ACADEMIC CURRICULA

POST GRADUATE DEGREE PROGRAMMES

Master of Technology

(Choice Based Flexible Credit System)

Regulations 2021

Volume – 24
Syllabi for School of Electrical Engineering Programmes

Professional Core and Elective Courses

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

ACADEMIC CURRICULA

Automation and Robotics & Electronics and Control Engineering

Common Professional Core Courses

Regulations 2021

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

Course Code	21EIC504J	Course Name	REAL TIME EMBEDDED SYSTEMS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

Pre-requisite Courses	Nil	Co- requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Instrumentation Engineering	Data Book / Codes / Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1:	impart the knowledge on the basic concepts of embedded processor
CLR-2:	learn the programming techniques in ARM processor
CLR-3:	know the steps involved in designing an embedded system
CLR-4:	introduce the real time scheduling algorithms

Course Outcomes (CO):	At the end of this course, learners will be able to:	Programme Outcomes (PO)		
		1	2	3
CO-1:	understand the evolution and architectures of ARM processors	1		
CO-2:	develop programming skill for ARM processor	1		2
CO-3:	analyze the instruction set and develop program for real world problems	1		2
CO-4	apply the knowledge of embedded system in real time application	1	1	3

Module-1 - Embedded Processor **20 Hour**

Review of Embedded Computing; Interfacing sensors embedded system design process; CPS and embedded Computing Architecture of ARM Cortex M3 and Cortex A series processors; ARM tool-chain for compilation, linking and execution phases; Memory system mechanism; Cache; Memory management units and address translation; Performance assessment of embedded processor; Introduction to Embedded Multicore Architecture; ARM virtual hardware: capabilities and use; QEMU for ARM processors

Practice:

1. *Interfacing sensors*
2. *Interfacing LED.*
3. *Interfacing DAC, ADC*
4. *Interfacing DIO, PWMs*

Module-2 - Programming **18 Hour**

Introduction set, Data transfer, Data processing, conditional and branch instructions, barrier and saturation operations, CortexM4-specific instructions, Thumb2 instructions, Programming of Embedded processors using assembly and C; models for program -- data flow graphs; Assembly language programming of ARM Cortex M3; Hardware software co-design

Practice:

1. *Interfacing keyboard*
2. *Interfacing stepper motor*
3. *Interfacing Temperature sensor*
4. *Interfacing potentiometer sensor*
5. *Interfacing electrical switches*

Module-3 – System Design	***18 Hour***
Design methodologies, Design flows, Requirement analysis, Multiple tasks and multiple processes, Preempt real time operating systems, Priority based scheduling, Distributed embedded systems, Examples of distributed embedded systems in industries, Wireless based embedded systems *Practice:* *1. Interfacing process (time-driven)* *2. Interfacing event schedule* *3. Debugging : Learn to find faults in a system* *4. Tracing : Understand instruction set logs, derive problem loops*	
Module-4 – Applications	***19 Hour***
Processes and real time operating systems; Multi-rate system; real time scheduling algorithms - RMA,EDF and their variants; Energy efficient scheduling algorithms; Data compression techniques, Examples of design of embedded systems. Architecture security features, Arm Confidential Compute Architecture (Arm CCA) – an isolation technology that builds on the strong security foundations of TrustZone- AUTOSAR ECUs with ARM processors : Next generation HPCs and Zonal ECUs *Practice: 1. Communication between MSPs ,2. Networking MSPs using Wi-Fi , 3. Smart automation*	

Learning Resources		
	1. Marilyn Wolf,, High Performance embedded Computing: Applications in Cyber Physical Systems and Mobile Computing, 2 nd Edition, Elsevier 2014 *2. JosephYiu,, The definitive Guide to ARM Cortex M3 and M4 Processors, 3 rd Edition, Elsevier 2020* *3. Ata Elahi-Trever Arjeski, ―ARM Assembly language with hardware experiment‖, Springer Int. Publishing, 2016.*	*4. William hohl and Christoper Hinds, ―ARM assembly language fundamentals and Techniques ‖CRC, 2 nd edition,2015.* *5. Marilyn Wolf, Computers as Components: Principles of Embedded Computing System Design, Third Edition, Elsevier 2022* *6. Daniel Kusswurm, Modern Arm Assembly Language Programming, Apress, 2020*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	-	*20 %*	*20%*	-
Level 2	*Understand*	*20%*	-	-	*20%*	*20%*	-
Level 3	*Apply*	*30%*	-	-	*30 %*	*30%*	-
Level 4	*Analyze*	*30%*	-	-	*30 %*	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. N. Natarajan, M.Eng., ETAS GmbH	*1. Prof. M. Sreekumar, IIITDM, msk@iiitdm.ac.in*	*1. Dr.J.Sam Jeba Kumar, SRMIST*
2. Himanshu Shekhar ,L&T Energy	*2. Dr. K. Srinivasan, NIT, srinikkn@nitt.edu*	

Course Code	21EIC505T	Course Name	ARTIFICIAL INTELLIGENCE IN AUTOMATION	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electronics and Instrumentation Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*introduce the concepts of AI-driven automation*
CLR-2:	*explore the principles of IA technologies*
CLR-3:	*learn about AI techniques implemented for intelligent automation in real world applications*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*understand the concepts of Intelligent Automation*	*1*	*1*	-
CO-2:	*demonstrate proficiency in AI techniques for Intelligent Automation.*	*2*	-	-
CO-3:	*interpret the AI techniques for Automation in real world applications for SDGs*	*3*	*2*	*2*

Module-1 – Introduction to Intelligent Automation	***15 Hour***
Evolution of Automation, stages of automation, Sustainability Development Goals and automation, Introduction to Artificial Intelligence- key concepts and Principles, Artificial Intelligence in industries, Introduction to Intelligent Automation (IA) - its principles, applications, and impact on industries, components of intelligent automation technology, Examples of intelligent automation, Understanding IA, Differentiation of IA with AI, Impact of Automation in Enterprise	
Module-2 – IA technologies	***15 Hour***
Robotic Process Automation (RPA), Business Process Management, Business Intelligence, IA technologies Framework - Vision, Execution, Language, Thinking and Learning, Challenges in implementing IA, Chatbots and Virtual Assistants, Applications of IA technologies framework in various industries, intelligent automation techniques for environmental monitoring, intelligent *automation for optimizing renewable energy systems, grid integration*	
Module-3 – AI techniques for Automation and SDGs	***15 Hour***
Overview of key AI techniques applicable to automation processes - Supervised, unsupervised, and reinforcement learning techniques for automating decision-making processes, Techniques for processing and understanding human language in automation systems, Applications of NLP in automated customer service, chatbots, and text analytics, Integration of AI techniques with robotics for automation of physical tasks, Reinforcement learning for robotic control and motion planning, Introduction to Sustainability Development Goals (SDGs). Intelligent Automation and Sustainability; intelligent automation for precision agriculture; intelligent automation for sustainable urban planning	

Learning Resources	1. *Debanjana Das Gupta, Intelligent Automation Simplified - BPB Publications, 2022.* 2. *Bornet, P, Barkin, I. and Wirtz, J., Intelligent automation: welcome to the world of hyper automation: Learn How to Harness Artificial Intelligence to Boost Business & Make Our World More Human, World Scientific Publishers, 2021*	3. *R. Arumugam et al, Hands-On Natural Language Processing with Python: A practical guide to applying deep learning architectures to your NLP applications, Packt Publishers, 2018* 4. *Pascal Bornet, Pascal. Barkin Bornet, Ian Barkin, Jochen Wirtz, "Intelligent Automation", World Scientific, 2020*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Manoj Gupta, Mitsubishi Electric, manoj.gupta@asia.meap.com	1. *Prof. M. Sreekumar, IIITDM, msk@iiitdm.ac.in*	*1. Dr.Sridhar P.A. SRMIST*
	2. *Dr. K. Srinivasan, NIT, srinikkn@nitt.edu*	

ACADEMIC CURRICULA

Electronics and Control Engineering

Professional Core Courses

Regulations 2021

SRM INSTITUTE OF SCIENCE & TECHNOLOGY
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Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

Course Code	21EIC501J	Course Name	ADVANCED CONTROL SYSTEMS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

Pre-requisite Courses	Nil	Co- requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Electronics and Instrumentation Engineering	Data Book / Codes / Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*learn the System Representation and Identification*
CLR-2:	*provide System Response and Analysis*
CLR-3:	*impart the Stability of the system*
CLR-4:	*understand Controller Design for industrial processes*

Course Outcomes (CO):	At the end of this course, learners will be able to:	Programme Outcomes (PO)		
		1	*2*	*3*
CO-1:	*employ the System Representation and Identification*	*3*		
CO-2:	*design the System Response and Analysis*	*2*		
CO-3:	*analyse the Stability of the system*	*3*		
CO-4:	*implement the skills required of Controller Design for industrial processes.*			*1*

Module-1 - System Representation and Identification ***20 Hour***

Introduction to the system – continuous and discrete time systems – Types of continuous time system: linear system, non-linear system, static system, dynamic system, time-variant system, time in-variant system, casual system, non-causal system, stable system and unstable system – Laplace Transform: properties – Region of convergence for various classes of system - Representation of system using transfer function model and state space model – Different forms of state space model – Transfer function to state space model conversion - Identification of first order plus dead time model - Identification of second order plus dead time model – Off-line and on-line identification of TITO system.

