DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
ANNA UNIVERSITY, CHENNAI – 25

VISION:

The vision of the department is to produce analytically proficient and technologically competent Electrical and Electronics Engineers who can serve and take forward the academic, industry and research organizations to newer heights and be effective for building the nation.

MISSION:

- To impart high quality technical education with the state of the art laboratory practice.
- To provide conducive academic ambience to enable best teaching and learning processes.
- To generate resources through research and consultancy projects for pursuing research and developmental activities in emerging areas.
- To associate with academic and industrial organizations for research activities to develop and provide vital and viable solutions for social needs indigenously.
- To develop leadership skills in students with high degree of ethics, morals and values and instill confidence to lead the organization.

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ANNAUNIVERSITY, CHENNAI
UNIVERSITYDEPARTMENTS
CHOICE BASED CREDIT SYSTEM

M.E. CONTROL AND INSTRUMENTATION ENGINEERING

1. PROGRAMME EDUCATIONAL OBJECTIVES(PEOs)

I.	To provide students good foundation from engineering fundamentals, mathematical modelling to hardware-software programming intelligence towards latest trends in measurements and control.
II.	To provide students, the ability to develop smart solutions for the purpose of system automation
III.	To promote student awareness, for life-long learning and introduce them to professional ethics and code of practice.
IV.	To encourage students to work in interdisciplinary and frontier areas.

2. PROGRAMME OUTCOMES(POs)

On successful completion of the programme, the graduate would have	
PO1	An ability to independently carry out research/investigation and development work to solve practical problems
PO2	An ability to write and present a substantial technical report/document
PO3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program
PO4	Design and develop modern control and industrial automation systems using various control techniques, smart sensors and actuators.
PO5	Work on automation platforms such as PLC, SCADA and IIOT for analysis and design of industrial automation.
PO6	Develop innovative control and instrumentation techniques based on AI and Machine Learning algorithms with due concern aligning with latest trends and socio-economic values.

3. MAPPING OF PEOs with POs

PEO	PO					
	1	**2**	**3**	**4**	**5**	**6**
I.	3	1	2	1	1	2
II.	3	2	3	2	3	3
III.	1	1	3	2	1	1
IV.	1	1	3	1	2	1

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Mapped with 1,2,3 &- scale :1-low ; 2-medium ; 3-high

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PROGRAM ARTICULATION MATRIX

		COURSE NAME	PO1	PO2	PO3	PO4	PO5	PO6
YEAR I	SEM I	Applied Mathematics For Electrical Engineers	3	3	3	3	2	2
		Research Methodology and IPR	3	3	3	3	2	2
		Instrumentation System Design	3	3	3	2	3	1
		Control System Design	2.6	2.5	2.75	3	2.4	2.4
		Intelligent Controllers	**3**	**1.6**	**1**	**1.5**	**1**	**3**
		Control System Design Lab	**1**	**-**	**2**	**3**	**-**	**-**
		Intelligent Controllers Lab	**1.66**	**1.33**	**1**	**2.33**	**-**	**1.33**
	SEM II	Machine Learning For Instrumentation	**2**	**1.8**	**2**	**2.6**	**3**	**3**
		Non Linear control	**3**	**2**	**2.6**	**3**	**2.8**	**2.2**
		Modern Automation Systems	**3**	**2.8**	**2.8**	**3**	**2.8**	**2.8**
		Professional Elective I						
		Professional Elective II						
		Automation Lab	**3**	**3**	**3**	**2**	**3**	**1**
		Advanced Measurements Lab	**3**	**3**	**3**	**3**	**1**	**3**
YEAR II	SEM III	Professional Elective III						
		Professional Elective IV						
		Professional Elective V						
		Project Work I	3	3	3	3	3	3
	SEM IV	Project Work II	3	3	3	3	3	3

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UNIVERSITY DEPARTMENTS
REGULATIONS-2023
CHOICE BASED CREDIT SYSTEM
M.E. CONTROL AND INSTRUMENTATION ENGINEERING

CURRICULUM AND SYLLABUS I TO IV SEMESTERS

SEMESTER I

S.No	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	MA3156	Applied Mathematics for Electrical Engineers	FC	4	0	0	4	4
2.	RM3151	Research Methodology and IPR	RMC	2	1	0	3	3
3.	CO3101	Instrumentation System Design	PCC	3	0	0	3	3
4.	CO3151	Control System Desgn	PCC	4	0	0	4	4
5.	CO3152	Intelligent Controllers	PCC	3	0	0	3	3
6.		Professional Elective I	PEC	3	0	0	3	3
PRACTICALS								
7.	CO3111	Control System Design Laboratory	PCC	0	0	4	4	2
8.	CO3112	Intelligent Controllers Laboratory	PCC	0	0	4	4	2
		TOTAL		**19**	**1**	**8**	**28**	**24**

SEMESTER II

S.No	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	CO3201	Machine Learning for Instrumentation	PCC	3	0	0	3	3
2.	CO3252	Non Linear Control	PCC	3	1	0	4	4
3.	CO3251	Modern Automation Systems	PCC	3	0	0	3	3
4.		Professional Elective II	PEC	3	0	0	3	3
5.		Professional Elective III	PEC	3	0	0	3	3
PRACTICALS								
6.	CO3211	Automation Laboratory	PCC	0	0	4	4	2
7.	CO3212	Advanced Measurements Laboratory	PCC	0	0	4	4	2
		TOTAL		**15**	**1**	**8**	**24**	**20**

Attested

SEMESTER III

S.No	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.		Professional Elective IV	PEC	3	0	0	3	3
2.		Professional Elective V	PEC	3	0	0	3	3
3.		Professional Elective VI	PEC	3	0	0	3	3
PRACTICALS								
4.	CO3311	Project Work I	EEC	0	0	12	12	6
		TOTAL		**9**	**0**	**12**	**21**	**15**

SEMESTER IV

S.No	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
PRACTICALS								
1.	CO3411	Project Work II	EEC	0	0	24	24	12
		TOTAL		**0**	**0**	**24**	**24**	**12**

TOTAL NO. OF CREDITS: 71

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FOUNDATION CORE COURSES (FC)

S. No	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CRE DITS
				L	T	P		
1.	MA3156	Applied Mathematics for Electrical Engineers	FC	4	0	0	4	4

RESEARCH METHODOLOGY AND IPR (RMC)

S.No	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			L	T	P		
1.	RM3151	Research Methodology and IPR	2	1	0	3	1
					TOTAL	3	

PROGRAM CORE COURSES (PCC)

S.No	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CRE DITS
				L	T	P		
1.	CO3101	Instrumentation System Design	PCC	3	0	0	3	3
2.	CO3151	Control System Design	PCC	4	0	0	4	4
3.	CO3152	Intelligent Controllers	PCC	3	0	0	3	3
4.	CO3111	Control System Design Lab	PCC	0	0	4	4	2
5.	CO3112	Intelligent Controllers Lab	PCC	0	0	4	4	2
6.	CO3201	Machine Learning for Instrumentation	PCC	3	0	0	3	3
7.	CO3252	Non Linear Control	PCC	3	1	0	4	4
8.	CO3251	Modern Automation Systems	PCC	3	0	0	3	3
9.	CO3211	Automation Lab	PCC	0	0	4	4	2
10.	CO3212	Advanced Measurements Lab	PCC	0	0	4	4	2

PROFESSIONAL ELECTIVE COURSES (PEC)

S.No	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	CO3001	Advanced Non-linear Control	PEC	3	0	0	3	3
2.	CO3002	Converters and Electrical Drives	PEC	3	0	0	3	3
3.	CO3057	Optimal Control and Filtering	PEC	3	0	0	3	3
4.	CO3003	System Identification	PEC	3	0	0	3	3
5.	CO3058	System Theory	PEC	3	0	0	3	3
6.	CO3004	Robotics and Control	PEC	3	0	0	3	3
7.	CO3005	Robust Control	PEC	3	0	0	3	3
8.	CO3006	Dynamics and Control of Industrial Process	PEC	3	0	0	3	3
9.	CO3055	Model Predictive Control	PEC	3	0	0	3	3
10.	CO3056	Multi Sensor Data Fusion	PEC					

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				3	0	0	3	3
11.	CO3007	Networked Control System	PEC	3	0	0	3	3
12.	CO3059	Wireless Sensor Networks	PEC	3	0	0	3	3
13.	CO3052	Cyber Physical Systems	PEC	3	0	0	3	3
14.	CO3051	Biomedical Instrumentation	PEC	3	0	0	3	3
15.	CO3054	Intelligent Transportation Systems	PEC	3	0	0	3	3
16.	CO3008	Building and Infrastructure Systems and Automation	PEC	3	0	0	3	3
17.	CO3053	Industrial Internet of Things	PEC	3	0	0	3	3

PROFESSIONAL ELECTIVES COURSES (PEC)

(OFFERED BY OTHER P.G. PROGRAMMES)

S.No	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	IN3051	Safety Instrumented Systems	PEC	3	0	0	3	3
2.	ET3151	Design of Embedded Systems	PEC	3	0	0	3	3
3.	ET3252	Embedded Control for Electric Drives	PEC	2	0	2	4	3
4.	ET3063	Python Programming for Machine Learning	PEC	3	0	0	3	3
5.	ET3060	IoT for Smart Systems	PEC	3	0	0	3	3
6.	ET3055	Embedded Networking and Automation of Electrical System	PEC	3	0	0	3	3
7.	ET3059	Intelligent System Design	PEC	3	0	0	3	3
8.	ET3053	Digital Image Processing and Computer Vision	PEC	3	0	0	3	3
9.	ET3058	Intelligent Control and Automation	PEC	3	0	0	3	3
10.	ET3065	Robotics and Automation	PEC	3	0	0	3	3
11.	ET3062	MEMS and NEMS Technology	PEC	3	0	0	3	3
12.	ET3054	Embedded Controllers for EV Applications	PEC	3	0	0	3	3
13.	ET3057	Information Modelling for Smart Process	PEC	3	0	0	3	3
14.	ET3052	Blockchain Technologies	PEC	3	0	0	3	3
15.	ET3051	Big Data Analytics	PEC	3	0	0	3	3
16.	PE3152	Modelling of Electrical Machines	PEC	3	0	0	3	3

17.	PE3252	Special Electrical Machines	PEC	3	0	0	3	3
18.	PE3051	Control of Power Electronic Circuits	PEC	3	0	0	3	3
19.	PE3055	Vector Control of AC Machines	PEC	3	0	0	3	3
20.	PS3252	Smart Grid	PEC	3	0	0	3	3
21.	PS3053	Optimization Techniques to Power System Engineering	PEC	3	0	0	3	3
22.	PS3054	Wind Energy Conversion Systems	PEC	3	0	0	3	3
23.	PS3051	Computational Intelligence Techniques to Power Systems	PEC	3	0	0	3	3
24.	PW3052	Electric Vehicles and Power Management	PEC	3	0	0	3	3
25.	PW3055	IOT for Smart Power Systems	PEC	3	0	0	3	3
26.	HV3152	Electromagnetic Field Computation and Modelling	PEC	3	0	0	3	3

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

S.No	COURSE CODE	COURSE TITLE	PERIODSPER WEEK			CRE DITS	SEME STER
			L	T	P		
1.	CO3311	Project Work I	0	0	12	6	3
2.	CO3411	Project Work II	0	0	24	12	4
				TOTAL		18	

SUMMARY

	Programme: M.E. Control & Instrumentation Engineering					
	Subject Area	Credits per Semester				Credits Total
		I	II	III	IV	
1.	FCC	04	00	00	00	04
2.	PCC	14	14	00	00	28
3.	PEC	03	06	09	00	18
4.	RMC	03	00	00	00	03
5.	EEC	00	00	06	12	18
	Total Credit	**24**	**20**	**15**	**12**	**71**

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MA3156 APPLIED MATHEMATICS FOR ELECTRICAL ENGINEERS **LT P C**
4 0 0 4

UNIT I MATRIX THEORY 12

The Cholesky decomposition - Generalized Eigen vectors, Canonical basis - QR factorization - Least squares method - Singular value decomposition

UNIT II CALCULUS OF VARIATIONS 12

Concept of variation and its properties – Euler's equation – Functionals dependant on first and higher order derivatives – Functionals dependant on functions of several independent variables – Variational problems with moving boundaries - Direct methods: Ritz and Kantorovich methods

UNIT III ONE DIMENSIONAL RANDOM VARIABLES 12

Random variables - Probability function – moments – moment generating functions and their properties – Binomial, Poisson, Geometric, Uniform, Exponential, Gamma and Normal distributions – Function of a Random Variable

UNIT IV LINEAR PROGRAMMING 12

Formulation – Graphical solution – Simplex method – Two phase method - Transportation and Assignment Models

UNIT V FOURIER SERIES 12

Fourier Trigonometric series: Periodic function as power signals – Convergence of series – Even and odd function: cosine and sine series – Non-periodic function: Extension to other intervals - Power signals: Exponential Fourier series – Parseval's theorem and power spectrum

TOTAL: 60 PERIODS

OUTCOMES:

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

CO1 Apply the concepts of Matrix theory in Electrical Engineering problems.

CO2 Use calculus of variation techniques to solve various engineering problems.

CO3 Solve electrical engineering problems involving one-dimensional random variables.

CO4 Formulate and solve linear programming problems in electrical engineering.

CO5 To solve engineering problems using Fourier series techniques.

REFERENCES:

1. Andrews L.C. and Phillips R.L., Mathematical Techniques for Engineers and Scientists, Prentice Hall of India Pvt. Ltd., New Delhi, 2005.
2. Elsgolts, L., Differential Equations and the Calculus of Variations, MIR Publishers, Moscow, 2003.
3. Grewal, B.S., Higher Engineering Mathematics, Khanna Publishers, 44th Edition, New Delhi, 2017.
4. Gupta, A.S., Calculus of Variations with Applications, Prentice Hall of India Pvt. Ltd., New Delhi, 2004.
5. Johnson R. A. and Gupta C. B., "Miller & Freund's Probability and Statistics for Engineers", Pearson Education, 8th Edition, New Delhi, 2015.
6. Oliver C. Ibe, "Fundamentals of Applied Probability and Random Processes, Academic Press, (An imprint of Elsevier), Boston, 2014.
7. O'Neil, P.V., Advanced Engineering Mathematics, Thomson Asia Pvt. Ltd., 8th Edition, Singapore, 2017.
8. Richard Bronson, "Matrix Operation", Schaum's outline series, McGraw Hill, 2nd Edition, New York, 2011.
9. Taha, H.A., "Operations Research, An introduction", Pearson education, 10th Edition, New Delhi, 2017.

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MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	2
CO2	3	3	3	3	2	2
CO3	3	3	3	3	2	2
CO4	3	3	3	3	2	2
CO5	3	3	3	3	2	2
Avg.	**3**	**3**	**3**	**3**	**2**	**2**

RM3151 RESEARCH METHODOLOGY AND IPR **LT P C**
2 1 0 3

UNIT I RESEARCH PROBLEM FORMULATION **9**
Objectives of research, types of research, research process, approaches to research; conducting literature review- information sources, information retrieval, tools for identifying literature, Indexing and abstracting services, Citation indexes, summarizing the review, critical review, identifying research gap, conceptualizing and hypothesizing the research gap

UNIT II RESEARCH DESIGN AND DATA COLLECTION **9**
Statistical design of experiments- types and principles; data types & classification; data collection - methods and tools

UNIT III DATA ANALYSIS, INTERPRETATION AND REPORTING **9**
Sampling, sampling error, measures of central tendency and variation,; test of hypothesis- concepts; data presentation- types of tables and illustrations; guidelines for writing the abstract, introduction, methodology, results and discussion, conclusion sections of a manuscript; guidelines for wring thesis, research proposal; References – Styles and methods, Citation and listing system of documents; plagiarism, ethical considerations in research

UNIT IV INTELLECTUAL PROPERTY RIGHTS **9**
Concept of IPR, types of IPR – Patent, Designs, Trademarks and Trade secrets, Geographical indications, Copy rights, applicability of these IPR; , IPR & biodiversity; IPR development process, role of WIPO and WTO in IPR establishments, common rules of IPR practices, types and features of IPR agreement, functions of UNESCO in IPR maintenance.

UNIT V PATENTS **9**
Patents – objectives and benefits of patent, concept, features of patent, inventive steps, specifications, types of patent application; patenting process - patent filling, examination of patent, grant of patent, revocation; equitable assignments; Licenses, licensing of patents; patent agents, registration of patent agents.

TOTAL: 45 PERIODS

COURSE OUTCOMES:
Upon completion of the course, the student can
CO1: Describe different types of research; identify, review and define the research problem
CO2: Select suitable design of experiment s; describe types of data and the tools for collection of data
CO3: Explain the process of data analysis; interpret and present the result in suitable form
CO4: Explain about Intellectual property rights, types and procedures

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CO5: Execute patent filing and licensing

REFERENCES:

1. Cooper Donald R, Schindler Pamela S and Sharma JK, “Business Research Methods”, Tata McGraw Hill Education, 11e (2012).
2. Soumitro Banerjee, “Research methodology for natural sciences”, IISc Press, Kolkata, 2022,
3. Catherine J. Holland, “Intellectual property: Patents, Trademarks, Copyrights, Trade Secrets”, Entrepreneur Press, 2007.
4. David Hunt, Long Nguyen, Matthew Rodgers, “Patent searching: tools & techniques”, Wiley, 2007.
5. The Institute of Company Secretaries of India, Statutory body under an Act of parliament, “Professional Programme Intellectual Property Rights, Law and practice”, September 2013.

CO3101	**INSTRUMENTATION SYSTEM DESIGN**	**L T P C**
		3 0 0 3

UNIT I SIGNAL CONDITIONING AND INTERFACE 9

Sensor linearization - Processing of Analog Measurement signals – Digital processing of measurement signals – wide area measuring systems – Sensors with built-in interface – Computer measuring systems and simulation studies.

UNIT II SMART SENSORS 9

Definition – Integrated smart sensors - Universal Sensor Interface – converters - front end circuits DAQ design - Digital conversion techniques - Microcontrollers and digital signal processors for smart sensors – ADC and DAC modules –IEEE latest standards for smart sensor interface.

UNIT III COMMUNICATION PROTOCOLS 9

Introduction-Evolution of signal standard – HART communication protocol – applications OSI models - Foundation field bus & Profibus - CAN bus, LIN bus, MOD bus, Industrial Ethernet.

UNIT IV PC-BASED INSTRUMENTATION SYSTEMS 9

Functional components of an instrument platform - Multiple-processor systems - Architecture of instruments for automated environments - The complete "computer-on-a-chip" and portable instrumentation - Choosing a PC platform - Computer operating systems - Applications of programming languages and packages.

UNIT V DATA PROCESSING CONSIDERATIONS 9

Computer-based instrument capacities - Organizing data (data structures) - Time or frequency basis of modeling - Software architectures for input/output – Case studies

TOTAL: 45 PERIODS

COURSE OUTCOMES

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

CO1: To impart the knowledge on signal conditioning and interfacing.
CO2: To equip students with the necessary knowledge and skills to work effectively with smart sensors and related technologies in both academic and professional settings.
CO3: To understand communication protocols and to effectively design, implement, and manage advanced automation systems.
CO4: To understand components and considerations for designing and implementing effective and efficient instrumentation platforms for automated environments.
CO5: To provide students with a comprehensive understanding of computer-based instrument capacities, effective data organization, modeling principles, and software architectures.

Attested

REFERENCES:
1. Ernest O Doebelin and Dhanesh N Manik, "Measurement Systems Application and Design", 5thEdition, Tata Mc-Graw Hill, 2011.
2. Ifan G. Hughes and Thomas P.A. Hase, Measurements and their Uncertainties: A Practical Guide to Modern Error Analysis, Oxford University Press, 2010.
3. Handbook on "Practical Design Techniques for Sensor Signal Conditioning" published by Analog Devices, Vern vice hall.
4. Patrick H.Garrett "High Performance Instrumentation And Automation" CRC Press, Taylor & Francis Group, 2005
5. Gerard C.M. Meijer, Smart Sensor Systems, John Wiley and Sons, 2008
6. G Silverman, H Silver , "Modern Instrumentation - A Computer Approach", 1st Edition, CRC Press.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	2	3	1
CO2	3	3	3	2	3	1
CO3	3	3	3	2	3	1
CO4	3	3	3	2	3	1
CO5	3	3	3	2	3	1
Avg.	3	3	3	2	3	1

Note: 1-low, 2-medium, 3-high, '-"- no correlation

CO3151 CONTROL SYSTEM DESIGN **LT P C**
4 0 0 4

UNIT I ANALYSIS OF LINEAR SYSTEMS 12

Review of system models –Transfer function and state space form– Time and Frequency Response – stability- Discretization –Need for Discretization –Sample and Hold devices – Effect of sampling on transfer function and state models – Analysis – Test for controllability and Observability.

UNIT II DESIGN OF SISO SYSTEM 12

Design Specifications –In continuous domain – Limitations – Controller Structure – Multiple degrees of freedom – PID controllers and Lag-lead compensators- Design – Discretization and direct discrete design - Design in continuous and discrete domain

UNIT III STATE SPACE DESIGN 12

Pole assignment design – State and Output Feedback – observers – Estimated State Feedback – Design Examples (Continuous and Discrete).

UNIT IV OPTIMAL CONTROL 12

Introduction: Classical control and optimization, formulation of optimal control problem, Typical performance measures – Linear quadratic regulator problem – solution – Application examples.

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UNIT V OPTIMAL FILTERING 12

Filtering – Linear system and estimation – System noise smoothing and prediction – Kalman Filter –Recursive estimation.

TOTAL: 60 PERIODS

COURSE OUTCOMES:

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

CO1 Analyse controllers for linear systems defined in transfer function and state space forms.
CO2 Design controllers for linear systems defined in transfer function and state space forms.
CO3 Apply state space forms to continuous and discrete systems.
CO4 Apply optimal control to linear systems in continuous and discrete systems
CO5 Apply filtering concepts to linear systems in continuous and discrete systems.

