Vel Tech
Rangarajan Dr. Sagunthala
R&D Institute of Science and Technology
(Deemed to be University Estd. u/s 3 of UGC Act, 1956)

M.Tech Programme

Embedded Systems and Technologies

CHOICE BASED CREDIT SYSTEM

[CBCS]

M.TECH VTR PGE 2023

CURRICULUM

PROGRAM OUTCOMES:

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.

PROGRAM SPECIFIC OUTCOMES:

PSO1: Provide suitable solutions to real time engineering problems in industry sectors using embedded technologies.

PSO2: To explore research problems in the field of embedded system and provide optimized solutions.

PROGRAM EDUCATIONAL OBJECTIVES:

PEO1: Ability to define, analyze, investigate and address problems in embedded system design.
PEO2: To impart the expertise in embedded system required for employability and entrepreneurship at global level.
PEO3: To develop effective communication skill, pursue research, lifelong learning and solve societal problems.

Minimum Credits required in Course Categories

Course Category	Minimum Credits Required
Program Core	34
Programme Elective	18(12+6)
Open Elective	3
Independent Learning	4
Project Work	21
Total	**80**

School of Electrical and Communication

Department of Electronics & Communication Engineering

M.Tech Embedded Systems and Technologies

VTR PGE 2023

Curriculum

Program Core

Course Code	Course Name	L	T	P	C
20231EC101	Advanced Embedded System	4	0	0	4
20231EC102	Real Time Operating System	4	0	0	4
20231EC103	Virtual Instrumentation	4	0	0	4
20231EC104	Embedded Communication Protocol	4	0	0	4
20231EC105	Modern Mathematics for Embedded Systems	4	0	0	4
20231EC106	Digital Signal Processing for Embedded Systems	4	0	0	4
20231EC201	Embedded Programming	3	0	0	4
20231EC202	VLSI Design Methodology and Programming in HDL	3	0	2	4
20231EC301	RTOS Lab	0	0	2	1
20231EC302	Virtual Instrumentation Lab	0	0	2	1

Program Elective

Course Code	Course Name	L	T	P	C
20232EC101	Embedded Systems Security	3	0	0	3
20232EC102	Automotive Embedded System	3	0	0	3
20232EC103	Intelligent Control and Automation	3	0	0	3
20232EC104	Embedded Computing	3	0	0	3
20232EC105	Modern Automotive Electronics Systems	3	0	0	3
20232EC106	Advanced Machine Learning and Deep Learning	3	0	0	3
20232EC107	Advanced Embedded Programming	3	0	0	3
20232EC108	Hardware-Software Co Design	3	0	0	3
20232EC109	Internet of Things	3	0	0	3
20232EC110	Real Time Systems with FPGA	3	0	0	3
20232EC111	Multimedia Compression Techniques	3	0	0	3
20232EC112	Wearable Embedded Technology	3	0	0	3

20232EC113	In Vehicle Networking	3	0	0	3

Open Elective

Course Code	Course Name	L	T	P	C
20233EC101	Electric Vehicle Technology	3	0	0	3
20233EC102	Medical Robotics	3	0	0	3
20233EC103	Modern Automotive Electrical and Electronics Systems	3	0	0	3

Independent Learning

Course Code	Course Name	L	T	P	C
20234EC401	Research Methodology	0	0	0	2
20234EC402	Business Communication	0	0	0	2

Project Work

Course Code	Course Name	L	T	P	C
20234EC701	Project Work Phase-I	0	0	6	3
20234EC702	Project Work Phase-II	0	0	12	6
20234EC703	Project Work Phase-III	0	0	24	12

Course Code	Course Title	L	T	P	C
20231EC101	ADVANCED PROCESSOR AND ARCHITECTURES	4	0	0	4

a) Course Category

Program Core

b) Preamble

The objective is to impart the concepts and architecture of ARM processors and to make the students capable of designing ARM core embedded systems. The course examines contemporary issues and problems in the design, development, and test of contemporary real-time ARM systems while emphasizing solid design practices to ensure reliability.

c) Prerequisite

Nil

d) Related Courses

Nil

e) Course Outcomes

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

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Explain the processors architecture with low power design examples.	K2
CO2	Develop ARM Cortex M4 and STM32F4 microcontroller programming	K3
CO3	Identify the suitable interrupts ,power management and timers in STM32F4 microcontroller	K2
CO4	Illustrate the importance of ARM processor cores, Memory management and synchronization.	K2
CO5	Build a working model of ARM processor for real time applications.	K3

f) Correlation of COs with POs

	PO1	PO2	PO3	PSO1	PSO2
CO1	H	L	-	-	-
CO2	H	L	H	M	L
CO3	M	M	M	L	-
CO4	M	M	L	L	-
CO5	H	H	H	H	H

g) Course Content

UNIT I INTRODUCTION TO PROCESSOR DESIGN 12

Processor Architecture Organization-Abstraction in Hardware Design - MU0-A Simple Processor - Instruction Set Design - Processor Design Tradeoffs - Reduced Instruction Set Computer - Design for Low Power Consumption - Examples.

UNIT II ARM ARCHITECTURE 12

STM32F4 Microcontroller: Central Processing Unit-Memory-General Purpose Input and Output IO Ports-Clock and Timer Modules-Analog Modules-Digital Communication Modules-Other Modules.
Assembly Language: ARM Cortex M4 Instruction Set-Executing Machine Language Code in Microcontroller.
STM32F4 Board: General Information-Pin Layout-Powering the Board and Programming Microcontroller.

UNIT III INTERRUPTS, POWER MANAGEMENTS & TIMERS 12

Interrupt Concept in Embedded System-Interrupts in STM32F4-Interrupts Setup in STM32F4 microcontroller-Interrupt setup via Micropython-Interrupts usage in STM32F4 microcontroller-Power Management in STM32F4-Using Power Modes in Code.
Timers in Embedded System-Base Timers, Base Timer, System Trainer, Watchdog Timers and Real Time Clock in STM32F4 controller-Applications-Timing operation in robot vaccum cleaners.

UNIT IV ARM PROCESSOR CORES 12

ARM7TDMI - ARM8 - ARM9TDMI - ARM10TDMI, Memory Hierarchy: On-chip memory, Caches, Memory management, The ARM system control coprocessor, ARM protection unit, ARM MMU architecture, Synchronization and Context switching.

UNIT V EMBEDDED ARM APPLICATIONS 12

VLSI Ruby II Advanced Communication Processor - VLSI ISDN Subscriber Processor - OneC™ VWS22100 GSM chip - Ericsson-VLSI Bluetooth Baseband Controller - ARM7500 and ARM7500FE - ARM7100, SA-1100, Self-timed design, AMULET1, DRACO telecommunications controller.