Practices

1. *Identify the RoC for different classes of systems.*
2. *Real-time realization of the transfer function for a nonlinear system.*
3. *Real-time realization of state space model for a nonlinear system.*
4. *Transform the transfer function model into canonical forms.*

Module-2 - System Response and Analysis ***15 Hour***

Response of first-order system for different test signals - Response of second order undamped, under damped, critically damped and overdamped systems for different test signals - State transition matrix- Properties of a state transition matrix- Computation of state transition matrix using Laplace transform and Cayley Hamilton method for the system with various number of inputs and outputs – Estimation of Controllability and Observability for MIMO systems.

1. *Obtain the response of the second order system and identify the damping condition.*
2. *Obtain the step and impulse response of the state space model.*
3. *Determine the state transition matrix of the given state space Model*

4. *Test the Controllability and the observability of system with various number of inputs and outputs*	
Module-3 – Stability Analysis	***20 Hour***
Concept of stability – pole-zero plot – Routh Hurwitz stability criterion - Equilibrium stability of nonlinear continuous-time systems - Direct method of Lyapunov functions for linear continuous-time systems- Non-linearity – classification of nonlinearities – stability study on nonlinearities - Lyapunov functions for nonlinear continuous-time systems - Krasovskii's Method - Variable Gradient Method - Sylvester's Theorem: - Stability analysis of discrete-time systems: Jury stability test – bi- linear transformation. 1. *Determine the stability of a given system by using the Routh Hurwitz stability test.* 2. *Determine the stability of a given system by using the Jury stability test.* 3. *Determine the stability of a given system by using direct method of Lyapunov.* 4. *Determine the stability of a given system by using Krasovskii's Method and Variable Gradient Method*	
Module-4 - Controller Design	***20 Hour***
Stabilizability and detectability-Test for continuous time Systems - Time-varying and time-invariant case - Output controllability – Reducibility - Controllable and observable companion forms - SISO and MIMO systems – Effect of state feedback on controllability and observability - Pole placement by state feedback for both SISO and MIMO systems - Full order and reduced order observers. 1. *Check for the controllability and observability of a given system.* 2. *Obtain state feedback gain matrix for the given system.* 3. *Design a full state observer for the system.* 4. *Design of Kalman filter for linear state space system.*	

Learning Resources	1. *Norman S. Nise, Control Systems Engineering. 7th Edition, Wiley, 2014.* 2. *Nagrath LG, Gopal M., Control Systems Engineering, 6th edition multicolor, New Age International Publishers, 2018*	3. *Ogata.K. Modem Control Engineering, 5th edition, Pearson, 2015* 4. *Kuo Benjamin C., Automatic Control Systems, 10th ed., Wiley India Pvt. Ltd, 2017*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	-	20 %	*20%*	-
Level 2	*Understand*	*20%*	-	-	20%	*20%*	-
Level 3	*Apply*	*30%*	-	-	30 %	*30%*	-
Level 4	*Analyze*	*30%*	-	-	30 %	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	*Experts from Higher Technical Institutions*	**Internal Experts**
1. *Mr. Manoj Gupta, Mitsubishi Electric, manoj.gupta@asia.meap.com*	1. *Prof. M. Sreekumar, IIITDM, msk@iiitdm.ac.in*	*Dr. A.Vimala Juliet, SRMIST*
	2. *Dr. K. Srinivasan, NIT, srinikkn@nitt.edu*	

Course Code	21EIC502J	Course Name	ADVANCED DIGITAL SIGNAL PROCESSING	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electronics & Instrumentation Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the various transform techniques applicable to discrete time signals*
CLR-2:	*know the design procedure for digital IIR & FIR filters using various methods*
CLR-3:	*know about wavelet transform and multirate signal processing*
CLR-4:	*provide the exposure to the architectures of various digital signal processors and to Impart knowledge on various algorithms in DSP for solving real-time problems*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*select the required sampling rate and required DFT points to avoid aliasing in time / frequency*		2	
CO-2:	*design digital IIR & FIR filter from a given set of specifications and realize the filter in any required Digital Filter Structure*			2
CO-3:	*Apply wavelet transform for multirate signal processing*			3
CO-4	*implement algorithms in digital signal processor for solving real-time problems.*			2

Module-1 – Discrete Fourier Transform	***20 Hour***
Introduction- Classification of signals and systems - System response - Circular convolution, Direct computation of DFT - Linear using circular convolution - Direct computation of IDFT - computational complexity - FFT: Radix 2, Twiddle factor - Decimation in time FFT algorithm - Computation of DFT using DIT algorithm - Decimation in frequency FFT algorithm - Computation of DFT using DIF algorithm - IDFT using FFT algorithms. - Computation of IDFT using FFT algorithm 1. *Generation of continuous and discrete time signals* 2. *To perform convolution between D.T signals* 3. *To compute DFT using DIT & DIF algorithm*	
Module-2 – Design of Filters	***15 Hour***
Design procedures for digital IIR filters - frequency transformation techniques - Design of digital IIR filters - Design of Low pass and high pass Butterworth filter - Design of band pass Butterworth filter - Design of band reject Butterworth filter - Design of digital IIR filters using Chebyshev approximations - Design of digital IIR filters using Bilinear transformation method - Design of digital FIR filters using Fourier series method- Low pass filter design - High pass filter design using Fourier series method - Windowing technique: Rectangular , Hamming window, Hanning window - Realization of FIR filters. - Direct, cascade and parallel form 1. *To design a LPF for the given specifications* 2. *To design a HPF for the given specifications* 3. *To design a BPF for the given specifications*	
Module-3 – Wavelet Transform	***20 Hour***

Introduction to continuous wavelet transform - discrete wavelet transform - orthogonal wavelet decomposition – Multi resolution Analysis - Wavelet function-DWT - orthogonal Basis - Scaling function, Wavelet coefficients - Multirate signal processing - relationship to filter banks- Digital filtering interpolation - Decomposition filters - Reconstruction filters - MRA-Multiresolution Analysis - Haar Transform *1. To design a BRF for the given specifications* *2. To apply wavelet transform for the given signal* *3. To apply Haar transform for the given signal*
Module-4 - Digital Signal Processors and Applications ***20 Hour***
Introduction- categorization of DSP Processors - Processor for Fixed Point, Floating Point and Speech Processor- Basics of Architecture - Computational building blocks - Central Processing Unit - Arithmetic and logic unit - Linear prediction and optimum linear filters: forward and backward linear prediction, normal equations, AR lattice and ARMA lattice-ladder filters, Wiener filters - Mapping of DSP algorithm onto hardware - Design of Filter- Implementation of FFT Algorithm - Application of DSP in Signal processing - Application of DSP in Image processing - Application of DSP in Radar system- TMS320C50 digital signal processor.

Learning Resources	*1. John G Proakis and Manolakis, "Digital Signal Processing Principles, Algorithm and Applications", Pearson, 4th Edition, 2007* *2. Mithra, S.K., "Digital Signal Processing: A Computer Based Approach", 3rdEdition, 2005*	*3. Johnson, J.R.," Introduction to Digital Signal Processing", Prentice Hall of India, 2009* *4. NPTEL Video Lecture series on, "Digital Signal Processing" by Prof. S.C. Dutta Roy, IIT Delhi*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	-	20 %	*20%*	-
Level 2	*Understand*	*20%*	-	-	20%	*20%*	-
Level 3	*Apply*	*30%*	-	-	30 %	*30%*	-
Level 4	*Analyze*	*30%*	-	-	30 %	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. Manoj Gupta, Mitsubishi Electric, manoj.gupta@asia.meap.com	*1. Prof. M. Sreekumar, IIITDM, msk@iiitdm.ac.in*	*1. Dr. A. Asuntha, SRMIST*
	2. Dr. K. Srinivasan, NIT, srinikkn@nitt.edu	

Course Code	21EIC503J	Course Name	ADVANCED INDUSTRIAL AUTOMATION	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electronics and Instrumentation Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the hardware components of Programmable Logic Controller*
CLR-2:	*introduce the logic program for control application and troubleshooting techniques in Programmable Logic Controller*
CLR-3:	*provide basic knowledge in SCADA and DCS in the field of automation*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*assess and select the appropriate I/O modules in PLC for process control*	*2*		
CO-2:	*develop the logic program for control application*		*2*	*3*
CO-3:	*develop any application based on SCADA and DCS along with GUI using SCADA software*			*3*

