Standalone and grid interactive systems.
Wind Energy: Wind speed and power relation, power extracted from wind, wind distribution and wind speed predictions. Wind power systems: system components, Types of Turbines, Turbine rating. Choice of generation, turbine rating, electrical load matching, variable speed operation, maximum power operation, control systems, system design features, stand alone and grid connected operation.

Module III
Energy storage and hybrid system configurations: Energy storage, Battery types, equivalent circuit, performance characteristics, battery design, charging and charge regulators. Battery management. Flywheel-energy relations, components, benefits over battery. Fuel Cell energy storage systems.
Grid Integration: Standalone systems, Concept of Micro-Grid and its components, Hybrid systems -hybrid with diesel, with fuel cell, solar-wind, wind hydro systems, Electric and Hybrid Electric vehicles, Hydrogen-Powered-Electric Vehicles.

Text Books:

1. R. Ramesh, Renewable energy technologies, Narosa publication.
2. G. D. Rai, Non-Conventional Sources of Energy, Khanna Publishers.

Reference Books:

1. Mittal, Non-Conventional energy Systems, Wheelers Publication
2. S. Rao Parulkar, Energy Technology, Khanna Publication.
3. B. H. Khan, Non-Conventional Energy Resources, Tata McGraw Hill, 2009.

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH
Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.
Syllabus (Effective from 2023-24)

School/ Department: School of Electronic Sciences
Course: M. Tech. (SSP, Part Time), Programme: Instrumentation and Control Engineering (ICE), Duration: 3 years (Six Semesters)

PE 3	EI6232	Analog Instrumentation	3	0	0	3

Prerequisite:
Analog Electronics.

Course Outcomes:
1. Basic idea about analog Instrumentation and Measurement system.
2. To know the design and application of various analog circuits used for Instrumentation System.
3. Basic Concept of noise and signal generator circuits.
4. Familiar with various signal conditioning circuits like noise reduction circuits filter circuits.

Module I
Introduction to Analog Instrumentation: Basic concepts of analog instrumentation using OPAMP, Importance and applications of analog instrumentation, Overview of measurement systems using differential amplifiers and Measurement Circuits.
Analog Instrumentation Circuits: Voltage and current measurement techniques, Instrumentation amplifiers, Bridges and their applications, Signal generators and waveform synthesis. Analog Multiplier, Divisor, Summer, and squaring Circuits
Noise and Interference: Sources of noise and interference in analog instrumentation, Noise analysis and characterization, Noise reduction techniques, Grounding, and shielding strategies.

Module II
Instrumentation System Design: Design considerations for analog instrumentation systems, Performance specifications and requirements, Selection and evaluation of components, Design of measurement systems.
Analogue oscilloscopes: advantages and limitations, Arbitrary waveform generators (AWG): Fundamentals, AWGs as sampled data systems, Different kinds of AWG, Waveform editing features in AWGs, Performance factors of AWGs.

Module III
Analog Filters: Introduction to filtering and filter design, components for filter implementation, active low-pass, high-pass, band-pass, band-reject and all-pass filters – design and realization, Frequency Response of different types of filters, Switch capacitance filter.

Text Books:

1. Electronic Instrumentation and Measurement Techniques by William D. Cooper and Albert D. Helfrick.
2. Analogue Instrumentation Fundamentals (The Blacksburg continuing education series) by Vincent F. Leonard, Financial Times Prentice Hall.
3. Digital and Analogue Instrumentation: testing and measurement by Nihal Kularatna, The Institution of Engineering and Technology.

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.

Syllabus (Effective from 2023-24)

School/ Department: School of Electronic Sciences
Course: M. Tech. (SSP, Part Time), Programme: Instrumentation and Control Engineering (ICE), Duration: 3 years (Six Semesters)

OE 1	Any One from the List of OE 1 (Appendix-I)	3	0	0	3

Refer Appendix-I for detailed Syllabus.

School/ Department: School of Electronic Sciences
Course: M. Tech. (SSP, Part Time), Programme: Instrumentation and Control Engineering (ICE), Duration: 3 years (Six Semesters)

PR 1	EI6622	Project (Specialization Related)	0	0	4	2

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.