TEXT BOOKS:

1. M.Gopal, "Digital Control and State Variable Methods", 4th edition, McGraw Hill India,2012
2. K. Ogata, 'Modern Control Engineering', 5th Edition, Pearson, 2012.
3. K. P. Mohandas, "Modern Control Engineering", Sanguine Technical Publishers, 2006.
4. Kirk D.E., 'Optimal Control Theory – An introduction', Prentice
5. hall, N.J., 1970.
6. Sage, A.P., 'Optimum System Control', Prentice Hall N.H., 1968.
7. Anderson, BD.O. and Moore J.B., 'Optimal Filtering', Prentice hall Inc., N.J., 1979.

REFERENCES:

1. M.Gopal, Modern Control System Theory, 3rd edition, New Age International Publishers, 2014.
2. William S Levine, "Control System Fundamentals," The Control Handbook, CRCPress, Taylor and Francis Group, 2011.
3. AshishTewari, 'Modern Control Design with Matlab and Simulink', John Wiley, NewDelhi, 2002.
4. T. Glad and L. Ljung, "Control Theory –Multivariable and Non-Linear Methods",Taylor & Francis, 2002.
5. M. Chidambaram and R. Padma Sree, "Control of Unstable Single and Multi-Variable Systems", Narosa Publishing, 2017.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	-	-	3	3	2	2
CO2	-	-	-	3	2	2
CO3	3	-	3	3	3	2
CO4	3	2	3	3	2	3
CO5	2	3	2	3	3	3
Avg.	2.6	2.5	2.75	3	2.4	2.4

Note: 1-low, 2-medium, 3-high, '-"- no correlation

CO3152	INTELLIGENT CONTROLLERS	LT P C 3 0 0 3

UNIT I OVERVIEW OF ARTIFICIAL NEURAL NETWORK (ANN) & FUZZY LOGIC **9**

Review of fundamentals - Biological neuron, Artificial neuron, Activation function, Supervised learning network- Single Layer Perceptron – Multi Layer Perceptron – Back propagation algorithm (BPA) – Unsupervised learning network – Maxnet – Mexican Hat net ; Fuzzy set theory – Fuzzy sets – Operation on Fuzzy sets - Scalar cardinality, fuzzy cardinality, union and intersection, complement (yager and sugeno), equilibrium points, aggregation, projection, composition, fuzzy relation – Fuzzy membership functions.

UNIT II NEURAL NETWORKS FOR MODELLING AND CONTROL **9**

Generation of training data - optimal architecture – Model validaltion- Control of non-linear system using ANN- Direct and Indirect neuro control schemes- Adaptive neuro controller – Casestudy - Familiarization of Neural Network Control Tool Box.

UNIT III FUZZY LOGIC FOR MODELLING AND CONTROL **9**

Modeling of nonlinear systems using fuzzy models (Mamdani and Sugeno) –TSK model - Fuzzy Logic controller – Fuzzification – Knowledge base – Decision making logic – Defuzzification- Examples of Fuzzy control system design - Adaptive fuzzy systems - Case study -Familiarization of Fuzzy Logic Tool Box.

UNIT IV GENETIC ALGORITHM **9**

Basic concept of Genetic algorithm and detail algorithmic steps, adjustment of free parameters. Solution of typical control problems using genetic algorithm. Concept on some other search techniques Firefly algorithm, Differential Evolution and Particle Swarm Optimization.

UNIT V HYBRID CONTROL SCHEMES **9**

Fuzzification and rule base using ANN–Neuro fuzzy systems-ANFIS –Optimization of membership function and rule base using Genetic Algorithm and Particle Swarm Optimization -Case study– Familiarization of ANFIS Tool Box.

TOTAL: 45 PERIODS

COURSE OUTCOMES:
At the end of the course, students will be able to

CO1 : Understand the basic architectures of NN and Fuzzy sets
CO2 : Design and implement ANN architectures, algorithms and know their limitations.
CO3 : Identify and work with different operations on the fuzzy sets.
CO4 : Develop ANN and fuzzy logic based models and control schemes for non-linearsystems.
CO5 : Understand and explore hybrid control schemes and PSO

REFERENCES:

1. LaureneV.Fausett, “Fundamentals of Neural Networks, Architecture, Algorithms, and Applications”, Pearson Education, 2008.
2. Timothy J Ross, “Fuzzy Logic With Engineering Applications” VISIONIAS, Third Edition,2020.
3. David E.Goldberg, “Genetic Algorithms in Search, Optimization, and Machine Learning”, Pearson Education, 2009.
4. W.T. Miller, R.S.Sutton and P.J.Webrose, “Neural Networks for Control”, MIT Press, 1996
5. George J.Klir and Bo Yuan, “Fuzzy Sets & Fuzzy Logic Theory And Applications” VISIONIAS, 2020.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	-	2	1	-	-	-
CO2	-	2	1	-	-	-
CO3	-	1	-	-	-	-
CO4	3	2	-	2	-	-
CO5	-	1	-	1	1	3
AVg.	**3**	**1.6**	**1**	**1.5**	**1**	**3**

Note: 1-low, 2-medium, 3-high, '-"- no correlation

CO3111 CONTROL SYSTEM DESIGN LABORATORY **LT P C**
0 0 4 2

LIST OF EXPERIMENTS

1. Analog simulation of linear systems
2. Digital simulation of linear and non-linear systems
3. Modelling and analysis of physical systems
4. Tuning methods of PID controller
5. Design of Lag-Lead compensators
6. Design of state feedback and optimal controller
7. Design of optimal estimator
8. Real time simulation of physical systems
9. Hardware in loop simulation of closed loop system
10. Design a closed loop controller for a physical system

TOTAL: 60 PERIODS

COURSE OUTCOMES:
At the end of this course, the students will demonstrate the ability
CO1: Model, simulate and analyze the physical process in analog and digital platforms
CO2: Design and Implement various control strategies to improve the system response
CO3: Develop hardware in loop simulation of closed loop control system

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	-	2	3	-	-
CO2	1	-	2	3	-	-
CO3	1	-	2	3	-	-
AVg.	**1**	**-**	**2**	**3**	**-**	**-**

Note: 1-low, 2-medium, 3-high, '-"- no correlation

CO3112 INTELLIGENT CONTROLLERS LABORATORY LT P C
0 0 4 2

LIST OF EXPERIMENTS

1. To implement adaline and madaline with bipolar inputs and outputs using NN toolbox.
2. To implement back propagation for a given input pattern using NN toolbox.
3. To implement Maxnet – Mexican Hat net network and test for given input pattern using NNtoolbox.
4. To implement fuzzy set operation and properties using FUZZY toolbox.
5. To perform max-min composition of two matrices obtained from Cartesian productusing 'm file' in MATLAB.
6. Write a program to verify the various laws associated with fuzzy set using FUZZY toolbox.
7. Write a matlab program for maximizing f(x) =x2 using GA, where x is ranges from 0 to31 (Perform only 5 iterations). Find the function and 'x' value.
8. Design FLC for a FOPDT process using FUZZY toolbox.
9. Design a Neuro model for an inverted pendulum using NN toolbox.
10. Design Fuzzy model for an inverted pendulum using FUZZY toolbox.

TOTAL: 60 PERIODS

COURSE OUTCOMES:
At the end of the course, students will be able to

CO1 : Equip students with the knowledge and practical skills required to implement and test neural network models using the NN toolbox.
CO2 : Focus on understanding of fuzzy set operations, properties, and laws, allowing students to apply these concepts to real-world problems.
CO3: Equip students with the fundamental understanding and practical skills required to utilize optimization algorithms like Genetic Algorithms and advanced techniques like Fuzzy Logic, Neural Networks for control system design and optimization.

MAPPING OF COs WITH POs

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CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	3	-	2
CO2	1	1	1	2	-	1
CO3	1	1	1	2	-	1
AVg.	**1.66**	**1.33**	**1**	**2.33**	**-**	**1.33**

Note: 1-low, 2-medium, 3-high, '-"- no correlation

CO3201 MACHINE LEARNING FOR INSTRUMENTATION LT P C
3 0 0 3

UNIT I INTRODUCTION TO ARTIFICIAL INTELLIGENCE 9
Introduction-Foundations of AI- History of AI Intelligent agents: Agents and Environment- Reactive agent- deliberative- goal-driven, utility driven, and learning agents -Artificial Intelligence programming techniques.

UNIT II SUPERVISED LEARNING 9
Linearly separable and nonlinearly separable populations – Multi Layer Perceptron –Back propagation Learning Algorithm – Radial Basis Function Network – Support VectorMachines: - Kernels – Risk and Loss Functions - Support Vector Machine Algorithm – Introduction to Deep Learning networks.

UNIT III UNSUPERVISED LEARNING AND BAYSIAN LEARNING 9
Introduction – Clustering:- Partitioning Methods:- K-means algorithm - Hierarchical clustering – Fuzzy Clustering – Clustering High-Dimensional Data:- Problems – Challenges – Subspace Clustering – Biclustering - Self Organizing Map (SOM) - SOM algorithm - Bayesian Classification – Bayesian Networks – Learning Bayesian Networks – Hidden Markov Models.

UNIT IV REINFORCEMENT LEARNING 9
Introduction to Reinforcement Learning – Exploration and Control – MDPs and Dynamic programming – Dynamic Programming Algorithms – Model Free Prediction and Control – Function Approximation – Planning and Model – Policy Gradient and Actor-Critic methods – Approximate Dynamic Programming – Multistep and Off Policy Algorithms

UNIT V APPLICATIONS AND CASE STUDIES 9
Machine Learning algorithms in Measurements, Monitoring, Parameter estimation, Identification, optimization and control.

TOTAL: 45 PERIODS

COURSE OUTCOMES
On completion of this course, the students will be able to
CO1: Understand basic AI algorithms.
CO2: Identify appropriate AI methods to solve a given problem.
CO3: Acquire knowledge about AI/ ML/DL techniques in Industrial instrumentation.
CO4: Understand the levels instrumentation
CO5: Equip students with the knowledge, skills, and practical experience required to leverage machine learning algorithms effectively in measurements, monitoring, parameter estimation, identification, optimization, and control applications.

Attested

TEXT BOOKS
1. Stuart Russell and Peter Norvig Artificial Intelligence - A Modern Approach, Prentice Hall, 3rd

edition, 2011.
2. Rich and Knight, "Artificial Intelligence", 3rd Edition, Tata McGraw Hill, 2014.
3. M.P.Groover, “Automation, Production Systems and Computer Integrated Manufacturings”, 5th edition, Pearson Education, 2009.
4. Luigi Fortuna, Salvatore Graziani, Alessandro Rizzo and Maria G. Xibilia, “Soft Sensors for Monitoring and Control of Industrial Processes”, Springer, 2007.
5. Sutton, R. S., & Barto, A. G. (2018). *Reinforcement learning: An introduction* (2nd ed.). The MIT Press.

REFERENCE BOOKS

1. Anuradha Srinivasaraghavan, Vincy Joseph “Machine Learning”, Wiley, 2019
2. Wolfgang Ertel,” Introduction to Artificial Intelligence”, Second Edition, Springer, 2017.
3. Rajiv Chopra, “Deep Learning”, 1st edition, Khanna Publishing House, 2018.
4. Deepak Khemani, “A First Course in Artificial Intelligence”, McGraw Hill Education, 2013.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	2	2	3	3
CO2	1	1	2	2	3	3
CO3	3	3	2	3	3	3
CO4	1	1	2	3	3	3
CO5	3	3	2	3	3	3
Avg.	**2**	**1.8**	**2**	**2.6**	**3**	**3**

Note: 1-low, 2-medium, 3-high, ‘-“- no correlation

CO3252 **NON LINEAR CONTROL** **LT P C 3 1 0 4**

UNIT I PHASE PLANE ANALYSIS 9+3

Concepts of phase plane analysis- Phase portraits- singular points- Symmetry in phase planeportraits- Constructing Phase Portraits- Phase plane Analysis of Linear and Nonlinear Systems- Existence of LimitCycles. Analysis using computer simulations

UNIT II DESCRIBING FUNCTION 9+3

Describing Function: Fundamentals – Definitions – Assumptions - Computing Describing Functions - Common Nonlinearities and its Describing Functions - Nyquist Criterion and its Extension- Existence of Limit Cycles-Stability of limit Cycles. Analysis using computer simulations

Attested

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UNIT III LYAPUNOV THEORY 9+3

Nonlinear Systems and Equilibrium Points - Concepts of Stability - Linearization and LocalStability - Lyapunov's Direct Method - Lyapunov Functions – construction - - Control Design based on Lyapunov's Direct Method. Analysis using computer simulations

UNIT IV FEEDBACK LINEARIZATION 9+3

Feedback Linearization and the Canonical Form - Mathematical Tools - Input-State Linearization of SISOSystems – input - Output Linearization of SISO Systems - Generating a Linear Input-Output Relation - Normal Forms - The Zero Dynamics - Stabilization and Tracking - Inverse Dynamics and Non Minimum Phase Systems-Feedback Linearization of MIMO Systems Zero-Dynamics and Control Design. Analysis using computer simulations

UNIT V SLIDING MODE CONTROL 9+3

Sliding Surfaces - Continuous approximations of Switching Control laws - The Modeling / Performance Trade-Offs- MIMO Systems. Analysis using computer simulations

L: 45 + T: 15 TOTAL: 60 PERIODS

COURSE OUTCOMES:

Ability to

CO1 :Analyse system performance in the presence of control non-linearity

CO2 :Analyse system performance using describing function method

CO3 :Analyse non-linear system performance by constructing Lyapunov function

CO4 :Analyse and Design robust controllers for non-linear systems for parameter variations butwith stable zero-dynamics.

CO5 : Implement controllers for MIMO systems using computer simulations

REFERENCES:

1. J A E Slotine and W Li, Applied Nonlinear control, PHI, 1991.
2. K. P. Mohandas, Modern Control Engineering, Sanguine, India, 2006
3. Hasan Khalil, "Nonlinear systems and control", Prentice Hall.
4. S H Zak, "Systems and control", Oxford University Press, 2003.
5. Torkel Glad and Lennart Ljung, "Control Theory – Multivariable and Nonlinear Methods", Taylor& Francis, 2002.
6. G. J. Thaler, "Automatic control systems", Jaico publishers, 2006.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	3	3
CO2	3	1	2	3	3	2
CO3	3	2	2	3	3	2
CO4	3	3	3	3	3	2
CO5	3	3	3	3	2	2
AVg.	**3**	**2**	**2.6**	**3**	**2.8**	**2.2**

Note: 1-low, 2-medium, 3-high, '-"- no correlation

Attested

CO3251 **MODERN AUTOMATION SYSTEMS** **LT P C**
3 0 0 3

UNIT I INTRODUCTION TO AUTOMATION 9

Sensing and actuation, Communication – Globalization and emerging issues – Cyber Physical systems - Cyber security - Challenges and prospective of AI and 5G enabled technologies – Effect of integrated IT systems on enterprise competitiveness - requirement for automation – Automation system controllers, Industry 4.0 and 5.0 standards and implementation – Robotics 4.0

UNIT II PLC 9

PLC — Hardware – Internal architecture – Ladder and functional block programming – IL, SFC and ST programming methods - Communication Networks for PLC – Case study.

UNIT III DCS AND SCADA 9

Distributed Control System – Functional components- Diagnostics & IOS – Controllers – Work station – Features of Distributed Control System – Functional Safety – SCADA – RTU – Communication technologies – Operator Interface – Case study

UNIT IV VIRTUAL INSTRUMENTATION 9

Virtual Instrumentation (VI) – Architecture – Programming Techniques – Front Panel and Block diagram – Data flow programming – G programming concepts – Creating and saving VIs – Wiring, Editing and Debugging of Vis – Creating Sub Vis – Control structures – Nodes – Arrays – Cluster controls and indicators – Error handling – String controls – File I/O VIs and functions – Augmented Reality – Case Study

UNIT V INDUSTRIAL INTERNET OF THINGS 9

INDUSTRIAL INTERNET OF THINGS: Introduction – Architecture – Sensing, communication – Big data analytics – Security and Fog computing, cloud computing- Internet for energy – Case Study

TOTAL: 45 PERIODS

COURSE OUTCOMES:

In the end of the course the students will be:
CO1: able to gain the knowledge on fundamentals of automation.
CO2: able to understand the concepts of PLC, DCS and SCADA
CO3: able to understand Virtual Instrumentation for engineering processes.
CO4: able to gain the knowledge on Industrial Internet of Things
CO5: able to apply the concepts and develop automation for different systems.

REFERENCES:

1. Lamb, Frank, “Industrial Automation: Hands-On”, 1st Edition, New York: McGraw-Hill Education, 2013.
2. Mehta B.R and Reddy Y.J, “Industrial Process Automation Systems: Design and Implementation”, Waltham MA: Butterworth-Heinemann, 2015.
3. Giacomo Veneri , Antonio Capasso, “ Hands on Industrial Internet of things” , Packt, 2018
4. Labview based Advanced Instrumentation systems, S. Sumathi & P. Surekha, Springer Publications, 2018 Edition
5. Dag H. Hanssen, Programmable Logic Controllers, A Practical Approach to IEC 61131-3 using CODESYS, John Wiley & Sons Ltd., 2015
6. David Bailey & Edwin Wright,”Practical SCADA for Industry’’, Elsevier 2010.

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MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	3	2	2
CO2	3	3	3	3	3	3
CO3	3	3	3	3	3	3
CO4	3	3	3	3	3	3
CO5	3	3	3	3	3	3
Avg	**3**	**2.8**	**2.8**	**3**	**2.8**	**2.8**

Note: 1-low, 2-medium, 3-high, '-"- no correlation

CO3211 AUTOMATION LABORATORY **LT P C**
0 0 4 2

LIST OF EXPERIMENTS

1. Configuration of instrumentation bus protocols
2. Development of an alarm and monitoring system to detect abnormal levels in a physical system
3. Design a GUI application to mimic closed loop performance of physical systems.
4. Control of flow and pressure in a tank process using Variable Frequency Drive.
5. Development of Ladder logic programme for control of process
6. Design of combinational and sequential logic application using PLC
7. Development of Cascade, ratio and feedback controller using DCS simulation software
8. Simulation of SCADA based control of physical system.
9. Mathematical modelling and transfer function analysis of a physical system using Virtual Instrumentation packages.
10. Mathematical modelling and state space analysis of a physical system using virtual Instrumentation packages.
11. Development of a state diagram-based application using virtual instrumentation package.
12. Design and development of IOT based transmitter
13. Design of IOT based robot arm.
14. Analysis and control of EV motors
15. Mini Project

TOTAL: 60 PERIODS

COURSE OUTCOMES:

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

CO1: To understand the concepts of configuring instrumentation, developing monitoring and control systems, designing graphical interfaces, and implementing control strategies using various techniques and tools.
CO2: To gain expertise in PLC programming, DCS simulation, SCADA-based control, and mathematical modeling using various software tools.

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CO3: To gain proficiency in developing state diagram-based applications, IoT-enabled devices, robotic systems, and control strategies for electric vehicle motors.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	2	3	1
CO2	3	3	3	2	3	1
CO3	3	3	3	2	3	1
Avg.	**3**	**3**	**3**	**2**	**3**	**1**

Note: 1-low, 2-medium, 3-high, '-"- no correlation

CO3212 ADVANCED MEASUREMENTS LABORATORY **LT P C**
0 0 4 2

EXPERIMENT LIST

1. Position measurement using LVDT and LDR by real-time and interfacing.
2. Measurement of physical parameters using Data Acquisition System
3. PC based measurement of Temperature using Temperature transducers.
4. Measurement of mechanical parameters in real-time environment.
5. Measurement of flow and pressure in a tank process using variable frequency drive.
6. Design of signal conditioning circuits for physical systems.
7. Analyzing the characteristics of IOT based transmitters in Machine Learning environment.
8. Physical parameter estimation using Gray box model of industrial process.
9. Classification of measurement data using Supervised learning algorithm.
10. Clustering physical parameters using Unsupervised learning algorithm.
11. State estimation of physical parameters using Kalman filters.
12. Calibration and characterization of industrial instruments
13. PID Controller tuning using optimization algorithm.
14. Mini project

TOTAL: 60 PERIODS

COURSE OUTCOMES:
At the end of this course, the students will demonstrate the ability
CO1: To measure and interface a physical parameter using data acquisition system.
CO2: To design signal conditioning circuits for various transducers.
CO3: To analyse the measurement data in machine learning environment
CO4: To estimate the physical parameters using system identification method
CO5: To measure the parameters in a physical system and evaluate its performance.

Attested

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	1	3
CO2	3	3	3	3	1	3
CO3	3	3	3	3	1	3
CO4	3	3	3	3	1	3
CO5	3	3	3	3	1	3
Avg.	**3**	**3**	**3**	**3**	**1**	**3**

Note: 1-low, 2-medium, 3-high, '-"- no correlation

CO3001 ADVANCED NON-LINEAR CONTROL **LT P C**
3 0 0 3

UNIT I PERTURBATION THEORY 9
Vanishing and Non vanishing Perturbations – Continuity of solutions on the infinite interval – Interconnected systems – Slowly varying systems – Perturbation method – Averaging - Weakly nonlinear second-order oscillators – Exercises

UNIT II SINGULAR PERTURBATIONS 9
Standard singular perturbation model – Time scale properties – Singular perturbation on the infinite interval – Slow and fast manifolds – stability analysis – exercises

UNIT III GAIN SCHEDULING AND FEEDBACK LINEARIZATION 9
Control problem – stabilization via linearization – integral control via linearization – gain scheduling – Input output linearization – Full state linearization – state feedback control – tracking- exercises

UNIT IV INPUT-OUTPUT STABILITY 9
L stability – L stability of state models – L_2 gain – feedback system: small gain theorem – exercises –Passivity – State models - L_2 and Lyapunov stability.