Total: 60 Hrs

h) Learning Resources

Text books

1. Steve Furber, “ARM System-on-Chip Architecture”, 2nd Edition, Pearson Education, 2000.
2. ÜnsalanC., Gurhan, H.D. and Yucel, M.E., “Embedded system design with Arm Cortex-M microcontrollers: applications with C, C++ and MicroPython”. Cham: Springer, 2022.

References

1. Andrew N Sloss, Dominic Symes, Chris Wright, “ARM System Developer's Guide - Designing and Optimizing System Software”, Elsevier, 2006.
2. Hermann Kopetz: “Real-time Systems: Design Principles for distributed embedded applications, Kluwer academic publishers, 2002.
3. Arnold. S. Berger, “Embedded Systems Design - An introduction to Processes, Tools and Techniques”, Easwer Press, 2001.

Online Resources

1. ARM architecture, https://youtu.be/JPfG0UQd3x4?si=SgnkIiwWFu7pROaO
2. ARM Programming, https://youtu.be/gPBsoOefyUk?si=vAfYx8D0a6_fCHlX
3. RISC architecture, https://youtu.be/O6Xj3LUdeOI?si=PkdKAg_Msr6KR6RS

Course Code	Course Title	L	T	P	C
20231EC102	REAL TIME OPERATING SYSTEM	4	0	0	4

a) Course Category

Program Core

b) Preamble

This course introduces the concept and development procedures of real-time operating system for aselected embedded architecture.

c) Prerequisite

Nil

d) Related Courses

Nil

e) Course Outcome

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

CO Nos.	Course Outcomes	Knowledge Level (Based on revised Bloom's Taxonomy)
CO1	Explain fundamental concept of real-time operating system.	K2
CO2	Implement task management functions for any ARM processor architecture.	K3
CO3	Identify task scheduler functions for any ARM processor architecture.	K3
CO4	Develop task synchronization functions for any ARM processorarchitecture.	K3
CO5	Build inter task communication functions for any ARM processorarchitecture.	K3

f) Correlation of COs with Pos

	PO1	PO2	PO3	PSO1	PSO2
CO1	H	M	L	M	L
CO2	M	L	L	L	L
CO3	M	L	L	L	M
CO4	M	M	L	L	M
CO5	H	M	L	L	M

g) Course Content

UNIT I FUNDAMENTALS OF RTOS **12**

Introduction to Operating System: Functions, Structure – Need for RTOS – RTOS Characteristics – Kernel components – reentrant functions – foreground/ background systems – interrupt mechanism – bootloader – RTOS based system development process – RTOS porting. Introduction to ARM Controllers – ARM7 Programming.

UNIT II TASK MANAGEMENT FUNCTIONS **12**

Task structure – task types: kernel task, application task – task states – task priorities – context switching – implementation on ARM7 Controllers: task structure, stack, context switch functions, task wait list, setting/ changing task priority, system task, task creation/ deletion, delaying a task.

UNIT III TASK SCHEDULER FUNCTIONS **12**

Task scheduling algorithms: preemptive, nonpreemptive, fixed priority, dynamic priority – RTOS initialization – implementation on ARM7 Controllers: scheduler initialization, scheduler suspend/resume, round robin scheduler, preemptive, nonpreemptive, Earliest Deadline First scheduler, Rate Monotonic Scheduler.

UNIT IV TASK SYNCHRONIZATION FUNCTIONS **12**

Mutual exclusion – deadlock: occurrence, avoidance – semaphores – semaphore management functions – implementation on ARM7 Controllers: semaphore structure, semaphore wait list, semaphore creation/deletion, waiting on semaphore, signaling a semaphore, obtaining status of semaphore.

UNIT V INTER TASK COMMUNICATION FUNCTIONS **12**

Need for communication – Inter task communication objects: mailbox, message queue – mailbox management functions – message queue management functions – implementation on ARM7 Controllers: memory partitions, mailbox waiting list, mailbox creation/deletion, waiting for message, sending a message, reading a message, obtaining status of mailbox.

Total 60 Hrs

h) Learning Resources

Textbooks

1. J. J. Labrosse, “MicroC/OS-II: The Real Time Kernel”, Taylor & Francis, 2002.
2. A. N. Sloss, D. Symes and C. Wright, “ARM System Developer’s Guide – Designing and Optimizing System Software”, Elsevier, 2014.

References

1. J. J. Labrosse, “Embedded Systems Building Blocks: Complete and Ready-to-use Modules in C”, Taylor &Francis, 2000.
2. Colin Walls, “Embedded RTOS Design”, Newnes, 2020.
3. Brian Amos, “Hands-On RTOS with Microcontrollers: Building real-time embedded systems using FreeRTOS, STM32 MCUs, and SEGGER debug tools”, Packt Publishing Limited, 2020.

Online Resources

1. Real Time Operating System, NPTEL https://archive.nptel.ac.in/courses/106/105/106105172.
2. Introduction to RTOS, https://www.youtube.com/watch?v=F321087yYy4&list=PLEBQazB0HUyQ4hAPU1cJED6t3DU0h34bz.

Course Code	Course Title	L	T	P	C
20231EC103	VIRTUAL INSTRUMENTATION	4	0	0	4

a) Course Category

Program Core

b) Preamble

Virtual instrumentation provides the basics of Graphical Programming techniques using LabVIEW software, Real-time data acquisition and interfacing techniques and machine vision with Realtime applications in Embedded Systems.

c) Prerequisite

Nil

d) Related Courses

Virtual Instrumentation Lab

e) Course Outcome

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

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Illustrate the fundamentals of virtual instrumentation.	K2
CO2	Describe the basics of VI programming using graphical user interface functions in LabVIEW.	K2
CO3	Interpret the various indicators in LabVIEW.	K2
CO4	Build real time data acquisition system using DAQ assistant.	K3
CO5	Explain the basics of IMAQ vision and its applications.	K2

f) Correlation of Cos with POs

	PO1	PO2	PO3	PSO1	PSO2
CO1	H	H	M	-	-
CO2	H	H	M	L	L
CO3	H	H	M	L	L
CO4	M	M	M	M	M
CO5	H	M	M	L	L

g) Course Content:

UNIT I FUNDAMENTALS OF VIRTUAL INSTRUMENTATION 12

History of Instrumentation systems, Evolution of Virtual Instrumentation, Premature Challenges, programming requirements, Drawbacks of recent approaches, conventional Virtual Instrumentation, Distributed Virtual Instrumentation, Virtual Instrumentation versus Traditional Instruments, Advantages.

UNIT II VIRTUAL INSTRUMENTATION USING LabVIEW 12

Introduction, Advantages of LabVIEW, software Environment, Front panel, Block diagram, Data flow programming. VI & sub-VI, loops, shift registers, feedback node, formula node, case and sequence structures, arrays and clusters.

UNIT III INDICATOR TOOLS IN LabVIEW 12

Waveform Graphs, Waveform charts, files I/O, local and global variables. Case Study: GUI design for temperature and pressure monitoring system.

