ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

SCHOOL OF ELECTRONIC SCIENCES

Open Elective

B. Tech in Electronics and Instrumentation Engineering

Curriculum and Syllabus

(**2023-24 admitted students**)

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

Techno Campus, MahalaxmiVihar, Ghatikia, Bhubaneswar-751029.

Syllabus (Admission Batch: 2023-24)

School/ Department: SCHOOL OF ELECTRONIC SCIENCES

Course: B. Tech **Programme: Electronics and Instrumentation Engineering**

Abbreviation used:

AC	Audit course	LC	Laboratory 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/BS/HS	Mandatory/ Common Course	EA	End-Semester Assessment		
ACC	Advanced Competency Course				
*Internal Assessment Mark (40 marks) consists of (i) Mid Semester (20 marks) (ii) Quiz/ Assignment/Attendance (20 marks)					

OPEN ELECTIVES I

Sl. No.	Subject Type	Subject Code	Subject Name	Teaching Hours			Credit	Maximum Marks			
				L	T	P		IA	EA	PA	Total
1	OE	EI4301	Sensors & Transducers	3	0	0	3	40	60	-	100
2		EI4303	Logic & Distributed Control System	3	0	0	3	40	60	-	100
3		EI4305	Neural Network & Fuzzy Logic	3	0	0	3	40	60	-	100
4		EI4307	Electronics for Sensor Design	3	0	0	3	40	60	-	100

OPEN ELECTIVES II, III & IV (EVEN SEM)

Sl. No.	Subject Type	Subject Code	Subject Name	Teaching Hours			Credit	Maximum Marks			
				L	T	P		IA	EA	PA	Total
1	OE	EI4302	MEMS and NEMS	3	0	0	3	40	60	-	100
2		EI4304	System on Chip	3	0	0	3	40	60	-	100
3		EI4306	Automation and Control	3	0	0	3	40	60	-	100
4		EI4308	Smart & Wireless Instrumentation	3	0	0	3	40	60	-	100
5		EI4310	Building Automation System	3	0	0	3	40	60	-	100
6		EI4312	Modern Control Techniques	3	0	0	3	40	60	-	100
7		EI4314	Embedded Controller	3	0	0	3	40	60	-	100
8		EI4316	Signal Conditioning & Data Acquisition Circuits	3	0	0	3	40	60	-	100

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Syllabus (Admission Batch: 2023-24)

SUBJECT NAME	SUBJECT CODE	L-T-P	CREDIT
SENSOR & TRANSDUCER	**EI4301**	**3-0-0**	**3**

Prerequisite: Knowledge of Physics & Chemistry.

Course Outcomes:

At the end of the course, a student will be able to:

CO1: Characterize measurement system and elastic sensors for accurate calibration.

CO2: Analyze resistive, capacitive, inductive, and electromagnetic sensors using signal conditioning.

CO3: Evaluate advanced sensors like piezoelectric and electrochemical for industrial applications.

CO4: Implement smart sensor systems with instrumentation amplifiers and digital interfaces for real-time monitoring.

Module I: **07 Hours**

Static Characteristics: systematic characteristics, statistical characteristics, calibration; Dynamic characteristics of measurement systems: transfer functions of typical sensing elements, step, and frequency response of first and second order elements, and dynamic error in measurement systems.

Module II: **08 Hours**

Techniques for dynamic compensation, loading effect, signal and noise in measurement system, Propagation of errors. Elastic sensing elements: Bourdon tube, bellows, and diaphragms; force and torque measurement. Basics of Flow Measurement: Pitot-Static Tube, Flow-Obstruction Elements, Centrifugal Force Element, Static Vane Elements, Rotating Vane Systems, Rotameter Float System, Thermoelectric sensing elements: thermocouple laws, characteristics, installation problems, cold junction compensation.

Module III: **08 Hours**

Transducers and sensors, Resistive sensing elements: potentiometers, Resistance Temperature Detector (RTD), Thermistors, strain gauges and associated bridge circuits. Capacitive sensing elements: variable separation, area and dielectric; Inductive sensing elements: variable reluctance, LVDT and RVDT displacement sensors; Electromagnetic sensing elements, push-pull configuration for improvement of linearity.

Module IV: **07 Hours**

Piezoelectric sensor, Piezoresistive Sensor, Instrumentation amplifier, Electrochemical sensor: Ion selective electrodes, Electrochemical gas sensor, chemically sensitive Field Effect Transistors, Hall Sensor, IC temperature sensor. Introduction smart sensors, digital sensors with interfacing fundamentals, and their applications.

Total lecture hours: **30 Hours**

Text Book:

1. Principles of Measurement Systems-J.P. Bentley (3/e), Pearson Education, New Delhi.
2. Introduction to Measurement and Instrumentation-A.K.Ghosh (3/e), PHI Learning, New Delhi.
3. Measurement Systems Application and Design- E.O. Doeblin (4/e), McGraw-Hill, International, NY.
4. Morris, A. S., & Langari, R, Measurement and Instrumentation: Theory and Application (3rd ed.), Elsevier, 2020.

Reference Book:

1. Transducers and Instrumentation-D.V.S. Murthy(2/e), PHI Learning, New Delhi.
2. Instrumentation for Engineering Measurements-J.W. Dally, W.F. Riley and K. G. McConnel (2/e), John Wiley, NY.
3. Sensor Technology Handbook, Jon S. Wilson—Newnes, 2004.
4. Jacob Fraden, Handbook of Modern Sensors: Physics, Designs, and Applications, Springer.

CO-PO-PSO MAPPING

SENSOR & TRANSDUCER															
Course outcome	**Program Outcomes**												**Program Specific Outcomes**		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO l	PSO 2	PSO 3
CO1	3	2	2	2	-	-	-	-	-	-	1	2	2	2	-
CO2	3	2	2	1	-	-	-	-	-	-	-	2	2	2	-
CO3	3	3	3	2	1	-	1	-	-	-	2	2	3	2	1
CO4	3	3	3	3	2	1	-	-	-	-	1	2	3	2	2
Average	3.0	2.5	2.5	2	0.75	0.25	0.25	-	-	-	1	2	2.5	2	0.75 s
Level of Correlation:			3 - High			2 - Medium			1 - Low						

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Techno Campus, MahalaxmiVihar, Ghatikia, Bhubaneswar-751029.