Syllabus (Effective from 2023-24)

School/ Department: School of Electronic Sciences
Course: M. Tech. (SSP, Part Time), Programme: Instrumentation and Control Engineering (ICE), Duration: 3 years (Six Semesters)

4th Semester

PC 4	EI6124	Digital Control System	3	0	0	3

Prerequisite: Engineering Mathematics and Linear Control System.
Course Outcomes: After successful completion of the course, student will be able to:

1. Understand mathematical models of linear discrete-time control systems using transfer functions and state-space models.
2. Analyze transient and steady state behaviors of linear discrete time control systems.
3. To design controllers and observers for linear discrete-time control systems so that their performance meets specified design criteria.
4. To design digital controllers, assess their design through the constraint specifications.

Module I
Introduction to Discrete Time Control System Basic building blocks of Discrete Time Control system, Sampling Theorem, Z transform and Inverse Z transform for applications for solving differential equations, Mapping between the S-plane and the Z-plane, Impulse sampling, and Data Hold.

Module II
Pulse Transfer Function and Digital PID Controllers The pulse transfer function, pulse transfer function of Closed Loop systems, Pulse transfer function of Digital PID controller, Velocity & Position forms of Digital PID Controller, Realization of Digital Controllers, Deadbeat response and ringing of poles.

Module III
Design of Discrete Time Control System by conventional methods Stability analysis in Z-plane, Jury stability criterion, Bilinear transformations, Design based on the root locus method, Digital Controller Design using Analytical Design Method. Optimal Control Quadratic Optimal Control and Quadratic performance index, Optimal state regulator through the matrix riccati equations, Steady State Quadratic Optimal Control.

Text Books:

1. Discrete Time Control systems by K. Ogata, Prentice Hall, Second Edition, 2003.
2. Digital Control and State Variable Methods by M. Gopal, Tata McGraw Hill, 2003.

Reference Books:

1. Digital control of Dynamic Systems by G.F. Franklin, J. David Powell, Michael Workman 3rd Edition, Addison Wesley, 2000.
2. Digital Control Engineering by M. Gopal, Wiley Eastern Ltd, 1989.
3. Digital Control by Kannan Moudgalya, John Wiley and Sons, 2007.
4. Digital Control by Forsytheand W. and Goodall R.N McMillan,1991.
5. Digital Control Systems by Contantine H. Houpis and Gary B. Lamont, Second Edition, McGraw-Hill International, 2002.

PE 4	EI7221	IoT and its Applications	3	0	0	3

Prerequisites:
Basic Knowledge in Computer Networks, OSI Model, Programming Skills.

Course Outcomes:
At the end of this course, students will be able to:
1. Interpret and apply the concept of IoT and M2M.
2. Apply IoT architecture and applications in various fields.
3. Apply the security and privacy issues in IoT.
4. Implement IoT Applications.

MODULE I
Introduction to Internet of Things: Application areas of IoT, Characteristics of IoT, Things in IoT, IoT stack, Enabling technologies, IoT challenges, IoT levels, IoT and cyber-physical system, IoT and WSN.
Sensors, Microcontrollers, and Their Interfacing: Sensor interfacing, Types of sensors, Controlling sensors, Microcontrollers, ARM.

MODULE II
Protocols for IoT: Messaging protocols, Transport protocols, IPv4, IPv6, URI.
Cloud for IoT: IoT and cloud, Fog computing, Security in cloud.
Application Building with IoT: Various applications of IoT: Food, Healthcare, Lavatory maintenance, Water quality, Warehouse, Retail, Driver Assistance, Collision impact.

MODULE III
Arduino and Raspberry Pi: Arduino: Architecture, Programming and Application.
Raspberry Pi: Architecture, Programming and Application.
IoT Security: Various security issues and need, architecture, requirement, challenges and algorithms.

Text Books:

1. Vijay Madisetti and Arshdeep Bahga, "Internet of Things (A Hands-on-Approach)", 1st Edition, VPT, 2014.
2. Internet of Things, Vasudevan, Nagrajan and Sundaram, Wiley India.

Reference Books:

1. IoT Fundamentals, David Hence at el, Cisco Press.
2. Francis da Costa, "Rethinking the Internet of Things: A Scalable Approach to Connecting Everything", 1st Edition, A press Publications, 2013.
3. Cuno Pfister, "Getting Started with the Internet of Things", O. Reilly Media, 2011.