UNIT V BAKSTEPPING CONTROL ALGORITHMS 9
Passivity based control – High gain observers – stabilization – Regulation via integral control - exercises

TOTAL : 45 PERIODS

COURSE OUTCOMES
CO1 :Understanding different types of perturbation models.
CO2 :Analysis of Stability of various perturbation models.
CO3 :Apply gain schedule all kind of perturbation systems.
CO4 :Apply L stability and lyapunov stability conditions for systems
CO5 :Apply Bakstepping control algorithms.

REFERENCES

1. Hasan Khalil," Nonlinear systems and control", 3rd ed, PHI,
2. Slotine, J A E Slotine and W Li, "Applied Nonlinear control",1991, PHI
3. S.H. Zak," Systems and control", Oxford University Press

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MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	-	1
CO2	3	3	3	3	-	3
CO3	3	3	3	3	3	2
CO4	3	3	3	2	2	2
CO5	3	-	2	3	1	3
AVg.	**3**	**3**	**2.8**	**2.8**	**2**	**2.2**

Note: 1-low, 2-medium, 3-high, '-"- no correlation

CO3002 CONVERTERS AND ELECTRICAL DRIVES LT P C
3 0 0 3

UNIT I POWER ELECTRONIC CONVERTERS FOR DRIVES 9
Power electronic switches- Working of AC-DC converters for RLE load; single phase and three phase; , DC – DC converters for RLE load, AC- AC converters and DC- AC Converters; Single phase and three phase.

UNIT II CONTROL OF DC DRIVES 9
Modelling of DC machines-block diagram/transfer function-phase control-1phase/3phase converter fed DC drives- Chopper fed DC drives-four quadrant chopper circuit-closed loop control-speed control-current control-cascade control –constant torque/power operation-comparison of chopper/converter fed drives- techniques-merits/demits.

UNIT III REFERENCE FRAME THEORY 9
Historical background – phase transformation and commutator transformation – transformation of variables from stationary to arbitrary reference frame – transformation of balanced set-variables observed from several frames of reference.

UNIT IV VSI AND CSI FED STATOR CONTROLLED INDUCTION MOTOR CONTROL 9
AC voltage controller – six step inverter voltage control-closed loop variable frequency PWM inverter fed induction motor (IM) with braking-CSI fed IM variable frequency motor drives – pulse width modulation techniques – simulation of closed loop operation of stator controlled induction motor drives

UNIT V ROTOR CONTROLLED INDUCTION MOTOR DRIVES 9
Static rotor resistance control – injection of voltage in the rotor circuit – static scherbius drives – static and modified Kramer drives – sub-synchronous and super-synchronous speed operation of induction machines – simulation of closed loop operation of rotor controlled induction motor drives.

TOTAL: 45 PERIODS

Attested

COURSE OUTCOMES
CO1: understand Power Electronic Converter Switches and different PWM approach.
CO2: design and analyze converter and chopper driven dc drives.

CO3: analyze converter and chopper driven dc drives.
CO4: understand conventional control techniques of Induction motor drive.
CO5: understand V/f Control and Vector control

REFERENCES

1. Paul C. Krause, Oleg Wasynczuk, Scott D. Sudhoff, Steven D. Pekarek, "Analysis of Electric Machinery and Drive Systems", 3rd Edition, Wiley-IEEE Press, 2013.
2. R. Krishnan, Electric Motor & Drives: Modeling, Analysis and Control, Pearson Education, 1st Imprint, 2015..
3. Thyristor control of Electric drives, Vedam Subrahmanyam, Tata McGraw Hill, 1988
4. Ion Boldea & S.A.Nasar "ELECTRIC DRIVES", CRC Press, 2006
5. Simon Ang, Alejandro Oliva "POWER SWITCHING CONVERTERS", CRC Press, 2005
6. Buxbaum, A. Schierau, and K.Staughen, "A design of control systems for DC Drives", Springer- Verlag, Berlin,1990.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	-	1
CO2	3	3	3	3	-	1
CO3	3	3	3	3	-	1
CO4	3	3	3	3	-	1
CO5	3	3	3	3	-	1
AVg.	**3**	**3**	**3**	**3**	**-**	**1**

Note: 1-low, 2-medium, 3-high, '-"- no correlation

CO3057 OPTIMAL CONTROL AND FILTERING **LT P C**
3 0 0 3

UNIT I INTRODUCTION 9
Statement of optimal control problem – Problem formulation and forms of optimal Control– Selection of performance measures. Necessary conditions for optimal control – Pontryagin's minimum principle – State inequality constraints – Minimum time problem.

UNIT II LINEAR QUADRATIC TRACKING PROBLEMS 9
Linear tracking problem – LQG problem – Computational procedure for solving optimal control problems – Characteristics of dynamic programming solution – Dynamic programming application to discrete and continuous systems – Hamilton Jacobi Bellman equation.

UNIT III NUMERICAL TECHNIQUES FOR OPTIMAL CONTROL 9
Numerical solution of 2-point boundary value problem by steepest descent and Fletcher Powell method - solution of Ricatti equation by negative exponential and interactive Methods

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UNIT IV FILTERING AND ESTIMATION 9

Filtering – Linear system and estimation – System noise smoothing and prediction – Gauss Markov discrete time model – Estimation criteria – Minimum variance estimationLeast square estimation – Recursive estimation.

UNIT V KALMAN FILTER AND PROPERTIES 9

Filter problem and properties – Linear estimator property of Kalman Filter – Time invariance and asymptotic stability of filters – Time filtered estimates and signal to noise ratio improvement – Extended Kalman filter.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Ability to

CO1 : Understand the concept of Optimal Control problem.

CO2 : Identify, Formulate and measure the performance of Optimal Control.

CO3 : understand the Linear Quadratic Tracking Problems and implement dynamic programmingapplication for discrete and continuous systems.

CO4 : Solve Numerical solution of 2-point boundary value problem by steepest descent andFletcher Powell method.

CO5 : Understand Filtering problem their properties, linear estimator property of Kalman Filter andTime invariance and asymptotic stability of filters.

REFERENCES:

1. KiRk D.E., 'Optimal Control Theory – An introduction', Prentice hall, N.J., 1970.
2. Sage, A.P., 'Optimum System Control', Prentice Hall N.H., 1968.
3. Anderson, BD.O. and Moore J.B., 'Optimal Filtering', Prentice hall Inc., N.J., 1979.
4. S.M. Bozic, "Digital and Kalman Filtering", Edward Arnould, London, 1979.
5. Astrom, K.J., "Introduction to Stochastic Control Theory", Academic Press, Inc, N.Y., 1970.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	-	2	2	-	-
CO2	-	-	1	2	-	-
CO3	-	1	3	1	-	-
CO4	3	2	1	1	-	-
CO5	1	1	2	2	-	-
AVg.	**1.7**	**1.3**	**1.8**	**1.6**	**-**	**-**

Note: 1-low, 2-medium, 3-high, '- '- no correlation

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CO3003 SYSTEM IDENTIFICATION LT P C
3 0 0 3

UNIT I MODELS FOR INDENTIFICATION 9

Mathematical Models – Model sets – structures – properties – Identifiability – Linear Models -State Space Models - Distributed Parameter models - OE model - Models for Time-varying and Non-linear systems: Models with Nonlinearities – Nonlinear state-space models - Black box models, Fuzzy models.

UNIT II NON-PARAMETRIC AND PARAMETRIC IDENTIFICATON 9

Transient response and Correlation Analysis – Frequency response analysis – Spectral Analysis – Least Square – Recursive Least Square –Forgetting factor- Maximum Likelihood – Instrumental Variable methods.

UNIT III NON-LINEAR IDENTIFICATION 9

Open and closed loop identification: Approaches – Direct and indirect identification – Joint input-output identification – Non-linear system identification – Wiener models – Power series expansions - State estimation techniques – Nonlinear identification using Neural Network and Fuzzy Logic.

UNIT IV CONVERGENCE, DISTRIBUTION AND COMPUTING THE PARAMETER ESTIMATES 9

Conditions – Prediction error approach - Expressions for the Asymptotic Variance -Correlation Approach - Subspace Methods for Estimating State Space Models – Recursive Instrumental Variable Method - Recursive Prediction-Error Methods - Recursive Pseudo Linear Regressions.

UNIT V CASE STUDIES 9

Inverted Pendulum, Robot arm, process control application: heat exchanger, Distillation column, application to power system, Ship steering control.

TOTAL : 45 PERIODS

COURSE OUTCOMES

Ability to

CO1: Model LTI system and to analyse the Non-linear state-space model of a black box.

CO2: Analyse frequency, spectral, correlation and transient response of a system

CO3: Identify the Open & closed Loop of a Non-linear system by Neural network and Fuzzy Logic controller.

CO4: Understand the distribution and computation of parameter estimates

CO5: Apply different Identification techniques to various applications

REFERENCES

1. Lennart Ljung,” System Identification Theory for the User”, 2nd Edition, PHI, 1999.
2. Torsten Soderstrom, Petre Stoica, “System Identification”, prentice Hall `International (UK) Ltd,1989.
3. Karel J. Keesman, : System identification AN Introduction” Springer 2011, Ist Edition
4. Dan Simon, “Optimal State Estimation Kalman, H-infinity and Non-linear Approaches”, John Wiley and Sons, 2006
5. Van der Heijden, F., Duin, R.P.W., De Ridder, D., and Tax, D.M.J., “Classification, Parameter Estimation and State Estimation”, An Engineering Approach Using MATLAB, John Wiley & Sons Ltd., 2017, 2nd Edition.
6. Tao Liu and Furong Gao, “Industrial Process Identification and control design, Step-test and relay-experiment-based methods”, Springer- Verlag London Ltd., 2012, 1st Edition.

Attested

MAPPING OF COs WITH POs

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

Note: 1-low, 2-medium, 3-high, '-"- no correlation

CO3058 SYSTEM THEORY LT P C
3 0 0 3

UNIT I STATE VARIABLE REPRESENTATION 9

Introduction-Concept of State-State equation for Dynamic Systems -Time invariance and linearity- Non uniqueness of state model-State Diagrams - Physical System and State Assignment.

UNIT II SOLUTION OF STATE EQUATIONS 9

Existence and uniqueness of solutions to Continuous-time state equations-Solution of Nonlinear and Linear Time Varying State equations-Evaluation of matrix exponential-System modes- Role of Eigenvalues and Eigenvectors.

UNIT III CONTROLLABILITY AND OBSERVABILITY 9

Controllability and Observability-Stabilizability and Detectability-Test for Continuous time Systems- Time varying and Time invariant case-Output Controllability-Reducibility-System Realizations.

UNIT IV STABILTY 9

Introduction-Equilibrium Points-Stability in the sense of Lyapunov-BIBO Stability-Stability of LTI Systems-Equilibrium Stability of Nonlinear Continuous Time Autonomous Systems-The Direct Method of Lyapunov and the Linear Continuous-Time Autonomous Systems-Finding Lyapunov Functions for Nonlinear Continuous Time Autonomous Systems-Krasovskii and Variable-Gradiant Method.

UNIT V MODAL CONTROL 9

Introduction-Controllable and Observable Companion Forms-SISO and MIMO Systems – The Effect of State Feedback on Controllability and Observability-Pole Placement by State Feedback for both SISOand MIMO Systems-Full Order and Reduced Order Observers.

TOTAL : 45 PERIODS

Attested

COURSE OUTCOMES

CO1 :To understand the concept of State-State equation for Dynamic Systems andthe uniqueness of state model.

CO2 :To understand the concept of the uniqueness of state model.

CO3 :Analyse Controllability and Observability for Time varying and Time invariant case

CO4 :Analyse the linear systems in state space

CO5 :Design controllers in state space

REFERENCES:

1. M. Gopal, “Modern Control System Theory”, New Age International, 2005.
2. K. Ogatta, “Modern Control Engineering”, PHI, 2002.
3. John S. Bay, “Fundamentals of Linear State Space Systems”, McGraw-Hill, 1999.
4. D. Roy Choudhury, “Modern Control Systems”, New Age International, 2005.
5. John J. D’Azzo, C. H. Houpis and S. N. Sheldon, “Linear Control System Analysis and Design withMATLAB”, Taylor Francis, 2003.
6. Z. Bubnicki, ”Modern Control Theory”, Springer, 2005.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	-	1	-	-	-	-
CO2	1	-	1	-	-	-
CO3	3	3	3	-	-	-
CO4	-	-	1	3	-	-
CO5	-	-	-	-	-	-
AVg.	**2**	**2**	**1.6**	**3**	**-**	**-**

Note: 1-low, 2-medium, 3-high, ‘-“- no correlation

CO3004 ROBOTICS AND CONTROL **LT P C 3 0 0 3**

UNIT I INTRODUCTION AND TERMINOLOGIES 9

Definition-Classification-History- Robots components-Degrees of freedom-Robot joints-coordinates- Reference frames-workspace-Robot languages-actuators-sensors-Position, velocity and acceleration sensors-Torque sensors-tactile and touch sensors-proximity and range sensors- vision system-socialissues

UNIT II KINEMATICS 9

Mechanism-matrix representation-homogenous transformation-DH representation-Inverse kinematics- solution and programming-degeneracy and dexterity

UNIT III DIFFERENTIAL MOTION AND PATH PLANNING 9

Jacobian-differential motion of frames-Interpretation-calculation of Jacobian-Inverse Jacobian-RobotPath planning

UNIT IV DYNAMIC MODELLING 9

Lagrangian mechanics- Two-DOF manipulator- Lagrange-Euler formulation – Newton- Euler formulation – Inverse dynamics

UNIT V ROBOT CONTROL SYSTEM 9

- Linear control schemes- joint actuators- decentralized PID control- computed torque control – force control- hybrid position force control- Impedance/ Torque control

TOTAL : 45 PERIODS

COURSE OUTCOMES:

Ability to

CO1 :understand the components and basic terminology of Robotics

CO2 :understand kinematic relations and dynamic model of robots

CO3 :understand differential motion, path planning and dynamic model of robots

CO4 :develop kinematic and dynamic models for two degrees of freedom

CO5 : apply control techniques for robot position and force control.

REFERENCES

1. R.K. Mittal and I J Nagrath, “ Robotics and Control”, Tata MacGraw Hill, Fourth edition.
2. Saeed B. Niku ,’’Introduction to Robotics ’’, Pearson Education, 2002.
3. Fu, Gonzalez and Lee Mcgrahill ,’’Robotics ", international edition.
4. R.D. Klafter, TA Chmielewski and Michael Negin, "Robotic Engineering, An Integrated approach",Prentice Hall of India, 2003.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	3	3
CO2	3	2	3	1	2	3
CO3	3	3	3	2	-	3
CO4	3	3	2	1	3	2
CO5	2	2	3	2	2	2
AVg.	**2.8**	**2.6**	**2.8**	**1.8**	**2.5**	**2.6**

Note: 1-low, 2-medium, 3-high, ‘-“- no correlation

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CO3005 **ROBUST CONTROL** **LT P C**
3 0 0 3

UNIT I INTRODUCTION 9

Norms of vectors and Matrices – Norms of Systems – Calculation of operator Norms – vector Random spaces- Specification for feedback systems – Co-prime factorization and Inner functions – structured and unstructured uncertainty- robustness.

UNIT II H_2 OPTIMAL CONTROL 9

Linear Quadratic Controllers – Characterization of H_2 optimal controllers – H_2 optimal estimation- Kalman Bucy Filter – LQG Controller.

UNIT III H-INFINITY OPTIMAL CONTROL-RICCATI APPROACH 9

Formulation – Characterization of H-infinity sub-optimal controllers by means of Riccati equations – H-infinity control with full information – Hinfinity estimation.

UNIT IV H-INFINITY OPTIMAL CONTROL- LMI APPROACH 9

Formulation – Characterization of H-infinity sub-optimal controllers by means of LMI Approach – Properties of H-infinity sub-optimal controllers – H-infinity synthesis with pole-placement constraints

UNIT V SYNTHESIS OF ROBUST CONTROLLERS & CASE STUDIES 9

Synthesis of Robust Controllers – Small Gain Theorem – D-K –iteration- Control of Inverted Pendulum- Control of CSTR – Control of Aircraft – Robust Control of Second-order Plant-Robust Control of Distillation Column.

TOTAL : 45 PERIODS

COURSE OUTCOMES

Ability to

CO1 :Understand the structured and unstructured uncertainty of robustness.

CO2 :Design an H2 optimal controller and to implement kalman Bucy filter.

CO3 :Design an H-Infinity optimal control using Riccati and LMI Approach.

CO4 :synthesis of Robust Controller and application of small gain theorem.

CO5 : Implement robust Controllerfor CSTR and Distillation Column.

REFERENCES

1. U. Mackenroth “Robust Control Systems: Theory and Case Studies”,Springer International Edition,2010.
2. J. B. Burl, “ Linear optimal control H2 and H-infinity methods”, Addison WWesley, 1998
3. D. Xue, Y.Q. Chen, D. P. Atherton, "Linear Feedback Control Analysis and Design withMATLAB, Advances In Design and Control”, Society for Industrial and Applied Mathematics, 2007.
4. I.R. Petersen, V.A. Ugrinovskii and A. V. Savkin, “Robust Control Design using H-infinityMethods”, Springer, 2000.
5. M. J. Grimble, “Robust Industrial Control Systems: Optimal Design Approach for Polynomial Systems”, John Wiley and Sons Ltd., Publication, 2006.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	-	1	2	-	-	-
CO2	1	1	-	-	-	-
CO3	2	1	1	-	-	-
CO4	1	2	1	-	-	-
CO5	-	-	-	1	1	1
AVg.	**1.33**	**1.25**	**1.33**	**1**	**1**	**1**

Note: 1-low, 2-medium, 3-high, '-"- no correlation

CO3006 DYNAMICS AND CONTROL OF INDUSTRIAL PROCESS **LT P C**
3 0 0 3

UNIT I PROCESS DYNAMICS & CONTROL **9**

Need for process control – Hierarchical decomposition of Control Functions - Continuous and batch processes – P&ID diagram - Self regulation - Interacting and non-interacting systems - Mathematical model of Level, Flow and Thermal processes – Lumped and Distributed parameter models – Linearization of nonlinear systems - Characteristic of ON-OFF, P, P+I, P+D and P+I+D control modes
– Digital PID algorithm – Auto/manual transfer - Reset windup – Practical forms of PID Controller.

UNIT II PID CONTROLLER TUNING – SINGLE LOOP REGULATORY CONTROL **9**

Evaluation criteria – IAE, ISE, ITAE and ¼ decay ratio – Tuning - Process reaction curve method- Z-N and Cohen-Coon methods, Continuous cycling method and Damped oscillation method – optimization methods – Auto tuning

UNIT III MODEL BASED CONTROL SCHEMES **9**

Cascade control – Split-range - Feed-forward control – Ratio control – Inferential control –override control - Smith predictor control scheme - Internal Model Controller - IMC PID controller– Single Loop Dynamic Matrix Control – Adaptive control – Introduction to Model Predictive Control.

UNIT IV MULTIVARIABLE SYSTEMS & MULTI-LOOP REGULATORY CONTROL **9**

Multivariable Systems – Transfer Matrix Representation – Poles and Zeros of MIMO System - - Multi-loop Control - Introduction – Process Interaction – Pairing of Inputs and Outputs -The Relative Gain Array (RGA) – Properties and Application of RGA - Multi-loop PID Controller - Decoupling Control.

Attested

UNIT V CASE STUDIES **9**

Introduction to Multivariable control – Multivariable PID Controller –Predictive PID

Control - Control Schemes for Distillation Column, CSTR, Four-tank system and Additive Dosing Control.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1 :Ability to Apply knowledge of mathematics, science, and engineering to the build andanalyze models for flow, level, and thermal processes.

CO2 : Ability to determine the advanced Features supported by the Industrial Type PIDController.

CO3 : Ability to Design, tune and implement SISO P/PI/PID Controllers to achieve desiredPerformance for various processes.

CO4 :Ability to Analyze Multivariable Systems and Design Multi-variable and Multi-loop Control Schemes for various processes namely four-tank system, pH process, bio-reactor,distillationcolumn.

CO5 : Ability to Identify, formulate, and solve problems in the process control domain.

REFERENCES

1. B.Wayne Bequette, “Process Control: Modeling, Design, and Simulation”, Pearson, second edition,2023.
2. George Stephanopolus, "Chemical Process Control", Pearson, first edition, 2015.
3. Chidambarm. M, “Computer control of processes”, Narosa Publications, Reprint 2006.chennai.
4. Dale E. Seborg, Duncan A. Mellichamp, Thomas F. Edgar, and Francis J. Doyle, III “Process Dynamics and Control”, John Wiley and Sons, 3rd Edition, 2010.
5. Jose A. Romagnoli and Ahmet Palazoglu , & quot ;Introduction to Process Control & quot;, CRC Press, Taylor and Francis Group, Third Edition, 2020.
6. Coleman Brosilow and Babu Joseph, & quot; Techniques of Model-based Control & quot;, Prentice Hall InternationalSeries, PTR, New Jersey, 2002.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	1	2	2	-
CO2	-	-	-	1	3	2
CO3	-	-	-	3	2	-
CO4	-	-	-	1	2	-
CO5	1	1	-	-	-	-
AVg.	**1.5**	**1**	**1**	**1.75**	**2.25**	**2**

Note: 1-low, 2-medium, 3-high, ‘-“- no correlation

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CO3055 MODEL PREDICTIVE CONTROL LT P C
3 0 0 3

UNIT I INTRODUCTION 9
Models for MPC-Linear Dynamic Models, Input-Output Models, Distributed Models, Constraints and Unconstrained model.

UNIT II MODEL ANALYSIS AND DISTURBANCE MODELING 9
Model stability; Observability and controllability Representing uncertainty; White, colored and integrating noise

UNIT III STATE ESTIMATION AND MULTIVARIABLE MPC 9
State observer; Pole placement; Stability; Kalman Filter; Stochastic filtering theory; Multivariate MPC.

UNIT IV CONSTRAINED AND UNCONSTRAINED LQ CONTROL 9
Constrained LQ-Time variant and Invariant case: Estimation, control and output; Unconstrained LQ control; Nonlinear Constrained system

UNIT V STATE-SPACE MPC AND CASE STUDIES 9
State-space MPC; deterministic formulation; state feedback control, State-Space Output-Feedback MPC-separation principle; Implementation of output feedback MPC; MPC-Applications : solar power plant.