Syllabus (Admission Batch: 2023-24)

SUBJECT NAME	SUBJECT CODE	L-T-P	CREDIT
LOGIC & DISTRIBUTED CONTROL SYSTEM	**EI4303**	**3-0-0**	**3**

Prerequisite: Control System

Course Outcomes:

At the end of the course, a student will be able to:

- **CO1:** List the process automation technologies.
- **CO2:** Develop a PLC ladder programming for simple process applications.
- **CO3:** Demonstrate the procedures for PLC installation, troubleshooting, maintenance in industrial environments.
- **CO4:** Compare different architectures and process interfacing issues in Distributed Control Systems.

Module I: **8 Hours**

Basic building blocks of computer-controlled systems, Data acquisition system, Supervisory control, Direct digital control, SCADA: - Hardware and software, Remote terminal units, Master Station and Communication architectures.

Module II: **8 Hours**

Programmable logic controller (PLC) basics: Definition, overview of PLC systems, Block diagram of PLC. General PLC programming procedures: ON/OFF instruction, Timer instruction sets, Counter Instruction sets -Design, development and simulation of PLC programming using above instruction sets for simple applications.

Module III: **8 Hours**

PLC Data manipulation instruction - Arithmetic and comparison instruction- Skip, Master Control Reset (MCR) and Zone Control Last state (ZCL) instruction - PID and other important instruction set. PLC Installation, troubleshooting and maintenance. Design of alarm and interlocks, networking of PLC - Case studies, using above instruction sets.

Module IV: **8 Hours**

Distributed Control System (DCS), Various Architectures, Comparison of different Local control unit architectures, Process interfacing issues, Communication facilities.

Total lecture hours: **32Hours**

Text Book:

1. John W. Webb and Ronald A. Reis, Programmable Logic Controllers - Principles and Applications, Prentice Hall Inc., New Jersey, 5th Edition,2003.
2. Lukcas M.P Distributed Control Systems, Van Nostrand Reinhold Co., New York, 1986.
3. Frank D. Petruzella, Programmable Logic Controllers, McGraw Hill, New York, ed. 5, 2016.

Reference Book:

1. Curtis D. Johnson, Process Control Instrumentation Technology, Pearson New Intl., ed. 8, 2013.
2. Krishna Kant, Computer-based Industrial Control, Prentice Hall, NewDelhi, ed. 2, 2011.
3. T.A. Hughes, Programmable Controllers, Fourth edition, ISA press, 2005.
4. D. Popovic and V.P.Bhatkar,' Distributed computer control for industrial Automation' Marcel Dekker, Inc., Newyork, 1990.

CO-PO-PSO MAPPING

LOGIC & DISTRIBUTED CONTROL SYSTEM															
Course outcome	**Program Outcomes**												**Program Specific Outcomes**		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO l	PSO 2	PSO 3
CO1	3	2	3	3	3	_	_	_	_	_	_	2	3	3	2
CO2	3	3	2	3	3	_	_	_	_	_	_	2	3	3	2
CO3	3	3	3	3	3	_	_	_	_	_	_	2	3	3	2
CO4	3	2	2	3	3	_	_	_	_	_	_	2	3	3	2
Average	3	2.5	2.5	3	3	-	-	-	-	-	-	2	3	3	2
Level of Correlation: 3 - High 2 - Medium 1 – Low															

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Syllabus (Admission Batch: 2023-24)

SUBJECT NAME	SUBJECT CODE	L-T-P	CREDIT
NEURAL NETWORK & FUZZY LOGIC	EI4305	3-0-0	3

Prerequisite: Mathematics, programming, set theory and logic

Course Outcomes:

At the end of the course, a student will be able to:

- **CO1:** Apply neural network models like perceptrons and RBF for function approximation.
- **CO2:** Analyse competitive and associative networks for stability and applications.
- **CO3:** Evaluate fuzzy logic controllers and genetic algorithms for optimization.
- **CO4:** Implement hybrid systems combining neural networks, fuzzy logic, and evolutionary algorithms.

Module I: Introduction and Fundamental Neural Network Concepts 07 Hours

Human Brain & Neural Intelligence: Biological neurons, computational models, and machine intelligence paradigms. **Artificial Neuron Models**: McCulloch-Pitts model, Perceptron. **Activation Functions:** Sigmoid, ReLU, Tanh — properties and uses. **Network Architecture**: Neural networks as directed graphs; layers and connectivity. **Learning Rules:** Hebbian and Delta learning rules. **Perceptron**: Single-layer model, mathematical formulation, and learning algorithm.

Module II: Multi-Layer Networks and Function Approximation 08 Hours

Multi-Layer Perceptrons (MLPs): Architecture, backpropagation algorithm, and mathematical model. Function Approximation: Key concepts and real-world applications. Basis Function Networks: Introduction and structure. Radial Basis Function (RBF) Networks: Architecture, training, and comparison with MLPs. Support Vector Machines (SVMs): Basic principles, kernel functions, and application areas.

Module III: Competitive and Associative Networks 08 Hours

Adaptive Resonance Theory (ART): ART-1 architecture and learning algorithm. Kohonen SOMs: Architecture, training process, and applications. Associative Memory Networks: Linear and recurrent associative memory models. Bidirectional Associative Memory (BAM): Structure and functioning. Hopfield Networks: Energy function, stability analysis, and applications.

Module IV: Fuzzy Logic and Evolutionary Systems 07 Hours

Fuzzy Systems: Introduction, fuzzy sets, relations, numbers, and linguistic descriptions. Fuzzy Control: Rule-based systems and practical applications. Defuzzification Methods: Centroid, center of sum, and mean of maxima. Neuro-Fuzzy & Neuro-GA Systems: Hybrid architectures and learning system equilibrium. Genetic Algorithms (GAs): Concepts, encoding, reproduction, crossover, mutation, and applications.

