COURSE STRUCTURE AND DETAILED SYLLABUS

of

Master of Technology in Electrical and Electronics Engineering

Specialization: Sensors & Cyber Physical System

(Two Years Regular Course)

(Applicable for the batches admitted from 2022-2023)

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

VEER SURENDRA SAI UNIVERSITY OF TECHNOLOGY

BURLA, SAMBALPUR

ODISHA-768018

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VEER SURENDRA SAI UNIVERSITY OF TECHNOLOGY, BURLA, ODISHA

DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING

VISION OF THE DEPARTMENT

The postgraduates in Electrical & Electronics Engineering program of VSSUT, Burla strives to be recognized globally for imparting outstanding technical education and research leading to well qualified truly world class leaders and to unleash technological innovations to serve the global society with an ultimate aim to improve the Quality-of-Life.

MISSION OF THE DEPARTMENT

The Masters' in Electrical & Electronics Engineering program of VSSUT, Burla strives to create world class Electrical & Electronics Engineers by

M1	Establishing state of the art research facilities to provide enabling environment to create, analyze, apply and disseminate knowledge.
M2	Fortifying collaboration with world class R&D organizations, educational institutions, industry and alumni for excellence in teaching, research and consultancy practices to fulfill "Make in India" policy of the Government.
M3	Providing the students with academic environment of excellence, leadership, ethical guidelines and lifelong learning needed for a long productive career.

PROGRAM EDUCATIONAL OBJECTIVES

The educational objectives of PG program in Electrical and Electronics Engineering (Sensors & Cyber Physical System) of VSSUT, Burla are:

PEO1	To gain expertise in designing, modelling, and handling real-world challenges in order to meet industrial issues and conduct research in a broad area of electrical and electronics engineering.
PEO2	To prepare students to succeed in their professional careers, entrepreneurial skills, research, and higher education, and to take the lead in the idea, design, and implementation of innovative products, processes, services, and systems those are appropriate for the current socio-economic context.
PEO3	To give students the specialist workforce in the fields of sensors and cyber physical system in domain industries, educational institutions and cutting-edge research labs, as well as the opportunity to work and communicate effectively as part of a team, and to participate in the lifelong learning process.

MISSION OF THE PROGRAM – PEOs MATRIX

	M1	M2	M3
PEO1	3	1	1
PEO2	1	3	2
PEO3	2	3	3

PROGRAM OUTCOMES OF M.TECH. (EEE)

PO1	An ability to independently carry out research/investigation and development work to solve practical problems related to sensors and cyber physical system.
PO2	An ability to write and present a substantial technical report/document.
PO3	An ability to demonstrate the knowledge and skills in the area of specialization, which is at a level higher than the requirements of the undergraduate program in Electrical & Electronics Engineering.
PO4	An ability to create, learn and apply appropriate methodology and modern engineering tools for design and implementation of specific problem domain.
PO5	An ability to meet international standards in the field specialization through their team playing and self-learning capabilities.
PO6	Acquire integrity and ethics of research to execute projects efficiently and independently.

PROGRAM SPECIFIC OUTCOMES (PSOs) OF M. TECH (EEE)

PSO1	An ability to apply conventional and modern state of the art tools and techniques for development of intelligent engineering systems.
PSO2	Develop suitable techniques and cutting-edge engineering hardware and software to solve problems in the domain of sensors and cyber physical system.

Course Structure

1st Year-I Semester

Sl. No.	Course Code	Subject	L	P	Credits
1		Introduction to Cyber Physical Systems	3	-	3
2		Introduction to Internet of Things	3	-	3
3		**Elective – I** • Robot Modelling and Control • Security in Cyber Physical Systems • Advanced Control • Modern Control Theory	3	-	3
4		**Elective – II** • Digital Signal Processing • Digital Image Processing • Mixed Signal Processing • Sensors and Measurements	3	-	3
5		**Common** Research Methodology & IPR	3	-	3
6		**Audit-I** English For Research Paper Writing	3	-	-
7		Automation and Signals Laboratory	-	6	4
		Total Credits			**19**

1st Year-II Semester

Sl. No.	Course Code	Subject	L	P	Credits
1		Artificial Intelligence and Machine Learning	3	-	3
2		Telemetry and Remote Control	3	-	3
3		**Elective – III** • Smart Grid • Grid Integration of Renewable Energy • Programmable Logic Controllers & Applications • Industrial Automation and Control	3	-	3
4		**Elective – IV** i. Intelligent Sensors and Instrumentation ii. Micro and Nano Electromechanical Systems (M-NEMS) iii. Real Time Systems iv. Image Sensor Design and Applications	3	-	3
5		Minor Project and Seminar	2	-	2
6		**Audit II**	3	-	-
7		Real Time Digital Simulation Laboratory	-	6	4
		Total Credits			**18**

2nd Year-III Semester

Sl. No.	Course Code	Subject	L	P	Credits
1		**Elective – V** • Edge and Fog Computing • Programming & Embedded System • Electric Vehicle - V2G and G2V • Data Communication & Ad-hoc Networking	3	-	3
2		Open Elective	3	-	3
3		Comprehensive Viva-Voce	-	-	2
5		Project Work Stage – I	-	-	8
		Total Credits			**16**

2nd Year-IV Semester

Sl. No.	Course Code	Subject	L	P	Credits
1		Project Work Stage – II	-	-	16
		Total Credits			**16**

Grand Total Credit: 19 + 18 + 16 + 16 = **69**

Audit II

Sl. No.	Subject name
1	Disaster Management
2	Sanskrit for Technical Knowledge
3	Value Education
4	Constitution of India
5	Pedagogy Studies
6	Stress Management by Yoga
7	Personality Development through Life Enlightenment Skills

Course Code	Course Title	Hrs./Week L: T: P	Credits
EEE	Introduction to Cyber Physical Systems	3:0:0	3

Course Objectives:

- Introduce modeling of CPS
- Introducing the benefits of CPS and ability to analyse smart grid and smart city infrastructure as per new grid codes

UNIT I (8 Hours)
Motivation and examples of CPS e.g. Energy, Medical and Transportation cyber physicalsystems; Key design drivers and quality attributes of CPS. Attributes of high confidence CPS.

UNIT II (8 Hours)
Continuous systemsmodeling; Discrete time system modeling; Finite state machine

UNIT III (8 Hours)
Extendedstate machines; Hybrid system modeling; Classes of Hybrid Systems.

UNIT IV (8 Hours)
Basic concepts of embedded systems; Embedded Processors; Input-outputs; Invariants andTemporal Logic; Linear Temporal Logic;

UNITV (8 Hours)
Equivalence and Refinement; Development of modelsfrom specifications; Rechability analysis and Model Checking

Text Books:

1. R. Rajkumar, D. de. Niz and M. Klein, (2017), Cyber Physical Systems, Addision-Wesely

Reference Books:

1. E.A.Lee and S A Shesia, (2018), Embedded system Design: A Cyber-Physical Approach,Second Edition, MIT Press.
2. A.Platzer, (2017), Logical Foundations of Cyber Physical Systems, Springer.

COURSE OUTCOME:
After completion of this course, students will be able to:

CO1:Know various modeling formalisms for CPS
CO2: Identify safety specifications and critical properties
CO3: Understand CPS security and safety aspects
CO4: Understand abstraction in system designs
CO5: Realize the basics of CPS implementation

Course Articulation Matrix:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	-	2	2	2	-
CO2	3	-	3	3	3	-
CO3	3	-	3	3	1	-
CO4	3	-	3	3	3	-
CO5	3	-	3	3	2	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix for the Course:

	PO1	PO2	PO3	PO4	PO5	PO6
CO	3	-	3	3	2	-

Course Code	Course Title	Hrs./Week L: T: P	Credits
EEE	**Introduction to Internet of Things**	**3:0:0**	**3**

Course Objectives:

- Provide overview of applications of IoT and relevant technologies

UNIT I (8 Hours)
Introduction to IoT: Sensing, Actuation, Basics of IoT Networking, IoT Architecture, Communication Protocols for IoT

UNIT II (8 Hours)
Sensor Networks: Wireless Sensor Network, Sensor nodes

UNIT III (8 Hours)
Machine to machine Communication: Introduction, Node types and M2M Applications, Integration of Sensors and Actuators for Implementation of IoT

UNIT IV (8 Hours)
Introduction to Cloud, Fog, and Edge Computing,

UNITV (8 Hours)
Smart cities and Smart homes, Industrial IoT

Text Books:

1. Kamal, R., (2017), Internet of Things - Architecture and Design Principles, 1st Edition, Mcgraw Hill.

Reference Books:

1. Misra, S., Introduction to Internet of Things, NPTEL Course Material, Department of Computer Science and Engineering, Indian Institute of Technology Kharagpur, https://nptel.ac.in/courses/106105166/.