TOTAL: 45 PERIODS

BOOKS AND REFERENCES

1. J.B. Rawlings, D.Q. Mayne and M.M. Diehl (2018) Model Predictive Control: Theory, Computation, and Design, Nobb Hill.
2. E.F. Camacho and C. Bordons (2007) Model Predictive Control, Springer.

COURSE OUTCOMES:
CO1 :Ability to understand the concepts of developing various models for a physical system.
CO2 :Ability to analyze the models and incorporate the uncertainties.
CO3 :Ability to comprehend State Estimation And Multivariable MPC
CO4 :Ability to understand the design of Linear Quadratic control techniques and state space MPC
CO5 :Ability to design a model predictive controller to various applications

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	1	1
CO2	3	3	3	3	1	1
CO3	3	3	3	3	1	1
CO4	3	3	3	3	1	1
CO5	3	3	3	3	1	1
AVg.	**3**	**3**	**3**	**3**	**1**	**1**

Note: 1-low, 2-medium, 3-high, '- '- no correlation

Attested

CO3056 **MULTI SENSOR DATA FUSION** **LT P C**
3 0 0 3

UNIT I MULTISENSOR DATA FUSION INTRODUCTION 9

sensors and sensor data, Use of multiple sensors, Fusion applications. The inference hierarchy: output data. Data fusion model. Architectural concepts and issues. Benefits of data fusion, Mathematical tools used: Algorithms, co-ordinate transformations, rigid body motion. Dependability and Markov chains, Meta – heuristics.

UNIT II ALGORITHMS FOR DATA FUSION 9

Taxonomy of algorithms for multisensor data fusion. Data association. Identity declaration.

UNIT III ESTIMATION: 9

Kalman filtering, practical aspects of Kalman filtering, extended Kalmal filters. Decision level identify fusion. Knowledge based approaches.

UNIT IV ADVANCED FILTERING 9

Data information filter, extended information filter. Decentralized and scalable decentralized estimation. Sensor fusion and approximate agreement. Optimal sensor fusion using range trees recursively. Distributed dynamic sensor fusion.

UNIT V HIGH PERFORMANCE DATA STRUCTURES: 9

Tessellated, trees, graphs and function. Representing ranges and uncertainty in data structures. Designing optimal sensor systems within dependability bounds. Implementing data fusion system.

TOTAL : 45 PERIODS

COURSE OUTCOMES

CO1 : Ability to explain and use multiple sensor data in data fusion model.
CO2 : Capable to use algorithms for data fusion.
CO3 : Ability to estimate using kalman filter.
CO4 : Ability to estimate using advance filtering such as data, extended information filtering.
CO5 : Ability to handle various high performance data structures.

REFERENCES:

1. David L. Hall, Mathematical techniques in Multisensor data fusion, Artech House, Boston, 1992.
2. R.R. Brooks and S.S. Iyengar, Multisensor Fusion: Fundamentals and Applications withSoftware, Prentice Hall Inc., New Jersey, 1998.
3. Arthur Gelb, Applied Optimal Estimation, The M.I.T. Press, 1982.
4. James V. Candy, Signal Processing: The Model Based Approach, McGraw –Hill BookCompany, 1987.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	-	-	-	3	2	2
CO2	1	-	1	2	2	3
CO3	1	2	1	-	-	-
CO4	1	2	1	-	-	-
CO5	-	-	-	1	1	2
AVg.	**1**	**2**	**1**	**2**	**1.66**	**2.33**

Note: 1-low, 2-medium, 3-high, '-"- no correlation

CO3007 NETWORKED CONTROL SYSTEM LT P C
3 0 0 3

UNIT I FUNDAMENTALS OF STOCHASTIC PROCESSES 9

Stochastic process – Introduction to random variables and their role in probability theory and statistics, discrete and continuous random variables, probability mass/density functions, cumulative distribution functions, and transformations., Expectations, Moments, variance, skewness, and kurtosis to analyze the distribution of random variables., stationary and non-stationary process: significance, Differentiating between stationary and non-stationary processes, properties and implications in modeling and analysis.

UNIT II NETWORK MODELING AND CONSTRAINTS 9

Network models – Stochastic model: probability theory, random processes, methods to analyze network behavior. communication network constraints: bandwidth limitations, latency, jitter, and capacity constraints, network performance and design considerations, packet delay, packetloss-mitigation strategies for minimizing packet delay and loss, uncertain observation - model and uncertain observations for better decision-making and network management., Markov chain based model.

UNIT III ESTIMATION 9

Estimation of networked control system – Observer for networked system - types – design and implementation - estimate the unmeasured states of a system, Kalman filter - discrete-time and continuous-time.

UNIT IV CONTROL STRATEGIES 9

Control strategies –State feedback control - state-space representation, controllability, state feedback controllers. Output feedback control - observability, observers, controller design, Predictive control - modeling, optimization-based control.

UNIT V GRAPH THEORY 9

Introduction to graph theory: an overview - nodes, edges, graphs, graph representations, algorithms, applications - network analysis, routing, scheduling- Simulation of network control system: principles and techniques - Application of networkcontrol system.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of this course, the students will be able to

CO1: Model the network control system with packet delay, loss and uncertain observation.
CO2: Design control system in the presence of quantization, network delay or packet loss.
CO3: Understand distributed estimation and control suited for network control system.
CO4: Develop simple application suited for networked control systems.
CO5: Equip students with a solid foundation in graph theory and its applications in control systems.

TEXT BOOKS

1. J. Medhi, “Stochastic Processes”, 3rd Edition, New Age Science, 2009.
2. Jagannathan Sarangapani, Hao Xu, “Optimal Networked Control Systems with MATLAB”,1st Edition, CRC press, Taylor and Francis group, 2016.
3. Xia Y., Fu M., Liu GP., “Analysis and Synthesis of Networked Control System, Lecture Notes in Control and Information Sciences”, Springer-Verlag Berlin Heidelberg, 2011.

REFERENCES

1. Anderson, B.D.O. and Moore J.B., “Optimal Filtering”, Prentice-Hall, Englewood Cliffs, New Jersey, 1979.
2. K You, N Xiao, L Xie, “Analysis and Design of Networked Control System, Communications and Control Engineering”, Springer London Heidelberg New York Dordrecht, 2015.
3. Srikant, Rayadurgam, Lei Ying, “Communication networks: an optimization, control, and stochastic networks perspective. Cambridge University Press,2013.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	3	3	-	-
CO2	1	1	2	1	-	-
CO3	1	1	3	2	-	-
CO4	2	2	3	3	-	-
CO5	2	2	3	3		
Avg.	**1.6**	**1.4**	**2.8**	**2.4**	-	-

Note: 1-low, 2-medium, 3-high, ‘-“- no correlation

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CO3059 **WIRELESS SENSOR NETWORKS** **L T P C**
3 0 0 3

UNIT I ARCHITECTURE OF WIRELESS SENSOR NETWORKS 9

Challenges for wireless sensor networks, Comparison of sensor network with ad hoc network, Single node architecture — Hardware components, energy consumption of sensor nodes, Network architecture — Sensor network scenarios, types of sources and sinks, single hop versus multi-hop networks, multiple sinks and sources, design principles, Development of wireless sensor networks.

UNIT II FUNDAMENTALS OF WIRELESS COMMUNICATION AND CHANNEL CHARACTERISTICS 9

Wireless channel and communication fundamentals — frequency allocation, modulation and demodulation, wave propagation effects and noise, channels models, spread spectrum communication, packet transmission and synchronization, quality of wireless channels and measures for improvement, physical layer and transceiver design consideration in wireless sensor networks, energy usage profile, choice of modulation, power management.

UNIT III MAC AND LINK LAYER PROTOCOLS 9

MAC protocols –fundamentals of wireless MAC protocols, low duty cycle protocols and wakeup concepts, contention-based protocols, Schedule-based protocols, Link Layer protocols — fundamentals task and requirements, error control, framing, link management

UNIT IV METHODS OF NETWORKING COMMUNICATION, ROUTING, DESIGN 9

Gossiping and agent-based uni-cast forwarding, Energy-efficient unicast, Broadcast and multicast, geographic routing, mobile nodes, Data –centric and content-based networking – Data –centric routing, Data aggregation, Data-centric storage, Higher layer design issue

UNIT V SENSOR NETWORK APPLICATIONS 9

Target detection and tracking, Habitat monitoring, Environmental disaster monitoring, Practical implementation issues, IEEE 802.15.4 low rate WPAN, Sensor Network Platforms and tools-Sensor node hardware, Node-level software platforms, node –level simulators.

TOTAL: 45 PERIODS

COURSE OUTCOMES

On completion of this course, the students will be able to

CO1: Understand challenges, architectural components, energy considerations, network scenarios, and design principles of wireless sensor networks,

CO2: Equip students with a comprehensive understanding of wireless communication fundamentals and their specific application in wireless sensor networks.

CO3: Design, analyse, and implement efficient MAC protocols for reliable communication in wireless environments.

CO4: Gain advanced knowledge in gossiping, energy-efficient communication, geographic routing, and data-centric networking.

CO5: Design and implement wireless sensor network solutions for real-world applications.

REFERENCES

1. Feng Zhao and Leonidas J. Guibas, "Wireless Sensor Networks: An Information Processing Approach", Elsevier, 2004.
2. Holger Karl and Andreas Willig, "Protocols and Architectures for Wireless Sensor Networks", John Wiley, 2007.
3. Ivan Stojmenovic, "Handbook of Sensor Networks: Algorithms and Architectures", Wiley, 2005.
4. Kazem Sohraby, Daniel Minoli and Taieb Znati, "Wireless Sensor Networks: Technology,

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Protocols and Applications", John Wiley, 2007.
5. Bhaskar Krishnamachari, "Networking Wireless Sensors", Cambridge University Press, 2011.

MAPPING OF COs WITH POs AND PSOs

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

Note: 1-low, 2-medium, 3-high, '-"- no correlation

CO3052 CYBER PHYSICAL SYSTEMS LT P C
3 0 0 3

UNIT I INTRODUCTION 9

Introduction-key features of cyber physical systems- Continuous dynamics: Newtonian mechanics-actor models-properties of systems-feedback control-Discrete dynamics: Discrete systems- Finite state machines.

UNIT II SYNCHRONOUS AND ASYNCHRONOUS MODEL 9

Synchronous model: Reactive components-properties of components-composing components- synchronous design, Asynchronous model- asynchronous processes-asynchronous design primitives- coordination protocols.

UNIT III SAFETY AND LIVENESS REQUIREMENT 9

Safety specifications- verifying invariants- Enumerative search- Temporal logic-Model checking- reachability analysis- proving live-ness

UNIT IV TIMED MODEL AND REAL-TIME SCHEDULING 9

Timed processes- Timing based protocols: Timing-Based Distributed Coordination-Audio Control Protocol- Timed automata: Model of Timed Automata-Region Equivalence-Matrix- Based Representation for Symbolic Analysis, Real-time scheduling.

UNIT V HYBRID SYSTEMS **9**

Classes of Hybrid Systems-Hybrid dynamic models: Hybrid Processes-Process Composition- Zeno Behaviors-Stability- designing hybrid systems- linear hybrid automata.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

On completion of this course, the students will be able to

CO1: Apply mathematical knowledge and basis of science and engineering todevelop model for continuous and discrete systems.

CO2: Develop synchronous and asynchronous models

CO3: Assess the safety requirements of the cyber physical systems

CO4: Apply automata for modeling timed systems

CO5 : Analyze the stability of hybrid systems

REFERENCES:

1. Rajeev Alur, Principles of cyber-physical systems, The MIT press, 2015.
2. E. A. Lee and S. A. Seshia, Introduction to Embedded Systems - A Cyber-PhysicalSystems Approach, Lulu.com, First Edition, Jan 2013.
3. Sang C.Suh , U.John Tanik and John N.Carbone , Applied Cyber-Physical systems,Springer,2014

MAPPING OF COs WITH POs AND PSOs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	1	-	-	-
CO2	1	2	2	-	-	-
CO3	1	-	-	2	1	-
CO4	-	-	-	2	2	1
CO5	-	-	-	1	1	1
AVg.	**1.33**	**2**	**1.5**	**1.66**	**1.33**	**1**

Note: 1-low, 2-medium, 3-high, '-"- no correlation

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CO3051 BIOMEDICAL INSTRUMENTATION **L T P C**
3 0 0 3

UNIT I BIOMEDICAL MEASUREMENTS AND SAFETY CONSIDERATIONS 9

Physiological systems and measurable variables- Nature and complexities of biomedical measurements- Medical equipment standards- organization, classification and regulation- Biocompatibility - Human and Equipment safety — Physiological effects of electricity, Micro and macro shocks, thermal effects.

UNIT II MODELING AND SIMULATION IN BIOMEDICAL INSTRUMENTATION 9

Modeling and simulation in Biomedical instrumentation – Difference in modeling engineering systems and physiological systems — Model based analysis of Action Potentials - cardiac output – respiratory mechanism - Blood glucose regulation and neuromuscular function.

UNIT III CLASSIFICATION OF BIOLOGICAL SIGNALS 9

Types and Classification of biological signals – Signal transactions – Noise and artifacts and their management - Biopotential electrodes- types and characteristics - Origin, recording schemes and analysis of biomedical signals Electrocardiography(ECG), with typical examples of and Electroencephalography(EEG), Electromyography (EMG)– Processing and transformation of signals- applications of wavelet transforms in signal compression and denoising.

UNIT IV IMAGING MODALITIES AND ANALYSIS 9

Advanced medical imaging techniques and modalities -Instrumentation and applications in monitoring and diagnosis- Computed tomography, Magnetic Resonance Imaging and ultrasound- Algorithms and applications of artificial intelligence in medical image analysis andDiagnosis-Telemedicine and its applications in tele monitoring.

UNIT V IMPLANTABLE MEDICAL DEVICES 9

Artificial valves, vascular grafts and artificial joints- cochlear implants - cardiac pacemakers – Microfabriation technologies for biomedical Microsystems- microsensors for clinical applications – biomedical microfluid systems

TOTAL: 45 PERIODS

COURSE OUTCOMES

On completion of this course, the students will be able to

CO1: Gain a comprehensive understanding of physiological systems, biomedical measurements, and the critical aspects of safety in medical equipment

CO2: Create mathematical models for various physiological systems, allowing for in-depth analysis and simulation of complex biomedical phenomena.

CO3: Manage noise and artifacts, utilizing biopotential electrodes, and applying signal processing techniques, including wavelet transforms, to biomedical signals.

CO4: Understand the applications and benefits of artificial intelligence in medical image analysis and diagnosis, along with the potential of telemedicine in enhancing healthcare through remote monitoring and consultations.

CO5: Understand the various implantable biomedical devices and microsystems.

REFERENCES

1. John G.Webster, “Bioinstrumentation”, John Wiley & Sons, 2008.
2. Shayne C.Gad, “Safety Evaluation of Medical Devices”, CRC Press, Second Edition, 2002.
3. Michael C.K.Khoo, “Physiological Control Systems: Analysis, Simulation and Estimation,IEEE Press, 2000.
4. John G.Webster, “Medical Instrumentation Application and Design”, John Wiley & Sons,Third Edition, 2009.
5. L.Cromwell, Fred J. Weibell and Erich A.Pfeiffer, “Biomedical Instrumentation andMeasurements”, Prentice Hall of India, Digitized 2010.

6. P.Strong, "Biophysical Measurements", Tektronix, Digitized 2007.
7. K.Najarian and R. Splinter, "Biomedical Signal and Image Processing", CRC Press, 2012.
8. John L.Semmlow, "Biosignal and Biomedical Image Processing", CRC Press, First Edition,2004.
9. Joseph J.Carr and John M.Brown, "Introduction to Biomedical Equipment Technology",Prentice Hall, Fourth Edition, 2004.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	-	-	3
CO2	3	3	3	-	-	3
CO3	3	3	3	-	-	3
CO4	3	3	3	-	-	3
CO5	3	3	3	-	-	3
AVg.	**3**	**3**	**3**	**-**	**-**	**3**

Note: 1-low, 2-medium, 3-high, '-"- no correlation

CO3054 INTELLIGENT TRANSPORTATION SYSTEMS LT P C
3 0 0 3

UNIT I INTRODUCTION TO INTELLIGENT TRANSPORTATION SYSTEMS 9

Definition of ITS and Identification of ITS Objectives, Historical Background, Benefits of ITS - ITS Data collection techniques – Detectors, Automatic Vehicle Location (AVL), Automatic Vehicle Identification (AVI), Geographic Information Systems (GIS), video data collection.

UNIT II TELECOMMUNICATIONS IN ITS 9

Importance of telecommunications in the ITS system, Information Management, Traffic Management Centres (TMC). Vehicle – Road side communication – Vehicle Positioning System

UNIT III ITS FUNCTIONAL AREAS 9

Advanced Traffic Management Systems (ATMS), Advanced Traveler Information Systems (ATIS), Commercial Vehicle Operations (CVO), Advanced Vehicle Control Systems (AVCS), Advanced Public Transportation Systems (APTS), Advanced Rural Transportation Systems (ARTS).

UNIT IV ITS USER NEEDS AND SERVICES 9

Travel and Traffic management, Public Transportation Management, Electronic Payment, Commercial Vehicle Operations, Emergency Management, Advanced Vehicle safety systems, Information Management.

UNIT V AUTOMATED HIGHWAY SYSTEMS 9

Vehicles in Platoons – Integration of Automated Highway Systems. ITS Programs in the World – Overview of ITS implementations in developed countries, ITS in developing countries, Case studies.

Attested

TOTAL : 45 PERIODS

COURSE OUTCOMES:

Upon completion of this course, the students should be able to:

CO1: understand the sensor technologies
CO2: understand the communication techniques
CO3: apply the various ITS methodologies
CO4: understand the user needs
CO5: define the significance of ITS under Indian conditions

REFERENCES:

1. ITS Hand Book 2000: Recommendations for World Road Association (PIARC) by Kan Paul Chen, John Miles.
2. Sussman, J. M., Perspective on ITS, Artech House Publishers, 2005.
3. National ITS Architecture Documentation, US Department of Transportation, 2007 (CD-ROM).
4. Chowdhary, M.A. and A Sadek, Fundamentals of Intelligent Transportation systems planning. Artech House Inc., US, 2003.
5. Williams, B., Intelligent transportation systems standards. Artech House, London,2008.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	2	1	3	3
CO2	1	1	3	-	2	2
CO3	2	-	1	-	1	2
CO4	-	1	-	-	-	-
CO5	1	1	-	-	-	-
AVg.	**1.5**	**1**	**2**	**1**	**2**	**2.3**

CO3008 BUILDING AND INFRASTRUCTURE SYSTEMS AND AUTOMATION **LT P C 3 0 0 3**

UNIT I INTRODUCTION TO BUILDING & INFRASTRUCTURE SYSTEMS & AUTOMATION 9

Overview of buildings & campuses – residential community, commercial, industrial, Concept and application of buildings automation (BA) - Requirements and design considerations of BA. Effect on energy & utility services efficiency of building services operations. Architecture and components of BA, BMS (Building Management Systems) concept and overview

UNIT II BUILDINGS & INFRASTRUCTURE SYSTEMS 9

Infrastructures – commercial/industrial campuses, malls, high-rise buildings, hotels & resorts, sports-complex, smart-community & smart-city, metro-trains, airports, seaports, ships, surface transports (road-bridges, highways, waterways) - Buildings & Infrastructure Systems: Typical subsystems HVAC**:** Different components of HVAC system

Attested

UNIT III LIGHTING AND ACCESS CONTROL SYSTEMS 9

Various components of lighting systems, efficient use of electricity, lighting control systems, components of CCTV system like cameras, cables, etc., concept of automation in access control system

UNIT IV VERTICAL TRANSPORTATION SYSTEM 9

Structure of lift and escalator, traffic analysis, lift drives, supervisory control and remote monitoring of lift, safety aspects -Fire & Alarm system - Other utility & subsystems: Water sources-storage-distribution - cooking gas source-distribution system, community halls &gym, air/gas utility supply & distribution systems, facility-estate management, safety, O&M

UNIT V ELECTRICAL UTILITY AND AUTOMATION 9

Typical sources - power-grid utility & diesel-gensets, stable and uninterrupted power supply, components of electrical power distribution in buildings- infrastructure, transformers, meters, distribution system components, wiring, common/large loads – pumps, compressors, motors & drives, VFDs Building Automation: Role of automation in operation of B&I System/subsystems (HVAC/Lighting/Lifts/Electricity etc.). Relevant sensors-actuators, BA controllers DDC, PLC,SCADA, HMI, RMVCD Centers.

TOTAL: 45 PERIODS

COURSE OUTCOMES

On completion of this course, the students will be able to

CO1 : Understand the architecture and basic building blocks of Building and Infrastructureof Automation systems

CO2: Design and evaluate various subsystems for Building Automation systems

CO3: To design and implement control strategies for HVAC systems for energymanagement system

CO4: Grasp the advanced principles for incorporating the safety and acquire efficientresource management skills within Building Automation systems.

CO5: Enhance energy efficiency, operational effectiveness, and overall functionality in various built environments.