Total lecture hours: 30 Hours

Text Book:

1. S. Rajasekaran and G.A.V. Pai, Neural Networks, Fuzzy Logic and Genetic Algorithms, PHI, 2003.
2. Keller, J. M., Fundamentals of Computational Intelligence: Neural Networks, Fuzzy Systems, and Evolutionary Computation. IEEE Press/Wiley, 2016.
3. Haykin, S., Neural Networks and Learning Machines, 3rd Edition, Pearson Education, 2009.
4. Melin, P., Kacprzyk, J., & Castillo, O. (Eds.), Design of Intelligent Systems Based on Fuzzy Logic, Neural Networks, and Nature-Inspired Optimization, 2015.

Reference Book:

1. B. Yegnanarayana, Artificial Neural Networks, PHI, 2009.
2. Zurada, J. M., Introduction to Artificial Neural Systems, Jaico Publishing House, 2007.
3. Bart Kosko, Neural Networks and Fuzzy Systems, Prentice Hall.
4. Fausett, L., Fundamentals of Neural Networks: Architectures, Algorithms and Applications. Pearson Education,2008.

CO-PO-PSO MAPPING

NEURAL NETWORK & FUZZY LOGIC														
Course outcome	**Program Outcomes**												**Program Specific Outcomes**		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO l	PSO 2	PSO 3
CO1	3	3	2	2	3	1	-	-	2	2	-	3	3	2	2
CO2	3	3	2	3	2	1	-	-	2	2	-	3	3	2	2
CO3	3	3	3	2	3	1	-	-	2	2	-	3	3	2	2
CO4	3	3	3	3	3	1	-	-	3	3	2	3	3	2	2
Average	3.0	3.0	2.5	2.5	2.75	1.0	-	-	2.25	2.25	1.0	3.0	3.0	2.0	2.0
Level of Correlation:					3 - High				2 - Medium				1 – Low		

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Syllabus (Admission Batch: 2023-24)

SUBJECT NAME	SUBJECT CODE	L-T-P	CREDIT
ELECTRONICS FOR SENSOR DESIGN	**EI4307**	**3-0-0**	**3**

Prerequisite: Basic electronics, Mathematics, Physics

Course Outcomes:

At the end of the course, a student will be able to:

CO1: Identify the sensor interface and signal conditioning using op-amps.

CO2: Analyze ADC/DAC and noise reduction techniques for accurate sensor data.

CO3: Evaluate sensor system performance in terms of signal quality.

CO4: Design integrated sensor networks using adaptive processing.

Module I: Fundamentals of Sensors and Electronic Interfacing **07 Hours**

Introduction to sensor classification and characteristics, Electrical properties of sensors (resistive, capacitive, inductive, piezoelectric), Electronic characteristics: impedance, bandwidth, linearity, hysteresis, Signal interfacing basics: loading effect, impedance matching, protection circuits. internet

Module II: Signal Conditioning and Analog Electronics for Sensors **08 Hours**

Operational Amplifiers: Inverting, non-inverting, differential amplifiers, and voltage followers. Signal Conditioning Circuits: Amplification, filtering (low-pass, high-pass), and impedance matching. Sensor-Specific Circuits: Bridge circuits for resistive sensors (e.g., strain gauges, RTDs), charge amplifiers for piezoelectric sensors. Noise Reduction Techniques: Grounding, shielding, and low-noise amplifier design.

Module III: Digital Electronics and Sensor Interfacing **08 Hours**

Analog-to-Digital Conversion (ADC): Types (successive approximation, sigma-delta), resolution, and sampling. Digital-to-Analog Conversion (DAC): Binary-weighted and R-2R ladder DACs. Microcontroller Interfacing: Interfacing sensors with microcontrollers (e.g., Arduino, PIC, Raspberry Pi) using I2C, SPI, or UART protocols. Smart Sensors: Architecture, embedded processing, and data communication.

Module IV: Signal Processing and Applications of Sensor Systems **07 Hours**

Adaptive Signal Processing: Filtering techniques (FIR, IIR), noise cancellation. Sensor Network Design: Wireless sensor networks, IoT integration, and data fusion. Applications: Sensor systems in industrial automation, environmental monitoring, and healthcare.

Total lecture hours: **30 Hours**

Text Book:

1. J. Fraden,Handbook of Modern Sensors: Physics, Designs, and Applications, 4th Ed., Springer, 2010.
2. J. G. Webster,The Measurement, Instrumentation and Sensors Handboo*k*, CRC Press, 1999.
3. S. Franco,Design with Operational Amplifiers and Analog Integrated Circuits, 4th Ed., McGraw Hill, 2014.
4. S. C. Mukhopadhyay,Smart Sensors, Measurement and Instrumentation, Springer, 2013.

Reference Book:

1. A. D. Helfrick, & W.D. Cooper,Modern Electronic Instrumentation and Measurement Techniques, 5th Ed., PHI, 2003.
2. N. Kirianaki, S. Yurish, N. Shpak, & V. Deynega**,**Data Acquisition and Signal Processing for Smart Sensors, John Wiley & Sons, 2002.
3. Joseph J. Carr, Sensors and Circuits, Prentice Hall, 1993.
4. C. S. Rangan, G.R. Sarma, &V.S. V Mani, Instrumentation Devices and Systems, Tata McGraw Hill, 2008.

CO-PO-PSO MAPPING

ELECTRONICS FOR SENSOR DESIGN															
Course outcome	**Program Outcomes**												**Program Specific Outcomes**		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO l	PSO 2	PSO 3
CO1	3	2	3	1	3	-	-	-	2	1	-	2	3	2	-
CO2	3	3	2	3	3	-	-	1	2	-	-	-	3	3	2
CO3	3	3	2	3	3	2	2	-	2	2	-	3	3	3	3
CO4	3	3	3	3	3	3	3	2	3	2	2	3	3	3	3
Average	3.00	2.75	2.50	2.50	3.00	1.75	1.75	1.00	2.25	1.75	1.00	2.50	3.00	2.75	2.25
Level of Correlation:			3 – High			2 – Medium				1 – Low					

OPEN ELECTIVE II, III, IV

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

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Syllabus (Admission Batch: 2023-24)

SUBJECT NAME	SUBJECT CODE	L-T-P	CREDIT
MEMS & NEMS	EI4302	3-0-0	3

Prerequisite: Nil

Course Outcomes:

At the end of the course, a student will be able to:

CO1: Evaluate the knowledge of mechanisms in MEMS.