Module-1 - PLC Hardware Components ***15 Hour***

Architecture of a PLC, Principles of Operations, PLC size and application, Discrete I/O modules, Analog I/O module, PLC control panel wiring, Special I/O modules, Developing logic circuit from Boolean expression, Converting Relay Schematics into PLC Ladder programs, Contractors, switches Electromagnetic control relays, Sensors, Output control devices, Seal-in circuits, Electrical Interlocking circuits, Program Scan

1.Market survey on different PLC's, and its comparison

Module-2 - PLC Programming and Troubleshooting ***30 Hour***

PLC programming languages Ladder Logic, Timer Instructions, Cascading timer, Counter Instructions, Cascading Counter, High speed Counters, RS function block, SR function block, FBD equivalents to LL, FBD programming, Data manipulation, Data compare instructions, Math instructions, IL Programming, PLC Enclosures, PLC mounting, Electrical noise, Leaky inputs and outputs, Grounding Voltage variations, Surge control, Program editing, Commissioning, Programming and Monitoring, Preventive maintenance, Troubleshooting PLC software, Troubleshooting PLC hardware, Input-Output malfunctions, Comparative study of PLCs in Lab, Comparative study of Industrial PLCs

1.Development of control logic for filling and draining of liquid in a single tank
2.Development of control logic for Material handling
3.Development of control logic for automatic Bottle filling process
4.Development of control logic for Temperature control
5.Development of control logic for Flow control
6.Development of control logic for Lift control
7.Development of control logic for Car parking
8.Study of DCV's and Development of control logic for Stamping machine control

Module-3 - SCADA and DCS	***30 Hour***
Elements of SCADA, Functionality of SCADA, Analog signals measurement Control techniques, Discrete signals measurement Control techniques, Remote terminal unit, Analog and Discrete control, Master terminal unit, Communication system components, Field/RTU communication, Communication Topology, RTU/MTU communication, Monitoring alarms, Status points, Control interfacing, Parallel operator interface- Evolution of Distributed Control System, DCS Architecture, Local control unit, Architectural parameters, Operator interface, Operator Interface Requirements, Interfacing level transmitter to a DCS Operator input - output devices, Low-level Operator Interface, Operator displays, Engineering interface, Low-level engineering interface, High-level engineering interface, DCS Application in Power plant Automation strategy, DCS Application in cement plant System architecture, DCS Application in steel plant System architecture- OPC *1.SCADA Development for the level process control training plant* *2.SCADA Development for the flow process control training plant* *3.SCADA Development for the temperature process control training plant* *4.DCS control panel wiring diagram and creating control panel layout* *5.On line monitoring and control of SLO-2 level process using DCS* *6.A mini project in process automation*	

Learning Resources	*1. Frank D. Petruzella, "Programmable Logic Controller", Tata McGraw Hill 5th Edition, 2017.* *2. Bolton. W, "Programmable Logic Controllers", 6th Edition, Elsevier Newnes, 2016.* *3. Bela G Liptak, "Process Software and Digital Networks", Instrument Engineer's Hand Book, CRC, ISA, 4th Edition, 2012.*	*4. Stuart Boyer A, "SCADA : Supervisory control and data Acquisition", Fourth Edition, ISA-The Instrumentation, Systems, and Automation Society, 2010* *5. IDC Technologies, "Practical Distributed Control Systems (DCS) for Engineers and Technicians"2012.* *6. NPTEL Video Lecture series on "Industrial Automation and Control "by Prof. S. Mukhapadhyay, IIT Kharagpur*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	-	*20%*	*20%*	-
Level 2	*Understand*	*20%*	-	-	*20%*	*20%*	-
Level 3	*Apply*	*30%*	-	-	*30%*	*30%*	-
Level 4	*Analyze*	*30%*	-	-	*30%*	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. Manoj Gupta, Mitsubishi Electric, manoj.gupta@asia.meap.com	*1. Prof. M. Sreekumar, IIITDM, msk@iiitdm.ac.in*	*1. Dr. G. Joselin Retna Kumar, SRMIST*
	2. Dr. K. Srinivasan, NIT, srinikkn@nitt.edu	

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Electronics and Control Engineering

Professional Elective Courses

Regulations 2021

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

Course Code	21EIE502T	Course Name	COMPUTER VISION SYSTEM	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electronics and Instrumentation Engineering*	**Data Book / Codes / Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the basics of image formation and processing.*
CLR-2:	*analyze the concepts of feature- based alignment and motion estimation.*
CLR-3:	*analyze the machine learning concepts for recognition and image based rendering.*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*apply the knowledge to select the appropriate image processing tool for various applications.*	3		
CO-2:	*ability to align the samples based on features and estimate the motion.*	3		2
CO-3:	*evaluate the performance of machine learning models for recognition and rendering applications.*	2	2	2

Module-1 – Introduction to Image Formation and Processing	***15 Hour***
Computer Vision - Geometric primitives and transformations - Photometric image formation - The digital camera - Point operators - Linear filtering - More neighborhood operators - Fourier transforms - Pyramids and wavelets - Geometric transformations - Global optimization, Points and patches - Edges - Lines - Segmentation - Active contours - Split and merge - Mean shift and mode finding - Normalized cuts - Graph cuts and energy-based methods.	
Module-2 - Feature-Based Alignment and Motion Estimation	***15 Hour***
2D and 3D feature-based alignment - Pose estimation - Geometric intrinsic calibration - Triangulation - Two-frame structure from motion - Factorization - Bundle adjustment - Constrained structure and motion - Translational alignment - Parametric motion - Spline-based motion - Optical flow - Layered motion	
Module-3 - Image-Based Rendering and Recognition	***15 Hour***
View interpolation Layered depth images - Light fields and Lumigraphs - Environment mattes - Video-based rendering-Object detection - Face recognition - Instance recognition - Category recognition - Context and scene understanding- Recognition databases and test sets.	

Learning Resources		
	1. *Richard Szeliski, "Computer Vision: Algorithms and Applications", Springer- Texts in Computer Science, Second Edition, 2022.*	4. *Richard Hartley and Andrew Zisserman, Multiple View Geometry in Computer Vision, Second Edition, Cambridge University Press, March 2004.*
	2. *Computer Vision: A Modern Approach, D. A. Forsyth, J. Ponce, Pearson Education, Second Edition, 2015.*	5. *Christopher M. Bishop; Pattern Recognition and Machine Learning, Springer, 2006.*
	3. *Milan Sonka, Vaclav Hlavac, Roger Boyle, "Image Processing, Analysis, and Machine Vision", 4nd edition, Thomson Learning, 2013.*	6. *E. R. Davies, Computer and Machine Vision, Fourth Edition, Academic Press, 2012.*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. Manoj Gupta, Mitsubishi Electric, manoj.gupta@asia.meap.com	*Prof. M. Sreekumar, IIITDM, msk@iiitdm.ac.in*	*1. Dr. A. Brindha, SRMIST*
	Dr. K. Srinivasan, NIT, srinikkn@nitt.edu	

Course Code	21EIE503T	Course Name	MODEL BASED PREDICTIVE CONTROL	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electronics Instrumentation Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the general principles of Model Predictive Control and provide a comprehensive description of Model Predictive Control schemes.*
CLR-2:	*know the concept of state space-based Model Predictive Control.*
CLR-3:	*introduce the skills required to design Model Predictive Control schemes.*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*analyze the various MPC schemes and solve the model predictive control schemes for a given process.*	1		2
CO-2:	*design Model Predictive Control algorithms and validate through simulations.*			3
CO-3:	*identify, formulate and solve problems in the field of Process Control domain using MPC.*	1		2

Module-1 – Introduction to Model Predictive Control and its Schemes ***18 Hour***

Introduction to Model Predictive Control - Models and modeling - Input-Output Models - Linear Dynamic Models - Deterministic and Stochastic - MPC regulator - Linear Optimal State Estimation Least Squares Estimation - Convergence of the State Estimator - Model Predictive Control Schemes - MPC algorithms architecture - Dynamic Matrix Control - stability - Stabilizing Conditions - Exponential Stability - Design on Controllability and Observability - Controllability and Observability - Time-Varying Systems - Unconstrained Linear Quadratic Regulator - Unconstrained Linear Periodic Systems - Stable Linear Systems with Control Constraints - Linear Systems with Control and State Constraints - Constrained Nonlinear Systems - Constrained Nonlinear Time-Varying Systems