UNIT IV DATA ACQUISITION USING DAQ ASSISTANT 12

Introduction, fundamentals of sensors and transducers, Signals, Signal conditioning, DAQ Hardware configuration, DAQ Hardware, Analog inputs, Analog outputs, counters, Digital I/O, DAQ software architecture, DAQ assistant.

UNIT V IMAGE MANIPULATION USING LabVIEW 12

Vision basics, Image processing and analysis, particle analysis, Machine vision, Machine vision hardware and software, building a complete Machine Vision system, acquiring and displaying images with NI-IMAQ driver software, Image processing tools and functions in IMAQ vision and Machine Vision applications.

Total:60 Hrs

h) Learning Resources

Textbooks

1. Jovitha Jerome, "Virtual Instrumentation Using LabVIEW", PHI Learning Pvt. Ltd., 2nd edition, 2010.
2. John Essic, "Introduction to LabVIEW for Scientists and Engineers", 4th Edition, Oxford University Press, 2018.

References

1. Yik Yang, "LabVIEW Graphical Programming Cookbook", Packt Publishing, 1st edition, 2014.
2. Johnson, "LabVIEW Graphical Programming", 4th Edition, McGraw Hill, 2011.
3. Robert H. Bishop, "Learning with Lab VIEW", Prentice Hall, 1st edition, 2003.

Online resources

1. Industrial IT and Automation. (March 30, 2017). Getting Started with LabVIEW [Video]. YouTube.https://www.youtube.com/watch?v=63f8GVjPeOY&list=PLdb-TcK6Aqj2_aDQVCQgMu9Hz77pLhVqa
2. Introduction to LabVIEW Tutorial. https://www.ni.com/getting-started/labview-basics/
3. Getting Started with NI-DAQmx. https://www.ni.com/en/support/documentation/supplemental/06/getting-started-with-ni-daqmx--main-page.html.

Course Code	Course Title	L	T	P	C
20231EC104	EMBEDDED COMMUNICATION PROTOCOL	4	0	0	4

a) Course Category

Program Core

b) Preamble

This course introduces the basics of communication protocols in embedded systems, Synchronous/Asynchronous protocol and its structures in Embedded System. It explains interfacing digital and analog external device and its interconnection on Embedded Systems also defining embedded system's hardware protocols and configurations

c) Prerequisite

Nil

d) Related Courses

Automotive Embedded System

e) Course Outcomes

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

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Summarize sufficient background for undertaking different protocols for embedded systems	K2
CO2	Relate about Serial communication, buses and protocols of embedded devices.	K2
CO3	Illustrate the concept of communication protocols and architecture.	K2
CO4	Classify the hardware protocols and configurations of Embedded Systems.	K2
CO5	Develop the visualization of communication protocols applicability on embedded devices.	K3

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PSO 1	PSO 2
CO1	H	H	L	L	M
CO2	H	H	L	L	M
CO3	H	H	L	L	M
CO4	H	H	L	L	M
CO5	H	H	L	L	M

g) Course Content

UNIT I FUNDAMENTALS OF COMMUNICATIONS AND PROTOCOLS 12

Introduction: Communication, Networks, Protocols, need of communication protocols, Need for Networks. Communication: Serial/ Parallel Communication, Synchronous/Asynchronous Communication, Bit rate, Baud rate, Duplexing, Multiplexing. Protocols: Need of protocols in Embedded Systems and Case study.

UNIT II SERIAL & PARALLEL COMMUNICATION AND INTERFACES 12

Serial Busses - Physical interface, Data and Control signals, features, limitations and applications of RS232, RS485, I2C, SPI, Case Study.

UNIT III HARDWARE PROTOCOLS AND CONFIGURATIONS 12

PCIe - Revisions, Configuration space, Hardware protocols, applications Case Study. CAN (Controller Area Network), Ethernet. MQTT (Message Queuing Telemetry Transport), Bluetooth Low Energy (BLE).

UNIT IV COMMUNICATION SECURITY PROTOCOLS 12

USB - Transfer types, enumeration, Descriptor types and contents, Device driver

UNIT V APPLICATIONS OF EMBEDDED PROTOCOLS 12

Data Streaming Serial Communication Protocol - Serial Front Panel Data Port (SFPDP) using fiber optic and copper cable – Case Studies

Total: 60 Hrs

h) Learning Resources

Text Books

1. Jonathan W. Valvano, Embedded Systems: Real-Time Interfacing to ARM Cortex-M Microcontrollers", Volume 2, Fourth Edition, Texas Instruments., July 2014
2. Jan Axelson, “Serial Port Complete - COM Ports, USB Virtual Com Ports, and Ports for Embedded Systems”, Lakeview Research, 2nd Edition, December 2007.
3. Kalinka Branco, Alex Pinto, Daniel Pigatto, “Communication in Critical Embedded Systems: First Workshop, WoCCES 2013”,Springer International Publishing AG; 1st ed. 2017 edition, July 2017.

Online Resources

1. Introduction to Embedded System Design: https://onlinecourses.nptel.ac.in/noc20_ee98/preview
2. M2M & IoT Interface Design & Protocols for Embedded Systems:
https://www.coursera.org/learn/m2m-iot-interface-design-embedded-systems
3. Embedded Microcontroller Serial Communication protocols:
https://www.classcentral.com/course/udemy-embedded-systems-communication-88496

Course Code	Course Title	L	T	P	C
20231EC105	MODERN MATHEMATICS FOR EMBEDDED SYSTEMS	4	0	0	4

a) Course Category

Program Core

b) Preamble

The following course is designed to provide a comprehensive understanding of several critical areas in mathematical and operational research methodologies. The course focusing on a distinct aspect of the field, aiming to equip students with both theoretical knowledge and practical problem-solving skills. The course develop a strong foundation in graph theory, queuing theory, optimization techniques, and probability distributions in reliability analysis.

c) Prerequisite

Nil

d) Related Courses

Nil

e) Course Outcome

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

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Solve problems related to graph isomorphism and other complex graph theoretic issues.	K3
CO2	Model real-world scenarios using linear programming to optimize resources and improve decision-making processes	K3
CO3	Identify the general characteristics of time-to-failure distributions and their impact on system reliability.	K3
CO4	Construct mathematical representations of queuing systems with finite and infinite capacities.	K3
CO5	Build statistical models for Completely Randomized Designs (CRD) and Randomized Block Designs (RBD).	K3

f)Correlation of COs with POs and PSOs

	PO1	PO2	PO3	PSO1	PSO2
CO1	H	L	M	L	L
CO2	H	L	M	L	L
CO3	H	L	M	L	-
CO4	H	L	L	L	-
CO5	H	L	L	L	L

g) Course Content

UNIT I GRAPH THEORY **12**

Introduction to paths, trees, vector spaces-Matrix coloring and directed graphs-some basic algorithms-Shortest path algorithms-Depth-first search on a graph-Isomorphism-Other graphs-Theoretic algorithms-Performance of graph theoretic algorithms-Graph theoretic computer languages

UNIT II OPTIMIZATION TECHNIQUE **12**

Linear Programming-Model Formulation-Graphical solution-Simplex Method- Transportation Problem –Assignment Problem.