CO2: Calculate the design parameters in MEMS fabrication.

CO3: Apply the knowledge of basic approaches for various sensors and actuators design.

CO4: Implement the knowledge of nano-structured materials, micro and nano-scale devices.

Module I: **06 Hours**

Micro and Nano scale systems: Introduction to Design of MEMS and NEMS, Overview of Nano and Micro electromechanical Systems. Applications of Micro and Nano electro mechanical systems. Materials for MEMS: Silicon, silicon compounds, polymers, metals.

Module II: **08 Hours**

Microsystem fabrication processes: Photolithography, Ion Implantation, Diffusion, Oxidation. Thin film depositions: LPCVD, Sputtering, Evaporation, Electroplating; Etching techniques: Dry and wet etching, electrochemical etching; Micromachining: Bulk Micromachining, Surface Micromachining, High Aspect-Ratio (LIGA) Technology; Packaging: Microsystems packaging.

Module III: **08 Hours**

MEMS Sensors: Design of Acoustic wave sensors, resonant sensor, Vibratory gyroscope, Capacitive and Piezo-resistive Pressure sensors. Design of Actuators: Actuation using thermal forces, Actuation using shape memory Alloys, Actuation using piezoelectric crystals, Actuation using Electrostatic forces (Parallel plate, Torsion bar, Comb drive actuators), Micromechanical Motors and pumps.

Module IV: **08 Hours**

Molecular and Nanostructure Dynamics: Shrodinger Equation and Wave function Theory, Density Functional Theory, Nanostructures and Molecular Dynamics, Electromagnetic Fields and their quantization, Molecular Wires and Molecular Circuits.

Total lecture hours: **30 Hours**

Text Book:

1. Tai-ran Hsu, MEMS and microsystems design and manufacture, Nanoscale Engineering, TMGH, 2008.
2. Microelectromechanical Systems by Nitaigour Mahalik .
3. Chang Liu, Foundations of MEMS, Pearson Education Inc., 2012.
4. Sergey Edward Lyshevski, MEMS and NEMS: Systems, Devices, and Structures, CRC, 2002.

Reference Book:

1. Stephen D Senturia, Microsystem Design, Springer Publication, 2000.
2. P.Seshu, Text Book of Finite Element Analysis, PHI,2006.
3. Designing CMOS MEMS by Lisa Su and Marija Vasilevska.
4. Introduction to Microelectromechanical Systems Engineering by Nadim Maluf and Kirt Williams.

CO-PO-PSO MAPPING

MEMS & NEMS															
Course outcome	**Program Outcomes**												**Program Specific Outcomes**		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO l	PSO 2	PSO 3
CO1	3	2	2	1	2	-	-	-	3	2	1	-	3	2	1
CO2	3	-	2	1	2	-	-	-	2	2	1	-	3	2	-
CO3	3	3	-	2	-	-	-	-	1	-	-	1	3	2	2
CO4	3	3	-	2	-	-	-	-	1	-	-	1	3	1	1
Average	3	2	1	1.5	1	-	-	-	1.75	1	0.5	0.5	3	1.75	1
Level of Correlation: 3 - High 2 - Medium 1 – Low															

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Syllabus (Admission Batch: 2023-24)

SUBJECT NAME	SUBJECT CODE	L-T-P	CREDIT
SYSTEM ON CHIP	EI4304	3-0-0	3

Prerequisite: Digital Design and Microprocessor Applications

Course Outcomes:

At the end of the course, a student will be able to:

- **CO1:** Identify the SoC Design and its Methodology.
- **CO2:** Execute the SoC Design Flow.
- **CO3:** List the concepts of System on Chip & its Design Validation.
- **CO4:** Design different embedded memories.

Module I: **06 Hours**

System on chip concepts and methodology – SoC design issues -SoC challenges and components. Design Methodological for Logic Cores- SoC Design Flow.

Module II: **08 Hours**

SoC Design and Verification: Introduction, Design for Integration, Set-Top-Box SoC, Voice Over IP network, SoC verification. Physical Design: Introduction, Overview of Physical Design Flow, Some Tips and Guidelines for Physical Design.

Module III: **08 Hours**

Design Methodology for Memory and Analog Cores- Embedded memories - Specification of analog circuits – A to D converter –Phase locked loops –High I/O Design Validation- Core level validation – Test benches –SoC design validation

Module IV: **08 Hours**

SoC Testing- SoC Test Issues –Cores with boundary scan –Test methodology for design reuse– Testing of microprocessor cores – Built in self-method –testing of embedded memories. Design process for hard cores, Soft and firm Cores.

Total lecture hours: **30 Hours**

Text Book:

1. Nekoogar, F., & Nekoogar, F., From ASICs to SoCs: A Practical Approach. Pearson Education, 2003.
2. Rajsunah, R., System-on-a-Chip: Design and Test. Artech House, 2007.
3. Rashinkar, P., Paterson, P., & Singh, L., System-on-a-Chip Verification: Methodology and Techniques. Kluwer Academic Publishers, 2000.
4. Smith, M. J. S., Application-Specific Integrated Circuit. Addison-Wesley, 1997.

Reference Book:

1. Nurmi, J., Processor Design: System-On-Chip Computing for ASICs and FPGAs (1st ed.). Springer, 2007.
2. Smith, D. J., HDL Chip Design – A Practical Guide for Designing, Synthesizing and Simulating ASICs and FPGAs Using VHDL or Verilog. Doone Publications, 2000.
3. Martin, G., Bailey, B., & Piziali, A., ESL Design and Verification: A Prescription for Electronic System Level Methodology (1st ed.), Morgan Kaufmann, 2007.
4. Al-Hashimi, B. M. (Ed.), System on Chip: Next Generation Electronics, Institution of Engineering and Technology, 2006.