COURSE OUTCOME:
After completion of this course, students will be able to:

CO1: Able to apply mathematics and science in engineering applications.
CO2: Able to use techniques, skills, resources and modern engineering and IT tools necessary for engineering practice
CO3:understand various techniques to solve practical issues in daily life routine
CO4: know good cognitive load management skills related to project management and finance
CO5:value professional and ethical responsibility

Course Articulation Matrix:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	-	2	2	2	-
CO2	3	-	3	3	3	-
CO3	3	-	3	3	1	-
CO4	3	-	3	3	3	-
CO5	3	-	3	3	2	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix for the Course:

	PO1	PO2	PO3	PO4	PO5	PO6
CO	3	-	3	3	2	-

Course Code	Course Title	Hrs./Week L: T: P	Credits
EEE	Robot Modeling and Control	3:0:0	3

Course Objectives:

- To introduce fundamental aspects of modelling and control of robot manipulators.
- To provide a brief of results from geometry, kinematics, dynamics, motion planning and control

UNIT I (8 Hours)

Position Kinematics: Transformations, Rigid Motions, Forward Kinematics: Denavit-Hartenberg Convention, Inverse Kinematics

Velocity Kinematics: The Jacobian: Angular and Linear Velocity: Singularities, Accelerations

UNIT II (8 Hours)

Robot Dynamics: Equations of Motion, Kinetic and Potential Energy, Euler-Lagrange Equations, Recursive Newton-Euler Formulation Motion Planning and Vision based control

Path Planning: The Configuration Space, Planning in Configuration Space, Potential Fields, RRTs

Trajectory Planning: Point to Point Motion, Paths Specified by Via Points

UNIT III (8 Hours)

Computer Vision: Introduction to Computer Vision, The Geometry of Image Formation, Camera Calibration, Image Features, Segmentation

Vision-Based Control: Relation between End Effector and Camera Motions, Camera Motion and Interaction Matrix, Image-Based Control Laws, Partitioned Approaches

UNIT IV (8 Hours)

Linear Control: Feedback and closed-loop control, second-order linear systems, control of second order systems, Control-law partitioning, trajectory-following control, disturbance rejection, Continuous vs. Discrete time control, modelling and control of a single joint, architecture of an industrial-robot controller

UNITV (8 Hours)

Nonlinear control: Nonlinear and time-varying systems, multi-input, multi-output control systems, control of manipulators, practical considerations, Lyapunov stability analysis, cartesian-based control systems, adaptive control

Force Control: Interaction with Environment, Force Control, Hybrid Force/Motion control

Text Books:

1. Craig J. J (2008), Introduction to robotics: mechanics and control. Pearson 3rd Edition.
2. Spong M. W., Hutchinson, S., and Vidyasagar, M.(2020), Robot modeling and control. New York: Wiley 2nd Edition.

Reference Books:

1. Saha S. K. (2017), Introduction to robotics. Tata McGraw-Hill Education, 2nd edition.

COURSE OUTCOME:
After completion of this course, students will be able to:

CO1: Define basic concept of position and velocity kinematics.
CO2:Understand robot dynamics and construct various path trajectory planning techniques.
CO3: Develop the knowledge of computer vision and able to implement vision based control.
CO4: Understand different linear control techniques and apply to robot control.
CO5: Understand different non- linear control techniques, force control and implement for robot control.

Course Articulation Matrix:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	-	2	2	1	-
CO2	3	-	3	3	2	-
CO3	3	-	3	3	1	-
CO4	3	-	3	3	2	-
CO5	3	-	3	3	2	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix for the Course:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO	3	-	3	3	2	-

Course Code	Course Title	Hrs./Week L: T: P	Credits
EEE	Security in Cyber Physical Systems	3:0:0	3

Course Objectives:

- To introduce mathematical framework for Cyber Physical System attacks.
- To introduce centralized and decentralized techniques of attack detection

UNIT I

Review of graph theory based models; some examples from infrastructure system modelling Descriptor system; Unified modelling of CPS attack; case of undetectable attacks.

UNIT II

Graph theoretic characterization of attacks and its limitations; Centralized and distributed monitors; examples from power system, water distribution networks etc.

UNIT III

Security issues of Industrial Control Systems; Integrity attacks on SCADA systems.

UNIT IV

Model based technique to detect integrity attacks on sensors; threat model and its effect on control scheme; countermeasure for detecting such attacks; watermarking scheme.

UNITV

Design of observers under sensor and actuator attacks; design of observer for distributed environment under different attacks; applications of swarms of UAVs; Control design with denial service attack; case studies.

Text Books:

1. F. Pasqualetti, F. Dörfler and F. Bullo, "Attack Detection and Identification in Cyber-PhysicalSystems," in IEEE Transactions on Automatic Control, vol. 58, no. 11, pp. 2715-2729, Nov.2013.
2. H. Fawzi, P. Tabuada and S. Diggavi, "Secure Estimation and Control for Cyber PhysicalSystems Under Adversarial Attacks," in IEEE Transactions on Automatic Control, vol. 59, no.6, pp. 1454-1467, June 2014.

Reference Books:

1. Yilin Mo, Rohan Chabukswar and Bruno Sinopoli "Detecting Integrity Attacks on SCADASystems" in IEEE Transactions on Control System Technology, Vol. 22, No. 4, 2014.
2. F. Pasqualetti, F. Dörfler and F. Bullo "Control Theoretic methods for Cyber PhysicalSecurity", in IEEE Control System Magazine, pp. 110-127, Feb. 2015

COURSE OUTCOME:

After completion of this course, students will be able to:

CO1: Develop understanding about the cyber security and its criticalities in CPS.
CO2: Analyze the need of Graph theoretic characterization, and the Centralized and

distributed monitors.
CO3: Analyze the role of security issues of CPS in industrial control and electrical power systems applications.
CO4: Analyze model base techniques in security issues.
CO5: Develop understanding of real world needs by studding the different case studies.

Course Articulation Matrix:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	-	2	2	2	-
CO2	3	-	3	3	3	-
CO3	3	-	3	3	1	-
CO4	3	-	3	3	3	-
CO5	3	-	3	3	2	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix for the Course:

	PO1	PO2	PO3	PO4	PO5	PO6
CO	3	-	3	3	2	-

Course Code	Course Title	Hrs./Week L: T: P	Credits
EEE	Advanced Control	3:0:0	3

Course Objectives:

- To introduce Multi-Agent based Modeling control algorithms
- To introduce robust controller for distributed systems

UNIT I (8 Hours)

Review of state space analysis and feedback control design; Problem of estimation andobserver design; Cooperative control motivation and examples.

UNIT II (8 Hours)

Distributed Control: Sources of uncertainty and robust control; Concepts of Sliding Modecontrol and its applications to Robust control design for distributed systems; Robust observerdesign

UNIT III

Design behaviour of swarms Consensus problem and distributed flocking behaviour; Stability analysis of flocking motion

UNIT IV

Event Triggered Control: Introduction to event based sampling; stability with event basedsampling; event based multi agent systems; consensus with event triggered contro

UNITV

Control of Cyber physical systems: Control of CPS with logic specifications, symbolic models fornonlinear system and extension to large classes of systems.

Text Books:

1. Jeff Shamma, Cooperative Control of Distributed Multi-agent Systems, Wiley, 2008
2. Edwards, Christopher, and Sarah Spurgeon, Sliding mode control: theory and applications,CRC Press, 1998.

Reference Books:

1. Tabuada, Paulo. "Event-triggered real-time scheduling of stabilizing control tasks." IEEETransactions on Automatic Control 52.9 (2007): 1680-1685.

COURSE OUTCOME:
After completion of this course, students will be able to:

CO1:Analyze terminology and properties of cooperative control and applicability of state space for it.
CO2:Apply different techniques for robust control for distributed control.
CO3:Analyze the swarm consensus problem.
CO4:Understand event triggered control.
CO5:Design distributed control for cyber physical systems.

Course Articulation Matrix:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	1	3	2	2	1
CO2	2	1	2	3	3	1
CO3	2	1	3	2	3	1
CO4	2	1	3	2	2	1
CO5	3	1	3	3	3	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix for the Course:

	PO1	PO2	PO3	PO4	PO5	PO6
CO	2	1	3	2	3	1

Course Code	Course Title	Hrs./Week L: T: P	Credits
EEEM1112	Modern Control Theory	3:0:0	3

Course Objectives:

- To facilitate the Evolution of state variable Approach for the Analysis of Control systems.
- To examine the importance of controllability and observability in Modern Control Engineering for Time Variant and Time-invariant systems.
- To examine the importance of controllability and observability in Jordan Canonical form.
- To enable Students to Analyze various types of nonlinearities and describing function analysis of non-linear systems.
- To construct trajectories using describing functions and phase plane analysis.
- To study the analysis of stability and instability of continuous time invariant system

UNIT-I

State Variable Analysis

The Concept of state – State Equations for Dynamic systems – State Diagram - Linear Continuous time model for physical Systems – Existence and Uniqueness of Solutions to Continuous – Time State Equations – Solutions – Linear Time Invariant Continuous – Time State Equations – State transition matrix and it's properties

UNIT-II

State Variable Techniques

General concept of Controllability - General concept of Observability Controllability tests for Continuous &Time Invariant systems - Observability tests for Continuous &Time Invariant systems .

Controllability and Observability of state model in Jordan Canonical form - Controllability and Observability Canonical forms of State model – State feedback controller Design through pole assignment.

UNIT-III

Non Linear Systems – I

Introduction – Non Linear Systems – Types of Non – Linearities – Saturation – Dead – Zone – Backlash – Jump Phenomenon etc; - Singular Points – Introduction to Linearization of nonlinear Systems, properties of Non Linear Systems – Describing function – describing function Analysis of nonlinear systems- Stability Analysis of Non – Linear systems through describing functions.

UNIT-IV

Non Linear Systems – II

Introduction to phase – plane Analysis, Method of Isoclines for Constructing Trajectories, singular points, phase – plane analysis of nonlinear control systems.

Learning outcomes:

- Construct Trajectories by using the method of Isoclines.(L5)
- Analyze the phase-plane analysis on nonlinear control systems.(L4)

UNIT-V

Stability Analysis

Stability in the sense of Lyapunov,Lyapunov's stability and Lyapunov's instability Theorems,StabilityAnalysisoftheLinearContinuoustimeinvariantsystemsbyLyapunovse condmethod-Generation of Lyapunov functions – Variable gradient method – Krasooviski'smethod.