UNIT III PROBABILITY DISTRIBUTIONS IN RELIABILITY ANALYSIS **12**

Introduction - State Variable - Time-to-Failure - General Characteristics of Time-to-Failure Distributions - Survivor Function - Failure Rate Function - Conditional Survivor Function - Mean Time-to-Failure - Additional Probability Metrics - Mean Residual Lifetime - Mixture of Time-to-Failure Distributions – Some Time-to-Failure Distributions - The Exponential Distribution - The Gamma Distribution - The Weibull Distribution - The Normal Distribution.

UNIT IV QUEUEING THEORY **12**

Single and multiple servers-Markovian queuing models-Finite and infinite capacity queues-Finite source model-Queuing applications.

UNIT VANALYSIS OF VARIANCE **12**

Some General Principles-Completely Randomized Designs -Randomized-Block Designs- Multiple Comparisons- Analysis of Covariance

Total: 60 Hrs

h) Learning Resources

Reference books

1. Narsingh ,Deo, “Graph theory with applications to engineering and computer science” Prentice Hall India Learning Private Limited; New edition, 1979.
2. Harary F, “Graph Thoery”,Narosa publishing House, 2001.
3. Hamdy A. Taha,“Operations Research An Introduction Tenth Edition”, Global Edition, Pearson edition limited, 2017.
4. Sharma J K, “Operations Research theory and applications” Sixth Edition, Trinity Press, New Delhi 2016
5. Marvin Rausand, Anne Barros, Arnljot Hoyland,“System Reliability Theory Models, Statistical Methods, and Applications”, Third edition , John Wiley & Sons, Inc. 2021.
6. Kishor S. Trivedi, “Probability and Statistics with Reliability, Queuing, and Computer Science Applications” Second edition, John Wiley & Sons, Inc. 2016
7. Richard A. Johnson, “Miller & Freund’s Probability and statistics For Engineers” Ninth edition, Pearson Education, Boston, 2017.
8. Narayanan S.,Manigavachagom Pillay T. K., Ramanaiah G.,“Advanced Mathematics For Engineering Students*”* Volume III S Viswanathan Pvt Ltd, 2000.
9. Montgomery D.C., Runger G.C., Hubele N. F. “Engineering Statistics”, John Wiley and Sons, Inc.USA, 2011.

Course Code	Course Title	L	T	P	C
20231EC106	DIGITAL SIGNAL PROCESSING FOR EMBEDDED SYSTEMS	4	0	0	4

a) Course Category

Program Core

b) Preamble

Signal Processing is an upcoming filed in embedded wherein many small systems and robots are built with signal processing functions. This course gives an idea of signal processing concepts for embedded systems.

c) Prerequisite

Nil

d) Related Courses

Nil

e) Course Outcomes

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

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Illustrate the basic concepts of digital signal processing	K2
CO2	Compare the applications of digital signal processing	K3
CO3	Apply optimization and guide lines in the development of DSP programming	K3
CO4	Explain the different DSP architectures and their synthesis	K2
CO5	Summarize the DSP applications in different areas such as automotive, industry and health care	K2

f) Correlation of COs with POs

	PO1	PO2	PO3	PSO1	PSO2
CO1	-	L	-	-	-
CO2	H	L	L	-	L
CO3	M	-	M	-	-
CO4	M	-	L	L	-
CO5	H	H	H	H	H

g) Course Content

UNIT I REPRESENTATION OF DSP SYSTEM 12

Single Core and Multicore, Architectural requirement of DSPs - high throughput, low cost, low power, small code size, embedded applications. Representation of digital signal processing systems – block diagrams, signal flow graphs, data-flow graphs, dependence graphs. Techniques for enhancing computational throughput - parallelism and pipelining.

UNIT II DSP APPLICATIONS 12

Spectral analysis and modulation – RLS estimation, pseudo-inverse. Kalmann filter – data compression methods, Hufmann algorithm, LZW coding, Vocoder, LPC, MP3 coding, Error correcting codes and channel coding, Hamming distance and error correction, CRC- Practical issues in using DSP.

UNIT III DSP PROGRAMMING, OPTIMIZATION AND GUIDELINES 12

Overview of DSP algorithms – Optimizing DSP software – RTOS for DSP, Testing and Debugging DSP systems – Embedded DSP Software Design using Multicore SoC architectures-Software Performance Engineering - Code Optimization – Algorithm Development Guidelines

UNIT IV DSP ARCHITECTURES AND THEIR SYNTHESIS 12

DSP System Architectures, Standard DSP Architecture, Ideal DSP Architectures, Multiprocessors and Multicomputers, Systolic and Wave Front Arrays, Shared Memory Architectures. Mapping of DSP algorithms onto Hardware, Implementation based on Complex PEs, Shared memory architecture with Bit – Serial PEs.

UNIT V APPLICATIONS OF DSP IN EMBEDDED SYSTEMS 12

General: Microwave ovens, Digital Cameras **Automotive:** Electric Power Steering, Airbag control, Antilock brake, **Industry:** Industrial Robots, Fault detection, Fire detection **Health care:** Hearing aids, Pacemakers and Defibrillators, ECG analyzers.

Total: 60 Hrs

h) Learning Resources

Text books

1. Dag Stranneby, William Walker, “Digital Signal Processors and Applications”, Elsevier, 2003.
2. Robert Oshana, “DSP Software Development Techniques for Embedded Real Time Applications", Elsevier, 2006.
3. Emmanuel C. Ifeachor, Barrie W. Jervis, “Digital Signal Processing – A Practical Approach”, 2nd Edition, Pearson edition, Asia, 2011.
4. Shibu K. V. “Introduction to Embedded Systems”, 2nd Edition, McGraw Hill, 2017.
5. F. Vahid “Embedded System Design – A Unified Hardware and Software Introduction”, 2nd Edition, John Wiley, 1999.