CO-PO-PSO MAPPING

SYSTEM ON CHIP															
Course outcome	**Program Outcomes**												**Program Specific Outcomes**		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO l	PSO 2	PSO 3
CO1	3	2	1	2	2	-	-	-	-	-	-	-	2	1	1
CO2	3	2	2	2	1	-	-	-	-	-	-	-	2	2	-
CO3	3	3	2	2	-	-	-	-	-	-	-	-	2	1	-
CO4	3	2	3	2	-	-	-	-	-	-	-	-	2	2	1
Average	3.0	2.25	2	2	0.75	-	-	-	-	-	-	-	2	1.5	0.5
Level of Correlation: 3 - High 2 - Medium 1 – Low															

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Syllabus (Admission Batch: 2023-24)

SUBJECT NAME	SUBJECT CODE	L-T-P	CREDIT
AUTOMATION AND CONTROL	EI4306	3-0-0	3

Prerequisite: Knowledge of sensors/ transducers and Control system.

Course Outcomes:

At the end of the course, a student will be able to:

- **CO1:** Identify the principles of controller, final control element, control strategy and automation technique used for control of a process.
- **CO2:** Analyze the performance of controllers, final control elements, control strategies and automation techniques.
- **CO3:** Select appropriate controller, final control element, control strategy and automation technique for control of a process.
- **CO4:** Design a process control loop.

Module I: **7 Hours**

Introduction to Process Control-Process definition, what is process-control, Block diagram with examples. Controller Principle-Introduction, Process characteristics, process load, process lag, self-regulation. Control system parameters-error, variable range, control parameter range, control lag, Dead Time, Cycling, Controller modes, Discontinuous controller modes-two position mode, Multi position mode, Floating control mode. Continuous control modes: P, I, D mode. Composite control modes: PI, PD, PID. Controller tuning –Process Reaction Curve (PRC), Ziegler Nichols tuning.

Module II: **6 Hours**

Electronics Controller-Introduction, electronic proportional controller, electronics integral controller, electronic derivative controller, PI, PD, PID controller.

Digital controller: Introduction, components and working of Direct Digital Control (DDC), benefits of DDC, Digital control realization.

Module III: **8 Hours**

Final control element: Introduction, Final control operation, Signal Conversion, Actuator-pneumatic actuation, hydraulic actuation, Electric actuation. Control element-Control valve characteristics, control valve categories.

Module IV: **9 Hours**

Programmable Logic Controllers: Introduction, Principle of operation, Architecture, Programming.

Distributed Control: Distributed vs. Centralized, Advantages, Functional Requirements, System Architecture, Distributed Control Systems (DCS), Communication options in DCS.

Total lecture hours: **30Hours**

Text Book:

1. Process Control Instrumentation Technology by C.D. Johnson,8th edition, PHI Learning.
2. Computer-Based Industrial Control by Krishna Kant,PHI, 2009
3. Process control principles and applications by S. Bhanot, Oxford university Press,2010.

Reference Book:

1. Chemical process control by George Stephanopoulos, PHI Learning Private Limited, New Delhi, 2009
2. Digital Control and State Variable Methods by M.Gopal, Tata McGraw Hill, 2003

CO-PO-PSO MAPPING

AUTOMATION AND CONTROL															
Course outcome	**Program Outcomes**												**Program Specific Outcomes**		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO l	PSO 2	PSO 3
CO1	3	2	3	2	3	_	_	_	_	_	_	2	3	3	2
CO2	3	3	2	2	3	_	_	_	_	_	_	2	3	3	2
CO3	3	3	3	2	3	_	_	_	_	_	_	2	3	3	2
CO4	3	2	2	2	3	_	_	_	_	_	_	2	3	3	2
Average	3	2.5	2.5	2	3	-	-	-	-	-	-	2	3	3	2
Level of Correlation: 3 - High 2 - Medium 1 – Low															

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

Techno Campus, MahalaxmiVihar, Ghatikia, Bhubaneswar-751029.

Syllabus (Admission Batch: 2023-24)

SUBJECT NAME	SUBJECT CODE	L-T-P	CREDIT
SMART & WIRELESS INSTRUMENTATION	**EI4308**	**3-0-0**	**3**

Prerequisite: Wireless Sensor Network, Digital Communication.

Course Outcomes:

At the end of the course, a student will be able to:

- **CO1:** Evaluate various performance parameters in smart and wireless Instrumentation.
- **CO2:** Develop applications using WSN (Wireless sensor Network).
- **CO3:** Design hardware related to smart & wireless Instrumentation.
- **CO4:** Analyze the wireless digital communication.

Module I: **04 Hours**

Introduction: Smart Instrumentation (Materials, automation systems, sensing and Sensors, Sensor Classifications, Wireless Sensor Networks, History of Wireless Sensor networks (WSN), Communication in a WSN, important design constraints of a WSN like Energy, Self-Management, Wireless Networking, Decentralized Management, Design Constraints, Security etc.

Module II: **08 Hours**

Node architecture: The sensing subsystem, Analog to Digital converter, the processor subsystem, architectural overview, microcontroller, digital signal processor, application specific integrated circuit, field programmable gate array (FPGA), comparison, communication interfaces, serial peripheral interface, inter integrated circuit, the IMote node architecture, The XYZ node architecture, the Hogthrob node architecture.

Module III: **08 Hours**

Fundamentals of Wireless Digital Communication Basic components, source encoding, the efficiency of a source encoder, pulse code modulation and delta modulation, channel encoding, types of channels, information transmission over a channel, error recognition and correction, modulation, modulation types, quadratic amplitude modulation, signal propagation.

Module IV: **10 Hours**

Applications: Structural health monitoring - sensing seismic events, single damage detection using natural frequencies, multiple damage detection using natural frequencies, multiple damage detection using mode shapes, coherence, piezoelectric effect, traffic control, health care - available sensors, pipeline monitoring, precision agriculture, active volcano, underground mining.