Module-2 – Generalized Predictive Control Scheme ***9 Hour***

Parametric Programming - Parametric Quadratic Programming - Constrained Linear Quadratic Control - Parametric Piecewise Quadratic Programming - Parametric Linear Programming - Design using Parametric Linear Programming - Uncoupled Input Constraints - Coupled Input Constraints - Disturbance Models and Zero Offset - Constrained M-Player Game - Design problem using chess playing - Design problem - Generalized Predictive Control Scheme for Industrial Processes - Multivariable Generalized Predictive Control Scheme - Design using Multivariable Generalized Predictive Control Scheme - Overview of numerical optimization problems - Design using optimization problems

Module-3 - State Space Based Model Predictive Control and Application ***18 Hour***

Introduction to state space model - Design using state space model - State based control synthesis - State based MPC - Predictive Model - MPC optimization problem - Kalman Update based filters - State Observer Based Model Predictive Control - QP solution - Nonlinear MPC stability - Control design issues - Nonlinear MPC - Moving horizon estimators - Constraints Handling - Amplitude Constraints - Rate Constraints - Robust Model Predictive Control - Design procedure for Robust Model Predictive Control - Adaptive Model Predictive Control - Design procedure for Adaptive Model Predictive Control - Model based Model Predictive Control - Case Study: MPC performance monitoring and diagnosis - Fast Methods for Implementing Nonlinear Model Predictive Control Scheme - Design for Implementing Nonlinear Model Predictive Control Scheme - Applications of MPC in systems, such as chemical processes, robotics, Power Electronics Applications, Building HVAC Systems, and aerospace systems - Implementing discrete-time controllers in numerical simulation software and toolboxes

Learning Resources	1. *Camacho, E.F., and Bordons, C., "Model Predictive Control", 2nd Edition, Advanced in Industrial Control Springer Verlag, 2013.* 2. *Liuping Wang, "Model Predictive Control System Design and Implementation Using MATLAB", Advanced In Industrial Control, Springer Verlag, 2009.* 3. *K Wayne Bequette, B., "Process Control: Modeling, Design, and Simulation", Prentice Hall of India, 2004.*	4. *NPTEL video lecture series on "Process Control-Design, Analysis And Assessment", by Prof.Dr.Raghunathan Rengasamy, IIT Madras.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Manoj Gupta, Mitsubishi Electric, manoj.gupta@asia.meap.com*	1. *Prof. M. Sreekumar, IIITDM, msk@iiitdm.ac.in*	1. *Dr. A.Asuntha , SRMIST*
	2. *Dr. K. Srinivasan, NIT, srinikkn@nitt.edu*	

Course Code	21EIE504T	Course Name	NETWORKED CONTROL SYSTEMS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electronics and Instrumentation Engineering*	**Data Book / Codes / Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the principles and challenges of networked control systems.*
CLR-2:	*explore different architectures and protocols for networked control systems.*
CLR-3:	*investigate applications of networked control systems in various domains*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*apply methodologies for modeling and analyzing network-induced delays and packet losses*	*3*	-	-
CO-2:	*develop skills for designing and implementing controllers resilient to network disturbances*	*3*	-	-
CO-3:	*apply the controllers in various domain applications.*	*3*	-	*2*

Module-1 – Fundamentals of Control Systems and Communication Networks	***15 Hour***
Introduction to Networked Control Systems Evolution from traditional to networked control systems Challenges and opportunities Review of control system principles Introduction to communication networks Interplay between control systems and communication networks Modeling and Analysis of Network-Induced Delays Time-domain and frequency-domain modeling Effects of delays on stability and performance Mitigation techniques: delay compensation, predictor-based control	
Module-2 – Networked Control System Architectures	***15 Hour***
Packet Loss and Network-Induced Phenomena Modeling packet losses and network disturbances Impact on control performance Fault-tolerant control strategies networked Control System Architectures Centralized vs. decentralized control architectures Event-triggered control Co-design of control and communication systems Protocols and Standards for Networked Control Systems Real-time Ethernet protocols (e.g., EtherCAT, PROFINET) Time-sensitive networking (TSN) Wireless communication standards (e.g., IEEE 802.11)	
Module-3 – Security and Privacy in Networked Control Systems	***15 Hour***
Security and Privacy in Networked Control Systems Threats and vulnerabilities Secure communication protocols Privacy-preserving control strategies Applications of Networked Control Systems Industrial automation and process control Smart grids and energy systems Autonomous vehicles and transportation systems Model Evaluation Techniques and Model selection criteria	

Learning Resources	1. *Alberto Bemporad and Maurice Heemels, "Networked Control Systems" Springer, 2018.* 2. *Yuanqing Xia and Qianchuan Zhao, "Networked Control Systems: Theory and Applications", Springer, 2015.*	3. *"Event-Based Control and Signal Processing in Networked Systems", by Shengyuan Xu and Tong Heng Lee, CRC Press, 2016.*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Manoj Gupta, Mitsubishi Electric, manoj.gupta@asia.meap.com*	1. *Prof. M. Sreekumar, IIITDM, msk@iiitdm.ac.in*	1. *Dr. Jekan P SRMIST*
	2. *Dr. K. Srinivasan, NIT, srinikkn@nitt.edu*	

Course Code	21EIE505T	Course Name	DESIGN OF MEMS AND APPLICATIONS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electronics and Instrumentation Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*introduce the steps involved in microfabrication*
CLR-2:	*know the need of MEMS devices in various fields*
CLR-3:	*impart basic knowledge in design and fabrication of MEMS devices*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*choose appropriate steps to design and to fabricate MEMS Devices*	*3*		
CO-2:	*select the right strategy for designing*	*3*		
CO-3:	*design MEMS Sensors for specific application.*	*3*		

Module-1 Overview of MEMS	***20 Hour***
Introduction to MEMS, Microsystem Vs MEMS, Challenges of MEMS , Microfabrication for MEMS - substrates, lithography patterning, doping, thin films, etching, wafer bonding, surface micromachining, Bulk Micromachining and process integration. Soft Lithography and Materials Properties in MEMS, Safety measures in MEMs fabrication – Clean room, contaminant, wafer cleaning process.	
Module 2. MEMS Transducers and Characterization Techniques	***15 Hour***
Design of Acoustic wave sensors, resonant sensor, Vibratory gyroscope-Parallel plate, Torsion bar, Comb drive Actuators, Scanning probe microscopy, Scanning, Electron microscopy, Transmission Electron microscope, Laser Doppler vibrometer, Interference based techniques, Atomic force microscope, Electron microprobe analysis, Infrared Spectro photometry- FTIR x-ray, and e-beam lithography, lift-off techniques. Fluorescence and phosphorescence spectroscopy-Electron spin resonance spectroscopy.	
Module-3 – Application of MEMS	***10 Hour***
Case studies- Power MEMS, Optical MEMS, Bio MEMS, MEMS actuator for aero control, MEMS in automotive industry, MEMS Gyroscope, MEMS accelerometer, MEMS in healthcare. Paper MEMS, Thermal MEMS, Recent application of MEMS	

Learning Resources		
	1. Stephen D. Senturia," Micro System Design" Kluwer Academic Publishers – 2002 *2. Chang Liu, "Foundations of MEMS" Prentice Hall, Second Edition – 2012* *3. Mohamed Gad-el-Hak, "MEMS Application" CRC Press, Second Edition – 2006* *4. Cornelius T. Leondes, "MEMS / NEMS Handbook Techniques and Applications" Springer – 2006*	*5. Vikas Choudhary, Krzysztof Iniewski, "MEMS Fundamental Technology and Applications", CRC Press – 2013* *6. Tai-ran-HSU "MEMS & Microsystems Design and Manufacture", McGraw Hill Education, 2017* *7. http://nptel.ac.in/courses/117105082/*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Manoj Gupta, Mitsubishi Electric, manoj.gupta@asia.meap.com*	1. *Prof. M. Sreekumar, IIITDM, msk@iiitdm.ac.in*	1. *Dr. S.Indirani SRMIST*
	2. *Dr. K. Srinivasan, NIT, srinikkn@nitt.edu*	

Course Code	21EIE507T	Course Name	ADVANCED MACHINE LEARNING	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electronics and Instrumentation Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*exploring cutting-edge research in machine learning for the development of new algorithms and methodologies in the field.*
CLR-2:	*understand the advanced machine learning concepts for building intelligent systems*
CLR-3:	*impart knowledge in advanced topics of machine learning to address challenges in diverse domains*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*understand the underlying principles of advanced machine learning concepts*	*1*	-	-
CO-2:	*develop the ability to critically evaluate and compare state-of-the-art machine learning techniques.*	*2*	*2*	-
CO-3:	*apply advanced machine learning algorithms and techniques to solve complex real-world problems across diverse domains*	*3*	*2*	*2*