Online Resources

1. DSP in Embedded Systems, https://peer.asee.org/dsp-in-embedded-systems.pdf
2. Digital Signal Processors, https://edurev.in/t/115040/Digital-Signal Processors#:~:text=Digital%20signal%20processors%20achieve%20real%2Dtime%20processing%20of%20signals%20by,real%2Dtime%20without%20significant%20delays.
3. Digital Signal Processing in Embedded Systems, https://medium.com/@lanceharvieruntime/digital-signal-processing-dsp-in-embedded-systems-68b4649ff441
4. Mapping Signal Processing Algorithms to Architectures, https://nptel.ac.in/courses/108106149

Course Code	Course Title	L	T	P	C
20231EC201	EMBEDDED PROGRAMMING	3	0	2	4

a) Course Category

Program Core

b) Preamble

The major goal of this course is to give students the practical knowledge and solid foundation they need to begin writing well-organized code from scratch. No prior programming experience in either embedded C or cortex-M is required for this course. This course, which has been built to be fully programmable in C, will serve as the perfect foundation for the applications and is readily available to embedded software engineers.

c) Prerequisite

Nil

d) Related Courses

Advanced Embedded Programming

e) Course Outcomes

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

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Explores the features of embedded System basics and the classification of ARM cortex series and an efficient architecture selection.	K2
CO2	Explicate the components of C code for an embedded system program development.	K3
CO3	Discuss the interfacing concept of basic peripherals of ARM and its programming techniques to establish communication with ARM	K3
CO4	Describe python libraries for Embedded development	K3
CO5	Implement an embedded system with python code for the desired application with ARM	K3
CO6	Develop simulate and implement Embedded C programs for ARM based systems for the given specifications.	S3
CO7	Develop simulate and implement Embedded Python programs	S3

f) Correlation of COs with POs

	PO1	PO2	PO3	PSO1	PSO2
CO1	M	L	L	L	L
CO2	L	L	L	L	L
CO3	M	M	M	H	L
CO4	L	L	L	L	L
CO5	M	M	M	H	L
CO6	M	M	L	H	L
CO7	M	L	M	H	L

g) Course Content

UNIT I INTRODUCTION TO EMBEDDED SYSTEM 9

Embedded System Overview: Design flow, Introduction to C, Software development process – ARM Hardware architecture overview and Selection: ARM Classic, Secure Core, Cortex M Series, Cortex R Series, Cortex A Series. Introduction to Cortex M0.

UNIT II INTRODUCTION TO EMBEDDED C 9

Basic Structure, Data Types, Operators and Expressions, Identifiers, Name space & Scope, Flow controls, Loops – Components: Comments, Global Variables, Local Variables, Main Function, pointers.

UNIT III PERIPHERALS PROGRAMMING 9

Interrupt programming, General Purpose Digital Interfacing, General Purpose Analog Interfacing: A-D interfacing, D-A interfacing, Timers control, Signal generators, PWM. Serial Communication: Universal Asynchronous Receiver Transmitter, Serial Peripheral Interface, Inter Integrated Circuits.

UNIT IV COMPONENTS OF EMBEDDED PYTHON 9

Variables and Constants -Data Types -Operators -Lists -Tuples -If Statement -else Statement -elif Statement- short if -for Loop- while Loop -Functions Lambda -Functions Exception Handling- Object Oriented Programming

UNIT V PROGRAMMING USING EMBEDDED PYTHON 9

Digital Control: Using output –lighting a LED ; Using input – adding a push button, Data Conversion – temperature sensor, Communication protocols – UART, IIC

Total:45 Hrs

h) LIST OF EXPERIMENTS

S.No	EXPERIMENTS	CO
1.	Design a system to Monitor the Logical Status of LED	CO6
2.	Design a system to Display Alpha Numerical Characters on LCD	CO6
3.	Design a system to intimate the switch status	CO6
4.	Design a system to control the rotation of a Stepper motor or DC Motor	CO6
5.	Design a system to Monitor the sensor data on a Personal Computer using UART Protocol	CO6
6.	Design a system to Store Data in EEPROM using IIC Protocol	CO6
7.	Design a system to blink LED in a serial manner	CO7
8.	Design a generic system to convert any analog signal into a data	CO7
9.	Design a system to rotate the servo motor	CO7
10.	Design a system to perform arithmetic functions	CO7

i) Learning Resources

Text books

1. Armstrong Subero, (2021) "Programming Microcontrollers with Python", Apress Berkeley, CA, Edition: 1https://doi.org/10.1007/978-1-4842-7058-5
2. Raj Kamal, "Embedded Systems -Architecture, Programming and Design", Tata McGrawHill,2017
3. Siegesmund, M. (2014). Embedded C Programming: Techniques and Applications of C and PIC MCUS. Netherlands: Elsevier Science.
4. Tollervey, N. H. (2017). Programming with MicroPython: Embedded Programming with Microcontrollers and Python. United States: O'Reilly Media.

Online Resources

1. Circuit Python Libraries, https://learn.adafruit.com/welcome-to-circuitpython/circuitpython-libraries

2. Manual for experiments: http://www.keil.com/arm/man/arm.htm

Course Code	Course Title	L	T	P	C
20231EC202	VLSI DESIGN METHODOLOGY AND PROGRAMMING IN HDL	3	0	2	4

a) Course Category

Program Core

b) Preamble

This course introduces basic techniques and algorithms for physical design and optimization of VLSI circuits. The necessary background in graph theory and mathematical optimization, application of different analytical and algorithmic techniques to physical design of VLSI circuits will be studied. The students shall emphasize VLSI design issues encountered in deep sub-micron technology. Throughout the course, students will be exposed to research methodology and to a set of academic and commercial CAD tools for physical design.

c) Related Courses

Nil

d) Pre requisite

Nil

e) Course Outcome

Upon the successful completion of the course, students will be able to design circuits.

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Explain the key consideration parameters in VLSI design	K2
CO2	Compare the different modeling and simulation in cadence using VHDL and Verilog	K2
CO3	Classify the Cadence design algorithms to meet the physical design parameters.	K2
CO4	Illustrate VLSI interconnects and routing strategies in deep sub-micron using FPGA	K2
CO5	Summarize the applications of VLSI in day-to-day life	K2
CO6	Write Combinational and sequential logic circuit VHDL/Verilog program using FPGA	S2

f) Correlation of COs with POs

	PO1	PO2	PO3	PSO1	PSO2
CO1	M	-	L	-	-
CO2	H	M	L	-	L
CO3	M	M	L	L	-
CO4	M	L	L	L	-
CO5	L	M	L	-	-
CO6	M	L	L	L	L

g) Course Content

UNIT I FUNDAMENTALS OF VLSI DESIGN 9

Overview of VLSI Design Flow- Overview of the different design abstractions and levels-system, architecture, logic, circuit, layout- Key considerations in VLSI design: performance, power, area, and reliability- Architecture Design, Logic Design, Circuit Design- Physical Design, Verification and Validation- Design for Manufacturability (DFM), Packaging and Integration, Emerging Trends and Challenges.

UNIT II DESIGN AND IMPLEMENTATION USING HDL 9

HDL: VHDL and Verilog, Gate level modelling: Signal Modelling, Gate modelling, Delay modelling, Connectivity modelling, Compiler driven simulation, Event driven simulation – Switch level modelling: Connectivity and Signal Modelling, Simulation Mechanisms – Combinational logic synthesis, Binary Decision Diagrams, two level logic synthesis.