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.

Syllabus (Effective from 2023-24)

School/ Department: School of Electronic Sciences
Course: M. Tech. (SSP, Part Time), Programme: Instrumentation and Control Engineering (ICE), Duration: 3 years (Six Semesters)

PE 4	EI7223	Soft Computing	3	0	0	3

Prerequisites:
Set Theory, linear and complex algebra, Anatomy of human brain.

Course Outcomes:
Upon completion of the course, the students will demonstrate the ability to:
1. Understand the overview of ANN and Fuzzy logic theory.
2. Solve and design various ANN models.
3. Apply and analyze the concept to existing systems.
4. Design of hybrid systems for engineering applications.

Module I
Overview of Artificial Neural Network (ANN) & Fuzzy Logic:
Review of fundamentals - Biological neuron, Artificial neuron, Activation function, Single Layer Perceptron - Limitations - Multi Layer Perceptron - Back propagation algorithm (BPA); Fuzzy set theory - Fuzzy sets - Operation on Fuzzy sets - Scalar cardinality, fuzzy cardinality, union and intersection, complement, equilibrium points, aggregation, projection, composition, decomposition, cylindrical extension, fuzzy relation - Fuzzy membership functions.
Module II
Neural Networks for Modeling and Control:
Modeling of nonlinear systems using ANN- NARX, NNSS, NARMAX - Generation of training data - optimal architecture - Model validation- Control of nonlinear system using ANN- Direct and Indirect neuro control schemes-Adaptive neuro controller - Familiarization of Neural Network Control Tool Box.
ANN Structures and Online Training Algorithms:
Recurrent neural network (RNN) - Adaptive resonance theory (ART) based network- Radial basis function network-Online learning algorithms: BP through time - RTRL algorithms – Least Mean square algorithm - Reinforcement learning.
Module III
Fuzzy Logic for Modeling and Control:
Modeling of nonlinear systems using fuzzy models - TSK model - Fuzzy Logic controller - Fuzzification - Knowledge base - Decision making logic - Defuzzification - Adaptive fuzzy systems - Familiarization of Fuzzy Logic Tool Box.
Hybrid Control Schemes:
Fuzzification and rule base using ANN- Neuro fuzzy systems - ANFIS - Fuzzy Neuron - Introduction to GA - Optimization of membership function and rule base using Genetic Algorithm - Introduction to Support Vector Machine- Evolutionary Programming-Particle Swarm Optimization - Case study - Familiarization of ANFIS Tool Box.

Text Books:

1. Laurence Fausett, Fundamentals of Neural Networks, Prentice Hall, Englewood cliffs, N.J.,1992.
2. Timothy J.Ross, *Fuzzy Logic with Engineering Applications*, McGraw Hill Inc., 1997.
3. Goldberg, Genetic Algorithm in Search, Optimization and Machine Learning, Addison Wesley Publishing Company, Inc. 1989.
4. Millon W.T., Sutton R.S., and Webrose P.J., *Neural Networks for Control*, MIT Press, 1992.
5. Ethem Alpaydin, *Introduction to Machine Learning* (Adaptive Computation and Machine Learning Series), MIT Press, 2004.
6. Corinna Cortes and V. Vapnik, *Support - Vector Networks, Machine Learning*,12, 1995.
7. Zhang, Huaguang, Liu, Derong, *Fuzzy Modeling and Fuzzy Control Series: Control Engineering, 2006.*

School/ Department: School of Electronic Sciences
Course: M. Tech. (SSP, Part Time), Programme: Instrumentation and Control Engineering (ICE), Duration: 3 years (Six Semesters)

PE 4	EI7225	Analytical Instrumentation	3	0	0	3

Prerequisite: Basic chemistry.

Course Outcomes:
At the end of this course students will be able to:
1. Select the required instruments for spectroscopic analysis.
2. Separate the constituents from a complex mixture using the knowledge of chromatography.
3. Evaluate different online and offline processes and identify suitable instruments for analysis of gaseous, liquid, or solid substance.
4. Evaluate the physical properties of samples using PH meters and conductivity meters.
5. Measure the composition of dissolved oxygen, sodium, silica elements present in the given samples quantitatively.
6. Analyze the interaction of electromagnetic radiations with matter and apply analytical techniques to accurately determine the elements present in the given sample.