Module-1 – Introduction to advanced Machine learning	***15 Hour***
Review of Basic Machine learning concepts, Meta-Learning, Self-Adaptive Learning, Semi-Supervised Learning, Transfer Learning, Domain Adaptation, Active Learning, Naive Bayes algorithm, conditional probability, and its application	
Module-2 – Clustering and Kernel Methods	***15 Hour***
Clustering data using k-means and hierarchical clustering, spectral clustering, model based clustering kernel algorithms, multiple kernels, graph kernels, Kernels in SVM, Probabilistic modelling, Dimensionality reduction	
Module-3 – Advanced Learning Algorithms	***15 Hour***
Reinforcement Learning, Deep Learning, Convolutional Neural Networks, Recurrent Neural Networks (RNN) Gaussian process, graph based semi supervised learning, natural language processing algorithms, Applications - ML algorithms for adaptive control systems, predictive maintenance, Image Classification, Semantic Segmentation	

Learning Resources	1. *Sutton R. S. and Barto, A. G., Reinforcement Learning: An Introduction, The MIT Press, Second Edition, 2018.* 2. *Goodfellow, I., Bengio, Y., and Courville, A., Deep Learning, The MIT Press, 2019*	3. *Aman Kedi, Hands-On Python Natural Language Processing Paperback, 2020*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Manoj Gupta, Mitsubishi Electric, manoj.gupta@asia.meap.com*	1. *Prof. M. Sreekumar, IIITDM, msk@iiitdm.ac.in*	1. *Dr. Sridhar P.A. SRMIST*
	2. *Dr. K. Srinivasan, NIT, srinikkn@nitt.edu*	

Course Code	21EIE601T	Course Name	SYSTEM IDENTIFICATION	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electronics and Instrumentation Engineering*	**Data Book / Codes / Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*introduce the basic knowledge in industrial automation and control systems*
CLR-2:	*understand the difference between IACS and IT paradigms*
CLR-3:	*explore the security methodologies and approaches for IACS*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*summarize the basic concepts of industrial automation and control systems*	*3*		*2*
CO-2:	*illustrate any application with add-on security features in industrial control systems*	*3*		*2*
CO-3:	*develop the security methodologies for industrial systems*	*3*		*2*

Module-1 - Identification for Linear Deterministic Systems	***15 Hour***
Historical developments - System Identification - Identifiability - A modeling example: liquid level system - Mathematical Descriptions of Processes: Models - Models for Discrete-Time LTI Systems - Difference equation form - State-space descriptions - Illustrative example in MATLAB: estimating LTI models - Transform-Domain Models for Linear Time-Invariant Systems - Sampling and Discretization	
Module-2 - Models for Random Processes	***15 Hour***
Random Processes - Random variables and probability - Time-Domain Analysis: Correlation Functions - Models for Linear Stationary Processes - Fourier Analysis and Spectral Analysis of Deterministic Signals - Spectral Representations of Random Processes.	
Module-3 - Estimation Methods and Identification of Dynamic Models	***15 Hour***
Introduction to Estimation - Goodness of Estimators - Least squares estimators - Non-linear least squares - Maximum likelihood estimators - Bayesian estimators - Non-Parametric and Parametric Models for Identification - Identification of Parametric Time-Series Models - Identification of State-Space Models - Case Studies	

Learning Resources	
1. *Ke Huang, Ka-Veng Yuen, "Bayesian Real-Time System Identification: From Centralized to Distributed Approach", Springer, 2023.*	3. *Fabien Lauer, Gérard Bloch, "Hybrid System Identification: Theory and Algorithms for Learning Switching Models", Springer, 2019.*
2. *Gianluigi Pillonetto, "Regularized System Identification Learning Dynamic Models from Data" Springer, 2022.*	4. *Arun K. Tangirala, "Principles of System Identification: Theory and Practice", CRC Press, 2015.*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Manoj Gupta, Mitsubishi Electric, manoj.gupta@asia.meap.com*	*Prof. M. Sreekumar, IIITDM, msk@iiitdm.ac.in*	1. *Dr. G.Y.Rajaa Vikhram, SRMIST*
	Dr. K. Srinivasan, NIT, srinikkn@nitt.edu	

Course Code	21EIE603T	Course Name	E-VEHICLE TECHNOLOGY	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electronics and Instrumentation Engineering*	**Data Book / Codes / Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*introduce the knowledge on System modelling, system simulation and validation*
CLR-2:	*provide the knowledge on control system battery management system used in electric vehicles*
CLR-3:	*impart basic information on stability aspects of control systems used in electric vehicle and its applications*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*summarize the system modulation used in electrical vehicle*	3		
CO-2:	*describe the control system and battery management system used in electrical vehicle*	3		
CO-3:	*analyze the stability aspects of control systems used in electric vehicle and its applications*	3		

Module-1 – Introduction to System Modelling, System Simulation and Validation	***18 Hour***
Introduction to system modelling- Importance of control system in electrical vehicle, study of control architecture in electric vehicle, systems models and their classifications, principles used in modelling of systems, fundamental studies of modelling of vehicle dynamics and control, longitudinal vehicle dynamics, vertical dynamics model and lateral vehicle dynamics model, Integrated vehicle dynamics- *System simulation, advantages and disadvantage, steps in simulation study, simulation of mechanical and electrical systems- Introduction to modelling and simulation for software in loop (SIL) and Hardware in loop (HIL), study of control architecture.*	
Module-2 – Model Based Control Approach for Electric Vehicle and Battery Management System	***15 Hour***
Introduction to P, PI & PID Controller and Internal Model Control (IMC) Design- Introduction to Model based control system- design for Electric Vehicle- Introduction to BMS, objectives of the BMS- discharging control, charging control, state-of-charge determination, state-of-Health determination, cell balancing- BMS topologies- distributed Topology, modular topology and centralized topology, firmware development, certification, aging.	
Module-3 – Stability Aspects of Control Systems and Applications	***12 Hour***
Stability concept, stability definition in the sense of Lyapunov, stability of continuous time linear systems- Lyapunov stability theorem- Vehicle stability analysis- Applications of control techniques in traction control, vehicle control, electric power steering control.	

Learning Resources	
1. *R. T. Stefani, B. Shahian, C. J. Savant, Jr., and G. H. Hostetter, Design of Feedback Control Systems, Oxford University Press, Fourth, Edition, 2002* 2. *Katsuhiko Ogata, Modern Control Engineering, PHI, Twelfth Edition, 2014* 3. *Rajesh Rajamani, Vehicle Dynamics and Control, Springer, Second Edition, 2012*	4. *Hui Zhang and Dongpu Cao and Haiping Du, Modelling, Dynamics and Control of Electrified Vehicles, WP Publishing, Elsevier ,2017* 5. *BOSCH, "Automotive Electrics, Automotive Electronics: Systems & Components, BOSCH", 4th Edition, 2005.*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
Mr. Manoj Gupta, Mitsubishi Electric, manoj.gupta@asia.meap.com	*1. Prof. M. Sreekumar, IIITDM, msk@iiitdm.ac.in*	*1. Dr.K.Vibha, SRM IST*
	2. Dr. K. Srinivasan, NIT, srinikkn@nitt.edu	

Course Code	21EIE606T	Course Name	PROCESS DATA ANALYTICS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electronics Instrumentation Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the design dynamics of process data and to impart knowledge on different methods of linear regression analysis*
CLR-2:	*know the applications for various model selection and regularization methods*
CLR-3:	*outline the process for developing appropriate sensors using simulation tools and introduce different software implementation techniques for data handling*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*recognize statistical terms and regression analysis to data analytics*	1		3
CO-2:	*analyze the performance of various model selection and regularization methods*			2
CO-3:	*design an appropriate software tool for data analysis*	1		2

Module-1 – Data Pre-Processing and Regression Analysis	***18 Hour***
Data mining and knowledge discovery – Data and relations, data scales, set and matrix representation, dissimilarity measures - Issues in data analytics, missing data, data outliers and false data - Data purification and handling – Sampling, quantization, filtering, transformation, integration, visualization – Principal component analysis - Histogram and spectral analysis - Linear Correlation, correlation and causality, chi-square test, assessing model accuracy - simple linear regression, multiple linear regression, estimating regression coefficient - Qualitative predictors in regression model, comparing linear regression with K-nearest neighbors - estimating regression coefficient - Linear discriminant analysis - Quadratic discriminant analysis	
Module-2 - Model Selection and Regularization	***9 Hour***
Cross Validation, leave-one-out cross validation, k-fold cross validation - Subset selection, stepwise selection, choosing the optimal model, shrinkage methods - Ridge regression - Least absolute shrinkage and selection operator (LASSO) - Regression in high dimension data - Dimension reduction methods – Principal Component Regression, Partial Least Squares	
Module-3 – Classification and Concept of Data Analytics	***18 Hour***
Classification vs. Regression, Linear and Logistic Regression, Gradient Descent, Support Vector Machines, Kernels, Decision Trees, ML and MAP Estimates, K Nearest Neighbor, Naive Bayes- Data analysis for representing functions, plotting data – rate information, scatter plots and their limitations, mean, median, mode and variance, covariance, multivariate distribution, curve fitting, weighted average, examining errors, least squares - Data Analysis with R programming, Commands, function, objects, basic computations, data visualization and graphics	