Total lecture hours: **30 Hours**

Text Book:

1. Fundamentals of wireless sensor networks: theory and practice - Waltenegus Dargie, Christian Poellabauer, A John Wiley and Sons, Ltd., Publication.
2. Smart Sensors, Measurement and Instrumentation, Subhas Chandra Mukhopadhyay, Springer Heidelberg, New York, Dordrecht London, 2013.
3. Wireless Sensors and Instruments: Networks, Design and Applications, Halit Eren, CRC Press, Taylor, and Francis Group, 2006.
4. Intelligent Instrumentation: Principles and Applications, Manabendra Bhuyan, CRC Press; 1st edition, 2017.

Reference Book:

1. Uvais Qidwai, Smart Instrumentation: A data flow approach to Interfacing, Chapman & Hall; 1st Edn, December 2013.
2. Wireless Sensor Networks: Architectures and Protocols, Edgar H. Callaway Jr., and Ed gar H. Callaway.

CO-PO-PSO MAPPING

SMART & WIRELESS COMMUNICATION															
Course outcome	**Program Outcomes**												**Program Specific Outcomes**		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO l	PSO 2	PSO 3
CO1	3	3	2	3	3	2	2	-	-	-	-	-	3	2	-
CO2	3	3	2	3	3	2	2	-	-	-	-	-	3	2	2
CO3	3	3	2	3	3	2	2	-	-	-	-	-	2	2	3
CO4	3	3	2	3	3	2	2	-	-	-	-	-	2	2	2
Average	3	3	2	3	3	2	2	-	-	-	-	-	2.5	2	2.3
Level of Correlation: 3 - High 2 - Medium 1 – Low															

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Syllabus (Admission Batch: 2023-24)

SUBJECT NAME	SUBJECT CODE	L-T-P	CREDIT
BUILDING AUTOMATION SYSTEM	**EI4310**	**3-0-0**	**3**

Prerequisite: Basic Electrical and Electronics Engineering, Control Systems

Course Outcomes:

At the end of the course, a student will be able to:

- **CO1:** Identify the components in building an automation system.
- **CO2:** Develop HVAC, Access Control and Fire Alarm System.
- **CO3:** Select components & equipment used in autonomous systems.
- **CO4:** Evaluate the design matrix of BMS elements.

Module I: **8 Hours**

Introduction Building Automation Systems, Architecture and Protocols: Intelligent building, Intelligent architecture and structure, Facilities management vs. intelligent buildings, Lifecycle of building, Evolution of intelligent buildings. Different types of subsystems in BAS which includes HVAC, access control, security, fire, lighting systems. Importance of each system in BAS. Process of BAS design, Role of different stakeholders in BAS System design. Different communication protocol and addressing concepts, in open Protocols like BACnet, LON, Profibus, Modbus, M-bus, and proprietary Protocols-N2, CBUS. Introduction to wireless – Wireless filed devices, controllers, routers, coordinators.

Module II: **6 Hours**

Comfort parameters for human being and measurement in BMS system: Temperature, Heat, Specific Heat, Sensitive Heat & Latent Heat, Enthalpy, Entropy, Heat transfer - conduction, convection, radiation. Working principle, characteristics of different types of temperature sensors, working principle of Psychometry, working principle of different types of relative humidity sensors, different types of pressure sensors, working of principal and construction of different air flow sensors, working of principal and construction of different water flow sensors, measurement of CO_2 level in air, clean air, grade of filtration, UV treatment, working principal of BTU meter.

Module III: **8 Hours**

HVAC Basic Concepts- Systems (Air Side)- Air handling unit & Terminal Unit: Concept of Air handling unit. Design, working of different components in AHU- damper, filter, cooling coil, heating coil, fan, heat recovery wheel, humidifier. Working, configuration, characteristics for different types of dampers. Design and working of different types of AHU. Operation of different modes. Concept of Variable Air Volume (VAV) system- working, use of different types of VAV- CAV, Design, working, use of radiation coil, chilled beam, CRAC unit, VRV systems, unit heater, Fan coil unit and unit ventilator. Concept of Variable Air Volume (VAV) system-Design, working, use of different types of VAV- CAV, cooling only, with reheat, series fan powered, parallel fan powered, pressure dependent, supply- exhaust VAV, and dual duct VAV. Working, use of radiation coil, chilled beam, CRAC unit, VRV systems, unit heater, Fan coil unit and unit ventilator

Module IV: **8 Hours**

HVAC Basic Concepts- Systems (Plant Side)- Chilled water system & Hot water system: Chilled Water Systems: Concept of refrigeration cycle. Working, mechanical configuration of different types of components used in refrigeration cycle- evaporator, condenser, compressor, expansion valve. Difference between air cooled chiller and water cooled chiller. Working, mechanical configuration of different types of cooling towers. Concept and working of Absorption chiller. Concept and working of heat pump, Design, working of different types of chilled water system- single chiller system, series chiller system, parallel chiller system. Working of different components of chilled water system- de-coupler line, bypass line, primary circuit, secondary circuit, and condenser pumps. Concept of free cooling-direct waterside, series waterside, parallel waterside free cooling. Sequencing of chilled water plant Hot water systems: Working and design of different types of boilers- fire tube, water tube, packaged boiler. Control of boiler-7 element control, fuel-air ratio control. Working and design of different types of heat exchanger. Concept of geothermal system, Working, design of different types of hot water system- with boilers, heat

exchanger with steam input, heat exchanger with hot water input, geothermal system, solar system and combination of all listed systems. Sequencing of Boiler Plant

Total lecture hours: **30 Hours**

Text Book:

1. Albert Ting-pat So, Wai Lok Chan, "Intelligent Building System Enhanced Edition", 1st Edition, Johnson Controls, 2009.
2. Roger W. Haines "HVAC Systems Design Handbook", 5th Edition, McGraw-Hill Publication, 2015.

Reference Book:

1. James E. Brumbaugh "HVAC Fundamentals", Volume 1 to 3, 4th Edition, AUDEL, 2014.
2. Basics of Air Conditioning" ISHRAE, Indian Society of Heating, Refrigerating & Air Conditioning Engineers, 2012.