REFERENCES:

1. Smart Buildings by Jim Sinopoli, Butterworth-Heinemann imprint of Elsevier, 2nd ed.,2010.
2. Understanding Building Automation Systems (Direct Digital Control, Energy Management, Life Safety, Security, Access Control, Lighting, Building Management Programs) by Reinhold A. Carlson, Robert A. Di Giandomenico, pub. by R.S. Means Company, 1991.
3. Intelligent Building Systems by Albert Ting-Pat So, WaiLok Chan, Kluwer Academicpublisher, 3rd ed., 2012.
4. Design of Special Hazards and Fire Alarm Systems by Robert Gagnon, ThomsonDelmarLearning; 2nd edition, 2007.
5. HVAC Controls and Systems by Levenhagen, John I.Spethmann, Donald H., McGraw-Hill Pub.
6. HVAC Control in the New Millennium by Hordeski, Michael F, Fairmont press, 2001.
7. Process Control- Instrument Engineers Handbook by Bela G. Liptak, Chilton book co.
8. Other resources like Published journal/conference papers, industrial products & manuals, Internet search/survey.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	1	-	-	-
CO2	2	2	1	-	-	-
CO3	-	-	-	1	2	1
CO4	-	-	-	2	2	1
CO5	3	3	2	2	2	1
Avg.	**2.33**	**2**	**1.33**	**1.67**	**2**	**1**

Note: 1-low, 2-medium, 3-high, '-"- no correlation

CO3053 INDUSTRIAL INTERNET OF THINGS **LT P C 3 0 0 3**

UNIT I INTERNET PRINCIPLES 9
Definition and Characteristics - IoT enabling technologies — Levels of deployment — Domainspecific IoTs - SDN and NFV for IoT — ISO/OSI model — MAC address and IP address - Overview of TCP/IP and UDP -Basics of DNS - Classes of IP addresses - Static and dynamic addressing –Salient features of IPV4 – Specifications of IPV6 and 6LoPAN.

UNIT II PHYSICAL AND LOGICAL DESIGN METHODOLOGIES 9
Requirements and Specifications – Device and Component Integration —Physical design using prototyping boards - Sensors and actuators, choice of processor, interfacing and networking - Logical Design — Open source platforms - Techniques for writing embedded code - Case studies and examples using Python programming and Arduino/Raspberry Pi prototyping boards
– IoT application development using Wireless Sensor Networks - Single Node Architecture - Hardware Components, Energy Consumption of Sensor Nodes.

UNIT III PROTOCOLS AND CLOUDS FOR IOT 9
Application layer protocols for IoT – MQTT and –Introduction to cloud storage models and communication APIs – Web application framework – Designing a web API – Web services - IoT device management.

UNIT IV INDUSTRIAL IOT AND SECURITY 9
Introduction to the Industrial Internet - Networked Control Systems – Network delay modeling - Architecture and design methodologies for developing IoT application for Networked Control Systems — Example using SCADA system - Software Design Concepts - Middleware IIOT platforms- securing the Industrial Internet- Introduction of Industry 4.0.

UNIT V PROCESS DATA ANALYTICS 9
Process analytics - Dimensions for Characterizing process- process Implementation technology Tools and Use Cases- open source and commercial tools for Process

analytics-Big data Analytics for process data - Analyzing Big process data problem — Crowdsourcing and Social BPM - Process data management in the cloud.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

On completion of this course, the students will be able to

CO1: Apply the knowledge of Internet principles and protocols to understand the architectureand specifications of a given network

CO2: Design simple IoT applications using prototyping boards

CO3: Select the appropriate protocol for a specific network implementation

CO4: Identify the security level needed for a particular industrial IOT application

CO5: Analyze the process data using cloud based process data management tools

REFERENCES:

1 ArshdeepBahga and Vijay Madisetti, "Internet of Things A Hands-on Approach",Universities Press (India), 2015

2 Alasdair Gilchrist," Industry 4.0:The Industrial Internet of Things", Apress, 2016.

3 Adrian McEwen and Hakim Cassimally, "Designing the Internet of Things", John Wiley &Sons, 2014

4 Francis Dacosta, "Rethinking the Internet of Things", Apress Open, 2014.

5 Beheshti, S.-M.-R., Benatallah, B., Sakr, S., Grigori, D., Motahari-Nezhad, H.R., Barukh, M.C., Gater, A., Ryu, S.H."Process Analytics Concepts and Techniques for Querying andAnalyzing Process Data" Springer International Publishing Switzerland,2016.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	3	3	3	3
CO2	2	2	-	3	3	2
CO3	3	3	2	1	3	3
CO4	3	-	3	2	2	3
CO5	3	3	3	3	3	3
AVg.	**2.6**	**2.25**	**2.75**	**2.4**	**2.8**	**2.8**

Note: 1-low, 2-medium, 3-high, '-"- no correlation

IN3051 **SAFETY INSTRUMENTED SYSTEMS** **L T P C**
3 0 0 3

UNIT I INTRODUCTION 9

Safety Instrumented System (SIS): need, features, components, difference between basic process control system and SIS - Risk: how to measure risk, risk tolerance, Safety integrity level, safety instrumented functions - Standards and Regulation – HSE-PES, AICHE-CCPS, IEC-61508, ANSI/ISA-84.00.01-2004 (IEC 61511 Mod) & ANSI/ISA – 84.01-1996, NFPA 85, API RP 556, API RP 14C, OSHA (29 CFR 1910.119 – Process Safety Management of Highly Hazardous Chemicals – SIS design cycle - Process Control vs Safety Control.

UNIT II PROTECTION LAYERS AND SAFETY REQUIREMENT SPECIFICATIONS 9

Prevention Layers: Process Plant Design, Process Control System, Alarm Systems, Procedures, Shutdown/Interlock/Instrumented Systems (Safety Instrumented Systems – SIS), Physical Protection - Mitigation Layers: Containment Systems, Scrubbers and Flares, Fire and Gas (F&G) Systems, Evacuation Procedures - Safety specification requirements as per standards, causes for deviation from the standards.

UNIT III SAFETY INTEGRITY LEVEL (SIL) 9

Evaluating Risk, Safety Integrity Levels, SIL Determination Method : As Low As Reasonably Practical (ALARP), Risk matrix, Risk Graph, Layers Of Protection Analysis (LOPA) – Issues related to system size and complexity –Issues related to field device safety – Functional Testing.

UNIT IV SYSTEM EVALUATION 9

Failure Modes, Safe/Dangerous Failures, Detected/Undetected Failures, Metrics: Failure Rate, MTBF, and Life, Degree of Modeling Accuracy, Modeling Methods: Reliability Block Diagrams, Fault Trees, Markov Models - Consequence analysis: Characterization of potential events, dispersion, impacts, occupancy considerations, consequence analysis tools - Quantitative layer of protection analysis: multiple initiating events, estimating initiating event frequencies and IPL failure probabilities.

UNIT V CASE STUDY 9

SIS Design check list - Case Description: Furnace/Fired Heater Safety Shutdown System: Scope of Analysis, Define Target SILs, Develop Safety Requirement Specification (SRS), SIS Conceptual Design, Lifecycle Cost Analysis, Verify that the Conceptual Design Meets the SIL, Detailed Design, Installation, Commissioning and Pre-startup Tests, Operation and Maintenance Procedures.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

On successful completion of the course, students will be able to:

- **CO1** understand Non-SIS layers of protection and the need for SIS in process industries.
- **CO2** state the associated SIS standards.
- **CO3** implement hazard analysis & risk assessment to identify process hazards & risks.
- **CO4** determine the target SIL & safety requirements specifications
- **CO5** develop detailed SIS design, installation & operation.
- **CO6** implement SIS analysis & design for a furnace/ fired heater system.

Attested

REFERENCES:

1. Paul Gruhn and Harry L. Cheddie," Safety Instrumented systems: Design, Analysis and Justification", ISA, 2nd edition, 2018.
2. Eric W. Scharpf, Heidi J. Hartmann, Harlod W. Thomas, "Practical SIL target selection: Risk analysis per the IEC 61511 safety Lifecycle", exida 2nd Edition 2016.
3. William M. Goble and Harry Cheddie, "Safety Instrumented Systems Verification: Practical Probabilistic Calculations" ISA, 2005.
4. Edward Marszal, Eric W. Scharpf, "Safety Integrity Level Selection: Systematic Methods Including Layer of Protection Analysis", ISA, 2002.
5. Standard - ANSI/ISA-84.00.01-2004 Part 1 (IEC 61511-1 Mod) "Functional Safety: Safety Instrumented Systems for the Process Industry Sector - Part 1: Framework, Definitions, System, Hardware and Software Requirements", ISA, 2004.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	-	-	-	-	-
CO2	3	-	-	-	-	-
CO3	-	-	2	2	-	-
CO4	-	-	-	2	-	-
CO5	-	3	2	-	-	-
CO6	-	-	2	-	-	-
AVg.	**3**	**3**	**2**	**2**	**-**	**-**

Note: 1-low, 2-medium, 3-high, '-"- no correlation

ET3151 DESIGN OF EMBEDDED SYSTEMS LT P C
3 0 0 3

UNIT I INTRODUCTION TO EMBEDDED SYSTEMS 9

Selection of Single-processor Architectures & Multi-Processor Architectures-built in features for embedded Target Architecture -Embedded Coprocessors-DMA- memory devices – Memory management methods-memory mapping, cache replacement policies- Timers and Counting devices, Techniques for enhancing computational throughput: parallelism and pipelining - Software Development tools-IDE, Incircuit emulator, Target Hardware Debugging.

UNIT II EMBEDDED NETWORKING BY PROCESSORS 9

Embedded Networking: Introduction, I/O Device Ports & Buses- multiple interrupts and interrupt service mechanism – Serial Bus communication protocols -RS232 standard–RS485–USB–Inter Integrated Circuits (I2C)- CAN Bus – Device Drivers -Wireless protocol based on Wifi , Bluetooth, Zigbee –IoT application.

UNIT III RTOS BASED EMBEDDED SYSTEM DESIGN 9

Introduction to basic concepts of RTOS- Synchronising and Scheduling in Uniprocessor and Multiprocessor OS- Task, process & threads, interrupt routines ,Multiprocessing and Multitasking, Preemptive and non-preemptive scheduling, inter task communication- context switching, interrupt latency and deadline, shared memory, message passing-, Interprocess Communication – synchronization between processes-semaphores,Mailbox, pipes, priority inversion, priority inheritance, comparison of Real time Operating systems:VxWorks, OS for mobile applications.

UNIT IV MODELLING WITH HARDWARE/SOFTWARE DESIGN APPROACHES 9

Modelling -embedded hardware and software development approach -Overview of UML modeling with UML, UML Diagrams- Co-Design & CoSynthesis Approaches for System Specification , modeling –Case examples of one DSProcessor, one automated vending machine.

UNIT V EMBEDDED SYSTEM APPLICATION DEVELOPMENT 9

DSProcessors - Architectural requirement and applications- Computational Features of DSProcessors for signal processing- Shifting , Buffering, IIR/FIR Filtering operation, Addressing Capabilities, Onchip peripherals and Features for External Interfacing& Program Execution–Case example of DSProcessor (TMS320CXX/ TMS320C67xx/ any other)based embedded application using audio, video processing.

TOTAL: 45 PERIODS

NOTE:

Practice through Mini Project/Exercise/Discussions on Design ,Development of embedded Products like : Digital Camera /Adaptive Cruise control in a Car /Mobile Phone / Automated Robonoid /discussions on interface to Sensors, GPS, GSM, Actuators

COURSE OUTCOMES:

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

CO1: To understand the functionalities of processor internal blocks, with their requirement.

CO2: Observe that Bus standards are chosen based on interface overheads without sacrificing processor performance

CO3: Understand the role and features of RT operating system, that makes multitask execution possible by processors.

CO4: Understand that using multiple CPU based on either hardcore or softcore helps data overhead management with processing- speed reduction for uC execution.

CO5: Guidelines for consumer product design based on DSP based Embedded processor

REFERENCES:

1. Rajkamal, 'Embedded system-Architecture, Programming, Design', TMH,2011.
2. Steven W.Smith,"The Scientist and Engineers Guide for Digital Signal Processing",Elseiver 2019.
3. Lyla B Das," Embedded Systems-An Integrated Approach",Pearson2013
4. Elicia White,"Making Embedded Systems",O'Reilly Series,SPD,2011
5. Bruce Powel Douglass,"Real-Time UML Workshop for Embedded Systems,Elsevier,2011
6. Advanced Computer architecture , By Rajiv Chopra, S Chand , 2010
7. Jorgen Staunstrup, Wayne Wolf , Hardware / Software Co- Design Principles and Practice, Springer, 2009.
8. Shibu.K.V, "Introduction to Embedded Systems", TataMcgraw Hill,2009
9. Tammy Noergaard, "Embedded System Architecture, A comprehensive Guide for Engineers and Programmers", Elsevier, 2006
10. Peckol, "Embedded system Design",JohnWiley&Sons,2010

Attested

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	-	-	3	2	1	-
CO2	2	-	1	2	-	-
CO3	-	2	2	3	-	-
CO4	2	-	3	3	-	-
CO5	2	-	1	2	-	2
Avg.	**2**	**2**	**2**	**2.4**	**1**	**2**

ET3252 EMBEDDED CONTROL FOR ELECTRIC DRIVES **L T P C**
2 0 2 3

UNIT I INTRODUCTION ELECTRICAL DRIVES **6**
Electric drive and its classifications, Four-quadrant drive, Dependence of load torque on various factors, Dynamics of motor-load combination-Solid State Controlled Drives-Machine learning and optimization techniques for electrical drives- IoT for Electrical drives applications.

UNIT II EMBEDDED PROCESSOR **6**
Embedded Processor architecture - RTOS - Hardware/software co-design Programming and optimization with SoC processors - control algorithms implementation for power converter.

UNIT III INDUCTION MOTOR CONTROL **6**
Types - Speed control methods - PWM techniques- VSI fed three - phase induction motor- Fuzzy logic Based speed control for three phase induction motor - FPGA based three phase induction motor control.

UNIT IV BLDC MOTOR CONTROL **6**
Overview of BLDC Motor - Speed control methods - PWM techniques - ARM processor based BDLC motor control - ANN for BLDC Motor control and operation.

UNIT V SRM MOTOR CONTROL **6**
Overview of SRM Motor - Speed control methods - PWM techniques - FPGA based SRM motor control - DNN for SRM Motor control and operation.

30 PERIODS

SKILL DEVELOPMENT ACTIVITIES (Hands on laboratory practice / Seminar/ Mini Project/etc)

30 PERIODS

1. Laboratory exercise: Use any System level simulator/MATLAB/open-source platform to give hands-on training on simulation study on Electric drives and control.
    a. Simulation of four quadrant operation and speed control of DC motor
    b. Simulation of 3-phasee inverter.
    c. Simulation of Speed control of Induction motor using any suitable software package.
    d. Simulation of Speed control of BLDC motor using any suitable software package.
    e. Simulation of Speed control of SRM using any suitable software package
2. Seminar: IoT-based Control and Monitoring for DC Motor/ any Electric drives.
3. Mini project.: Any Suitable Embedded processor-based speed control of Motors (DC/IM/BLDC/PMSM/SRM)

Attested

TOTAL : 60 PERIODS

COURSE OUTCOMES:

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

CO1: Interpret the significance of embedded control of electrical drives

CO2: Deliver insight into various control strategy for electrical drives.

CO3: Developing knowledge on Machine learning and optimization techniques for motor control.

CO4: Develop embedded system solution for real time application such as Electric vehicles and UAVs.

CO5: Improved Employability and entrepreneurship capacity due to knowledge up gradation on recent trends in embedded system skills required for motor control strategy.

REFERENCES:

1. R.Krishnan, "Electric Motor Drives - Modeling, Analysis and Control", Prentice-Hall of India Pvt. Ltd., New Delhi,2010.
2. Vedam Subramanyam, "Electric Drives - Concepts and Applications", Tata McGraw- Hill publishing company Ltd., New Delhi, 2002
3. K. Venkataratnam, "Special Electrical Machines", Universities Press, 2014.
4. Steve Furber, "ARM system on chip architecture", Addision Wesley,2010.
5. Ron Sass and AnderewG.Schmidt, "Embedded System design with platform FPGAs: Principles and Practices", Elsevier, 2010.
6. Steve Kilts, "Advanced FPGA Design: Architecture, Implementation, and Optimization" Willey, 2007.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	-	2	-	2	-
CO2	1	1	3	-	-	2
CO3	2	-	-	-	3	-
CO4	1	2	3	1	-	-
CO5	-	-	-	-	3	-
Average	**1.25**	**1.5**	**2.7**	**1**	**2.7**	**2**

ET3063 PYTHON PROGRAMMING FOR MACHINE LEARNING LT P C 3 0 0 3

UNIT I INTRODUCTION TO MACHINE LEARNING AND PYTHON 9

Introduction to Machine Learning: Significance, Advantage and Applications - Categories of Machine Learning - Basic Steps in Machine Learning: Raw Data Collection, Pre-processing, Training a Model, Evaluation of Model, Performance Improvement

Introduction to Python and its significance - Difference between C, C++ and Python Languages; Compiler and Interpreters - Python3 Installation & Running - Basics of Python Programming Syntax: Variable Types, Basic Operators, Reading Input from User - Arrays/List, Dictionary and Set - Conditional Statements - Control Flow and loop control statements

UNIT II PYTHON FUNCTIONS AND PACKAGES 9

File Handling: Reading and Writing Data - Errors and Exceptions Handling - Functions & Modules - Package Handling in Python - Pip Installation & Exploring Functions in python package - Installing the NumPy Library and exploring various operations on Arrays: Indexing, Slicing, Multi-Dimensional Arrays, Joining NumPy Arrays, Array intersection and Difference, Saving and Loading NumPy Arrays - Introduction to SciPy Package & its functions - Introduction to Object Oriented

Programming with Python

UNIT III IMPLEMENTATION OF MACHINE LEARNING USING PYTHON 9

Description of Standard Datasets: Coco, ImageNet, MNIST (Handwritten Digits) Dataset, Boston Housing Dataset - Introducing the concepts of Regression - Linear, Polynomial & Logistic Regression with analytical understanding - Introduction to SciPy Package & its functions - Python Application of Linear Regression and Polynomial Regression using SciPy - Interpolation, Overfitting and Underfitting concepts & examples using SciPy

UNIT IV CLASSIFICATION AND CLUSTERING CONCEPTS OF ML 9

Introduction to ML Concepts of Clustering and Classification - Types of Classification Algorithms - Support Vector Machines (SVM) - Decision Tree - Random Forest - Introduction to ML using scikit-learn - Using scikit-learn, loading a sample dataset, Learning & prediction, interpolation & fitting, Multiclass fitting - Implementation of SVM using Blood Cancer Dataset, Decision Tree using data from csv, Types of Clustering Algorithms & Techniques - K-means Algorithm, Mean Shift Algorithm & Hierarchical Clustering Algorithm - Introduction to Python Visualization using Matplotlib: Plotting 2-dimensional, 3-dimensional graphs; formatting axis values; plotting multiple rows of data in same graph - Implementation of K-means Algorithm and Mean Shift Algorithm using Python

UNIT V INTRODUCTION TO NEURAL NETWORKS AND EMBEDDED MACHINE LEARNING 9

Introduction to Neural Networks & Significance - Neural Network Architecture - Single Layer Perceptron & Multi-Layer Perceptron (MLP) - Commonly Used Activation Functions - Forward Propagation, Back Propagation, and Epochs - Gradient Descent - Introduction to Tensorflow and Keras ML Python packages - Implementation of MLP Neural Network on Iris Dataset - Introduction to Convolution Neural Networks - Implementation of Digit Classification using MNIST Dataset ML for Embedded Systems: Comparison with conventional ML - Challenges & Methods for Overcoming – TinyML and TensorFlow Lite for Microcontrollers – on-Board AI – ML Edge Devices: Arduino Nano BLE Sense, Google Edge TPU and Intel Movidius

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Develop skill in system administration and network programming by learning Python.

CO2: Demonstrating understanding in concepts of Machine Learning and its implementation using Python.

CO3: Relate to use Python's highly powerful processing capabilities for primitives, modelling etc.

CO4: Improved Employability and entrepreneurship capacity due to knowledge up gradation on recent trends in embedded systems design.

CO5: Apply the concepts acquired over the advanced research/employability skills

REFERENCES:

1. Mark Lutz, "Learning Python, Powerful OOPs", O'reilly, 2011
2. Zelle, John "M. Python Programming: An Introduction to Computer Science", Franklin Beedle & Associates, 2003
3. Andreas C. Müller, Sarah Guido, "Introduction to Machine Learning with Python", O'Reilly, 2016
4. Sebastian Raschka, VahidMirjalili, "Python Machine Learning - Third Edition", Packt, December 2019

Attested

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MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	-	-	2	3	3	-
CO2	3	1	3	-	3	1
CO3	2	1	2	-	3	3
CO4	3	2	3	3	3	3
CO5	-	-	-		3	-
Average	**2.66**	**1.33**	**2.5**	**3**	**3**	**2.33**

ET3060 IoT FOR SMART SYSTEMS LT P C
3 0 0 3

UNIT I INTRODUCTION TO INTERNET OF THINGS 9
Overview, Hardware and software requirements for IOT, Sensor and actuators, Technology drivers, Business drivers, Data streaming and cloud services tools- Typical IoT applications, Trends and implications.

UNIT II IOT ARCHITECTURE 9
IoT reference model and architecture - Node Structure - Sensing, Processing, Communication, Powering, Networking - Topologies, Layer/Stack architecture, IoT standards, Cloud computing for IoT, Bluetooth, Bluetooth Low Energy beacons.

UNIT III PROTOCOLS AND WIRELESS TECHNOLOGIES FOR IOT PROTOCOLS 9
NFC, SCADA and RFID, Zigbee MIPI, M-PHY, UniPro, SPMI, SPI, M-PCIe GSM, CDMA, LTE, GPRS, small cell.

Wireless technologies for IoT: WiFi (IEEE 802.11), Bluetooth/Bluetooth Smart, ZigBee/ZigBee Smart, UWB (IEEE 802.15.4), LoWPAN, Proprietary systems - Recent trends.

UNIT IV IOT PROCESSORS 9
Services/Attributes: Big-Data Analytics for IOT, Dependability, Interoperability, Security, Maintainability.

Embedded processors for IOT: Introduction to Python programming - Building IOT with RASPERRY PI and Arduino.

UNIT V CASE STUDIES 9
Data streaming and cloud services tools Industrial IoT, IoT for Utilities - Home Automation, IOE-Smart Grid, connected vehicles, electric vehicle charging, Environment, Agriculture, Productivity Applications, IoT for Defense - Smart Energy Management system - Smart Sustainable Cities and Smart Buildings.