Learning Resources	1. *Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani, "An Introduction to Statistical Learning with Applications in R", Springer Texts in Statistics, 2014.* 2. *Thomas A. Runkler, "Data Analytics: Models and Algorithms for Intelligent Data Analysis", Springer Vieweg, 2nd ed.,2016*	3. *Ethem Alpaydin, "Introduction to Machine Learning", MIT Press,2013* 4. *John Chambers, "Software for Data Analysis: Programming with R", Springer, 2008*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Manoj Gupta, Mitsubishi Electric, manoj.gupta@asia.meap.com*	1. *Prof. M. Sreekumar, IIITDM, msk@iiitdm.ac.in*	1. *Dr. A. Asuntha, SRMIST*
	2. *Dr. K. Srinivasan, NIT, srinikkn@nitt.edu*	

Course Code	21EIE607T	Course Name	WIRELESS SENSOR NETWORKS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electronics and Instrumentation Engineering*	**Data Book / Codes / Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*provide a comprehensive overview of wireless sensor networks, including their architecture, components, and applications.*
CLR-2:	*introduce the communication protocols and data management techniques used in WSNS.*
CLR-3:	*address the challenges of energy management and security in WSNs and explore various applications.*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*understand the architecture and components of wireless sensor networks.*	2		
CO-2:	*learn about communication protocols and data management in WSNs.*	2		
CO-3:	*develop practical skills in designing, deploying, managing and insights into energy management, data processing, and security challenges in WSNs.*	3	1	

Module-1 - Introduction to Wireless Sensor Networks	***15 Hour***
Overview of wireless sensor networks: definition, characteristics, and applications, Basic architecture and components of WSNs, Types of sensors and their applications *Network topologies and design considerations, Challenges in WSNs (e.g., energy efficiency, scalability, reliability)*	
Module-2 - Communication Protocols and Data Management	***15 Hour***
Communication protocols for WSNs (e.g., IEEE 802.15.4, Zigbee), Medium Access Control (MAC) protocols and their energy efficiency, Routing protocols for WSNs (e.g., LEACH, PEGASIS, Directed Diffusion), Data aggregation and fusion techniques, Time synchronization in WSNs	
Module-3 - Energy Management, Security, and Applications	***15 Hour***
Energy management techniques and power-aware protocols, Energy harvesting in WSNs, Security challenges and solutions in WSNs, Privacy issues and secure communication protocols. *Case studies of WSN applications (e.g., environmental monitoring, healthcare, industrial automation), Emerging trends and future directions in WSNs*	

Learning Resources	1. *Kazem Sohraby, Daniel Minoli, Taieb Znati, " Wireless Sensor Networks: Technology, Protocols, and Applications ", 2nd Edition, Wiley, 2020* 2. *Holger Karl, Andreas Willig, " Protocols and Architectures for Wireless Sensor Networks", 1st Edition, Wiley, 2007*	3. *Waltenegus Dargie, Christian Poellabauer, "Fundamentals of Wireless Sensor Networks: Theory and Practice", 1st Edition, Wiley, 2010* 4. *Ian F. Akyildiz, Mehmet Can Vuran, "Wireless Sensor Networks: Principles, Design, and Applications", 1st Edition, Wiley, 2010*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Manoj Gupta, Mitsubishi Electric, manoj.gupta@asia.meap.com*	1. *Prof. M. Sreekumar, IIITDM, msk@iiitdm.ac.in*	1. *Dr. C. Likith Kumar, SRMIST*
	2. *Dr. K. Srinivasan, NIT, srinikkn@nitt.edu*	

Course Code	21EIE608T	Course Name	INDUSTRIAL INTERNET OF THINGS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electronics and Instrumentation Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*impart the knowledge on the basic concepts of IoT in Industrial framework*
CLR-2:	*learn the data flow techniques employed in IIoT technology*
CLR-3:	*know the steps involved in designing a IIoT framework*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*relate the data flow, hardware components and software used in implementation of IIoT technology*	*3*		
CO-2:	*acquire the value created by collecting, communicating, coordinating, and leveraging the data from connected devices*	*3*		
CO-3:	*audit the system maintenance and fault diagnosis techniques in IIoT technology*	*3*	*2*	*2*

Module-1 – Industrial IoT Data Flow	***15 Hour***
Introduction to Industrial IoT- IIoT architecture and layers Industrial data flow architecture- OPC classic, OPC UA information model; Edge gateway, Edge architecture; IoT edge vs IIoT edge- Edge tools and computing, Edge Internet protocols; Industrial networking- Communication protocols; IEEE Network standards- Field bus architecture, Edge on field bus setup; Merits and demerits- IIoT data sources, IIoT data collection; Case studies on network standards.	
Module-2 – Implementation Framework	***15 Hour***
Overview of cloud server solutions- AZURE, Google cloud and AWS; Types of client server architecture- Registering on IoT core & client; Installation prerequisites- Configuration practices; Configuring authentication- Configuring security, Communication channel- Modes of communication, Server to client data transfer, Deployment of application, Literature survey on modes of communication in industries; First Data collection- Dataset creation techniques, Dataset processing techniques, Data optimization techniques, Data analytics tools, Data presentation tools.	
Module-3 – IoT Security	***15 Hour***
Security in IOT: Threat models, Defensive strategies and examples; Smart Cities- Collection of information including opportunistic sensing, crowd sensing, and adhoc sensing; Response of the system including analytics and optimization- distributed action, people as intelligent actuators, the risk for cyber-attacks in centralized and distributed systems, MAC Layer Protocols for IoT.	

Learning Resources		
	1. *R. Anandan, Suseendran, Souvik Pal and NoorZaman, Industrial Internet of Things, John Wiley & Sons, First edition, 2022.*	3. *Sudhip Mishra, Chandana Roy, A.Mukherjee, Introduction to Internet of Things & Industry 4.0, CRC Press, First edition, 2021*
	2. *Anand Tamboli, Build your own IoT platform ,A press Publisher, 2019*	4. *Adrian McEwen, Hakim Cassimally Designing the Internet of Things, Wiley 2013*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Mr. Manoj Gupta, Mitsubishi Electric, manoj.gupta@asia.meap.com*	1. *Prof. M. Sreekumar, IIITDM, msk@iiitdm.ac.in*	1. *Dr.S. Sharanya SRMIST*
	2. *Dr. K. Srinivasan, NIT, srinikkn@nitt.edu*	

ACADEMIC CURRICULA

Automation and Robotics & Electronics and Control Engineering

Common Professional Elective Courses

Regulations 2021

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

Course Code	21EIE501T	Course Name	ADVANCED POWER ELECTRONICS AND CONTROL	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electronics and Instrumentation Engineering*	**Data Book / Codes / Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the operation of advanced power semiconductor device and AC-DC Converter*
CLR-2:	*explore the concept of multi-level DC-AC Inverter*
CLR-3:	*know the process of Advanced Electrical drives for various application*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*identify the advanced power semiconductor devices and Advanced AC-DC Converter*	3		
CO-2:	*analyze the operation, switching techniques and basics topologies for multi-level Inverter*	3		
CO-3:	*analyse the process of Advanced Electrical drives for various application*			3

Module-1 AC-DC Converter	***18 Hour***
Review of power semiconductor devices, Thyristor, IGBT, MOSFET, IGCT, GTO and their driver circuits- Role of SiC in power semiconductor technology- Uncontrolled rectifier, semi-controlled rectifiers, fully controlled rectifiers with R, RL and RLE load- Effect of source inductance on performance of converter, firing schemes and circuits- Multi-pulse converters, 12,18 and 24 pulse converters, phase shifting transformers- Power factor improvement techniques, PWM rectifiers, sine PWM, single phase and three phase boost rectifier circuits.	
Module-2 Multi-level Inverter	***15 Hour***
Voltage Source Inverter- 120º and 180º conduction modes - Selective Harmonic Elimination (SHE), sine modulation- Third harmonic injection, hysteresis current Control, Sigma-Delta modulation, space vector pulse width modulation- Under modulation, overmodulation and their implementation- Current Source Inverter- Role in high power drives- Auto sequential current fed inverter, Pulse width Modulation of CSI Matrix converters- Three phase matrix converters and their control, basic input filter, protection of matrix converter- Multilevel inverters- Diode clamped MLI, Flying Capacitor MLI, Cascaded H-Bridge topology, operation with equal and unequal DC voltages- Carrier modulation schemes of multilevel inverter, SVPWM of Multilevel inverter- Neutral point balancing schemes.	
Module-3 Advanced Electrical Drives	***12 Hour***
Feedback control for converters- Regulation and control problem, control principles, model for feedback- P and PI control- Nonlinear dynamic modeling, Control and analysis of choppers, voltage mode and current mode control- Simulation- process, mechanics, techniques, PSPICE simulator- EMI and Power Quality Problems- Power conditioning- PLL, Microcomputer based converters and choppers- Power electronic converters for microgrid applications.	