CO-PO-PSO MAPPING

BUILDING AUTOMATION SYSTEM															
Course outcome	**Program Outcomes**												**Program Specific Outcomes**		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO l	PSO 2	PSO 3
CO1	3	3	3	3	3	_	_	_	_	_	_	2	3	3	2
CO2	3	3	3	3	3	_	_	_	_	_	_	2	3	3	2
CO3	3	3	3	3	3	_	_	_	_	_	_	2	3	3	2
CO4	3	3	3	3	3	_	_	_	_	_	_	2	3	3	2
Average	3	3	3	3	3	_	_	_	_	_	_	2	3	3	2
Level of Correlation: 3 - High 2 - Medium 1 – Low															

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

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Syllabus (Admission Batch: 2023-24)

SUBJECT NAME	SUBJECT CODE	L-T-P	CREDIT
MODERN CONTROL TECHNIQUES	**EI4312**	**3-0-0**	**3**

Prerequisite: Mathematics**,** Basic Control System

Course Outcomes:

At the end of the course, a student will be able to:

- **CO1:** Apply state-space modeling for mechanical and electrical systems.
- **CO2:** Analyse system stability using time- and frequency-domain methods.
- **CO3:** Evaluate MIMO system controllability and design state feedback controllers.
- **CO4:** Create optimal control and filtering solutions for robotics and aerospace.

Module I: Fundamentals of State-Space Modeling **07 Hours**

State variables, state vector, and state-space representation, Derivation of state equations for mechanical/electrical systems, Controllable and observable canonical forms (Ogata's Modern Control Engineering, Ch. 2–3).

Module II: System Response and Stability **08 Hours**

Transient/steady-state response of 1st/2nd-order systems, Routh's criterion, root locus, and frequency-domain methods, Nyquist/Bode plots for stability analysis (Brogan's Modern Control Theory, Ch. 4–5).

Module III: MIMO Systems and Controllability **08 Hours**

Multi-input multi-output (MIMO) modeling, Kalman's test for Controllability/observability, Pole placement, and state feedback (Kuo's Automatic Control Systems, Ch. 10).

Module IV: Advanced Topics **07 Hours**

Optimal control (LQR) and Kalman filtering, Nonlinear system linearization, Applications in robotics/aerospace (Dorf & Bishop's Modern Control Systems, Ch. 12).

Total lecture hours: **30 Hours**

Text Book:

1. K. Ogata, Ogata, Modern Control Engineering (5th ed.). Pearson Education, 2010.
2. W. L. Brogan, Modern Control Theory (3rd ed.). Pearson, 2011.
3. B. C. Kuo & F. Golnaraghi, Automatic Control Systems (9th ed.). Wiley, 2009.
4. R. C. Dorf & R. H. Bishop, Modern Control Systems (12th ed.). Pearson Education, 2011.

Reference Book:

1. N. S. Nise, Control Systems Engineering (7th ed.). Wiley, 2011.
2. I. J. Nagarath, & M. Gopal, Control Systems Engineering, New Age International, 2008.
3. F. H. Raven, Automatic Control Systems, McGraw-Hill, 1995.
4. J-J E. Slotine, &W. Li, Applied Nonlinear Control, Prentice Hall, 1991.

CO-PO-PSO MAPPING

MODERN CONTROL TECHNIQUES															
Course outcome	**Program Outcomes**												**Program Specific Outcomes**		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO l	PSO 2	PSO 3
CO1	3	3	2	2	2	-	-	-	-	-	-	2	3	2	-
CO2	3	3	2	3	3	-	-	-	-	-	-	2	3	2	2
CO3	3	3	3	2	3	-	-	-	-	-	2	2	3	3	2
CO4	3	3	3	3	3	2	2	2	2	2	2	3	3	3	3
Average	3.0	3.0	2.5	2.5	2.75	1.0	1.0	1.0	1.0	1.0	1.5	2.25	3.0	2.5	2.0
Level of Correlation:					3 - High				2 - Medium				1 – Low		

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Syllabus (Admission Batch: 2023-24)

SUBJECT NAME	SUBJECT CODE	L-T-P	CREDIT
EMBEDDED CONTROLLER	EI4314	3-0-0	3

Prerequisite: Basics of Microprocessor and Microcontroller

Course Outcomes:

At the end of the course, a student will be able to:

CO1: Identify the architecture and operation of microcontrollers.
CO2: Develop embedded software to interact with hardware.
CO3: Implement real-time control systems using embedded platforms.
CO4: Design interface circuits using microcontrollers.

Module I: **08 Hours**

Programming Embedded Systems in C Introduction. The 8051 Microcontroller Family Introduction, the external interface of the Standard 8051, Reset requirements, Clock frequency and performance, Memory issues, I/O pins, Timers, Interrupts, Serial interface, Power consumption.

Module II: **08 Hours**

Object-oriented programming with C.ARM Programming using C and Assembly: Simple C Programs using Function Calls, Pointers, Structures, Integer and Floating-Point Arithmetic, Assembly Code using Instruction Scheduling, Register Allocation, Conditional Execution and Loops.

Module III: **08 Hours**

Communication Peripherals in the MSP430, Serial Peripheral Interface, SPI with the USI, SPI with the USCI, A Thermometer Using SPI Modes, Inter-integrated Circuit Bus(I^2C) and its operations, State Machines for I^2C Communication.

Module IV: **06 Hours**

Compilation and linking, Compiling and Linking Multiple Source Files, Compiling Multi file Programs, Linking Multi file Programs, Using #include, External Variables Using an Object Library Manager Using MAKE Files. Case Study: Intruder Alarm System.

Total lecture hours: **30 Hours**

Text Book:

1. Embedded C - Michael J. Pont, 2nd Ed., Pearson Education, 2008.
2. Advanced C - Peter D. Hipson, Sams Publishing, USA, 1992.
3. PICmicro MCU C-An introduction to programming, The Microchip PIC in CCS C - Nigel Gardner.
4. Bhaskar Krishnamachari, 'Networking wireless sensors', Cambridge press 2005. Embedded Systems Design: A Unified Hardware/Software Introduction - Frank Vahid, Tony Givargis, John & Wiley Publications, 2002.