UNIT III ANALOG DESIGN AND SIMULATION USING HDL 9

Negative Feedback Amplifiers and Instrumentation Amplifier- Regenerative Feedback System - Astable and Monostable Multivibrator. Integrators and Differentiators- Analog Filters- Self-tuned Filter- Function Generator and Voltage-Controlled Oscillator- Automatic Gain Control (AGC)/Automatic Volume Control (AVC)- DC–DC Converter- Low Dropout (LDO)/Linear Regulator

UNIT IV FPGA BASED SYSTEM DESIGN 9

FPGA Features –Architecture- FPGA Kit -FPGA Pin Configuration – Implementation of Digital Circuits using FPGA hardware – Interfacing input/output devices with FPGA -Xilinx 3000 series FPGA- Programmable inter connects – Xilinx 4000 series FPGA**.**

UNIT V APPLICATIONS OF VLSI 9

Automation – Artificial Intelligence- Design of electronic components – Medical Electronics Systems- Digital Camera – Embedded Processor –Safety Systems – Personal Computers-entertainment systems

Total: 45 Hrs

h) LIST OF EXPERIMENTS

S.No	EXPERIMENTS	CO
1.	Write and simulate a Verilog code and realize all the logic gates using FPGA.	CO6
2.	Write and simulate an HDL code to interface hex key pad and display the key code on seven segment display using FPGA.	CO6
3.	Write and simulatei a Program in Verilog /VHDL for D Flip Flop and Full Adder	CO6
4.	Write and simulate a Program in Decoder and UART design.	CO6
5.	Write and simulate a Program in Verilog /VHDL for a comparator	CO6
6.	Write and simulate a Program in Verilog /VHDL N-bit Adder Design	CO6
7.	Write and simulate a Program in Clock divider on FPGA	CO6
8.	Write and simulate How to load a text file or an image into FPGA	CO6
9.	Write and simulate Verilog code for Clock divider on FPGA	CO6
10.	Write and simulate Verilog code for 4x4 Multiplier	CO6
11.	Write and simulate Interfacing GPIOs and PMODs with FPGA	CO6
12.	Write and simulate Implementation of IP Cores in FPGA.	CO6
13.	Design and Simulate Basic Common Source Amplifiers using Cadence	CO6

i) Learning Resources

Text books

1. Sabih H.Gerez,"AlgorithmsforVLSIDesignAutomation,"Wiley India Pvt. Ltd, 2006.
2. Naveed , A. Sherwani, "Algorithms for VLSI Physical Design Automation," Springer, 2005.
3. Ramachandran S , "Digital VLSI System Design: A Design Manual for Implementation, of Projects on FPGAs and ASICs using Verilog", Springer, 2019.
4. Dennis Fitzpatrick , "Analog Design and Simulation using OrCAD Capture and PSpice", Newnes Publisher, 2nd Edition, 2018.
5. Yuan Xie, Jason Cong, Sachin Sapatnekar, "Three-dimensional Integrated Circuit Design: EDA, Design and Microarchitectures (Integrated Circuits and Systems)", Springer International, 2010.
6. Phillip E. Allen, Douglas R. Holberg, "CMOS Analog Circuit Design", Oxford Series, 2016.
7. Jan M. Rabaey, Anantha Chandrakasan, Borivoje Nikolic "Digital Integrated Circuits: A Design Perspective", Pearson Education, 2nd Edition, 2003.

References

1. Charles J Alpert, Dinesh P Mehta, Sachin S Sapatnekar, “Handbook of Algorithms for Physical Design Automation,” CRC Press, 2008.
2. M. Sarrafzadeh and C.K. Wong, “An Introduction to VLSI Physical Design,” Mc GrawHill, 1996.

Online Resources

1. VLSI design using cadence
http://people.ece.umn.edu/~kia/Courses/EE5323/tutorial/Cadence_tutorial.html
2. Cadence design tools, https://www.eit.lth.se/cadsys/chapter1.pdf
3. Cadence tutorial, https://www.mics.ece.vt.edu/ICDesign/Tutorials/Cadence/index_old.html

Course Code	Course Title	L	T	P	C
20231EC301	RTOS LAB	0	0	2	1

a) Course Category

Program Core

b) Preamble

This course introduces the concept and development procedures of real-time operatingsystem for ARM7 architectures.

c) Prerequisite

Nil

d) Related Courses

Nil

e) Course Outcome

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

CO Nos.	Course Outcomes	Skill Level (Based on Dave's Taxonomy)
CO1	Perform RTOS fundamental concepts of embedded C programming with a focus on ARM7 architecture.	S2
CO2	Develop and implement a RTOS fundamental concepts of embedded C programming with a focus on ARM7 architecture.	S3

f) Correlation of Cos with Pos

	PO1	PO2	PO3	PSO1	PSO2
CO1	M	H	M	L	M
CO2	H	H	M	L	M

g) Course Content

List of Experiments:

Exp. No.	Experiment Title	CO Nos.
1	Simulate embedded C programming using ARM7	CO1
2	Simulate task creation/ deletion functions for ARM7 architecture	CO1
3	Develop context switching functions for ARM7 architecture	CO1
4	Write and simulate round robin scheduler for ARM7 architecture	CO2
5	Implement fixed priority preemptive scheduler for ARM7 architecture	CO2
6	Write and simulate semaphore creation/ deletion functions for ARM7 architecture	CO2
7	Implement semaphore signaling/ waiting functions for ARM7 architecture	CO2
8	Write and simulate mailbox creation/ deletion functions for ARM7 architecture	CO2
9	Implement message sending/ reading functions for ARM7 architecture	CO2
10	Design and implementation of deadlock for ARM7 architecture	CO2

h) Learning Resources

Textbooks

1. J. J. Labrosse, "MicroC/ OS-II: The Real Time Kernel", Taylor & Francis, 2002.
2. N. Sloss, D. Symes and C. Wright, "ARM System Developer's Guide – Designing and Optimizing System Software", Elsevier, 2014.

References

1. J. J. Labrosse, "Embedded Systems Building Blocks: Complete and Ready-to-use Modules in C", Taylor & Francis, 2000.
2. Colin Walls, "Embedded RTOS Design", Newnes, 2020.
3. Brian Amos, "Hands-On RTOS with Microcontrollers: Building real-time embedded systems using FreeRTOS, STM32 MCUs, and SEGGER debug tools", Packt Publishing Limited, 2020.