TOTAL: 45 PERIODS

COURSE OUTCOMES:
At the end of this course, the students will have the ability to
CO1: Analyze the concepts of IoT and its present developments.
CO2: Compare and contrast different platforms and infrastructures available for IoT
CO3: Explain different protocols and communication technologies used in IoT
CO4: Analyze the big data analytic and programming of IoT
CO5: Implement IoT solutions for smart applications

Attested

REFERENCES:

1. ArshdeepBahga and VijaiMadisetti: A Hands-on Approach “Internet of Things”,Universities Press 2015.
2. Oliver Hersent , David Boswarthick and Omar Elloumi “ The Internet of Things”, Wiley,2016.
3. Samuel Greengard, “ The Internet of Things”, The MIT press, 2015.
4. Adrian McEwen and Hakim Cassimally“Designing the Internet of Things “Wiley,2014.
5. Jean- Philippe Vasseur, Adam Dunkels, “Interconnecting Smart Objects with IP: The Next Internet” Morgan Kuffmann Publishers, 2010.
6. Adrian McEwen and Hakim Cassimally, “Designing the Internet of Things”, John Wiley and sons, 2014.
7. Lingyang Song/DusitNiyato/ Zhu Han/ Ekram Hossain,” Wireless Device-to-Device Communications and Networks, CAMBRIDGE UNIVERSITY PRESS,2015.
8. OvidiuVermesan and Peter Friess (Editors), “Internet of Things: Converging Technologies for Smart Environments and Integrated Ecosystems”, River Publishers Series in Communication, 2013.
9. Vijay Madisetti , ArshdeepBahga, “Internet of Things (A Hands on-Approach)”, 2014.
10. Zach Shelby, Carsten Bormann, “6LoWPAN: The Wireless Embedded Internet”, John Wiley and sons, 2009.
11. Lars T.Berger and Krzysztof Iniewski, “Smart Grid applications, communications and security”, Wiley, 2015.
12. JanakaEkanayake, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama and Nick Jenkins, “Smart Grid Technology and Applications”, Wiley, 2015.
13. UpenaDalal,”Wireless Communications & Networks,Oxford,2015.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	2	1	-	-	-
CO2	-	2	-	-	-	-
CO3	1	2	-	1	3	-
CO4	2		3	3	3	3
CO5	3	2	3	3	3	3
Average	**1.75**	**2**	**2.33**	**2.33**	**3**	**3**

ET3055 EMBEDDED NETWORKING AND AUTOMATION OF ELECTRICAL SYSTEM **LT P C 3 0 0 3**

UNIT I BUILDING SYSTEM AUTOMATION 9

Sensor Types & Characteristics: Sensing Voltage, Current, flux, Torque, Position, Proximity, Accelerometer - Data acquisition system - Signal conditioning circuit design - Uc Based & PC based data acquisition - uC for automation and protection of electrical appliances -processor based digital controllers for switching Actuators: Stepper motors, Relays -System automation with multi-channel Instrumentation and interface .

UNIT II EMBEDDED NETWORKING OF INSTRUMENT CLUSTER 9

Embedded Networking: Introduction - Cluster of Instruments in System - Comparison of bus protocols - RS 232C - embedded ethernet - MOD bus and CAN bus, LIN BUS - Introduction to WSN - Commercially available sensor nodes - Zigbee protocol - Network Topology Energy efficient MAC protocols - SMAC - Data Centric routing Applications of sensor networks - Database perspective on sensor networks - IoT Applications.

UNIT III AUTOMATION OF SUBSTATION 9

Substation automation - Distribution SCADA system principles - role of PMU, RTU, IEDs, BUS for smart Substation automation- Introduction to Role of IEC 61850, IEEEC37.118 std- Interoperability and IEC 61850 - challenges of Substations in Smart Grid - challenges of Energy Storage and Distribution Systems monitoring - Communication Challenges in monitoring electric utility asset.

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UNIT IV METERING OF SMART GRID 9

Characteristics of Smart Grid - Generation by Renewable Energy Sources based on solar grid - Challenges in Smart Grid and Microgrids - electrical measurements with AMI - Smart meters for EV plug in electric vehicles power management - Home Area Net metering and Demand side Energy Management applications.

UNIT V SMART METERS FOR PQ MONITORING 9

Power Quality issues of Grid connected Renewable Energy Sources -Smart meters for Power Quality monitoring and Control - Power Quality issues -Surges - Flicker - Interharmonics - Transients - Power Quality Benchmarking - Power Quality Meters- Meter data management In Smart Grid-, communication enabled Power Quality metering

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Demonstrate criteria of choice of sensors, components to build meters.

CO2: Illustrate the demand for BUS communication protocols are introduced

CO3: Analyse the need and standards in Substation automation

CO4: Deployment of PAN for metering networked commercial applications

CO5: Improved Employability and entrepreneurship capacity due to knowledge up gradation on recent trends in embedded networked communications.

REFERRENCES:

1. Control and automation of electrical power distribution systems, James Northcote-Green, Robert Wilson, CRC, Taylor and Francis, 2006
2. Krzysztof Iniewski," Smart Grid, Infrastructure& Networking", TMcGH,2012
3. Robert Faludi," Building Wireless Sensor Networks,O'Reilly,2011
4. Mohammad Ilyas And Imad Mahgoub, 'Handbook of sensor Networks: Compact wireless and wired sensing systems', CRC Press,2005
5. Shih-Lin Wu,Yu-Chee Tseng,{"Wireless Ad Hoc Networking, PAN, LAN, SAN, Aurebach Pub,2012
6. Sanjay Gupta, "Virtual Instrumentation, LABVIEW", TMH, New Delhi, 2003
7. Ernest O. Doeblin and Dhanesh N Manik, "Measurement Systems - Application and Design", 5th Edn, TMH, 2007.
8. Bhaskar Krishnamachari, 'Networking wireless sensors', Cambridge press 2005

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	2	1	2	1
CO2	1	-	2	2	3	1
CO3	3	1	2	-	-	-
CO4	2	-	2	3	3	2
CO5	2	1	2	-	-	3
Average	**2.2**	**1**	**2**	**2**	**2.66**	**1.75**

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ET3059 INTELLIGENT SYSTEM DESIGN **LT P C**
3 0 0 3

UNIT I INTELLIGENT SYSTEMS AND PYTHON PROGRAMMING 9
Introduction to Machine Learning and Deep Learning - Performance Improvement with Machine Learning - Building Intelligent Systems - Introduction to Python -Python Programming

UNIT II PYTHON FOR ML 9
Python Application of Linear Regression and Polynomial Regression using SciPy - Interpolation, Overfitting and Underfitting concepts & examples using SciPy - Clustering and Classification using Python.

UNIT III EMERGING TRENDS IN HARDWARE ARCHITECTURES FOR DEEP LEARNING 9
Quantization and Precision Reduction Techniques - Hardware aware neural Architecture. Hardware-software co-design for deep learning systems Memory hierarchy and cache optimization for deep learning Parallelization and distributed training of deep learning models Energy-efficient deep learning hardware architectures Hardware acceleration for specific deep learning applications (e.g., natural language processing, computer vision)

UNIT IV PYTHON FOR DL 9
Python Applications for DL - Python for CNN and YOLO

UNIT V CASE STUDIES 9
Development of Intelligent System for Power system protection - Smart Energy - IOE- Motor control - BMS - Intelligent systems for Industry 4.0 and Industry 5.0

TOTAL: 45 PERIODS

COURSE OUTCOMES:
At the end of this course, the students will have the ability in
CO1: Able to gain proficiency in the Python programming language and learn how to apply it in the context of intelligent systems
CO2: Able to learn Python libraries such as NumPy, Pandas, and scikit-learn to preprocess data, build and train Machine Learning models, and evaluate their performance
CO3: Able to learn Deep Learning libraries such as TensorFlow or PyTorch to build, train, and evaluate Deep Learning models for tasks such as image classification, natural language processing, and computer vision.
CO4: Able to learn hardware components, such as processors, memory, and accelerators, and how they are integrated.
CO5: Able to learn intelligent systems implementations, examine their design choices, evaluate their performance, and understand the challenges.

REFERENCES:

1."Intelligent Systems: Principles, Paradigms, and Pragmatics" by Rajendra P. Srivastava (Published in 2013)
2."Intelligent Systems: A Modern Approach" by Thomas Bäck, David B. Fogel, and Zbigniew Michalewicz (Published in 2000)
3."Intelligent Systems: Modeling, Optimization, and Control" by Grzegorz Bocewicz and Konrad Jackowski (Published in 2016)
4."Intelligent Systems: Architecture, Design, and Control" by Janos Sztipanovits and Gabor Karsai (Published in 2018)
5."Intelligent Systems: Concepts and Applications" by Veera M. Boddu (Published in 2017)

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MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	3	3
CO2	3	-	-	-	-	-
CO3	3	-	-	-	-	3
CO4	3	3	3	3	3	3
CO5	2	3	3	3	3	3
Average	**2.8**	**3**	**3**	**3**	**3**	**3**

ET3053 DIGITAL IMAGE PROCESSING AND COMPUTER VISION LT P C
3 0 0 3

UNIT I IMAGE PROCESSING AND VISION BASICS 9
Digital Image Processing - Various Fields that use Image Processing - Fundamentals Steps in Digital Image Processing - Components of an Image Processing System. Applications of Computer Vision - Recent Research in Computer Vision. Introduction to Computer Vision and Basic Concepts of Image Formation: Introduction and Goals - Image Formation and Radiometry - Geometric Transformation - Geometric Camera Models - Image Reconstruction from a Series of Projections.

UNIT II IMAGE PROCESSING CONCEPTS AND IMAGE FEATURES 9
Image Processing Concepts: Fundamentals - Image Transforms –camera pipeline- Image Filtering - Colour Image Processing - Mathematical Morphology - Image Segmentation. Image Descriptors and Features: Texture Descriptors - Color Features - Edge Detection - Object Boundary and Shape Representation - Interest or Cornet Point Detectors - Histogram Oriented Gradients - Scale Invariant Feature Transform - Image Enhancement.

UNIT III IMAGE PROCESSING WITH OPENCV 9
Introduction to OpenCV and Python: Setting up OpenCV - Image Basics in OpenCV - Handling Files and Images - Constructing Basic Shapes in OpenCV. Image Processing in OpenCV: Image Processing Techniques - Constructing and Building Histograms - Thresholding Techniques.

UNIT IV OBJECT DETECTION 9
Models and types - Importance of Object Detection. The Working: Inputs and outputs - Basic Structure - Model Architecture Overview - Object Detection on the Edge. Use Cases and Applications: Video Surveillance - Self-driving Cars. Embedded Boards: Connecting Cameras to Embedded Boards - Simple algorithms for processing Images and Videos.

UNIT V APPLICATIONS AND CASE STUDIES 9
Applications: VLSI implementation of Image processing algorithms - interfacing. Hardware for Vision implementation- Machine Learning algorithms and their Applications in Medical Image Segmentation - Motion Estimation and Object Tracking - Face and Facial Expression Recognition - Image Fusion. Case Studies: Face Detection - Object Tracing - Eye Tracking - Handwriting Recognition with HoG.

TOTAL: 45 PERIODS

COURSE OUTCOMES:
At the end of this course, the students will have the ability to
CO1: Understand the major concepts and techniques in computer vision and image processing
CO2: Infer known principles of human visual system
CO3: Demonstrate a thorough knowledge of Open CV
CO4: Develop real-life Computer Visions Applications.

CO5: Build design of a Computer Vision System for a specific problem.

REFERENCES:

1. "Digital Image Processing", 4th Edition (Global Edition), Rafael C Gonzalez and Richard E Woods, Pearson Education Limited, 2018.
2. "Computer Vision and Image Processing - Fundamentals and Applications", Manas Kamal Bhuyan, CRC Press, 2020.
3. "Mastering OpenCV 4 with Python", Alberto Fernández Villán, Packt Publishing, 2019.
4. "Practical Python and Open CV: Case Studies", 3rd Edition, Adrian Rosebrock, PyImageSearch, 2016.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	3	2	-	-	-
CO2	2	2	2	2	-	-
CO3	3	3	3	3	3	2
CO4	3	3	3	3	3	3
CO5	3	3	3	3	3	3
Average	**2.6**	**2.8**	**2.6**	**2.75**	**3**	**2.67**

ET3058 INTELLIGENT CONTROL AND AUTOMATION LT P C
3 0 0 3

UNIT I ARTIFICIAL NEURAL NETWORK AND FUZZY LOGIC 9
ARTIFICIAL NEURAL NETWORK: Learning with ANNs, single-layer networks, multi-layer perceptron's, Back propagation algorithm (BPA) ANNs for identification, ANNs for control, Adaptive neuro controller. Fuzzy Logic Control: Introdu ction, fuzzy sets, fuzzy logic, fuzzy logic controller design, Fuzzy Modelling & identification, Adaptive Fuzzy Control Design.

UNIT II GENETIC ALGORITHM 9
Basic concept of Genetic algorithm and detail algorithmic steps - Hybrid genetic algorithm - Solution for typical control problems using genetic algorithm. Concept on some other search techniques like Tabu search, Ant-colony search and Particle Swarm Optimization

UNIT III HYBRID CONTROL SCHEMES 9
Fuzzification and rule base using ANN-Neuro fuzzy systems-ANFIS-Optimization of membership function and rule base using Genetic Algorithm and Particle Swarm Optimization.

UNIT IV AUTOMATION 9
Introduction to Automation - Automation in Production System, Principles and Strategies of Automation, Basic Elements of an Automated System, Advanced Automation Functions, Levels of Automations- Industrial Automation -computer vision for automation- PLC and SCADA based Automation- IoT for automation- Industry 4.0.

UNIT V INTELLIGENT CONTROLLER FOR AUTOMATION APPLICATION 9
Applications of Intelligent controllers in Industrial Monitoring, optimization and control- Smart Appliances- Automation concept for Electrical vehicle- Intelligent controller and Automation for Power System.

TOTAL: 45 PERIODS

COURSE OUTCOMES:
At the end of this course, the students will have the ability in
CO1: Demonstrate the basic architectures of NN and Fuzzy logics
CO2: Design and implement GA algorithms and know their limitations.

CO3: Explain and evaluate hybrid control schemes and PSO
CO4: Interpret the significance of Automation concepts.
CO5: Develop the intelligent controller for automation applications.

REFERENCES:

1. Laurene V.Fausett, “Fundamentals of Neural Networks, Architecture, Algorithms, and Applications”, Pearson Education, 2008.
2. Timothy J.Ross, “Fuzzy Logic with Engineering Applications”, Wiley, Third Edition, 2010.
3. David E.Goldberg, “Genetic Algorithms in Search, Optimization, and Machine Learning”, Pearson Education, 2009.
4. W.T.Miller, R.S.Sutton and P.J.Webrose, “Neural Networks for Control”, MIT Press, 1996.
5. Srinivas Medida, Pocket Guide on Industrial Automation for Engineers and Technicians, IDC Technologies.
6. ChanchalDey and Sunit Kumar Sen, Industrial Automation Technologies, 1st Edition,CRC Press, 2022.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	1	1	-	1
CO2	2	2	3	3	3	2
CO3	3	2	2	2	-	-
CO4	3	2	2	2	-	-
CO5	3	-	3	3	-	2
Average	**2.4**	**1.75**	**2.2**	**2.2**	**3**	**1.67**

ET3065 ROBOTICS AND AUTOMATION **LT P C**
3 0 0 3

UNIT I INTRODUCTION TO ROBOTICS & AUTOMATION 9

Overview of Robotics & Automation - Principles and Strategies of Automation System -Hardware and software for Automation - Embedded Processors for Automation-Different Types of Robots - Various Generations of Robots - Asimov’s Laws Of Robotics - Key components of a robot - Design Criteria for Selection of a Robot - Role of embedded system in Robotics and Automation - Recent trends.

UNIT II SENSORS AND DRIVE SYSTEMS 9

Hydraulic, Pneumatic And Electric Drive Systems - Understanding how motor power, current torque, friction co-efficient affect the design of a Robot - Determination of Motor HP and Gearing Ratio - Variable Speed Arrangements. Sensors - Classification based on sensing type (including Optical, Acoustic, Magnetic) - Proximity Sensors - Ranging Sensors - Speed & Displacement Sensing - Tactile Sensors - Vision Sensing - Smart Sensors - MEMS sensors.

UNIT III MANIPULATORS AND GRIPPERS 9

Introduction to Manipulators - Joints and Degrees of Freedom - Construction of Manipulators - Manipulator Dynamics and Force Control - Electronic And Pneumatic Manipulator Control Circuits - End Effectors - Various Types Of Grippers - Design Considerations.

UNIT IV KINEMATICS AND PATH PLANNING 9

Kinematic Equations - Forward and Inverse Kinematics - Solution Of Inverse Kinematics Problem - Jacobian based Velocity Kinematics- Various Path Planning Algorithms - Hill Climbing Techniques - Robot Operating System - Simulation and modeling of a simple Path Planning application.

UNIT V CASE STUDIES **9**

Robot Cell Design - Humanoid Robot - Robots in healthcare applications - Robot Machine Interface - Robots in Manufacturing and Non-Manufacturing Applications - Self balancing robots - Micro/nano robots.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Choose suitable embedded boards for robots

CO2: Demonstrate the concepts of robotics & automation and Working of Robot

CO3: Analyze the Function of Sensors and actuators In the Robot

CO4: Develop Program to Use a Robot for a Typical Application

CO5: Apply and improve Employability and entrepreneurship capacity due to knowledge upgradation on Embedded system-based robot development

REFERENCES:

1. Mikell P. Weiss G.M., Nagel R.N., Odraj N.G., "Industrial Robotics", Mc Graw-Hill Singapore, 1996.
2. Ghosh, Control in Robotics and Automation: Sensor Based Integration, Allied Publishers, Chennai, 1998.
3. Deb. S.R., "Robotics Technology And Flexible Automation", John Wiley, USA 1992.
4. Klafter R.D.,Chimielewski T.A., Negin M., "Robotic Engineering - An Integrated Approach", Prentice Hall of India, New Delhi, 1994.
5. Mc Kerrow P.J. "Introduction to Robotics", Addison Wesley, USA, 1991.
6. Issac Asimov "Robot", Ballantine Books, New York, 1986.
7. Barry Leatham - Jones, "Elements of Industrial Robotics" PITMAN Publishing, 1987.
8. MikellP.Groover, Mitchell Weiss, Roger N.Nagel Nicholas G.Odrey, "Industrial Robotics Technology, Programming And Applications ", McGraw Hill Book Company 1986.
9. Fu K.S. Gonzaleaz R.C. And Lee C.S.G., "Robotics Control Sensing, Vision and Intelligence" McGraw Hill International Editions, 1987

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	2	-	3	-	-
CO2	-	3	-	-	-	-
CO3	-	-	-	-	-	-
CO4	-	-	-	2	3	1
CO5	-	-	2	1	-	3
Average	**1**	**2.5**	**2**	**2**	**3**	**2**

ET3062 **MEMS AND NEMS TECHNOLOGY** **LT P C**
3 0 0 3

UNIT I INTRODUCTION TO MEMS and NEMS **9**

Overview of micro and Nano technologies - Miniaturization significance and advantages -Micro electro mechanical systems and Nano Electro mechanical systems, devices and technologies, Laws of scaling - Survey of materials - Smart Sensors - Applications of MEMS and NEMS.

UNIT II MICRO-MACHINING AND MICROFABRICATION TECHNIQUES **9**

Photolithography - material Synthesis techniques - Film deposition - Etching Processes- wafer bonding - Bulk micro machining, silicon surface micro machining - LIGA process.

UNIT III MICRO SENSORS AND MICRO ACTUATORS 9

Transduction mechanisms in different energy domain-Micromachined capacitive, Piezoelectric, piezoresistive and Electromechanical and thermal sensors/actuators and applications

UNIT IV NANOELECTRONICS DEVICES AND NEMS TECHNOLOGY 9

Nano electronics devices and applications – SET– RTD – Memristor – QCA - molecular Electronics - Nano Fabrication techniques - atomic scale precision Engineering- NEMS in measurement, sensing, actuation and systems design.

UNIT V MEMS AND NEMS APPLICATION 9

Micro/Nano Fluids and applications- Bio MEMS- Optical NEMS- Micro and Nano motors-Quantum computing.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Explain the material properties and the significance of MEMS and NEMS for industrial automation.
CO2: Demonstrate knowledge delivery on micromachining and micro fabrication.
CO3: Apply the fabrication mechanism for MEMS sensor and actuators.
CO4: Apply the concepts of Nano electronics and NEMS to models, simulate and process the sensors and actuators.
CO5: Improved Employability and entrepreneurship capacity due to knowledge up gradation on MEMS and NEMS technology.

REFERENCES:

1. Chang Liu, “Foundations of MEMS”, Pearson International Edition, 2006.
2. Marc F madou “Fundamentals of micro fabrication” CRC Press 2002 2nd Edition Marc Madou.
3. M.H.Bao “Micromechanical transducers :Pressure sensors, accelerometers and gyroscopes”,Elsevier, Newyork, 2000.
4. Maluf, Nadim “An introduction to Micro Electro-mechanical Systems Engineering” AR Tech house, Boston 2000.
5. Mohamed Gad - el - Hak “MEMS Handbook” Edited CRC Press 2002 2. Sabriesolomon “Sensors Handbook”, Mc Graw Hill 1998.
6. Tai-Ran Hsu, “MEMS and Microsystems: design, manufacture, and Nanoscale”- 2nd Edition, John Wiley & Sons, Inc., Hoboken, New Jersey, 2008
7. Lyshevski, S.E. “Nano- and Micro-Electromechanical Systems: Fundamentals of Nano-and Microengineering “(2nd ed.). CRC Press,2005.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	3	-	2	-
CO2	3	3	2	-	2	2
CO3	3	3	3	-	2	2
CO4	3	3	3	-	3	2
CO5	3	2	3	2	3	3
Average	**3**	**2.6**	**2.8**	**2**	**2.4**	**2.25**

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ET3054 **EMBEDDED CONTROLLERS FOR EV APPLICATIONS** **LT P C**
3 0 0 3

UNIT I EMBEDDED SYSTEM AND ELECTRIC VEHICLES ARCHITECTURE 9
Overview of Electric vehicles - Evolution of Electric Vehicles - Definition and types of EV (BEV, HEV, PHEV) - EV Architecture - EV Components and Subsystems - Advantages and challenges of EV - Comparison of EV with Internal Combustion Engine - Emerging trends in EV Technologies- Embedded System Architecture- Open ECU-AUTOSAR.