Module I
Fundamentals of Analytical Instruments: Elements of an Analytical Instrument, Intelligent Analytical Instrumentation Systems, PC-based Analytical Instruments. Spectrophotometers: Ultraviolet and Visible Absorption Spectroscopy, Calorimeters, Photometers, Different types of Spectrophotometers, Sources of Errors and Calibration, Infrared Spectrophotometers – Basic Components and Types, Sample Handling Techniques, Flame Photometers – Principle, Constructional Details, Types and accessories, Atomic Absorption Spectrophotometers, and their instrumentation.

Module II
Chromatography: Gas Chromatograph – Basic Parts of a Gas Chromatograph, Methods of Measurement of Peak Areas, Liquid Chromatograph – Types, High Pressure Liquid Chromatograph. pH meters and Ion Analyzers: Principle of pH Measurement, Electrodes for pH Measurement, pH Meters, Ion Analyzers, Blood pH Measurement.
Gas Analyzers: Measurement of Blood pCO2 and pO2, Industrial Gas Analyzers – Types, Paramagnetic Gas Analyzer, Infrared Gas Analyzers, Industrial gas Analyzers Based on Other Methods.

Module III
Principles of Nuclear Magnetic Resonance: Nuclear Magnetic Resonance (NMR) Spectroscopy – Principle, Types and Construction details of NMR Spectrometers.
Radiochemical Instruments: Fundamentals of Radiochemical Methods, Radiation Detectors, Liquid Scintillation Counters, Gamma Spectroscopy. X-Ray Spectrometers: Instrumentation for X-Ray Spectrometry, X-Ray Diffractometers, X-Ray Absorption Meters, Electron Probe Micro analyzer.

Text Books:

1. “Handbook of Analytical Instruments”, by R.S. Khandpur, TMH Education Pvt. Ltd.

Reference Books:

1. Instrumental Methods of Analysis – by Willard H.H., Merrit L.L., Dean J. A. and Seattle F.L., CBS Publishing and Distributors, 6/e, 1999.
2. Instrument Technology – by Jones B.E., Butterworth Scientific Publ., London, 1987. Mechanical and Industrial Measurements by Jain R.K., Khanna Publishing, N. Delhi, 2/e, 1992.
3. Principles of Instrumental Analysis – by Skoog D.A. and West D.M., Holt Sounder Publication, Philadelphia, 1985.

School/ Department: School of Electronic Sciences
Course: M. Tech. (SSP, Part Time), Programme: Instrumentation and Control Engineering (ICE), Duration: 3 years (Six Semesters)

LC 3	EI6522	Industrial Instrumentation Lab	0	0	4	2

Course Outcomes:
The students will be able to:
1. Analyze time domain and frequency domain response of instrumentation system.
2. Analyze Loading effect in measurement.
3. Design negative feedback in instrumentation.
4. Develop Models using LabVIEW.

List of Experiments:
1. Time and frequency domain analysis of 1st order and 2nd order instrumentation system.
2. Loading effect in instrumentation.
3. Application and design of negative feedback in instrumentation.
4. Measurement of Dew Point.
5. Measurement of liquid Level.
6. Measurement of liquid density.
7. Measurement of flow using rotameter.
8. Measurement of temperature using RTD and Thermistor.
9. Experiment-1 using LabVIEW.
10. Experiment-2 using LabVIEW.

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.

Syllabus (Effective from 2023-24)

School/ Department: School of Electronic Sciences

Course: M. Tech. (SSP, Part Time), Programme: Instrumentation and Control Engineering (ICE), Duration: 3 years (Six Semesters)

5th Semester

PR 2	EI7621	Dissertation (Phase-I)	0	0	24	12

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.

Syllabus (Effective from 2023-24)

School/ Department: School of Electronic Sciences
Course: M. Tech. (SSP, Part Time), Programme: Instrumentation and Control Engineering (ICE), Duration: 3 years (Six Semesters)

6th Semester

PR 3	EI7622	Dissertation (Phase-II)	0	0	32	16