Learning outcomes:

- Understand Lyapunov's stability and instability theorems.(L2)
- Generate Lyapunov's functions by variable gradient and Krasooviskis method.(L5)

Textbooks:

- Modern Control System Theory by M. Gopal – New Age International –1984
- Modern Control Engineering by Ogata. K – Prentice Hall –1997

Reference Books:

- Nonlinear systems, Hassan K. Klalil, Prentice Hall,1996
- Modern control systems, Richard C. Dorf and Robert H. Bishop, 11th Edition, Pearson Edu, India,2009

COURSE OUTCOME:

After completion of this course, students will be able to:

CO1: Understand the concept of state, state equations, state modeling of LTI system and obtain solutions for LTI systems.
CO2: Analyze the concept of Controllability and Observability and design State feedback controller by pole placement.
CO3: Express knowledge on Nonlinear systems and perform stability analysis of the dynamical systems using describing function method.
CO4: Construct phase trajectories and do the phase-plane analysis on nonlinear control systems.
CO5: Understand Lyapunov's stability and instability theorems and generate Lyapunov's functions for nonlinear systems.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	-	2	2	1	-
CO2	3	-	3	3	2	-
CO3	3	-	3	3	2	-
CO4	3	-	3	3	2	-
CO5	3	-	3	3	2	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix for the Course:

	PO1	PO2	PO3	PO4	PO5	PO6
CO	3	-	3	3	2	-

Course Code	Course Title	Hrs./Week L: T: P	Credits
EEE	Digital Signal Processing	3:0:0	3

- **Course Objectives:**

UNIT I (8 Hours)

Discrete time signal and system: discrete- time signals (some elementary examples, classification of discrete-time signals), discrete- time system (block diagram representation, classification and interconnection of discrete time system), analysis of discrete time linear timeinvariant system (response of LTI systems to arbitrary inputs, properties of convolution and interconnection of LTI systems, casual linear time-invariant systems, stability of linear timeinvariant system), discrete-time systems described by difference equations, structure of LTI system, recursive and non-recursive realization of FIR systems, correlation of discrete time system.

UNIT II (10 Hours)

The Z-transform:The Z-transform, properties of Z-transform, inverse of Z-transform, the onesided Z-transform.

The Discrete Fourier transform: frequency domain sampling, the DFT, relationship of DFT to other, properties of the DFT, circular convolution, circular correlation, circular correlation by convolution, method linear convolution by overlap save method and by overlap add method.

UNIT III (10Hours)

Fast Fourier transform: operation counts by direct computation of DFT, divide and conquer approach to computation of the DFT, radix-2 FFT algorithm, decimation-in-time (DIT) and decimation-in frequency (DIF) algorithm, efficient computation of the DFT of real sequencesand a 2N-point real sequence.

UNIT IV (5 Hours)

Design of digital filter: causality and its implementation, design of linear phase FIR filters using different windows, design of IIR impulse response method and bilinear transformation method.

UNITV (7 Hours)

Power spectrum estimation: Estimation of spectral from finite duration signals, Nonparametric method of power spectrum estimations. The Bartieff method and the Blackman and Tukey method. Implementation of Discrete Time System structure of FOR Systems-Direct form, cascaded form. Structure IIR Systems - Direct form 1&11 realizations.

TEXT BOOKS:

1. J.G. Proakis and D.G. Manolakis, “Digital Signal Processing - Principles, Algorithms and Applications”, PHI Publisher.
2. Sanjit Mitra “Digital Signal Processing – A Computer based approach” TMH Publisher.

REFERENCE BOOKS:

1. S. Salivahanan, “Digital Signal Processing”, TMH Publisher.
2. R. Johnson, “Introduction of Digital Signal Processing”, PHI Publisher

COURSE OUTCOME:
After completion of this course, students will be able to:

CO1: Characterize signals and systems.
CO2: Analyze digital systems in the time and frequency domain.
CO3: Digital system characterization through DFT and FFT.
CO4: Realization and implementation of digital filters and systems.
CO5: Understand signal spectral estimation methods

Course Articulation Matrix:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	1	-	1	2	2	1
CO2	2	-	2	3	3	2
CO3	2	-	3	3	3	2
CO4	3	1	3	3	3	2
CO5	3	1	3	3	3	2

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix for the Course:

	PO1	PO2	PO3	PO4	PO5	PO6
CO	3	1	3	3	3	2

Course Code	Course Title	Hrs./Week L: T: P	Credits
EEE	Digital Image Processing	3:0:0	3

Course Objectives:

UNIT I (9 Hours)
Digital Image Fundamentals: Components of image processing system, image fundamentals, image sampling and quantization, basic relationships between pixels, color image fundamentals – RGB, YC bCr, HSI models, 2D-transforms – DFT, DCT, KLT, slant transform, Hough transform, Properties of transforms and applications, Fundamentals on wavelet transform.

UNIT II (9 Hours)
Image Enhancement: Enhancement in spatial domain: basic gray level transformations, histogram processing, smoothing and sharpening of spatial filters. Enhancement in frequency domain: Introduction to filtering in frequency domain, smoothing and sharpening of frequency domain filters.

UNIT III (6 Hours)
Image Restoration: Degradation model, restoration in presence of noise only – spatial filtering, linear, position invariant degradations, estimating degradation functions, inverse filtering, Wiener filtering.

UNIT IV (9 Hours)
Image compression: Redundancy and compression models, Lossless coding – Run length coding, Huffman coding, vector quantization, JPEG, concepts of fractals, fractal image compression.

UNITV (6 Hours) Image segmentation: Edge detection, Boundary description, Morphological image processing, Region based segmentation – region growing, region merging and splitting.

TEXT BOOKS
1. Rafael C. Gonzalez, Richard E. Woods, „Digital Image Processing', Pearson, Second Edition,2004.
2. Anil K. Jain, „Fundamentals of Digital Image Processing', Pearson 2002.

REFERENCES
1. Rafael C. Gonzalez, Richard E. Woods,' Digital Image Processing usingMATLAB', Pearson Education, Inc., 2004.
2. William K. Pratt, „Digital Image Processing", John Wiley, New York, 2002.

COURSE OUTCOME:

After completion of this course, students will be able to:

CO1: Analyze general terminology and properties of digital image processing.
CO2: Apply different techniques for image enhancement in spatial and frequency domain.
CO3: Analyze techniques for image restoration.
CO4: Recognize techniques of image compression.
CO5: Analyze the methodologies for image segmentation.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	-	2	2	1	-
CO2	3	-	3	3	2	-
CO3	3	-	3	3	1	-
CO4	3	-	3	3	2	-
CO5	3	-	3	3	2	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix for the Course:

	PO1	PO2	PO3	PO4	PO5	PO6
CO	3	-	3	3	2	-

Course Code	Course Title	Hrs./Week L: T: P	Credits
EEE	Mixed Signal Processing	3:0:0	3

Course Objectives:

- To introduce the design of Bipolar Operational amplifiers, CMOS op-amps, current mirrors, active filters, Switched-Capacitor filter and integrator,Voltage controlled oscillator, Phase locked loop.
- To provide the design of combination of analog and digital signal processing circuits: digital to analog converter, analog to digital converter, switched current filter, current cell, simple second order structure, analog multiplexer, sample and Hold Circuits.

UNIT I

Bipolar operational amplifiers. MOS diode, active resistor and current mirrors, CMOS amplifier and operational amplifier. Approximation functions: Butterworth, Chebyshev and Bessel approximations, Frequency transformation.

UNIT II

Continuous time filter: Active filter; Second order filter: Single amplifier and multiple amplifier structures and filter parameter sensitivities. Cascade filter. Sampled data filter: Switched Capacitor filter; Switched capacitor integrator and filter. Filter transfer function in z-domain, Filter parameter sensitivities with respect to capacitor ratios.

UNIT III

Mixed signal circuits: Introduction to Switched current filter, current cell. Simple second order structure. Analog multiplexer, Sample and Hold Circuits, aliasing error and anti-aliasing filter, Digital to analog converter (DAC), Analog to Digital Converter (ADC), flash, dual slope and multi slope ADC.

UNIT IV

Over sampling method for A/D and D/A conversion. Delta-Sigma data converter. Noise and noise reductions. Interference signals and their reduction: Capacitive, inductive coupling and ground loop interferences and its reduction.

UNITV

Logarithmic and exponential amplifiers, analog multipliers and divider, Voltage controlled oscillator, Phase locked loop. Waveform generator and Oscillator.

Text Books:

1. R.Schaumann and M.E. Valkenberg,Design of Analog Circuits, Oxford University Press
2.

Reference Books:

COURSE OUTCOME:

After completion of this course, students will be able to:

CO1: express the basic design of bipolar and CMOS op-amps, active resistor and current mirrors.
CO2: implement different kind of continuous time filter and sampled data filter.
CO3: implement various mixed signal circuits that is a combination of analog and digital signal processing.
CO4: analyze the concept of noise and interference signals reduction in mixed-signal processing.
CO5: express the basic design of VCO, PLL and waveform generator.

Course Articulation Matrix:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	3	2	2	-
CO2	3	3	3	2	2	-
CO3	3	3	3	2	2	-
CO4	3	3	3	2	2	-
CO5	3	3	3	2	2	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix for the Course:

	PO1	PO2	PO3	PO4	PO5	PO6
CO	3	3	3	2	2	-

Course Code	Course Title	Hrs./Week L: T: P	Credits
EEE	Sensors and Measurements	3:0:0	3

Course Objectives:

- Introduce the students to sensors, as transducers from physical parameters to signals
- Explain the sensing principles for displacement, force, pressure, acceleration, temperature, optical radiation, nuclear radiation
- Explain the sensor range, sensitivity, accuracy, repeatability, noise

UNIT I

Definitions, terminology, classification, Static vs dynamic properties of transducers, Transfer functions, Ideal and realistic transducer models, Resolution, linearization, dynamic range, detection threshold, Selectivity & sensitivity,

UNIT II

Calibration, Errors of the experimental measurements, Noise: electronics, environmental & internal. Capacitance, Magnetism, Induction, Resistance,

UNIT III

Piezoelectric effect, Pyroelectric effect, Hall effect, Thermoelectric effect, Temperature and thermal properties of materials and heat transfer,

UNIT IV

Optics, Fiber optics and waveguides. Input characteristics of interface circuits, Amplifiers, Light to voltage converters, Capacitance to voltage converters, Bridge Circuits, Excitation circuits.

UNITV

Case Studies: Inertial Sensors (Accelerometer & gyroscope), Healthcare Sensors (Glucometer, ECG & MRI), Smart building Sensors (Smoke & occupancy sensors).

Text Books:

1. Jacob Fraden, (2010), Handbook of Modern Sensors, 5th Edition, Springer.

2. J. W. Gardner, (1996), Microsensors, Principles and Applications, 1 st Edition, Wiley.

Reference Books:.

1. S. M. Sze, (1994), Semiconductor Sensors, 1 st Edition, Wiley.

COURSE OUTCOME:

After completion of this course, students will be able to:

CO1: Develop understanding smart sensors and transducers, and their static and dynamic behaviors.
CO2: Analyze the need of calibration of sensors and impact of noises and other influencial parameters.
CO3: Develop understanding of different thermal and electromagnetic sensors.