Learning Resources		
	1. *G. K. Dubey, S. R. Doradla, A. Joshi and R. M. K. Sinha, "Thyristorised Power controllers", New Age International Publishers, First Edition, Reprint 2005.*	4. *Yang Han, "Modeling and Control of Power Electronic Converters for Microgrid Applications", springer, 2022*
	2. *Ned Mohan, Tore M. Undeland and William P. Robb and, John Wiley and Sons, Third Edition, 2002, "Power Electronics Converter and Applications design".*	5. *Bacha, Seddik, Munteanu, Iulian, Bratcu, Antoneta Iuliana, "Power Electronic Converters Modeling and Control", Springer, 2014.*
	3. *Fang Lin Luo, Hong Ye, "Power Electronics Advanced Conversion Technologies", Second Edition, CRC press, 2018.*	6. *Vinod Kumar, Ranjan Kumar Behera, Dheeraj Joshi, Ramesh Bansal, "Power Electronics, Drives, and Advanced Applications", CRC press 2020*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Manoj Gupta, Mitsubishi Electric, manoj.gupta@asia.meap.com*	1. *Prof. M. Sreekumar, IIITDM, msk@iiitdm.ac.in*	1. *Dr.K.Vibha, SRM IST*
	2. *Dr. K. Srinivasan, NIT, srinikkn@nitt.edu*	

Course Code	21EIE506T	Course Name	MODEL BASED DEVELOPMENT OF CYBER - PHYSICAL SYSTEMS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electronics and Instrumentation Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*introduce the basic concepts of cyber-physical system and modeling of a continuous and discrete system*
CLR-2:	*impart the adequate information about hybrid system and state machines*
CLR-3:	*impart the knowledge about verification and validation of embedded system design*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*infer the basic concepts of CPS and modeling in continuous and discrete domain*	3		2
CO-2:	*formulate the hybrid system and its interactions*	3		2
CO-3:	*design, develop and validate the embedded system design for specific applications*	3		2

Module-1 - Introduction to Continuous and Discrete Dynamics Modeling	***15 Hour***
Structure of Cyber-Physical Systems - Design Process - Modeling – Design – Analysis - Actor Models - Properties of Systems, Causal Systems, Memoryless systems - Linear-Time Invariant – Stability -Feedback Control - Transformation to Equivalent Model, Physical Dynamics, Modeling and Simulation Tools - Problems – BIBO Stability analysis - Discrete Systems - Event Triggered - Modeling Actors as Function - Finite-State Machines, Transitions, Reaction - Update Functions - Traffic light controller.	
Module-2 - Hybrid Systems and State Machines	***15 Hour***
Modal Models – Combining Discrete and Continuous Dynamics - Actor Model for State Machines - Actor representation of FSM - Thermostat example - State Refinements, Notations of Hybrid Systems, Classes of Hybrid systems -Timed Automata - Timed automation variant of traffic light controller - Hybrid system model for mass system - Automated guided vehicle, Composition of state machines, Concurrent composition - Side-by-Side Synchronous Composition - Side-by-Side Asynchronous Composition - Shared Variables - Cascade Composition - Hierarchical State Machines	
Module-3 - Design, Analysis and Verification of Embedded Systems	***15 Hour***
Embedded Processors - Parallelism vs concurrency - Instruction level parallelism, Memory Technologies, Memory Hierarchy - Memory maps - I/O Hardware - Sequential Software, A/D Interface, Multitasking - Basics of Scheduling – Invariants - Traffic light controller example - Safety, Liveness Properties, Models as Specifications - Abstraction and Refinement - Garage counter example, Finite sequences, Simulation Relations - Non-Uniqueness of Simulation - Bisimulation	

Learning Resources		
	1. *E.A.Lee, S.A.Sashia, Introduction to Embedded Sytems : A Cyber-Physical Systems Appproach, MIT Press, 2nd edition.,2017.*	3. *Nonita Sharma, L K Awasthi, Monika Mangla, K P Sharma, Rohit Kumar, Cyber-Physical Systems: A Comprehensive Guide, CRC Press, 2022.*
	2. *Walid M. Taha , Abd-Elhamid M. Taha , Johan Thunberg, Cyber-Physical Systems: A Model-Based Approach, Springer, 2021.*	4. *Anupam Baliyan, Kuldeep Singh Kaswan, Naresh Kumar, Kamal Upreti, Ramani Kannan, Cyber Physical Systems Concepts and Applications, CRC Press, 2023.*

Learning Assessment							
	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	20%	-	20%	-	20%	-
Level 2	Understand	20%	-	20%	-	20%	-
Level 3	Apply	30%	-	30%	-	30%	-
Level 4	Analyze	30%	-	30%	-	30%	-
Level 5	Evaluate	-	-	-	-	-	-
Level 6	Create	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. Manoj Gupta, Mitsubishi Electric, manoj.gupta@asia.meap.com	1. Prof. M. Sreekumar, IIITDM, msk@iiitdm.ac.in	1. Dr. G.Y.Rajaa Vikhram, SRMIST
	2. Dr. K. Srinivasan, NIT, srinikkn@nitt.edu	

Course Code	21EIE508T	Course Name	VFD AND HMI PROGRAMMING	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electronics and Instrumentation Engineering*	**Data Book / Codes / Standards**		*Nil*	

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*provide knowledge on the basics of inverter and its operation modes*
CLR-2:	*know the interfacing and configuration parameters for VFD*
CLR-3:	*provide knowledge on HMI Programming*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*use different modes of operations for VFD*	1		2
CO-2:	*select appropriate interfacing module and parameter settings*	2		
CO-3:	*develop a user interface for a particular sequence using HMI*	2		2

Module-1 – Variable Frequency Drive Operations	***15 Hour***
Basics of inverter -Inverter selection - Selection of peripheral devices - Motor types - Power and signal connections–Parameters - Different types of load patterns - Different modes of operations - PU, external& net mode, JOG operation - I/O assignment - Calibration function - PTC interface - Pulse Input, V/F control – SVC - Vector Control - PM Control - Auto tuning (offline, online), speed, torque, position control - Dynamic braking - Regenerative - braking - VFD Operational Faults and operational key based troubleshooting	
Module-2 - Interfacing	***12 Hour***
I/O option interface - Closed loop interface - Optional network interfaces- RS485, MODBUS, field bus, Ethernet, SSCNET - Inverter control using PLC - Direct communication interface with MODBUS, CC-Link, IE Communication - Troubleshooting -error massage, warning, alarm, major faults, reset function - Advance features - PID function -Brake sequence function	
Module-3 – Human Machine Interface	***18 Hour***
HMI monitor and enclosure - alarms, event history, trend, graphics library - New Project Creation - Configuration of GOT communication with PLC - OS Selection and Installation: Boot OS - Standard Monitor OS - Communication Driver - Different types of Screens - Screen Design using Various Objects like Switch/Lamps/Text and Numerical Display - Part Display and Part Routes - Comments/ Comment Groups/ Comment Display -User Alarms: Alarm configuration and Alarm Display - Objects from Library - Recipe function - Script: Project and Screen Scripts - Screen Security and Project Security configuration - Logging Functions and Time Action - Document display - Network Monitoring -Intelligent module Monitoring - Ladder Monitoring and Editor- Case study: VFD used in Closed loop for Controlling Mechanical rotatory equipment such as Oxidation Blower, Compressor, Pump and Vibrating Feeders	

Learning Resources	
1. *Malekar, A., Malekar, A., Learn Everything about Factory Automation: Practical Lessons on PLC, HMI, VFD, Servo Programming and Machine Automation, 2021*	3. *F. Gardner, R., F. Gardner, R., Introduction to Plant Automation and Controls. United States: CRC Press, 2020*
2. *Gurocak, H., Gurocak, H., Industrial Motion Control: Motor Selection, Drives, Controller Tuning, Applications. Germany: Wiley, 2016*	4. *Samuel Guccione, James McKirahan, Human Machine Interface, Concepts and Projects, Industrial Press, 2016*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. N. Natarajan, M.Eng,, ETAS GmbH	*1. Prof. M. Sreekumar, IIITDM, msk@iiitdm.ac.in*	1. *Dr. J. Sam Jeba Kumar, SRMIST*
2. Himanshu Shekhar ,L&T Energy	*2. Dr. K. Srinivasan, NIT, srinikkn@nitt.edu*	