UNIT II POWERTRAIN CONTROL AND ENERGY MANAGEMENT SYSTEM IN EV 9
Powertrain Components - Powertrain control and Optimization - Embedded Controllers for motor control- ECU for Energy Management system - Battery Management System (BMS) - Battery State of Charge (SoC) Estimation - Energy Consumption Monitoring - Charging Optimization- ECU for Charging.

UNIT III COMMUNICATION AND CONNECTIVITY IN EV 9
Vehicle-to-Vehicle Technology(V2V) - Vehicle-to-Infrastructure(V2I) Technology Communication - Communication Protocol (CAN, LIN, Ethernet, etc.) - Wireless Charging and Communication for EV - Over the air (OTA) Updates and Remote diagnostics in EV.

UNIT IV FAULT MONITORING AND DIAGNOSTICS IN EV 9
Overview of Fault Monitoring and Diagnostics in EV - Fault detection techniques - Fault Monitoring in Electric Powertrain - Fault Monitoring in Charging Infrastructure - On-board Diagnostics (OBD) with self-check mechanisms - Diagnostics and Reporting - Case studies on fault detection, Diagnosis and Resolution

UNIT V SAFETY, SECURITY AND AUTONOMOUS SYSTEMS IN EV 9
Safety Standards and Regulations for EVs - Functional Safety and ISO26262 in EV -Cybersecurity in EVs - Threats and Countermeasures - Antilock Braking system(ABS) -Electronic Stability Control (ESC) - Advanced driver Assistance systems (ADAS) -Autonomous Driving in EVs.

COURSE OUTCOMES:
CO1: Able to understand the principles and components of electric vehicles, including powertrain systems, energy storage systems, motor controllers, and vehicle dynamics.
CO2: Able to learn about the unique requirements and challenges associated with embedded controllers in EV applications.
CO3: able to learn about hardware platforms, such as microcontrollers and microprocessors, as well as communication protocols and interfaces used for control and monitoring of EV.
CO4: Able to gain hands-on experience in developing embedded control algorithms for various EV systems, including motor control, battery management, regenerative braking, and charging systems.
CO5: able to understand the integration of embedded controllers in autonomous electric vehicles

REFERENCES:

1."Embedded Control Systems for Electric Machines" by Jiming Wang, Shan Chai, and Shuxin Zhou (Published in 2011)
2."Electric and Hybrid Vehicles: Design Fundamentals" by Iqbal Husain (Published in 2013)
3."Electric and Hybrid Vehicles: Power Sources, Models, Sustainability, Infrastructure, and the Market" by Gérard-André Capolino (Published in 2010)
4."Embedded Systems for Electric Vehicles" by Jürgen Valldorf and Wolfgang Gessner (Published in 2011)
5."Power Electronics and Electric Drives for Traction Applications" by Gonzalo Abad, J. Miguel Guerrero, and Juan de la Casa (Published in 2016)

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	3	3
CO2	3	-	-	-	-	-
CO3	3	-	-	-	-	3
CO4	3	3	3	3	3	3
CO5	2	3	3	3	3	3
Average	**2.8**	**3**	**3**	**3**	**3**	**3**

ET3057 INFORMATION MODELLING FOR SMART PROCESS **LT P C**
3 0 0 3

UNIT I INTRODUCTION TO IMMERSIVE TECHNOLOGIES 9
Introduction on Virtual reality - Augmented reality - Mixed reality - Extended reality - VR Devices - AR Devices - Applications

UNIT II SOFTWARE TOOLS 9
Intro to Unity - Unity editor workspace - Intro to C# and visual studio - Programming in Unity - Intro to Unreal Engine - UE4 Editor workspace - Intro to Blueprint programming - Programming in

UNIT III BUILDING AR AND VR APPLICATIONS 9
AR SDKs for unity and unreal engine - Working with SDKs for unity - Developing AR application in unity - Building AR application Developing VR application in - Building VR application-

UNIT IV UAE 9
DRONE concept - DESIGN, FABRICATION AND PROGRAMMING - Drone Flying and Operation- Applications of Drone for Electrical Infrastructure Development and Monitoring.

UNIT V CASE STUDIES 9
AR, VR ,ER and MR based Applications development for Industrial Automation .

TOTAL: 45 PERIODS

COURSE OUTCOMES:
At the end of this course, the students will have the ability to
CO1: Able to understand the core concepts and principles behind immersive technologies, such as virtual reality (VR), augmented reality (AR), and mixed reality (MR)
CO2: Able to learn software tools specifically designed for information modeling in the context of smart processes.
CO3: Able to learn the principles and techniques for creating immersive AR/VR experiences, including 3D modeling, interaction design.
CO4: Able to learn about the unique challenges, opportunities, and requirements associated with implementing smart processes in the UAE.
CO5: Able to develop the ability to analyze and evaluate real-world case studies that demonstrate the use of augmented reality (AR), virtual reality (VR), extended reality (ER), and mixed reality (MR) technologies in smart process environments.

REFERENCES:
1."Smart Process: Designing the Future Enterprise" by Peter Fingar and Harsha Kumar (Published in 2009)
2. "Information Modeling and Relational Databases: From Conceptual Analysis to Logical Design" by Terry Halpin, Tony Morgan, and Steve Morgan (Published in 2008)

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3."Business Process Modeling, Simulation and Design" by Manuel Laguna and Johan Marklund (Published in 2013)
4."Enterprise Architecture at Work: Modelling, Communication, and Analysis" by Marc Lankhorst (Published in 2016)
5."Smart Business Processes: How to Manage the Process Revolution" by Gil Laware and Keith Harrison-Broninski (Published in 2014)

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	3	3
CO2	3	-	-	-	-	-
CO3	3	-	-	-	-	3
CO4	3	3	3	3	3	3
CO5	2	3	3	3	3	3
Average	**2.8**	**3**	**3**	**3**	**3**	**3**

ET3052 BLOCKCHAIN TECHNOLOGIES **L T P C**
3 0 0 3

UNIT I INTRODUCTION OF CRYPTOGRAPHY AND BLOCKCHAIN 9

Introduction to Blockchain, Blockchain Technology Mechanisms & Networks, Blockchain Origins, Objective of Blockchain, Blockchain Challenges, Transactions and Blocks, P2P Systems, Keys as Identity, Digital Signatures, Hashing, and public key cryptosystems, private vs. public Blockchain-Hardware architecture for Blockchain.

UNIT II BITCOIN AND CRYPTOCURRENCY 9

Introduction to Bitcoin, The Bitcoin Network, The Bitcoin Mining Process, Mining Developments, Bitcoin Wallets, Decentralization and Hard Forks, Ethereum Virtual Machine (EVM), Merkle Tree, Double-Spend Problem, Blockchain and Digital Currency, Transactional Blocks, Impact of Blockchain Technology on Cryptocurrency.

UNIT III INTRODUCTION TO ETHEREUM 9

Introduction to Ethereum, Consensus Mechanisms, Metamask Setup, Ethereum Accounts, , Transactions, Receiving Ethers, Smart Contracts.

UNIT IV INTRODUCTION TO HYPERLEDGER AND SOLIDITY PROGRAMMING 10

Introduction to Hyperledger, Distributed Ledger Technology & its Challenges, Hyperledger & Distributed Ledger Technology, Hyperledger Fabric, Hyperledger Composer. Solidity - Language of Smart Contracts, Installing Solidity & Ethereum Wallet, Basics of Solidity, Layout of a Solidity Source File & Structure of Smart Contracts, General Value Types.

UNIT V BLOCKCHAIN APPLICATIONS 8

Internet of Things, Medical Record Management System, Domain Name Service and Future of Blockchain, Alt Coins.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

After the completion of this course, student will be able to
CO1: Understand and explore the working of Blockchain technology
CO2: Analyze the working of Smart Contracts
CO3: Understand and analyze the working of Hyperledger
CO4: Apply the learning of solidity to build de-centralized apps on Ethereum
CO5: Develop applications on Blockchain

Attested

REFERENCES:
1. Imran Bashir, “Mastering Blockchain: Distributed Ledger Technology, Decentralization, and Smart Contracts Explained”, Second Edition, Packt Publishing, 2018.
2. Narayanan, J. Bonneau, E. Felten, A. Miller, S. Goldfeder, “Bitcoin and Cryptocurrency Technologies: A Comprehensive Introduction” Princeton University Press, 2016
3. Antonopoulos, Mastering Bitcoin, O’Reilly Publishing, 2014. .
4. Antonopoulos and G. Wood, “Mastering Ethereum: Building Smart Contracts and Dapps”, O’Reilly Publishing, 2018.
5. D. Drescher, Blockchain Basics. Apress, 2017.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	-	-	2	-	-	-
CO2	1	-	3	2	-	-
CO3	-	-	1	3	1	-
CO4	1	-	-	1	2	-
CO5	-	-	2	-	-	-
Average	**1**	**-**	**2**	**2**	**1.5**	**-**

ET3051 BIG DATA ANALYTICS L T P C
3 0 0 3

UNIT I INTRODUCTION TO BIG DATA 9
Introduction to Big Data Platform - Challenges of Conventional Systems - Intelligent data analysis - Nature of Data - Analytic Processes and Tools - Analysis Vs Reporting - Modern Data Analytic Tools- Statistical Concepts: Sampling Distributions - Re-Sampling - Statistical Inference - Prediction Error.

UNIT II SEARCH METHODS AND VISUALIZATION 9
Search by simulated Annealing - Stochastic, Adaptive search by Evaluation - Evaluation Strategies - Genetic Algorithm - Genetic Programming - Visualization - Classification of Visual Data Analysis Techniques - Data Types - Visualization Techniques - Interaction techniques - Specific Visual data analysis Techniques

UNIT III MINING DATA STREAMS 9
Introduction To Streams Concepts - Stream Data Model and Architecture - Stream Computing - Sampling Data in a Stream - Filtering Streams - Counting Distinct Elements in a Stream - Estimating Moments - Counting Oneness in a Window - Decaying Window - Real time Analytics Platform (RTAP) Applications - Case Studies - Real Time Sentiment Analysis, Stock Market Predictions

UNIT IV FRAMEWORKS 9
MapReduce - Hadoop, Hive, MapR - Sharding - NoSQL Databases - S3 - Hadoop Distributed File Systems - Case Study - Preventing Private Information Inference Attacks on Social Networks - Grand Challenge: Applying Regulatory Science and Big Data to Improve Medical Device Innovation

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UNIT V R LANGUAGE 9

Overview, Programming structures: Control statements - Operators -Functions - Environment and scope issues - Recursion - Replacement functions, R data structures: Vectors - Matrices and arrays - Lists - Data frames - Classes, Input/output, String manipulations

TOTAL:45 PERIODS

COURSE OUTCOMES:

CO1: Understand the basics of big data analytics

CO2: Ability to use Hadoop, Map Reduce Framework.

CO3: Ability to identify the areas for applying big data analytics for increasing the business outcome.

CO4: Gain knowledge on R language

CO5: Contextually integrate and correlate large amounts of information to gain faster insights.

REFERENCES:

1. Michael Berthold, David J. Hand, Intelligent Data Analysis, Springer, 2007.
2. Anand Rajaraman and Jeffrey David Ullman, Mining of Massive Datasets, Cambridge University Press, 3rd edition 2020.
3. Norman Matloff, The Art of R Programming: A Tour of Statistical Software Design, No Starch Press, USA, 2011.
4. Bill Franks, Taming the Big Data Tidal Wave: Finding Opportunities in Huge Data Streams with Advanced Analytics, John Wiley & sons, 2012.
5. Glenn J. Myatt, Making Sense of Data, John Wiley & Sons, 2007.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	-	-	2	-	-	-
CO2	1	-	3	2	-	-
CO3	-	-	1	3	1	-
CO4	1	-	-	1	2	-
CO5	-	-	2	-	-	-
Avg.	**1**	**-**	**2**	**2**	**1.5**	**-**

Attested

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PE3152 MODELLING OF ELECTRICAL MACHINES

L T P C	
3 0 0 3	

UNIT I PRINCIPLES OF ELECTRO MAGNETIC ENERGY CONVERSION 9

Magnetic circuits, permanent magnet, stored magnetic energy, co-energy - force and torque in singly and doubly excited systems – machine windings and air gap mmf– determination of winding resistances and inductances of machine windings – determination of friction coefficient and moment of inertia of electrical machines.

UNIT II DC MACHINES 9

Elementary DC machine and analysis of steady state operation - Voltage and torque equations – dynamic characteristics of permanent magnet and shunt DC motors – electrical and mechanical time constants - Time domain block diagrams –transfer function of DC motor-responses – digital computer simulation of permanent magnet and shunt DC machines.

UNIT III REFERENCE FRAME THEORY 9

Historical background of Clarke and Park transformations – power invariance and phase transformation and commutator transformation – transformation of variables from stationary to arbitrary reference frame - variables observed from several frames of reference.

UNIT IV INDUCTION MACHINES 9

Three phase induction machine, equivalent circuit and analysis of steady state operation –free acceleration characteristics – voltage and torque equations in machine variables and arbitrary reference frame variables – analysis of dynamic performance for load torque variations – modeling of multiphase machines - digital computer simulation of three phase induction machines.

UNIT V SYNCHRONOUS MACHINES 9

Three phase synchronous machine and analysis of steady state operation - voltage and torque equations in machine variables and rotor reference frame variables (Park's equations) – analysis of dynamic performance for load torque variations – digital computer simulation of synchronous machines.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

CO1: Ability to optimally design magnetics required in power supplies and drive systems.
CO2: Ability to acquire and apply knowledge of mathematics of machine dynamics in Electrical engineering.
CO3: Ability to model, simulate and analyze the dynamic performance of electrical machines using computational software.
CO4: Ability to formulate, design, simulate power supplies and loads for complete electrical machine performance
CO5: Ability to verify the results of the dynamic operation of electrical machine systems

TEXT BOOKS:

1. Paul C.Krause, Oleg Wasyzczuk, Scott S, Sudhoff, "Analysis of Electric Machinery and Drive Systems", John Wiley, Second Edition, 2010.
2. R Ramanujam,"Modelling and Analysis of Electrical Machines", I.K International Publishing Pvt. Ltd., New Delhi, 2018

REFERENCES:

1. P S Bimbhra, "Generalized Theory of Electrical Machines", Khanna Publishers, 2008.
2. A.E, Fitzgerald, Charles Kingsley, Jr, and Stephan D, Umanx, "Electric Machinery", Tata McGraw Hill, 5th Edition,199

MAPPING OF COs WITH POs

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

PE3252 SPECIAL ELECTRICAL MACHINES LT P C
3 0 0 3

UNIT I PERMANENT MAGNET BRUSHLESS DC MOTORS 9

Fundamentals of Permanent Magnets - Types- Principle of operation- Magnetic circuit analysis- Mechanical and Electronic Commutation - Hall Sensors- EMF and Torque equations- Characteristics – Inductance Calculation - Radial and Axial Flux Machines.

UNIT II PERMANENT MAGNET SYNCHRONOUS MOTORS 9

Rotor Configurations - EMF and Torque equations – Synchronous reactance - Phasor diagram - Power controllers – Circle Diagram - Torque speed characteristics – Torque / Ampere and kVA / kW for Sine wave and Square wave motors - Synchronous reluctance motor.

UNIT III SWITCHED RELUCTANCE MOTORS 9

Torque equation – Converter circuits - Control of SRM drive - Speed control – Current Control – Sensor less operation of SRM - Applications.

UNIT IV STEPPER MOTORS 9

Stepper Motor – Classification – Modes of Excitation – Static and Dynamic Characteristics – Static Torque Production – Motor Driver and Suppressor Circuits - Input Controller – Need for Closed loop Control – Concept of lead angle.

UNIT V OTHER SPECIAL MACHINES 9

Principle of operation and characteristics of Hysteresis motor – AC series motors – Linear motor – Applications.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

CO1: Ability to model and analyze power electronic systems and equipment using computational software.
CO2: Ability to optimally design magnetics required in special machines based drive Systems using FEM based software tools.
CO3: Ability to analyse the dynamic performance of special electrical machines
CO4: Ability to understand the operation and characteristics of other special electrical machines.
CO5: Ability to design and conduct experiments towards research.

TEXT BOOKS:

1. T.J.E. Miller, ‘Brushless magnet and Reluctance motor drives’, Claredon press,

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London, 1989.
2. R.Krishnan, ‘Switched Reluctance motor drives’, CRC press, 2001.
3. T.Kenjo, ‘Stepping motors and their microprocessor controls’, Oxford University press, New Delhi, 2000.

REFERENCES:

1. T.Kenjo and S.Nagamori, ‘Permanent magnet and Brushless DC motors’, Clarendon press, London, 1988.
2. R.Krishnan, ‘Electric motor drives’, Prentice hall of India, 2002.
3. D.P.Kothari and I.J.Nagrath, ‘ Electric machines’, Tata McGraw hill publishing company, New Delhi, Third Edition,2004.
4. Irving L.Kosow, “Electric Machinery and Transformers” Pearson Education, Second Edition, 2007.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	2	2	3	2
CO2	2	2	2	2	3	2
CO3	2	1	2	1	3	1
CO4	2	2	2	2	3	1
CO5	2	2	2	2	3	2
Average	**2**	**1.8**	**2**	**1.8**	**3**	**1.6**

PE3051 CONTROL OF POWER ELECTRONIC CIRCUITS **L T P C**
3 0 0 3

UNIT I CONTROLLER DESIGN FOR BASIC DC-DC CONVERTERS- PART I 9

Introduction, Review of Linear Control Theory, Linearization of Various Transfer Function Blocks, Feedback Controller Design in Voltage-Mode Control, Peak-Current Mode Control, Feedback Controller Design in DCM

UNIT II CONTROLLER DESIGN FOR BASIC DC-DC CONVERTERS- PART II 9

Introduction, Linear Feedback Control- Pole Placement by Full State Feedback, Pole Placement Based on Observer Design, Reduced Order Observers, Generalized Proportional Integral Controllers-Hamiltonian Systems Viewpoint - Application to power converters.

UNIT III CONTROLLER DESIGN FOR BASIC AC-DC CONVERTER CIRCUITS 9

Introduction, Operating Principle of Single-Phase PFCs, Control of PFCs, Designing the Inner Average-Current-Control Loop, Designing the Outer Voltage-Control Loop, Example of Single-Phase PFC Systems.

UNIT IV SLIDING MODE CONTROL 9

Introduction, Variable Structure Systems, Control of Single Switch Regulated Systems, Sliding Surfaces, Equivalent Control and the Ideal Sliding Dynamics, Accessibility of the Sliding Surface, Invariance Conditions for Matched Perturbations- Application to power converters.

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UNIT V FLATNESS BASED CONTROL 9

Flatness, the use of the differential flatness property, Controller development using flatness-Application to power converters

TOTAL : 45 PERIODS

COURSE OUTCOMES:

After completing the above course, students will be able to

CO1: Design controller for front end power factor corrector circuits.
CO2: Design controllers for UPS application.
CO3: Design controllers for AC-DC converters.
CO4: Design sliding mode control for power converters.
CO5: Design flatness based control for power converters.

TEXT BOOKS:

1. Hebertt Sira-Ramírez and Ramón Silva-Ortigoza,"Control Design Techniques in Power Electronics Devices " Springer-Verlag London Limited 2006
2. Ned Mohan, "Power Electronics: A First Course", John wiley, 2011
3. Marian K. Kazimierczuk and Agasthya Ayachit,"Laboratory Manual for Pulse-Width Modulated DC–DC Power Converters", Wiley 2016

REFERENCES:

1. Farzin Asadi and Kei Eguchi, Morgan &Claypool,"Dynamics and Control of DC-DC Converters", 2018
2. Andre Kislovski, "Dynamic Analysis of Switching-Mode DC/DC Converters" ,Springer 1991
3. Azar, Ahmad Taher, Zhu, Quannmin," Advances and Applications in sliding mode control systems" Springer, 2015
4. Levine, Jean, "Analysis and control of Non-linear systems A flatness-based approach" Springer, 2009

MAPPING OF COs WITH POs

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

PE3055 VECTOR CONTROL OF AC MACHINES

L	T	P	C
3	0	0	3

UNIT I VECTOR CONTROL OF PM SYNCHRONOUS MACHINE 9

Introduction-Smooth Air gap machine and salient pole machines- flux linkage space phasors- voltage equation- expression for electromagnetic torque. PMSM with surface mounted magnets- control scheme for of rotor oriented controlled PMSM with interior magnets

UNIT II VECTOR CONTROL OF SALIENT POLE MACHINE WITH ELECTRICALLY EXCITED ROTOR 9

Magnetizing flux oriented control –variable frequency operation of salient pole synchronous machine-rotor oriented control of reluctance machines-considerations of the effects of main flux saturation

UNIT III STATOR FLUX ORIENTED CONTROL OF INDUCTION MACHINE 9

Squirrel cage machine -Electromagnetic torque-voltage equations, doubly fed induction machines-control-static converter cascade

UNIT IV ROTOR FLUX ORIENTED CONTROL OF INDUCTION MACHINE 9

Control by a VSI – voltage equation-decoupling circuits- electromagnetic torque-voltage equations- current controlled PWM inverter- control by CSI – current controlled operation - control of slip ring induction machines

UNIT V MAGNETIC FLUX ORIENTED CONTROL OF INDUCTION MACHINE 9

The magnetizing flux oriented control of induction machine: Control by a VSI – voltage equation-decoupling circuits- electromagnetic torque-voltage equations- current controlled PWM inverter.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

CO1: Ability to carry out space phasor model for electrical machines.