CO4: Develop understanding of optical sensors and need of signal conditioning devices and its interface with sensing films/ devices.
CO5: Develop understanding of real world needs by studding the different case studies.

Course Articulation Matrix:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	-	2	2	2	-
CO2	3	-	3	3	2	-
CO3	3	-	3	3	1	-
CO4	3	-	3	3	2	-
CO5	3	-	3	3	3	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix for the Course:

	PO1	PO2	PO3	PO4	PO5	PO6
CO	3	-	3	3	2	-

Course Code	Course Title	Hrs./Week L: T: P	Credits
EEEM1213	Research Methodology and IPR	3:0:0	--

Course Objectives:

At the end of this course, students will demonstrate the ability to

- Study the research problemformulation.
- Study the research relatedinformation
- Study the researchethics

UNIT –I

Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem.

Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

UNIT –II

Effective literature studies approaches, analysis Plagiarism, Research ethics.

UNIT –III

Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

UNIT –IV

Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

UNIT –V

Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

UNIT –VI

New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

References:

- Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineeringstudents'"
- Wayne Goddard and Stuart Melville, "Research Methodology: AnIntroduction"
- Ranjit Kumar, 2nd Edition , "Research Methodology: A Step by Step Guide forbeginners"
- Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd,2007.
- Mayall , "Industrial Design", McGraw Hill,1992.

- Niebel , “Product Design”, McGraw Hill,1974.
- Asimov , “Introduction to Design”, Prentice Hall,1962.
- Robert P. Merges, Peter S. Menell, Mark A. Lemley, “ Intellectual Property in New Technological Age”,2016.
- T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand,2008

Course Outcomes:

At the end of this course, students will be able to

- Understand research problem formulation (L2)
- Analyze research related in formation (L4)
- Understand the researchethics (L2)
- Understand that today’s world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, andcreativity (L2).
- Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering inparticular (L2).
- Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and socialbenefits (L2).

COURSE OUTCOMES VS POs MAPPING (DETAILED; HIGH:3; MEDIUM:2; LOW:1**):**

S. NO.	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS01	PSO2
EEEM1213.1	2	-	-	-	-	-	-	2	-	2	1	-	1	2
EEEM1213.2	2	-	-	-	-	-	-	2	-	2	1	-	1	2
EEEM1213.3	2	-	-	-	-	-	-	2	-	2	1	-	1	2
EEEM1213.4	2	-	-	-	-	-	-	2	-	2	1	-	1	2
EEEM1213.5	2	-	-	-	-	-	-	2	-	2	1	-	1	2
EEEM1213.6	2	-	-	-	-	-	-	2	-	2	1	-	1	2
EEEM1213**	2	-	-	-	-	-	-	2	-	2	1	-	1	2

Course Code	Course Title	Hrs./Week L: T: P	Credits
EEEM1113	English for Research Paper Writing	3:0:0	--

Course Objectives:

- Study on how to improve your writing skills and level of readability.
- Study about what to write in each section
- Study the skills needed when writing a Title

UNIT-I

Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness

UNIT-II

Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticising, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts. Introduction

UNIT-III

Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check **.**

UNIT-IV

Key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature.

UNIT-V

Skills are needed when writing the Methods, skills needed when writingthe Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions

UNIT-VI

useful phrases, how to ensure paper is as good as it could possibly be
the first- time submission

Reference Books/studies.

- Goldbort R (2006) Writing for Science, Yale University Press (available on GoogleBooks)
- Day R (2006) How to Write and Publish a Scientific Paper, Cambridge UniversityPress
- Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM.Highman'sbook.
- Adrian Wallwork, English for Writing Research Papers, Springer New York Dordrecht Heidelberg London,2011.

Course Outcomes:

After completion of this course the students will be able to:

- Understand that how to improve your writing skills and level of readability(L2).
- Learn about what to write in each section (L2).
- Understand the skills needed when writing a Title (L2).

COURSE OUTCOMES VS POs MAPPING (DETAILED; HIGH:3; MEDIUM:2; LOW:1**):**

S. NO.	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS01	PSO2
EEEM1113.1	1	-	-	-	-	-	-	-	-	3	-	-	1	1
EEEM1113.2	1	-	-	-	-	-	-	-	-	3	-	-	1	1
EEEM1113.3	1	-	-	-	-	-	-	-	-	3	-	-	1	1
EEEM1113.4	1	-	-	-	-	-	-	-	-	3	-	-	1	1
EEEM1113.5	1	-	-	-	-	-	-	-	-	3	-	-	1	1
EEEM1113.6	1	-	-	-	-	-	-	-	-	3	-	-	1	1
EEEM1113**	1	-	-	-	-	-	-	-	-	3	-	-	1	1

Course Code	Course Title	Hrs./Week L: T: P	Credits
EEE	Automation and Signals Laboratory	0:0:6	4

Course Objectives:

- To introduce techniques to model/simulate different Cyber Physical Systems.
- To introduce techniques to verify different CPS models.

List of Experiments:

1. Data acquisition for the purpose of Gas leakages from the vessels of GIS/ substation automation.
2. Data acquisition for the purpose of humidity inside the vessels of GIS/ substation automation.
3. Study of temperature sensor for the applications related to substation automation.
4. Implementation of FFT of given sequence.
5. Implementation of LP FIR filter and LP IIR filter for a given sequence.
6. Impulse response of first order and second order systems.
7. Perform algebraic operations such as addition, subtraction, multiplication, and division on images.
8. Spatial domain operations: histogram processing, histogram equalization and histogram matching.
9. Morphological image processing: Dilation, Erosion, Opening and Closing.

COURSE OUTCOME:

After completion of this course, students will be able to:

CO1: Analyze fundamentals of data acquisition and automation .
CO2: Apply different techniques for FIR and IIR filters
CO3: Analyze techniques of algebraic operation for image.
CO1: Recognize techniques of spatial domain operation.
CO5: Analyze the methodologies for image processing.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	-	2	2	1	-
CO2	3	-	3	3	2	-
CO3	3	-	3	3	1	-
CO4	3	-	3	3	2	-
CO5	3	-	3	3	2	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix for the Course:

	PO1	PO2	PO3	PO4	PO5	PO6
CO	3	-	3	3	2	-

Course Code	Course Title	Hrs./Week L: T: P	Credits
EEE	AI and Machine Learning	3:0:0	3

UNIT I

Introduction to AI and Search Techniques Introduction to AI, production system, production rules, State-space problem, Problem Solving by Intelligent search: BFS, DFS, Iterative Deepening Search, Hill Climbing, Simulated Annealing, heuristic Search: A*,AO*, Adversary Search: MIN-MAX Algorithm, Alpha-Beta Cut-off algorithm.

UNIT II

Knowledge and Reasoning Propositional Logic, Theorem Proving by Propositional Logic, Resolution principle, Predicate Logic, wff conversion to clausal form, Dealing with Imprecision and Uncertainty: Probabilistic Reasoning, Dempster-Shafer Theory for Uncertainty Management.

UNIT III

Machine Learning Machine Learning: Supervised learning, unsupervised learning, Reinforcement learning, Artificial Neural Net, perceptron model, feed-forward neural network, Back propagation.

UNIT IV

Computational learning tasks for predictions, learning as function approximation, generalization concept. Linear models and Nearest-Neighbors (learning algorithms and properties, regularization). Neural Networks (MLP and deep models, SOM)

UNITV

Probabilistic graphical models. Principles of learning processes: elements of statistical learning theory, model validation. Support Vector Machines and kernel-based models. Introduction to applications and advanced models.

Text Books:

1. Fu, Gonzales and Lee, Robotics, McGraw Hill
2. Robotics and Control Mittal and Nagrath Tata McGraw-Hill Education
3. Artificial Intelligence and Soft Computing: Behavioral and Cognitive Modeling of the HumanBrain, Amit Konar, CRC Press
4. Artificial Intelligence, Dan W Patterson, Prentice Hall of India
5. S. Russel and P. Norvig, "Artificial Intelligence – A Modern Approach", Second Edition,Pearson Education.

Reference Books:

1. Robert Shilling, Fundamentals of Robotics-Analysis and control, PrenticeHall of India
2. Artificial Intelligence, Nils J. Nilsson, ELSEVIER.
3. E. Rich and K. Knight, Artificial Intelligence, - TMH

COURSE OUTCOME:
After completion of this course, students will be able to:

CO1:Acquire knowledge of Artificial intelligence and search techniques.
CO2: Understand logic propositions and apply it.
CO3: Analyze unsupervised and supervised learning for neural networks.
CO4: Apply neural network for prediction problem.
CO5: Apply advance network models.

Course Articulation Matrix:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	1	2	2	2	1
CO2	2	1	2	2	2	1
CO3	2	1	3	2	3	1
CO4	3	1	3	2	3	1
CO5	3	1	3	3	3	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix for the Course:

	PO1	PO2	PO3	PO4	PO5	PO6
CO	2	1	3	3	3	1

Course Code	Course Title	Hrs./Week L: T: P	Credits
EEE	Telemetry and Remote Control	3:0:0	3

Course Objectives:

To provide knowledge of signal transmission techniques, telemetry, remote control and SCADA.

UNIT I (8 Hours)

Introduction: Meaning and importance of telemetry, remote control, remote signaling and SCADA; Messages and signals; Signal formation; Conversion and transmission.

Signal Transmission Techniques I: Analog and digital modulation; Amplitude modulation; AM transmitter and receiver.

UNIT II (8 Hours)

Signal Transmission Techniques II: Frequency modulation, FM transmitter and receiver; Phase modulation; Pulse modulation techniques; Digital transmission techniques; Error detecting and correcting codes.

UNIT III (10 Hours)

Signal Transmission Media: Wires and cables; Power-line carrier communication, terrestrial and satellite radio links, optical fiber communication; Multiplexing – TDM, FDM and WDM.

Telemetry: Telemetry error; dc, pulse, and digital telemetry methods and systems; Multichannel telemetry schemes.