Reference Book:

1. Andrew N. Sloss, Dominic Symes, Chris Wright, "ARM Systems Developer's Guide- Designing & Optimizing System Software", 2008, Elsevier .
2. John H. Davies "MSP430 Microcontroller Basics",Elsevier Ltd Publications, Copyright 2008.
3. Tammy Noergaard "Embedded Systems Architecture: A Comprehensive Guide for Engineers and Programmers", Elsevier(Singapore) Pvt.Ltd.Publications, 2005.
4. Frank Vahid, Tony D. Givargis, "Embedded system Design: A Unified Hardware/Software Introduction", John Wily & Sons Inc.2002.

CO-PO-PSO MAPPING

EMBEDDED CONTROLLER															
Course outcome	**Program Outcomes**												**Program Specific Outcomes**		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO l	PSO 2	PSO 3
CO1	2	2	2	1	2	-	-	-	3	2	1	-	3	2	1
CO2	2	-	2	1	2	-	-	-	2	2	1	-	3	2	-
CO3	2	2	-	2	-	-	-	-	1	-	-	1	3	2	2
CO4	2	2	-	2	-	-	-	-	1	-	-	1	3	1	1
Average	2	1.5	1	1.5	1	-	-	-	1.75	1	0.5	0.5	3	1.75	1
Level of Correlation: 3 - High 2 - Medium 1 – Low															

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

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Syllabus (Admission Batch: 2023-24)

SUBJECT NAME	SUBJECT CODE	L-T-P	CREDIT
SIGNAL CONDITIONING & DATA ACQUISITION CIRCUITS	EI4316	3-0-0	3

Prerequisite: Analog Electronics

Course Outcomes:

At the end of the course, a student will be able to:

CO1: Identify the op-amp configurations used in various applications.
CO2: Design op-amp-based circuits for signal conditioning and waveform generation.
CO3: Implement active filters, voltage regulators, and timer circuits using op-amps.
CO4: Evaluate DAQ, DAC and ADC performance.

Module I: **04 Hours**

Introduction to Operational Amplifiers: Introduction, Block schematic of an Op-amp, Power supply connections, Characteristics of an Ideal OP-AMP, Inverting Amplifier, Non-inverting Amplifier, Voltage follower, Differential Amplifier, CMRR. (Relevant problems).

Operational Amplifier Characteristics: DC characteristics – Input bias current, Input offset current, Input offset voltage, Total output offset voltage, Thermal drift. AC characteristics – Frequency response, Slew rate, PSRR.
Basic op-amp applications – Scale changer/Inverter. Summing amplifier: Inverting summing amplifier, Non-inverting Summing amplifier, Subtractor, Instrumentation Amplifier. (Relevant problems).

Module II: **08 Hours**

Operational Amplifier Applications: V – I and I – V converter, Opamp circuit using diodes, sample and hold circuit, Differentiator and Integrator.

Comparator and waveforms generator: Comparator, Regenerative comparator (Schmitt Trigger), Astable mutivibrator, Monostable multivibrator and Triangular waveform generator. Phase shift oscillator, Wien bridge oscillator. (Relevant problems).

Module III: **08 Hours**

Voltage Regulators: Introduction, Series Op-amp regulator, IC voltage regulators, 723 general purpose regulators, switching regulator.

Active filters: First and Second order LPF, First and Second orders HPF, Band Pass Filters, Band Reject filters. (Design examples)
555 Timer: Description of Functional Diagram, Monostable operation, Astable and Bistable operations

Module IV: **10 Hours**

Data Acquisition Systems: Types of instrumentation systems, Components of analog data acquisition system, Digital data acquisition system, Use of recorders in digital systems, Digital recording systems.

Data Converters:
Digital to Analog Converters: Basic DAC techniques, Weighted Resistor DAC, R – 2R Ladder DAC, DAC 0800 (Data sheet: Features and description only).
Analog to Digital Converters: Functional diagram of ADC, Flash ADC, Counter type ADC, Successive approximation ADC, Dual slope ADC. ADC 0809 (Data sheet: Features, specifications and description only), DAC/ADC specifications.

Total lecture hours: **30 Hours**

Text Book:

1. R. A. Gayakwad, Op-Amps and Linear Integrated Circuits, 4th ed., PHI.
2. D. Roy Choudhury and S. B. Jain, Linear Integrated Circuits, 4th ed., New Delhi, India: New Age International, 2010.

3. K. Sawhney, A Course in Electrical & Electronic Measurements & Instrumentation, 19th ed., New Delhi, India: Dhanpat Rai Publications, 2011.
4. S. Sedra and K. C. Smith, Microelectronic Circuits, 7th ed., New York, NY, USA: Oxford Univ. Press, 2015.

Reference Book:

1. R. F. Coughlin and F. F. Driscoll, Operational Amplifiers and Linear Integrated Circuits, PHI/Pearson, 2006.
2. J. M. Fiore, Op-Amps and Linear Integrated Circuits, Thomson Learning, 2001.
3. S. Franco, Design with Operational Amplifiers and Analog Integrated Circuits, 3rd ed., TMH, 2005.
4. J. A. Svoboda and R. C. Dorf, Introduction to Electric Circuits, 9th ed., Hoboken, NJ, USA: Wiley, 2014.

CO-PO-PSO MAPPING

SIGNAL CONDITIONING & DATA ACQUISITION CIRCUITS															
Course outcome	**Program Outcomes**												**Program Specific Outcomes**		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO l	PSO 2	PSO 3
CO1	3	3	3	2	2	1	0	2	3	3	2	3	3	3	3
CO2	3	3	3	3	3	3	2	3	3	2	3	2	3	2	3
CO3	3	3	3	3	3	1	1	1	1	1	1	1	3	3	3
CO4	3	3	3	3	3	2	2	2	2	2	2	2	3	3	3
Average	3	3	3.0	2.75	2.75	2.5	1.25	2.0	.2.5	2.0	2.0	2.0	3	2.75	3
Level of Correlation:			3 - High			2 - Medium				1 – Low					