Online Resources

1. Real Time Operating System, NPTEL, https://archive.nptel.ac.in/courses/106/105/106105172.

2. Introduction to RTOS.
https://www.youtube.com/watch?v=F321087yYy4&list=PLEBQazB0HUyQ4hAPU1cJED6t3DU0h34bz.

Course Code	Course Title	L	T	P	C
20231EC302	VIRTUAL INSTRUMENTATION LAB	0	0	2	1

a) Course Category

Program Core

b) Preamble

Virtual instrumentation lab provides hands on exposure to Graphical Programming techniques through LabVIEW software, Real-time data acquisition and interfacing techniques with practical applications.

c) Prerequisite

Nil

d) Related Courses

Virtual Instrumentation

e) Course Outcome

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

CO Nos.	Course Outcomes	Skill Level (Based on Dave's Taxonomy)
CO1	Perform the basic VI programming using graphical user interface functions in LabVIEW.	S3
CO2	Apply the graphical programming functions in VI to simulate the application-specific analog and digital circuits.	S3
CO3	Demonstrate the real-time data acquisition using DAQ devices, control, and analysis of basic I/O devices.	S4

f) Correlation of Cos with POs

	PO1	PO2	PO3	PSO1	PSO2
CO1	H	H	M	-	-
CO2	H	H	M	M	M
CO3	M	M	M	M	M

h) Course Content:

- LabVIEW Programming techniques: creating and Saving VI, front panel controls and indicators, block diagram, Sub VI, Data types, Loops and charts, arrays and graphs, formula nodes, case and sequence structures.
- Introduction to data acquisition on PC, software and hardware installation, configuring data acquisition hardware using the drives in application software, Interface standards and PC buses, use of DAQ library functions for different analog and digital input/output operations. It is followed by a series of laboratory exercises.

LIST OF EXPERIMENTS **30 Hours**

S.No	List of Experiments	CO
1	Build a VI using Numeric, Boolean and String controls and indicators to perform various arithmetic operations.	CO1
2	Create a Sub VI to compute area and volume of planes and solids.	CO1
3	Develop a Sub VI using to solve a quadratic equation and display whether the roots are real or imaginary.	CO1
4	Build a VI to monitor the level of the tank using loop functions.	CO2
5	Build a VI to generate a Fibonacci series using loop and array functions.	CO2
6	Simulate a sine wave and square of variable amplitude and frequency and display the waveform using a graph. Manipulate the waveforms by changing its width and colour.	CO2
7	Design a VI to display a 7-segment LED using caste structures.	CO2
8	Build a VI for traffic light control for varying time delays using sequence structures.	CO2
9	Create a VI to calculate Body Mass Index (BMI) using Clusters and display the BMI status using LED and pop-up message.	CO2
10	Develop a VI to export data from DAQ assistant device and to spreadsheet.	CO3
11	Build a VI to measure temperature using thermocouple and DAQ.	CO3
12	Build a VI for image acquisition and processing using USB camera.	CO3
13	Interface MyRIO with various sensors, acquire data, and log the data to a file for analysis and visualization.	CO3

h) Learning Resources

Textbooks

1. Jovitha Jerome, "Virtual Instrumentation Using LabVIEW", PHI Learning Pvt. Ltd., 2nd edition, 2010.
2. John Essic, "Introduction to LabVIEW for Scientists and Engineers", 4th Edition, Oxford University Press, 2018.

Reference Books

1. Yik Yang, "LabVIEW Graphical Programming Cookbook", Packt Publishing, 1st edition, 2014.
2. Johnson, "LabVIEW Graphical Programming", 4th Edition, McGraw Hill, 2011.
3. Robert H. Bishop, "Learning with Lab VIEW", Prentice Hall, 1st edition, 2003.

Online resources

1. Industrial IT and Automation. (March 30, 2017). Getting Started with LabVIEW [Video]. YouTube. https://www.youtube.com/watch?v=63f8GVjPeOY&list=PLdb-TcK6Aqj2_aDQVCQgMu9Hz77pLhVqa
2. Introduction to LabVIEW Tutorial. https://www.ni.com/getting-started/labview-basics/
3. Getting Started with NI-DAQmx. https://www.ni.com/en/support/documentation/supplemental/06/getting-started-with-ni-daqmx--main-page.html

Course Code	Course Title	L	T	P	C
20232EC101	EMBEDDED SYSTEMS SECURITY	3	0	0	3

a) Course Category

Program Elective

b) Preamble

The embedded systems security course aims at providing a solid overview of the basic principles in cryptography and data security, with particular emphasis on this application in embedded systems. The course deals with both the theoretical and real time challenges of various security features in embedded systems, ensuring that students will be well prepared to address those in practice.

c) Prerequisite

Nil

d) Related Courses

Embedded Systems

e) Course Outcome

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

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Identify various computer and network security concepts, including OSI security architecture, security attacks, and security services and mechanisms.	K3
CO2	Solve encryption strategies utilizing the Data Encryption Standard (DES) and Advanced Encryption Standard (AES).	K3
CO3	Build comprehensive knowledge of core embedded OS security requirements.	K3
CO4	Compare and contrast different cryptographic practices and protocols for embedded devices.	K4
CO5	Utilize SSL and other security protocols effectively to secure wireless embedded systems.	K3

f) Correlation of COs with POs and PSOs

	PO1	PO2	PO3	PSO1	PSO2
CO1	H	H	M	L	-
CO2	H	M	L	L	L
CO3	H	L	M	L	L
CO4	H	L	M	M	-
CO5	H	L	L	L	-

g) Course Content

UNIT I FUNDAMENTALS OF SECURITY PRINCIPLES 9

Computer and network security concepts: Overview, OSI security architecture, Security attacks, Services and mechanisms fundamentals of security design principles, Attack surfaces and attack trees, model for network security.

UNIT II CLASSICAL SYMMETRIC CIPHERS 9

Classical encryption techniques: Symmetric cipher model, Substitution and transposition techniques, Block ciphers and DES: Traditional block cipher structure, Data Encryption Standard (DES), DES Example and strength. Advanced Encryption Standard (AES): AES Structure and transformation functions, AES key expansion.

UNIT III EMBEDDED THREAT MANAGEMENT 9

Embedded security trends, Security policies and threats, System software considerations: Role of operating system, Microkernel vs. Monolithic kernel, Core embedded OS security requirements, Access control and capabilities, Hypervisors and system virtualization, I/O virtualization, Remote management, Assuring Integrity of the Trusted Computing Base (TCB).

UNIT IV EMBEDDED CRYPTOGRAPHY AND DATA SECURITY 9

Cryptographic methods & Data Protection in embedded systems, Advanced cryptography for embedded systems, Data protection techniques in embedded systems, Embedded system cryptography and security protocols, Cryptographic practices and protocols for embedded devices, Embedded system data security, Secure data handling in embedded systems, Embedded cryptographic applications, Data security and cryptographic solutions for embedded systems.

UNIT V SECURITY PROTOCOLS AND STRATEGIES 9

Network communications protocols and built-in security, Security protocols and algorithms: Secured Socket Layer (SSL), Embedded security in wireless, Application-layer and Client/Server

protocols, Choosing and optimizing cryptographic algorithms for resource-constrained systems, Hardware-based security.