UNIT IV (6 Hours)

Remote Control and Remote Signaling: Principle of independent messages and combinatorial principle; Multi-wire FDM and TDM schemes.

UNIT V (8 Hours)

Supervisory Control and Data Acquisition: Layout, functions and operation of SCADA system; Remote terminal unit details; Control centre details; Communication between control centres; Communication between control centre and remote terminal units, introduction to phasor measurement unit (PMU).

Text Books:

1. Karp H. R. (Editor), “Basics of Data Communication”, McGraw Hill International Book Company. 1976
2. Tomasi W., “Electronic Communication Systems: Fundamentals”, 5th Ed., Pearson Education. 2008.
3. Gruenberg E. L., “Handbook of Telemetry and Remote Control”, McGraw-Hill International Book Company. 1967

Reference Books:

1. Ginzburg S. A., Lekhtman I. Ya. and Malov V. S., “Fundamentals of Automation and Remote Control”, Mir Publishers 1967.

2. Cegrell T., “Power System Control Technology”, Prentice Hall International Edition. 1986

COURSE OUTCOME:
After completion of this course, students will be able to:

CO1: Exposure about SCADA as a system and get introduced about fundamentals of communication systems involved in it.
CO2: Recognize analog, pulse and digital transmission/ reception techniques in telemetry system.
CO3: Analyze different wired/ wireless and multiplexing techniques in telemetry system.
CO4: Recognize techniques involved for the purposes of remote control.
CO5: Develop understanding about meager of telemetry and remote control together.

Course Articulation Matrix:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	-	2	2	1	-
CO2	3	-	3	3	2	-
CO3	3	-	3	3	1	-
CO4	3	-	3	3	2	-
CO5	3	-	3	3	2	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix for the Course:

	PO1	PO2	PO3	PO4	PO5	PO6
CO	3	-	3	3	2	-

Course Code	Course Title	Hrs./Week L: T: P	Credits
EEE	Smart Grid	3:0:0	3

Course Objectives:

OB1	Smart electric power grids, including definition, design criteria, technology and IoT.
OB2	Information processing and communications to the power grid.
OB3	Understanding the development of the smart grid,
OB4	Smart grid design, implementation, evaluation and management of smart electricity infrastructure

UNIT-I

Introduction to Smart Grid: Indian smart grid policy. Basic concept and definition of smart grid. Smart grid architecture. Smart grid technologies. Properties of smart grid: flexibility, reliability, demand response and other performance parameters. DC smart micro grids..

UNIT-II

Communication technologies: Generic model of communication network needed for Smart-grid, two way and real-time communication in power network, Introduction to different communication technologies available in the market (Latest standards. Emphasis on importance of inoperability and standardization of communication protocols), Matrix of different technologies against the smart-grid communication needs in a given utility environment, AMI, AMR & MDA: How it works and how it will help to; reduce peaks manage networks more efficiently and contribute towards smarter grids, Communication Standards IEC6150, Wide Area Situation awareness (WASA), Network stability

UNIT-III

Smart meters: Introduction, technology, data management, energy monitoring, smart energy meter, Phasor Measurement Unit (PMU), smart metering infrastructure, data acquisition.

Power Quality Management in Smart Grid: Power Quality & EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid, Web based Power Quality monitoring, Power Quality Audit.

UNIT-IV

Flexible AC transmission system (FACTS): Congestion management and load ability enhancement, reactive power compensation, concept of series compensation, shunt compensation, FACTS: working principle, classification, series controllers, shunt controllers, series-series controllers, series-parallel controllers.

UNIT-V

IoT for power systems: Internet of things for electricity infrastructure and energy management. SCADA, Demand response, AMI, IoT aided smart grid, Big data for power system and introduction to data analytics.

Application of smart grid: Challenges being faced during implementation of smart grid. Virtual power plants, Smart Utilities (case studies), Smart Grid Maturity Model (SGMM).

Text Books:

1. James Momoh, “Smart Grid: Fundamentals of design and analysis”, John Wiley & sons Inc, IEEE press 2012.
2. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, “Smart Grid: Technology and Applications”, John Wiley & sons inc, 2015.
3. Fereidoon P. Sioshansi, “Smart Grid: Integrating Renewable, Distributed & Efficient Energy”, Academic Press, 2012.
4. Clark W.Gellings, “The smart grid: Enabling energy efficiency and demand response”, Fairmont Press Inc, 2009.

Reference Books:

1. Andres Carvallo, John Cooper, “The Advanced Smart Grid: Edge Power Driving Sustainability: 1”, Artech House Publishers July 2011
2. James Northcote, Green, Robert G. Wilson “Control and Automation of Electric Power Distribution Systems (Power Engineering)”, CRC Press
3. MladenKezunovic, Mark G. Adamiak, Alexander P. Apostolov, Jeffrey George Gilbert “Substation Automation (Power Electronics and Power Systems)”, Springer
4. R. C. Dugan, Mark F. McGranghan, Surya Santoso, H. Wayne Beaty, “Electrical Power System Quality”, 2nd Edition, McGraw Hill Publication.
5. Yang Xiao, “Communication and Networking in Smart Grids”, CRC Press

COURSE OUTCOME:
After completion of this course, students will be able to:

CO1: Understand the smart grid architecture and standards.
CO2: Investigate the need of different information and communication layers.
CO3: Analyze the applications of PMU and smart meters in smart grid environment.
CO4: Distinguish different FACTs devices for power quality enhancement.
CO5: Apply IoT for smart grid.

Course Articulation Matrix:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	1	3	2	3	1
CO2	3	1	3	3	2	1
CO3	3	1	3	3	2	1
CO4	3	1	2	2	2	1
CO5	3	1	3	3	3	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix for the Course:

	PO1	PO2	PO3	PO4	PO5	PO6
CO	3	1	3	3	2	1

Course Code	Course Title	Hrs./Week L: T: P	Credits
EEE	**Grid Integration of Renewable Energy**	**3:0:0**	**3**

Course objectives: The objective of this course is to provide:

OB1	A strong understanding of power systems, their operation and control focused on the issues related to the integration of distributed renewable generation into the network.
OB2	Strong foundation for power system equipments used for integration.
OB3	Detailed knowledge about power quality and its management along with approaches for grid stabilization.
OB4	Deep understanding about integration techniques for RE sources

UNIT I

Introduction: Various techniques of utilizing power from renewable energy sources, concept of nano/micro/mini grid. Need of integrating large renewable energy sources, issues related to integration of large renewable energy sources, rooftop plants. Concept of VPP.

UNIT II

Power system equipments for grid integration: Synchronous generator: synchronization/integration to existing grid, load sharing during parallel operation, stability (swing equation and solution) Induction Generator: working principle, classification, stability due to variable speed and counter measures Power Electronics: need of power electronic equipments in grid integration, converter, inverter, chopper, ac regulator and cycloconverters for AC/DC conversion.

UNIT III

Power quality and management: THD, voltage sag, voltage swell, frequency change and its effects, network voltage management, frequency management, system protection, grid codes.

UNIT IV

Grid stabilization: Scheduling and dispatch, Forecasting, reactive power and voltage control, frequency control, operating reserve, storage systems, electric vehicles Ancillary services in Indian Electricity Market (regulatory aspect), CERC and CEA orders (technical and safety standards)

UNIT V

Integration of alternate sources of energy Introduction, principles of power injection: converting technologies, power flow; instantaneous active and reactive power control approach; integrating multiple renewable energy sources; DC link integration; AC link integration; HFAC link integration; islanding and interconnection.

Case studies Based on synchronous/induction generator for peak demand reduction, grid connected PV system.

TextBooks :

1. Integration of Alternative sources of Energy, Felix A. Farret and M. Godoy Simoes, IEEE Press – Wiley-Interscience publication, 2006.
2. Grid integration of solar photovoltaic systems, Majid Jamil, M. Rizwan, D.P.Kothari, CRC Press (Taylor & Francis group), 2017.
3. Renewable Energy Grid Integration, Marco H. Balderas, Nova Science Publishers, New York, 2009..

Reference Books :

1. Wind Power Integration connection and system operational aspects, B. Fox, D. Flynn L. Bryans, N. Jenkins, M. O' Malley, R. Watson and D. Milborrow, IET Power and Energy Series 50 (IET digital library), 2007.
2. Power Generation, Operation, and Control, Allen J. Wood, Bruce F. Wollenberg, Gerald B. Sheblé, John Wiley & Sons, New York, 2013 (3rd edition).

COURSE OUTCOME:

After completion of this course, students will be able to:

CO1: Understand the need of renewable energy and the problems associated with it.
CO2: Analyze the power system and power electronic interfaces for renewable energy.
CO3: Interprete the power quality management.
CO4: Understand standards for grid stability and control issues.
CO5: Investigate Control and integration techniques from case studies.

Course Articulation Matrix:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	1	2	2	2	1
CO2	3	1	3	3	3	1
CO3	3	1	3	2	2	1
CO4	3	1	3	3	3	2
CO5	3	1	3	3	3	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix for the Course:

	PO1	PO2	PO3	PO4	PO5	PO6
CO	3	1	3	3	3	1

Course Code	Course Title	Hrs./Week L: T: P	Credits
EEEM1111	Programmable Logic Controllers & Applications	3:0:0	3

Course Objectives: The objectives of the course are to make the students learn about:

- To study the Knowledge on PLC.
- To acquire the knowledge on programming of PLC.
- To understand different PLC registers and their description.
- To have knowledge on data handling functions of PLC.
- To know how to handle analog signal and converting of A/D in PLC.

UNIT-I

PLC Basics:

PLC system, I/O modules and interfacing, CPU processor, programming equipment, programming formats, construction of PLC ladder diagrams, devices connected to I/O modules.

Learning outcomes: After completion of this unit students will be able to

- Understand I/O modules and their interfaces(L2)
- Construct the PLC Ladder diagrams (L6)

UNIT-II

PLC Programming:

Input instructions, outputs, operational procedures, programming examples using contacts and coils. Drill press operation. Digital logic gates, programming in the Boolean algebra system, conversion examples. Ladder diagrams for process control: Ladder diagrams and sequence listings, ladder diagram construction and flow chart for spray process system.