Course Code	21EIE602T	Course Name	EMBEDDED CONTROL SYSTEMS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electronics and Instrumentation Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*know the significance of embedded controllers in Embedded Systems design*
CLR-2:	*impart knowledge on human Machine Interfaces and their design constraints*
CLR-3:	*introduce the significance of PetriNets and Statecharts in Embedded System Modeling*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*understand the significance of embedded controllers in Embedded Systems design*	-	2	-
CO-2:	*analyze the importance of HMI in an embedded control system*	-	-	3
CO-3:	*apply the knowledge of PetriNets and Statecharts in Embedded System Modeling*	3	-	3

Module-1 - Embedded Controller Design	***15 Hour***
Introduction to Embedded systems - Overview of cyber-physical systems - Real Time Embedded Control System - Real time scheduling - I/O Management - Embedded Operating Systems- Networking Protocols - Systems on chip - Memory Subsystem - Bus Structure - Interfacing Protocol - Peripheral Interfacing - Power Management - Embedded System Software Programming Optimization - Concurrent Programming	
Module-2 - Dynamics and Debugging	***15 Hour***
Continuous dynamics- Discrete dynamics - State machines - Security - Reliability testing - Heuristic evaluation- Interface requirements - Implementation challenges - Processes and real time operating systems - High level simulation - Low level simulation – Onboard debugging - Task level debugging - Emulation - Examples of system design	
Module-3 – Embedded System Modeling	***15 Hour***
State charts - Modeling Hierarchy - Specification Description Language (SDL) - Petri Nets - Embedded systems modeling with Petri Nets - Unified Modeling Language (UML) - Activity diagram - Class diagram - Component diagram - Use-case diagram - Sequence diagram - UML specification examples - Peripheral Interfaces used in Embedded Systems	

Learning Resources		
	1. *Steve heath, Embedded System Design, 3rd Edition, Packt Publishing, 2013* 2. *Josheph Yiu, The definitive Guide to ARM Cortex M3 and M4 Processors, 3rd Edition, Elsevier, 2013* 3. *Shanthanu Chattopadhyay, Embedded System Design, 1stEdition, PHI learning, 2013*	4. *Prof. Santanu Chaudhary, Introduction to Embedded Computing, NPTEL Course Material, Department of Electrical Engineering, Indian Institute of Technology Delhi, https://nptel.ac.in/courses/108102045* 5. *Lawrence J. Henschen, Julia C. Lee, "Embedded System Design Methodologies and Issues", Elsevier Science, 2023*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr.Vikranth, Asst Manager (R&D), TICMPL	*1. Prof. M. Sreekumar, IIITDM, msk@iiitdm.ac.in*	1. *Dr. R.Bakiya lakshmi, SRMIST*
	2. Dr. K. Srinivasan, NIT, srinikkn@nitt.edu	

Course Code	21EIE604T	Course Name	DEEP LEARNING TECHNIQUE	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electronics and Instrumentation Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the fundamentals of Machine Learning and Deep Learning*
CLR-2:	*analyze Various Deep Learning Architectures*
CLR-3:	*analyze the deep learning methods for speech, Image, and Biomedical signal processing*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*apply appropriate deep learning algorithms to analyze datasets and make accurate predictions.*	3		
CO-2:	*ability to design and implement advanced neural networks and deep learning networks for solving tasks.*	3		2
CO-3:	*evaluate the performance of deep learning models using appropriate metrics and optimizing them for better results with Speech, Image and Bio-medical Signals.*	2	2	2

Module-1 - Fundamentals of ML and DL	***12 Hour***
Basics of Machine Learning (ML), Supervised Learning, Unsupervised Learning, Stacked, Sparse, Denoising Autoencoders and Ladder Training, Cost functions, Learning Rate Dynamics and Optimization, Reinforcement Learning, Introduction to Deep Learning, Perceptron Algorithm, Multilayer Perceptron (Neural Networks), ML vs Deep Neural Networks.	
Module-2 – Deep Learning Algorithms	***13 Hour***
Basic Building Blocks of CNN, Forward and Back propagation in CNN, Classic CNN Architectures, Modern CNN Architectures, Basic Building Blocks of RNNs, RNNs and Properties, Deep RNN Architectures.	
Module-3 – DL in Speech, Image and Bio-Medical Signal Processing Applications	***20 Hour***
A case study approach on Real time Analysis of speech, image and Bio-medical signal Processing - Pre-processing, Feature extraction and Implementation of Classification based on Deep learning methods.	

Learning Resources	
1. *Uday Kamath • John Liu • James Whitaker, Deep Learning for NLP and Speech Recognition, Springer nature, 2019.*	4. *"Machine Learning for Audio, Image and Video Analysis", F. Camastra, Vinciarelli,*
2. *Deep Learning Projects Using TensorFlow 2, Vinita Silaparasetty, Apress, 2020.*	5. *Springer, 2007.Deep Learning with Python, FRANÇOIS CHOLLET, MANNING SHELTER ISLAND,2017*
3. *Deep Learning, Ian Goodfellow, Yoshua Bengio & Aaron Courville, MIT Press, 2016.*	6. *Pro Deep Learning with TensorFlow, Santanu Pattanayak, Apress,2017*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Manoj Gupta, Mitsubishi Electric, manoj.gupta@asia.meap.com*	1. *Prof. M. Sreekumar, IIITDM, msk@iiitdm.ac.in*	1. *Dr. A.Brindha, SRMIST*
	2. *Dr. K. Srinivasan, NIT, srinikkn@nitt.edu*	

Course Code	21EIE605T	Course Name	VIRTUAL AND AUGMENTED REALITY	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Electronics and Instrumentation Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*impart the implications of a virtual environment*
CLR-2:	*know the significance of GUI in virtual environment*
CLR-3:	*provide knowledge on the design requirements for 3D manipulation*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*understand the benefits and implications of a virtual environment*	-	2	-
CO-2:	*apply various controls for GUI design in virtual environment*	3	-	3
CO-3:	*analyze the design requirements for 3D manipulation*	-	-	3

Module-1 - Immersive Technologies	***15 Hour***
Virtual Reality and Virtual Environment-The historical development of VR –Scientific landmarks Computer Graphics- Real-time Computer Graphics- Virtual environments- Requirements of VR-Visual displays- Auditory displays- Haptic displays- Choosing Output devices for 3D User Interfaces- Input device characteristics- Desktop input devices- Tracking devices- 3D Mice- Special Purpose Input Devices- Direct Human Input- Home-Brewed Input Devices- Choosing Input devices for 3D interfaces	
Module-2 – Graphical User Interface Design	***15 Hour***
Database –World Space- World coordinate- World environment- Objects –Geometry- Position / Orientation- Hierarchy- Bounding Volume- Scripts and other attributes- VR Environment –VR Database- Tessellated Data-LODs- Cullers and Occluders- Lights and Cameras- Scripts- Interaction –Simple- Feedback- Graphical User Interface- Control Panel- 2D Controls- Hardware Controls- Room / Stage / Area Descriptions- World Authoring and Playback- VR toolkits	
Module-3 - 3D Module Design	***15 Hour***
3D Manipulation tasks- Manipulation techniques and Input devices- Interaction Techniques for 3D Manipulation- Design Guidelines –3D Travel tasks- Travel Techniques- Design Guidelines –Theoretical Foundations of Wayfinding- User Centered Wayfinding Support- Environment Centered Wayfinding Support- Evaluating Wayfinding Aids- Design Guidelines –System Control- Classification- Graphical Menus- Voice commands- Gestural Commands- Tools- Multimodal System Control Techniques- Design Guidelines	

Learning Resources	1. *Dieter Schmalstieg and Tobias Hollerer, Augmented Reality: Principles and Practice (Usability), Pearson Education (US), 1st Edition, Addison-Wesley Educational Publishers Inc, 2016.* 2. *C. Burdea and Philippe Coiffet, Virtual Reality Technology, 2nd Edition, Gregory, John Wiley and Sons Inc.,2008*	3. *Steve Aukstakalnis, Practical Augmented Reality: A Guide to the Technologies, Applications, and Human Factors for AR and VR (Usability), 1st Edition, Addison-Wesley Professional; 2016* 4. *Jason Jerald, The VR Book: Human-Centered Design for Virtual Reality. Association for Computing Machinery, 1st Edition, Morgan & Claypool, 2015* 5. *Manivannan, Course on Virtual Reality Engineering, Department of CSE, IIT Madras, https://nptel.ac.in/courses/121106013*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
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Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. Jai Nareesh, Manager AR/VR Programs, HP	*1. Dr. P. Karthikeyan, MIT Campus, Anna University*	1. *Dr. R.Bakiya lakshmi, SRMIST*
	2. Dr. K. Srinivasan, NIT, srinikkn@nitt.edu	

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

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