CO2: Ability to synthesis the vector controller for surface mount permanent magnet synchronous machines.

CO3: Able to synthesis the vector controller for buried type permanent magnet synchronous machines.

CO4: Able to compute and analyze the controllers of salient pole machines.

CO5: Able to understand and select the various control schemes suitable for induction motor.

CO6: Ability to comprehend the flux oriented control concepts of induction motor drive.

TEXT BOOKS:

1. Peter Vas, “Vector control of AC machines/Peter Vas”, Oxford [England]: Clarendon Press; New York: Oxford University Press, 1990.
2. BimalK.Bose, “Modern Power Electronics and AC Drives”, Prentice Hall PTR, 2002.
3. D. W. Novotny, T. A. Lipo, Vector Control and Dynamics of AC Drives, Clarendon Press, 1996.
4. Nguyen Phung Quang, Jörg-Andreas Dittrich, , Vector Control of Three-Phase AC Machines: System Development in the Practice Springer, 2015

REFERENCES:

1. Peter Vas, “Sensorless Vector and Torque Control”, Oxford University press, 1998.
2. PaulC.Krause, Oleg Wasyzczuk, Scott S, Sudhoff, “Analysis of Electric Machinery and Drive Systems”, John Wiley, Second Edition, 2010.
3. Andrzej M. Trzynadlowski, The Field Orientation Principle in Control of Induction Motors Springer, 1994
4. Andrzej M. Trzynadlowski, Control of Induction Motors, Academic Press, 2000.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	2	2	1
CO2	2	2	1	2	1	1
CO3	2	2	1	2	2	1
CO4	2	2	1	2	2	1
CO5	2	2	1	2	2	1
CO6	2	2	1	2	2	1
Average	**2.17**	**2**	**1**	**2**	**1.83**	**1**

PS3252 SMART GRID L T P C
3 0 0 3

UNIT I INTRODUCTION TO SMART GRID 9
Evolution of Electric Grid, Concept, Definitions and Need for Smart Grid, Smart grid drivers, Functions, opportunities, challenges and benefits, Difference between conventional & Smart Grid, National and International Initiatives in Smart Grid.

UNIT II SMART GRID TECHNOLOGIES (TRANSMISSION) 9
Technology Drivers, Smart energy resources, Smart substations, Substation Automation, Feeder Automation, Transmission systems: EMS, FACTS and HVDC, Wide area monitoring, Protection and control

UNIT III SMART GRID TECHNOLOGIES (DISTRIBUTION) 9
DMS, Volt/VAr control, Fault Detection, Isolation and service restoration, Outage management, High- Efficiency Distribution Transformers, Phase Shifting Transformers, and Plug in Hybrid Electric Vehicles (PHEV).

UNIT IV SMART METERS AND ADVANCED METERING INFRASTRUCTURE 9
Introduction to Smart Meters, Advanced Metering infrastructure (AMI) drivers and benefits, AMI protocols, standards and initiatives, AMI needs in the smart grid, Phasor Measurement Unit (PMU), Intelligent Electronic Devices (IED) & their application for monitoring & protection.

UNIT V COMMUNICATION PROTOCOLS FOR POWER SYSTEM AUTOMATION 9
Introduction to Communication Protocol, Comparison of Communication media and different communication network topologies Description of Different Communication Protocol - Physical based Protocol(RS-232,RS-485) - Layered Based Protocol(IEC-61850 - Substation Automation) (C37.118 - Wide Area Monitoring and Protection),(DNP3 - Distribution Automation),MODBUS.

TOTAL: 45 PERIODS

COURSE OUTCOMES
Students will be able to:
CO1:Understand on the concepts of Smart Grid and its present developments.
CO2:Analyze about different Smart Grid transmission technologies.
CO3:Analyze about different Smart Grid distribution technologies.
CO4:Acquire knowledge about different smart meters and advanced metering infrastructure.
CO5:Develop more understanding on LAN, WAN and Cloud Computing for Smart Grid applications.

Attested

REFERENCES
1. Stuart Borlase "Smart Grid :Infrastructure, Technology and Solutions",CRC Press 2016.

2. JanakaEkanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama, "Smart Grid: Technology and Applications",Wiley.
3. Vehbi C. Gungor, DilanSahin, TaskinKocak, SalihErgut, ConcettinaBuccella, Carlo Cecati ,and Gerhard P. Hancke, Smart Grid Technologies: Communication Technologies and Standards IEEE Transactions On Industrial Informatics, Vol. 7, No. 4, November 2011.
4. Xi Fang, SatyajayantMisra, GuoliangXue, and Dejun Yang "Smart Grid – The New and Improved Power Grid: A Survey" , IEEE Transaction on Smart Grid

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	-	-	1	-	-
CO2	1	2	-	1	1	1
CO3	1	2	-	1	2	-
CO4	1	-	-	1	1	2
CO5	1	2	2	1	-	2
Average	**1**	**2**	**2**	**1**	**1.33**	**1.67**

PS3053 OPTIMIZATION TECHNIQUES TO POWER SYSTEM ENGINEERING L T P C
3 0 0 3

UNIT I CLASSICAL OPTIMIZATION TECHNIQUES 9
Historical Development, Engineering Applications of Optimization, Statement of Optimization Problem. Single variable optimization, Multivariable optimization with no constraints; Multivariable optimization with Equality constraints – Solution by Direct Substitution method, Method of constrained variation, Method of Lagrangian multipliers; Multivariable optimization with inequality constraints: Kuhn-Tucker conditions – solution of economic dispatch problem.

UNIT II LINEAR PROGRAMMING 9
Introduction, Applications of Linear Programming, Standard Form of a Linear Programming, Basic Terminology and Definitions, Exceptional cases, Simplex method, Revised Simplex method, Duality.

UNIT III NONLINEAR PROGRAMMING 9
Steepest descent method, conjugates gradient method, Newton's Method, Sequential quadratic programming, Penalty function method, augmented Lagrange multiplier method.

UNIT IV DYNAMIC PROGRAMMING 9
Multistage decision processes, concept of sub-optimization and principle of optimality – solution of unit commitment problem.

UNIT V GENETIC ALGORITHM 9
Introduction to genetic Algorithm, working principle, coding of variables, fitness function, GA operators; Similarities and differences between Gas and traditional methods; Unconstrained and constrained optimization using genetic Algorithm, global optimization using GA, Applications to power system problems.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: learn about different classifications of optimization problems and classical optimization techniques.

CO2: analyze linear programming problems

CO3: analyze non-linear programming problems

CO4: explain the concepts of dynamic programming

CO5: explain Genetic algorithm and its application to power system optimization problems.

REFERENCES:

1. SingiresuS. Rao, "Engineering Optimization – Theory and Applications", Third Edition, John Wiley & Sons, Inc., 1996.
2. Luenberger G., "Introduction of Linear and Non-Linear Programming", Wesley Publishing Company, 2011.
3. Taha, H.A., "Operations Research—an Introduction", Tenth Edition, Pearson Education, 2019.
4. Vohra, N.D., "Quantitative Techniques in Management", Fifth Edition, Tata McGraw-Hill Education, 2017.
5. Rardin, R.L., "Optimization in operations research: Upper Saddle River", Second Edition, Pearson, 2017.
6. Kothari, D.P. and Dhillon, J.S., "Power system optimization", Second Edition, PHI Learning Private Limited, 2010.

MAPPING OF COs WITH POs

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

PS3054 WIND ENERGY CONVERSION SYSTEMS **L T P C**
3 0 0 3

UNITI INTRODUCTION 9

Components of WECS-WECS schemes-Power obtained from wind-simple momentum theory-Power coefficient-Sabinin's theory-Aerodynamics of Wind turbine

UNIT II WINDTURBINES 9

HAWT-VAWT-Power developed-Thrust-Efficiency-Rotor selection-Rotor design considerations- Tip speed ratio-No. Of Blades-Blade profile-Power Regulation-yaw control-Pitch angle control- stall control-Schemes for maximum power extraction.

UNIT III FIXED SPEED SYSTEMS 9

Generating Systems- Constant speed constant frequency systems -Choice of Generators-Deciding factors-Synchronous Generator-Squirrel Cage Induction Generator- Model of Wind Speed- Model wind turbine rotor - Drive Train model- Generator model for Steady state and Transient stability analysis.

UNIT IV VARIABLESPEED SYSTEMS 9

Need of variable speed systems-Power-wind speed characteristics-Variable speed constant frequency systems synchronous generator- DFIG- PMSG -Variable speed generators modelling - Variable speed variable frequency schemes.

UNIT V GRIDCONNECTED SYSTEMS 9

Wind interconnection requirements, low-voltage ride through (LVRT), ramp rate limitations, and supply of ancillary services for frequency and voltage control, current practices and industry trends wind interconnection impact on steady-state and dynamic performance of the power system including modeling issue.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Students will be able to:

CO1: Attain knowledge on the basic concepts of Wind energy conversion system.
CO2: Attain the knowledge of the mathematical modelling and control of the Wind turbine
CO3: Develop more understanding on the design of Fixed speed system
CO4: Study about the need of Variable speed system and its modelling.
CO5: Learn about Grid integration issues and current practices of wind interconnections with power system.

REFERENCES

1. L.L.Freris "Wind Energy conversion Systems", Prentice Hall,1990
2. S.N.Bhadra, D.Kastha,S.Banerjee, "Wind Electrical Systems", Oxford University Press,2010.
3. Ion Boldea, "Variable speed generators", Taylor & Francis group,2006.
4. E.W.Golding "The generation of Electricity by wind power", Redwood burn Ltd., Trowbridge,1976.
5. N. Jenkins," Wind Energy Technology" John Wiley &Sons,1997.
6. S.Heir "Grid Integration of WECS", Wiley1998.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	-	2	2	-	2
CO2	3	1	2	2	2	2
CO3	3	1	3	3	2	3
CO4	3	2	3	3	2	3
CO5	3	2	3	2	2	3
Average	**2.6**	**1.5**	**2.2**	**2.4**	**2**	**2.2**

PS3051 COMPUTATIONAL INTELLIGENCE TECHNIQUES TO POWER SYSTEMS

L	T	P	C
3	0	0	3

UNIT I ARTIFICIAL NEURAL NETWORKS (ANN) 9

Introduction to Artificial Neural Networks - Definition and Fundamental concepts - Biological Neural Network – Modeling of a Neuron -Activation functions – initialization of weights - Typical architectures-Leaning/Training laws - Supervised learning Unsupervised learning – Reinforcement learning-Perceptron – architectures-Linear Separability – Multi – layer perceptron using Back propagation Algorithm (BPA) – Application to Load forecasting.

UNIT II DEEP LEARNING 9

Introduction to deep neural networks - loss functions and optimization - regularization methods - convolutional neural networks - transfer learning- recurrent neural networks - long short-term memory and gated recurrent unit - deep belief network - Maximum Power Point Tracking of PV Grids using Deep Learning.

UNIT III FUZZY LOGIC 9

Introduction – Fuzzy versus crisp – Fuzzy sets – Membership function – Basic Fuzzy set operations – Properties of Fuzzy sets – Fuzzy cartesian Product – Operations on Fuzzy relations – Fuzzy logic – Fuzzy Quantifiers – Fuzzy Inference – Fuzzy Rule based system – Defuzzification methods – Application to Load frequency control and Reactive power control.

UNIT IV GENETIC ALGORITHM AND PARTICLE SWARM OPTIMIZATION 9

Genetic algorithms- Genetic Algorithm versus Conventional Optimization Techniques - Genetic representations and selection mechanisms; Genetic operators- different types of crossover and mutation operators -Bird flocking and Fish Schooling – anatomy of a particle- equations based on velocity and positions -PSO topologies - control parameters- Application to Economic load dispatch.

UNIT V MULTI OBJECTIVE OPTIMIZATION 9

Introduction- Concept of Pareto optimality - Non-dominant sorting technique-Pareto fronts-best compromise solution-min-max method-NSGA-II algorithm and application to general two objective optimization problem - Application to combined economic emission dispatch.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: analyze functional operation of a ANN and their bio-foundations
CO2: analyze functional operation of deep neural networks
CO3: design and develop fuzzy logic for simple control applications
CO4: design and develop genetic algorithms and particle swarm optimization for simple systems
CO5: solve multi-objective optimization problems to obtain Pareto fronts

REFERENCES

1. Sridhar S., and Vijayalakshmi M., "MACHINE Learning", Oxford University Press, First Edition, 2021.
2. Rajasekaran S. and Pai G.A.V., "Neural Networks, Fuzzy Logic & Genetic Algorithms", PHI, New Delhi, 2008.
3. Kalyanmoy Deb, "Multi-Objective Optimization using Evolutionary Algorithms", John Wiley & Sons, 2001.
4. Kothari, D.P. and Dhillon, J.S., "Power system optimization", Second Edition, PHI Learning Private Limited, 2010.
5. Weerakorn Ongsakul and Vo Ngoc Dieu, "Artificial Intelligence in Power System Optimization", CRC Press, 2013.

MAPPING OF COs WITH POs

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

PW3052 ELECTRIC VEHICLES AND POWER MANAGEMENT **LT P C**
3 0 0 3

UNIT I HYBRID ELECTRIC VEHICLE ARCHITECTURE AND POWER TRAIN COMPONENT 9
History of Evolution of Electric Vehicles (EV) - Comparison of Electric Vehicles with Internal Combustion Engines - Architecture of Electric Vehicles (EV) and Hybrid Electric Vehicles (HEV) – Plug-in Hybrid Electric Vehicles (PHEV)- Power Train Components and Sizing, Gears, Clutches, Transmission and Brakes

UNIT II MECHANICS OF HYBRID ELECTRIC VEHICLES 9
Fundamentals of Vehicle Mechanics - Tractive Force, Power and Energy Requirements for Standard Drive Cycles of HEV's - Motor Torque - Power Rating and Battery Capacity

UNIT III CONTROL OF DC AND AC MOTOR DRIVES 9
Speed control for Constant Torque, Constant HP operation of all Electric Motors - DC/DC chopper based Four Quadrant Operation of DC Motor Drives, Inverter-based V/f Operation (motoring and braking) of Induction Motor Drives, Vector Control Operation of Induction Motor and PMSM, Brushless DC Motor Drives, Switched Reluctance Motor (SRM) Drives

UNIT IV ENERGY STORAGE SYSTEMS 9
Battery: Principle of operation, Types, Estimation Of Parameters, Battery Modeling, SOC of Battery, Traction Batteries and their capacity for Standard Drive Cycles, Vehicle to Grid operation of EV's -Alternate sources: Fuel cells, Ultra capacitors, Fly wheels

UNIT V HYBRID VEHICLE CONTROL STRATEGY AND ENERGY MANAGEMENT 9
HEV Supervisory Control - Selection of modes - Power Spilt Mode - Parallel Mode - Engine Brake Mode - Regeneration Mode - Series Parallel Mode - Energy Management of HEV's

TOTAL: 45 PERIODS

COURSE OUTCOMES:
Upon completion of the course, students will be able to:
CO1: Learn the electric vehicle architecture and power train components.
CO2: Acquire the concepts of dynamics of Electrical Vehicles.
CO3: Understand the vehicle control for Standard Drive Cycles of Hybrid Electrical Vehicles (HEVs).
CO4: Ability to model and understand the Energy Storage Systems for EV.
CO5: Acquire the knowledge of different modes and Energy Management in HEVs.

REFERENCES:

1. Iqbal Husain, "Electric and Hybrid Electric Vehicles", First Edition, CRC Press, 2011
2. Wei Liu, "Hybrid Electric Vehicle System Modeling and Control", Second Edition, Wiley, 2017
3. James Larminie and John Lowry, "Electric Vehicle Technology Explained", Second Edition, 2012
4. Mehredad Ehsani, Yimi Gao, Stefano Longo and Kambiz Ebrahimi," Modern Electric, Hybrid Electric and Fuel cell Vehicles", Third edition, CRC Press, 2019
5. Jingsheng Yu and Vladimir V. Vantsevich, "Control Application of Vehicle Dynamics", First Edition, CRC Press, 2021

Attested

MAPPING OF COs WITH POs

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

PW3055 IOT FOR SMART POWER SYSTEMS LT P C
3 0 0 3

UNIT I INTRODUCTION 9
Evolution of Internet of Things (IoT) –Definitions and Characteristics – Technologies for IoT– Sensors, Actuators and its types –Basics of Web Service and CLOUD Computing - Big data analytics - Importance of IoT in power systems - IoT standards

UNIT II IOT ARCHITECTURE AND PROTOCOLS 9
IoT Architecture – Layers – Protocol: SCADA, RFID – Internet of Energy (IoE) architecture and its requirements for Power Systems - IoT communication topologies for power system application

UNIT III IOT FOR SMART GRID 9
Integration of Internet of Things (IoT) into Smart Grid (SG) – Smart Grid Architectures: Four layered IoT, Web-enabled SG Architecture - Big Data and Cloud for IoT aided SG system- Sensors for Smart Power Grids: Smart Metering and Grid Configuration- Synchronization of Current and Voltage Transducers - Phasor Measurement Units (PMU) - Sending Sensor data over the internet - Cyber Security for Smart Grid

UNIT IV IOT BASED SMART MONITORING SYSTEMS 9
Infrastructure for Smart Metering – Energy Efficiency in Residential, Commercial Buildings – Smart Power Quality Monitoring – Transformer Monitoring System - Smart Monitoring for EV Charging Infrastructure-Case studies

UNIT V IOT FOR ENERGY MANAGEMENT 9
Smart Energy Management – Cyber Physical Systems – Smart Electricity Management – Demand Side Management-Case Studies

TOTAL: 45 PERIODS

COURSE OUTCOMES:
Upon the successful completion of the course, students will be able to:
CO1: Gain knowledge about various IoT technologies and its importance in power system
CO2: Able to analyze different IoT architectures and communication topologies for power system applications
CO3: Understand IoT for Smart Grid
CO4: Attain knowledge about various IoT based smart monitoring systems
CO5: Apply IoT for Energy Management

REFERENCES:

1. Raj Kamal, "Internet of Things Architecture and Design Principles", McGraw Hill Education (India) Private Limited, Second Edition, 2022.

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2. Kostas Siozios, Dimitrios Anagnostos, Dimitrios Soudris, “IoT for Smart Grids: Design Challenges and Paradigms”, First Edition, Springer, 2019.
3. Pawan Kumar, Srete Nikolovski, Z Y Dong, “Internet of Energy Handbook”, 1st Edition, CRC Press, 2021.
4. Sharmeela C, Sanjeevikumar P, Sivaraman P, Meera Joseph, “IoT, Machine Learning and Blockchain Technologies for Renewable Energy and Modern Hybrid Power Systems”, First Edition, River Publishers, 2023.
5. Vahid Vahidinasab, Behnam Mohammadi-Ivatloo, “Electric Vehicle Integration via Smart Charging Technology, Standards, Implementation, and Applications”, First Edition, Springer, 2022.
6. Mohammadreza, Behnam, Kazem Zare, Amjad, "IoT Enabled Multi-Energy Systems", First Edition, Academic Press, 2023
7. O.V.Gnana Swathika, K.Karthikeyan, P.Sanjeevikumar,”IoT Analytics and Renewable Energy Systems - Vol. 1 and Vol.2”, First Edition, CRC Press, 2023

MAPPING OF COs WITH POs

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

HV3152 ELECTROMAGNETIC FIELD COMPUTATION AND MODELLING **LT P C 3 0 0 3**

UNIT I INTRODUCTION 9
Review of basic field theory – Maxwell’s equations – Constitutive relationships and Continuity equations – Laplace’s, Poisson’s and Helmholtz’s equation – principle of energy conversion – force/torque calculation.

UNIT II BASIC SOLUTION METHODS FOR FIELD EQUATIONS 9
Limitations of the conventional design procedure, need for the field analysis based design, problem definition, boundary conditions, solution by analytical methods-direct integration method – variable separable method – method of images, solution by numerical methods-Finite Difference Method

UNIT III FORMULATION OF FINITE ELEMENT METHOD (FEM) 9
Concept of FEM - Integral Formulation – Energy minimization – Discretization – Shape functions –Stiffness matrix –1D and 2D planar and axial symmetry problems

Attested

UNIT IV COMPUTATION USING FEM PACKAGES 9

Elements of FEM package-pre processor, processor, post processor –computation of Electric Field – Energy- Capacitance, Magnetic Field – Linked Flux – Inductance – Force – Torque , Skin effect – Resistance

UNIT V ELECTROMAGNETIC FIELD MODELLING AND ANALYSIS 9

Three phase transmission lines, Magnetic actuators, Transformers, Insulators, Rotating machines.

TOTAL = 45 PERIODS

COURSE OUTCOMES:

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

CO1 explain the concepts of electromagnetic field theory and energy conversion
CO2 formulate and compute Electromagnetic Field problems from Maxwell's equations
CO3 formulate FEM problems from the fundamental concepts
CO4 compute the respective fields and circuit parameters using FEM (post processing)
CO5 check and optimize the design of electrical power equipment

REFERENCES:

1. Matthew. N.O. Sadiku, S.V. Kulkarni, "Elements of Electromagnetics", Seventh Edition, Oxford University Press, Asian Edition 2021
2. Matthew. N.O. Sadiku "Numerical techniques in electromagnetics", Second Edition, CRC Press,2000.
3. Sivaji Chakravorti, "Electric Field Analysis", CRC Press (Taylor & Francis), USA, 2015
4. Nicola Bianchi, "Electrical Machine analysis using Finite Elements", Taylor and Francis Group, CRC Publishers, 2005.
5. S S Rao, "The Finite Element Method in Engineering", Fifth Edition, Butterworth-heinmann,2010.
6. J.N.Reddy, " An Introduction to the Finite Element Method". Fourth Edition, Mc Graw Hill Publications, 2019.

MAPPING OF COs WITH POs

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	-	3	-	2
CO2	2	1	-	3	-	2
CO3	2	1	-	3	-	2
CO4	2	1	1	3	-	3
CO5	2	1	3	3	-	3
Average	**2**	**1**	**2**	**3**	**-**	**2.4**

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