Learning outcomes: After completion of this unit students will be able to

- Understand logic gates construction(L2)
- Compose ladder diagrams(L2)

UNIT-III

PLC Registers:

Characteristics of Registers, module addressing, holding registers, input registers, output registers. PLC Functions: Timer functions and Industrial applications, counters, counter function industrial applications, Arithmetic functions, Number comparison functions, number conversion functions.

Learning outcomes: After completion of this unit students will be able to

- Understand Registers such as counters, Timer in industrial applications(L2)
- Understand the PLC functions (L2)

UNIT-IV

Data Handling functions: SKIP, Master control Relay, Jump, Move, FIFO, FAL, ONS, CLR and Sweep functions and their applications.

Learning outcomes: After completion of this unit students will be able to

- Understand Data handling functions
- Apply the functions in different applications(L3)

UNIT-V

Bit Pattern and changing a bit shift register, sequence functions and applications, controlling of two axis and three axis Robots with PLC, Matrix functions.

Learning outcomes: After completion of this unit students will be able to

- Understand bit pattern and bit shift registers(L2)
- Understand two axis and three axis robot(L2)
- Understand matrix functions(L2)

UNIT-VI

Analog PLC operation: Analog modules and systems, Analog signal processing, multi bit data processing, analog output application examples, PID principles, position indicator with PID control, PID modules, PID tuning, PID functions.

Learning outcomes: After completion of this unit students will be able to

- Understand analog input and output applications(L2)
- Understand PID principles(L2)

Text Books:

1. Programmable Logic Controller – Principle and Applications by John W. Webb and Ronald A. Reiss, Fifth Edition, PHI
2. Programmable Logic Controllers – Programming Method and Applications by JR. Hackworth and F.D Hackworth Jr. – Pearson, 2004.

Reference Books:

1. Introduction to Programmable Logic Controllers- Gary Dunning-Cengage Learning.
2. Programmable Logic Controllers –W. Bolton-Elsevier publisher

COURSE OUTCOME:
After completion of this course, students will be able to:

CO1: Analyze the PLCs and their I/O modules.(L2)
CO2: Develop control algorithms to PLC using ladder logic etc.(L6)
CO3: Recognize various PLC registers (L2)
CO4: Manage PLC registers for effective utilization in different applications.(L4)
CO5: Handle data functions and control of two axis and their axis robots with PLC.(L4)
CO6: Design PID controller with PLC.(L6)

Course Articulation Matrix:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	-	2	2	1	-
CO2	3	-	3	3	2	-
CO3	3	-	3	3	1	-
CO4	3	-	3	3	2	-
CO5	3	-	3	3	2	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix for the Course:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO	3	-	3	3	2	-

Course Code	Course Title	Hrs./Week L: T: P	Credits
EEE	INDUSTRIAL AUTOMATION AND CONTROL	3:0:0	3

- **Course Objectives:**

MODULE-I (7 Hours)

Introduction to process dynamics, its type and classifications. Control actions and controller tuning: Basic control actions-on/off, P, P+I, P+I+D, floating control, pneumatic and electronic controllers, controller tuning.

MODULE-II (7 Hours)

Introduction to PLC, PAC, DCS and SCADA. IEDs, RTUs, HMI, Smart Sensors and Actuators. Communication Networks for PLC. The Instrument Lists of PLC and HMI. System Architecture, Programming languages of PLC, Relay logic and Ladder logic, Ladder Diagram Elements.

MODULE-III (9 Hours)

Computer controlled processes: PLC based control of different types of processes such as liquid level system and flow control, open-and-closed chamber pressure control, temperature control, different types of heat exchangers.

MODULE-IV (9 Hours)

Physical Ladder Diagram and Programmable Ladder Diagram.Case Studies: frost free refrigerator / freezer system; composite discrete / continuous control; conveyor system; oven system; elevator system; uniformly heated liquid control system, and hydro-phonic system.

MODULE-V (7 Hours)

Advances in Automation: Programmable Automation Controllers. NI my-DAQ, my-RIO, c-RIO, and ELVIS. IEEE 802.11 / 15 Standards, IEEE 1451.5 Std. Role of Internet of Things and Cyber Physical System in Industry Automation, MQTT protocol.

Books:

1. Peter D. Harriot, “Process Control”, Tata McGraw-Hill, New Delhi, 2009.
2. Liptak, H. “Process Control: Instruments Engineer‟s Handbook”, Butterwirth Heinemann, 1995.
3. Curtis D. Johnson, “Process Control and Industrial Technology”, Pearson India, 8th ed., 2012.

Reference books:

1. Norman A Anderson, “Instrumentation for Process Measurement and Control”, CRC Press, 2018.
2. B. Wayne Bequette, “Process Control – Modeling, Design, and Simulation”, Pearson India, 2015.
3. John W. Webbs, “Programmable Logic Controllers – Principals and Applications”, fifth Edition, Pearson India /PHI (Old edition), 2012.

COURSE OUTCOME:
After completion of this course, students will be able to:

CO1: Understand the concept of process dynamics, its type and classifications, process control actions and controller tuning.
CO2: Express the required knowledge on PLC, PAC ,DCS, SCADA, instrumentation and System Architecture and communication networks and programming for PLC.
CO3: Understand PLC based computer control of different types of processes.
CO4: Analyze PLC / PAC algorithm using Ladder Logic Diagram or equivalent languages while handling a plant process.
CO5: Apply knowledge on advances in use of automation platform such as PACs and IoT while handling a plant process.

Course Articulation Matrix:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	-	2	2	1	-
CO2	3	-	3	3	2	-
CO3	3	-	3	3	1	-
CO4	3	-	3	3	2	-
CO5	3	-	3	3	3	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix for the Course:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO	3	-	3	3	2	-

Course Code	Course Title	Hrs./Week L: T: P	Credits
EEE	Intelligent Sensors and Instrumentation	3:0:0	3

Course Objectives:

To familiarize students with the state of art of smart, intelligent and network sensors, and instrumentation systems and their design.

UNIT I (8 Hours)

Review: Sensor, actuator and transducer; Classification of sensors on the basis of energy source and type of output signals; Signal conditioning; Meaning and types of smart sensors. Smart Sensor Technologies: Thick-film, thin-film and monolithic IC technologies and their use in making smart sensors; Bulk and surface micromachining technologies, wafer bonding, LIGA process, plasma etching, and their use in making smart sensors; Examples.

UNIT II (6 Hours)

MEMS Sensors: Concept and methods of making MEMS devices, sensors and actuators; Examples. Intelligent and Network Sensors: Concept and architecture of intelligent sensors; Concept and architecture of network sensors; Examples.

UNIT III (10 Hours)

Sensor Networking: 7-Layer OSI model of communication system, device-level networks, introduction to protocols and technologies for wired and wireless LANs; Ethernet, RS-485 and Foundation Fieldbus protocols; Wi-Fi; Zigbee and Bluetooth protocols; Concept of adhoc networks; Smart Transducer Interface Standard IEEE 1451.

UNIT IV (10 Hours)

Intelligent Instrumentation: Introduction meaning and advantages; Microprocessor application techniques; I/O techniques; Interfacing of I/O devices; Examples.

UNITV (6 Hours)

Future Trends: Neurosensors; Biosensors; Nano-technology; Softcomputing techniques in instrumentation.

Text Books:

1. Fraden J., “Handbook of Modern Sensors: Physics, Design and Applications”, AIP press. 2003
2. Frank R., “Understanding Smart Sensors”, Artech House publishers. 2000 3. Yamasaki H., “Intelligent Sensors”, Elsevier Eastern Limited. 1996

Reference Books:

1. Ramon P. A. and Webster J. G., “Sensors and Signal Conditioning” 2nd 2001 Ed., John Wiley and Sons.
2. Feng Z. and Leonidas G., “Wireless Sensor Networks”, Elsevier Eastern Limited. 2007
3. Barney G., “Intelligent Instrumentation”, Prentice-Hall International Editions. 1988

COURSE OUTCOME:
After completion of this course, students will be able to:

CO1: Develop understanding smart sensing technologies and their need in the modern arena.
CO2: Analyze the need of MEMS sensors and its benefits.
CO3: Develop understanding of wireless sensor networks for the purpose of data exchange.
CO4: Develop understanding of intelligent instrumentation and its critical components.
CO5: Analyze the need of future trends in smart/intelligent sensors and instrumentation areas.

Course Articulation Matrix:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	-	3	2	2	-
CO2	3	-	3	3	2	-
CO3	3	-	3	3	1	-
CO4	3	-	3	3	3	-
CO5	3	-	3	3	2	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix for the Course:

	PO1	PO2	PO3	PO4	PO5	PO6
CO	3	-	3	3	2	-

Course Code	Course Title	Hrs./Week L: T: P	Credits
EEE	**Micro and Nano Electro-mechanical Systems**	**3:0:0**	**3**

Objectives of the course

OB1	To learn about fundamentals and technological development in micromachining technologies.
OB2	To learn about fundamentals and technological development in micro/nano electronics technologies.
OB3	To get acquainted with the real life applications of both the technologies involved in design and development of smart and intelligent devices, namely, micromachining and micro/nano electronics.

Syllabus:

MODULE-I (5 hours)

Introduction to Micro-machining and Micro-electronics/ Nano-electronics Physics. Micro-machining and Micro-electronics/ Nano-electronics Technologies. Mechanical-Electronic Transitions in Sensing. Integration of Micro-machining and Micro-electronics.

MODULE-II (9 hours)

Micromachining Technology: Bulk micromachining, Wafer bonding, Si-to-Si bonding, Anodic bonding, Si fusion bonding; Surface micromachining; Other techniques: LIGA, Dry-etching processes, Micro-milling, Use of lasers in micromachining; Chemical etching and IC technology, Material types and Property; Films on micro/Nano structure, Micro-machining Metal structures.

MODULE-III (8 hours)

Applications and Case studies on Sensor Output: Sensor output characteristics, Wheatstone Bridge, Static vs Dynamic operation; Capacitive sensing, Piezoelectric sensing, Piezo-resistive sensing, Hall effect sensors, Gas sensors, Chemical sensors, Digital output of sensors, Need of Calibrating the sensors measurement, Noise/Interference aspects, Low-power, low-voltage sensors, Impedance measurement.

MODULE-IV (9 hours)

Micro/Nano-Electronics Technology: Amplification and Signal conditioning, Instrumentation amplifier, SLEEPMODE OPAMP, rail-to-rail OPAMP, Switched – capacitor amplifier, Industry Current-and-Voltage Standard Signal Transmitters and Receivers; Integrated Passive and Active Elements, Onboard A/D and D/A conversions.

MODULE-V (8 hours)

Advances in Signal Conditioning Technology: DSP control, PWM control, Communication links, Network Protocol, Networked Sensors/Actuators. Optical sensing. RFID technology.

Packaging, testing and reliability Implications of Smart/Intelligent Sensors: Hybrid packaging, Ceramic packaging, Multi-Chip modules, Dual-chip packaging. Forming Sensing Arrays.

Books:

1. Randy Frank, "Understanding Smart Sensors",2nd edition, Artech House, 2000.
2. "Handbook on Smart sensor and MEMS – Intelligent devices and Microsystems for industrial applications", Edited by Stoyan Nihtianov and Antonio Luque, Woodhead Publishing Ltd., 2014.
3. S. E. Lyshevski. "MEMS and NEMS: Systems, Devices, and Structures (Nano- and Microscience, Engineering, Technology and Medicine), CRC Press, 2002.

References books:

1. S. C. Mukhopadhyay and T. Islam, "Wearable Sensors- Applications, Design and Implementation", 1st edition, IOP Publishing, Bristol, UK, 2017.
2. James W. Dally, William F. Riley, and Kenneth G. McConnell, "Instrumentation for Engineering Measurements", Wiley student edition, Second edition, 2013.
3. Manabendra Bhuyan, "Intelligent Instrumentation – Principles and Applications", CRC Press, 2012.

COURSE OUTCOME:

After completion of this course, students will be able to:

CO1: Getting Exposed to Micromachining and Microelectronics/ Nanoelectronics technologies and their applications.
CO2: Develop understanding about fabrication processes about Micromachining Technology.
CO3: Recognizing the need of a smart sensor by understanding the case studies and solution finding approaches to deal with real life problem scenarios.
CO4: Develop understanding about fabrication processes about Micro/nano-electronics Technology.
CO5: Recognize the recent trends in signal conditioning circuits design and its integration with machining part.

Course Articulation Matrix:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	-	3	2	2	-
CO2	3	-	3	3	3	-
CO3	3	-	3	3	1	-
CO4	3	-	3	3	3	-
CO5	3	-	3	3	2	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix for the Course:

	PO1	PO2	PO3	PO4	PO5	PO6
CO	3	-	3	3	2	-

Course Code	Course Title	Hrs./Week L: T: P	Credits
EEE	Real Time Systems	3:0:0	3

Course Objectives:

- Introduce QoS and design criteria for real time communication for wired and wireless networks.

UNIT I
Introduction: Type of network, Quality of Service, Traffic Categorization

UNIT II
Real-Time Communication in Wired Networks: RTC in LAN, Soft and Hard read time communication, RTC over internet, Routing, resource reservation, traffic shaping and policing, scheduling, Real-Time Communication Via Ethernet in Industrial Automation Environments

UNIT III
Real-Time Communication in Packet-Switched Networks: Real-Time Scheduling Theory, Traffic Characterization, Connection-Level Processing, Per-Packet Processing, Scheduler-based Methods, Application-level Characteristics, Connection-level Issues.

UNIT IV
Real-Time Communication over Unreliable Wireless Links: A necessary and sufficient condition for feasibility, Utility maximization, broadcasting real-time flows with network coding and xor coding.

UNITV
Real-time communication protocols: Token-ring networks, Broadcast networks, Other networks, Real-time support in the higher layers, Blink protocol for Real-Time Communication for Wireless Cyber-Physical Systems

Text Books:

1. Mall R., Real-time Systems, NPTEL Course Material, Computer Science and Engineering, Indian Institute of Technology Kharagpur, https://nptel.ac.in/courses/106105086/6.
2. Decotignie J.-D., Ethernet Based Real-Time and Industrial Communications, Proc. of the IEEE, vol. 93, issue 6, pp. 1102-17, 2005.

Reference Books:

1. Hou I. and Kumar P. R., "Real-time communication over unreliable wireless links: a theory and its applications," in IEEE Wireless Communications, vol. 19, no. 1, pp. 48-59, 2012.
2. Hanssen F., & Jansen P.G., (2003), Real-time communication protocols: an overview

COURSE OUTCOME:

After completion of this course, students will be able to:

CO1: of network, Quality of Service, Traffic Categorization
CO2:understand Real-Time Communication in Wired Networks
CO3: know Real-Time Communication in Packet-Switched Networks
CO4:realize Real-Time Communication over Unreliable Wireless Links
CO5: know Real-time communication protocols

Course Articulation Matrix:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	1	2	2	2	1
CO2	3	1	3	3	3	1
CO3	3	1	3	2	2	1
CO4	3	1	3	3	3	2
CO5	3	1	3	3	3	1

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix for the Course:

	PO1	PO2	PO3	PO4	PO5	PO6
CO	3	1	3	3	3	1

Course Code	Course Title	Hrs./Week L: T: P	Credits
EEE	Image Sensor Design and Applications	**3:0:0**	**3**

Course Objectives:

- Introduce the design and analysis of CMOS image sensors.
- Explain the readout electronics behind the camera.
- Provide the knowledge of performance measures and tradeoffs involved in the camera design.

UNIT I

Introduction to photodetectors: Photodiode and photogate, photocurrent, dark current, quantum efficiency, spectral response and photo-conversion principles.

UNIT II

Introduction to Charge coupled devices and CMOS image sensors: Operation, performance metrics, noise and its types, spatial resolution and modulation transfer function. Concept of exposure triangle including aperture, shutter speed and ISO, color filters, Bayer pattern, Shutters and its types, motion blur, hard and soft reset, Introduction to imaging optics.

UNIT III

Readout electronics and image sensor characterization: Readout and its types, design tradeoffs and challenges, analysis of the signal path behind the camera, variable gain amplifiers, double sampling circuits, ADCs, reference and clock generation circuits, floor planning, placement and routing, image sensor characterization.

UNIT IV

Emerging trends: High speed cameras, high dynamic range cameras, 3D cameras for background light subtraction and depth estimation. Concepts of Polarization imaging, low light imaging, machine vision, backside illumination, stacked technology, target tracking.

UNITV

Color Processing: Color demosaicing, color correction and white balance (2 Lectures). Applications: Smart city, health care, autonomous vehicles, sports, motion detection, surveillance.

Text Books:

1. Ohta, J., (2007), Smart CMOS Image sensors and Applications, CRC press.

Reference Books:

1. O. Y. Pecht, and Cummings, R. E., (2004), CMOS imagers: From Photo transduction to Image processing.

2. Albert J.P. Theuwissen, Harvest imaging, https://harvestimaging.com/

3. Albert J.P. Theuwissen, Image sensors blog http://image-sensors-world.blogspot.com/

COURSE OUTCOME:

After completion of this course, students will be able to:

CO1: express the concepts of photodetectors.
CO2: design and implement charge coupled devices and CMOS image sensors.
CO3: explain the readout electronics and image sensor characterization
CO4: express and analyzes the emerging cameras.
CO5: express the concept of color processing.

Course Articulation Matrix:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	3	2	2	-
CO2	3	3	3	2	2	-
CO3	3	3	3	2	2	-
CO4	3	3	3	2	2	-
CO5	3	3	3	2	2	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix for the Course:

	PO1	PO2	PO3	PO4	PO5	PO6
CO	3	3	3	2	2	-

Course Code	Course Title	Hrs./Week L: T: P	Credits
EEE	**Minor Project & Seminar**	**0:0:4**	**2**

Course description:
As a part of the curriculum, this is a sessional course, in which the students are trained in basic tools and presentation skills.

COURSE OUTCOME:
After completion of this course, students will be able to:

CO1: Demonstrate a sound technical knowledge of their selected mini project topic.
CO2: Undertake problem identification, formulation, and solution.
CO3: Design engineering solutions to complex problems utilizing a systems approach.
CO4: Communicate with engineers and the community at large.
CO5: Demonstrate the knowledge, skills, and attitudes of a professional engineer.

Course Articulation Matrix:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	2	1	2	3
CO2	3	3	2	1	3	3
CO3	3	3	3	1	3	3
CO4	2	3	3	2	3	3
CO5	2	3	3	2	3	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix for the Course:

	PO1	PO2	PO3	PO4	PO5	PO6
CO	3	3	3	2	3	3

Course Code	Course Title	Hrs./Week L: T: P	Credits
EEE	Real Time Digital Simulation Laboratory	0:0:6	4

List of Experiments:

1. Study of HIL or virtual system using RTDS.
2. Study of Symmetrical Fault analysis
3. Study of Unsymmetrical Fault analysis
4. Economic Load Dispatch with & without transmission losses
5. Transient Stability Analysis Using Point By Point Method
6. Load Frequency Control of Single Area Control & Two Area Control system with and without controllers.
7. Determination of operating characteristics of biased differential relay.
8. Determination of operating characteristics of an induction type over current relay.

COURSE OUTCOME:

After completion of this course, students will be able to:

CO1:express use of RTDS in virtual systems
CO2: Know fault analysis
CO3:understand load despatch
CO4:understand stability in a power system
CO5:know relay characteristics

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	-	2	2	1	-
CO2	3	-	3	3	2	-
CO3	3	-	3	3	1	-
CO4	3	-	3	3	2	-
CO5	3	-	3	3	2	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix for the Course:

	PO1	PO2	PO3	PO4	PO5	PO6
CO	3	-	3	3	2	-

Course Code	Course Title	Hrs./Week L: T: P	Credits
EEE	Edge and Fog Computing	3:0:0	3

Course Objectives:

- This course will introduce design concepts, frameworks, and applications in Edge Computing to the audience

UNIT I (8 Hours)

Introduction of Edge and Fog Computing: Internet of Things (IoT) and New computing paradigms, Fog computing: A platform for Internet of Things and analytics, Emergence of edge computing, Legal aspects of operating IoT applications in the fog.

UNIT II (8 Hours)

Edge Architecture: Multi-Tier cloud computing framework; Data services with clouds at home; Leveraging mobile devices to provide cloud service at the edge; Fast, scalable and secure onloading of edge functions.

UNIT III (8 Hours)

Networking for Edge & Fog: Integrating IoT + Fog + Cloud Infrastructures: System modeling and research Challenges, Management and Orchestration of network slices in 5G, Fog, Edge, and Clouds. System Design: Optimization problems in fog and edge computing, Middleware for fog and edge Computing: Design issues, A Lightweight container middleware for edge cloud architectures.

UNIT IV (8 Hours)

Data Processing: Data management in fog computing, Predictive analysis to support fog application deployment, Using machine learning for protecting the security and privacy of Internet of Things (IoT) systems, fog Computing realization for Big data analytics.

UNITV (8 Hours)

Applications and Case Studies: Fog computing realization for Big data analytics, exploiting fog computing in health monitoring, Smart surveillance video stream processing at the edge for real-time human objects tracking, Fog computing model for evolving smart transportation applications. (6 Lectures)

Text Books:

- R. BUYYA, S.N. SRIRAMA (2019), Fog and Edge Computing: Principles and Paradigms, Wiley-Blackwell, 2019.

Reference Books:

COURSE OUTCOME:
After completion of this course, students will be able to:

CO1: Get exposed to new age technologies as IoT, Edge and Fog computing and their role in developing smart cities and smart grid infrastructure.
CO2: Develop understanding about Edge Architecture.
CO3: Analyze networking architecture techniques in edge and fog computing.
CO4: Analyze data processing techniques and big data analytics in IoT.
CO5: Develop understanding of real world needs by studding the different case studies.

Course Articulation Matrix:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	-	3	2	2	-
CO2	3	-	3	3	3	-
CO3	3	-	3	3	1	-
CO4	3	-	3	3	3	-
CO5	3	-	3	3	2	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix for the Course:

	PO1	PO2	PO3	PO4	PO5	PO6
CO	3	-	3	3	2	-

Course Code	Course Title	Hrs./Week L: T: P	Credits
EEE	Programming and Embedded System	3:0:0	3

Course Objectives:

- To introduce concepts of different architectures and programming languages of embedded processors.
- To introduce design of embedded systems.

UNIT I (8 Hours)

.Review of Embedded Computing; embedded system design process; CPS and embedded Computing Architecture of ARM Cortex M3 and Cortex A series processors; Memory system mechanism; Cache;

UNIT II (8 Hours)

Memory management units and address translation; Performance assessment of embedded processor; Introduction to Embedded Multicore Architecture

UNIT III (8 Hours)

Programming of Embedded processors using assembly and C; models for program --data flow graphs;

UNIT IV (8 Hours)

Assembly language programming of ARM Cortex M3; Hardware software co-design

UNITV(8Hours)

Processes and real time operating systems; Multi-rate system; real time scheduling algorithms e.g. RMA,EDF and their variants; Energy efficient scheduling algorithms; Examples of design of embedded systems.

Text Books:

1. JosephYiu, (2013), The definitive Guide to ARM Cortex M3 and M4 Processors, 3 rd Edition, Elsevier. 2. Marilyn Wolf, (2014),
2. High Performance embedded Computing: Applications in Cyber Physical Systems and Mobile Computing, 2 nd Edition, Elsevier

Reference Books:

1. Marilyn Wolf, Computers as Components: Principles of Embedded Computing System Design, Third Edition, Elsevier 2012.

COURSE OUTCOME:
After completion of this course, students will be able to:

CO1: Analyze design of embedded systems.
CO2:Recognize memory interfacing and multicore architecture.
CO3: Implement programming language appropriate for the development of embedded system.
CO4: Analyze the hardware and software interface design.
CO5: Implement embedded system design.

Course Articulation Matrix:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	-	2	2	1	-
CO2	3	-	3	3	2	-
CO3	3	-	3	3	1	-
CO4	3	-	3	3	2	-
CO5	3	-	3	3	2	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix for the Course:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO	3	-	3	3	2	-

Course Code	Course Title	Hrs./Week L: T: P	Credits
EEE	Electric Vehicle - V2G and G2V	3:0:0	3

- **Course Objectives:**
  - To understand about basics of hybrid electric vehicle
  - To understand about drives and control.
  - Select battery, battery indication system for EV applications
  - Design battery charger for an EV

UNIT I

Review of Conventional Vehicle: Introduction to Hybrid Electric Vehicles: Types of EVs, Hybrid Electric Drive-train, Tractive effort in normal driving,

UNIT II

Energy consumption Concept of Hybrid Electric Drive Trains, Architecture of Hybrid Electric Drive Trains, Series Hybrid Electric Drive Trains, Parallel hybrid electric drive trains, Electric Propulsion unit, Configuration and control of DC Motor drives, Induction Motor drives, Permanent Magnet Motor drives, switched reluctance motor

UNIT III

Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles:- Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Hybridization of different energy storage devices. Sizing the drive system, Design of Hybrid Electric Vehicle and Plug-in Electric Vehicle

UNIT IV

Energy Management Strategies, Automotive networking and communication, EV charging standards, V2G, G2V, V2B, V2H. Business: E-mobility business, electrification challenges, Business- E-mobility business, electrification challenges,

UNITV

Connected Mobility and Autonomous Mobility- case study Emobility Indian Roadmap Perspective. Policy: EVs in infrastructure system, integration of EVs in smart grid, social dimensions of EVs. Connectors- Types of EV charging connector, North American EV Plug Standards, DC Fast Charge EV Plug Standards in North America, CCS (Combined Charging System), CHAdeMO, Tesla, European EV Plug Standards,

Text Books:

- Emadi, A. (Ed.), Miller, J., Ehsani, M., "Vehicular Electric Power Systems" Boca Raton, CRC Press, 2003
- Husain, I. "Electric and Hybrid Vehicles" Boca Raton, CRC Press, 2010.

Reference Books:

- Larminie, James, and John Lowry, "Electric Vehicle Technology Explained" John Wiley and Sons, 2012
- Tariq Muneer and Irene IllescasGarcía, "The automobile, In Electric Vehicles: Prospects and Challenges", Elsevier, 2017

- Sheldon S. Williamson, "Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles", Springer, 2013

COURSE OUTCOME:

After completion of this course, students will be able to:

CO1: Express the introductory knowledge about EVs and HEVs.
CO2: Analyze drive trains and electric propulsion used in EVs and HEVs.
CO3: Develop storage systems and drive systems for EVs and HEVs.
CO4: Develop energy Management and communication Strategies and electrification challenges for in EVs and HEVs.
CO5:Analyze different Connected Mobility, Autonomous Mobility and EV Plug Standards for different countries.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	-	2	2	1	-
CO2	3	-	3	3	2	-
CO3	3	-	3	3	1	-
CO4	3	-	3	3	2	-
CO5	3	-	3	3	2	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix for the Course:

	PO1	PO2	PO3	PO4	PO5	PO6
CO	3	-	3	3	2	-

Course Code	Course Title	Hrs./Week L: T: P	Credits
EEE	Data Communication and Ad-hoc Networking	3:0:0	3

Course Objectives:

- Expose the students to distinguishing features of wireless networks
-

UNIT I

Fundamentals: Layered architecture overview, data communication techniques, motivations for cross-layer protocol design, motivations for performance analysis, forward error correction and re-transmission performances

UNIT II

Network layer and topology design: Markov and semi-Markov processes, Little's theorem, M/M/m/k, M/G/1 systems, priority queueing, network of queues, network traffic behavior, routing algorithms and analysis, distributed networks, design constraints, bounded latency networks, optimization, cognitive networks

UNIT III

Network Management: Power management, time synchronization, localization, energy-efficient protocols for sensor networks

UNIT IV

Mechanisms to improve performance: Self-Organizing Network, Software-Defined Networking

UNITV

Transport and Application Layers: congestion control and quality of service, scheduling, multimedia, key aspects and design issues (7 Lectures) Reliability and security: Security requirement and attacks, Encryption techniques, reliable and secure communication protocols

Text Books:

1. Dargie, W., and Poellabauer, C., (2010), Fundamentals of Wireless Sensor Networks: Theory and Practice, Wiley.
2. Stallings, W., (2007), Data and Computer Communications, 8th Edition, Pearson
3. Bertsekas, D. P. and Gallager, R. G., (1992), Data Networks, 2 nd Edition, Prentice Hall

Reference Books:

1. Mishra, S., Wireless Adhoc and Sensors Networks, NPTEL Course Material, Department of Electrical and Electronics Communication Engineering, Indian Institute of Technology Kharagpur, https://nptel.ac.in/courses/106105160/
2. Zou, Y., Zhu, J., Wang, X., and Hanzo, L., "A Survey on Wireless Security: Technical Challenges, Recent Advances, and Future Trends," in Proceedings of the IEEE, vol. 104, no. 9, pp. 1727-1765, Sept. 2016.
3. W. Xia, Y. Wen, C. H. Foh, D. Niyato and H. Xie, "A Survey on Software-Defined Networking," in IEEE Communications Surveys & Tutorials, vol. 17, no. 1, pp. 27-51, First quarter 2015.

COURSE OUTCOME:

After completion of this course, students will be able to:

CO1: express the fundamental of layered architecture and data communication techniques.
CO2: design and implement network layer and topology.
CO3: express the concept of network management.
CO4: analyze the mechanisms to improve the network performance.
CO5: analyze the concept of transport and application layers.

Course Articulation Matrix:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	3	2	2	-
CO2	3	3	3	2	2	-
CO3	3	3	3	2	2	-
CO4	3	3	3	2	2	-
CO5	3	3	3	2	2	-

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) -: No Correlation

Program Articulation Matrix for the Course:

	PO1	PO2	PO3	PO4	PO5	PO6
CO	3	3	3	2	2	-