Total: 45 Hrs

h) Learning Resources

Text books

1. William Stallings, "Cryptography and Network Security: Principles and Practice", 7th Edition, Pearson Education Limited, 2017.
2. David Kleidermacher and Mike Kleidermacher, "Embedded Systems Security: Practical Methods for Safe and Secure Software and Systems Development", Newnes (an imprint of Elsevier), 2012.
3. Timothy Stapko, "Practical Embedded Security: Building Secure Resource-Constrained Systems", Newnes (an imprint of Elsevier), 2008.

Reference books

1. Christof Paar, Jan Pelzl, "Introduction to Cryptography", Springer, 2010.
2. Ingrid Verbauwhede (Ed.), "Secure Integrated Circuits and Systems", Springer, 2010.
3. Stefan Mangard, Elisabeth Oswald, Thomas Popp, "Power Analysis Attacks", Springer, 2007.
4. Debdeep Mukhopadhyay, Rajat Subhra Chakraborty, "Hardware Security: Design, Threats, and Safeguards", CRC Press, 2015. ISBN: 9781439895832.
5. Marc Joye, Michael Tunstall, "Fault Analysis in Cryptography", Springer, 2012.

Online resources

1. NPTEL Course-Hardware Security: https://onlinecourses.nptel.ac.in/noc22_cs48/preview
2. COURSERA- Internet of Things Security: https://www.coursera.org/learn/iot-security
3. EDX-https://www.edx.org/learn/embedded-systems/the-university-of-texas-at-austin-embedded systems-shape-the-world-microcontroller-input-output
4. EDX-https://www.edx.org/learn/embedded-systems/arm-education-embedded-systems-essentials-with-arm-getting-started

Course Code	Course Title	L	T	P	C
20232EC103	INTELLIGENT CONTROL AND AUTOMATION	3	0	0	3

a) Course Category

Program Elective

b) Preamble

This course aims to equip students with foundational knowledge and advanced techniques for intelligent control systems used in automation. By combining concepts from Artificial Neural Networks (ANN), Fuzzy Logic (FL), Genetic Algorithms (GA), and recent industrial automation methods, students will learn to design and optimize intelligent control systems for various applications.

c) Prerequisite

Nil

d) Related Courses

Advance Machine Learning and Artificial Intelligence.

e) Course Outcome

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

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Utilize adaptive neuro-controllers integrating both ANN and fuzzy logic principles.	K3
CO2	Solve optimization problems by utilizing a combination of Genetic Algorithms and other search techniques.	K3
CO3	Build different combinations of ANN, fuzzy logic, and optimization methods to achieve superior control performance.	K3
CO4	Identify and apply concepts of industrial automation, including PLC and SCADA systems.	K3
CO5	Choose appropriate intelligent control strategies for different industrial automation applications.	K3

f) Correlation of COs with POs and PSOs

	PO1	PO2	PO3	PSO1	PSO2
CO1	M	L	M	L	-
CO2	M	L	M	L	M
CO3	M	L	M	M	-
CO4	H	M	L	M	L
CO5	H	M	L	M	L

g) Course Content

UNIT I ARTIFICIAL NETWORK AND FUZZY LOGIC 9

Learning with ANNs, Single-layer and multi-layer perceptron, Back Propagation Algorithm, ANNs for identification and control, Adaptive neuro controller, Fuzzy Logic Control: Fuzzy sets, fuzzy logic, fuzzy logic controller design, Fuzzy modelling and identification, Adaptive fuzzy control design.

UNIT II GENETIC ALGORITHM 9

Basic concept of Genetic Algorithms and detailed algorithmic steps, Hybrid Genetic Algorithms, Solution for typical control problems using Genetic Algorithms, Other search techniques: Tabu Search, Ant-colony, Search, Particle Swarm Optimization.

UNIT III COMBINED ANN, FUZZY LOGIC, AND OPTIMIZATION METHODS 9

Fuzzification and rule base using ANN, Neuro-fuzzy systems, Adaptive Neuro-Fuzzy Inference System (ANFIS), Optimization of membership functions and rule base using Genetic Algorithms and Particle Swarm Optimization.

UNIT IV INDUSTRIAL AUTOMATION 9

Automation components: Discrete switches, analog sensors, relays, actuators, and automation tools, Automation in production systems: Principles and strategies, basic elements of an automated system, advanced automation functions, Industrial automation: Computer vision, PLC, SCADA.

UNIT V INTELLIGENT CONTROLLERS FOR INDUSTRIAL AUTOMATION APPLICATION **9**

Applications of intelligent controllers in industrial monitoring, optimization, and control, Automation of smart appliances, Automation concepts for electric vehicles, intelligent controllers and automation for power systems.

Total: 45 Hrs

h) Learning Resources

Text books

1. Ronald L. Krutz, "Industrial Automation and Control System Security Principles", Wiley, 2020.
2. Eyal Wirsansky "Hands-On Genetic Algorithms with Python" Paperback, 2020.
3. Dan W. Patterson, "Artificial Neural Networks and Machine Learning", Prentice Hall, 2017.
4. Timothy J. Ross, "Fuzzy Logic with Engineering Applications", Wiley, 4th Edition, 2016.
5. David E. Goldberg, "Genetic Algorithms in Search, Optimization, and Machine Learning", Pearson Education, 2009.

Reference books

1. Chanchal Dey and Sunit Kumar Sen, "Industrial Automation Technologies", 1st Edition, CRC Press, 2022.
2. Alasdair Gilchrist, "Industry 4.0: The Industrial Internet of Things", Apress, Kindle Edition, 2016.
3. Frank D. Petruzella, "Programmable Logic Controllers", McGraw Hill, New York, 2016.
4. Lawrence (Larry) M. Thompson and Tim Shaw, "Industrial Data Communications", ISA Press, 5th Edition, 2015.
5. Stuart A. Boyer, "SCADA: Supervisory Control and Data Acquisition Systems", ISA Press, 2010.

Online resources

1. Artificial Neural Networks and Deep Learning: https://www.deeplearningbook.org/
2. Genetic Algorithms Overview: https://in.mathworks.com/help/gads/what-is-the-genetic-algorithm.html
3. Introduction to Genetic Algorithms - MIT OpenCourseWare: https://www.youtube.com/watch?v=kHyNqSnzP8Y
4. Introduction to Industrial Automation: https://www.surecontrols.com/what-is-industrial-automation/
5. PLC Programming and SCADA Systems: https://www.plcacademy.com/
6. IoT and Industry 4.0: https://www.epicor.com/en/blog/what-is-industry-4-0/
7. Automation of Smart Appliances: https://www.sciencedirect.com/science/article/abs/pii/S0957417414004343
8. Automation for Electric Vehicles: https://ieeexplore.ieee.org/document/9247271

Course Code	Course Title	L	T	P	C
20232EC109	INDUSTRIAL INTERNET OF THINGS	3	0	0	3

a) Course Category

Program Elective

b) Preamble

The course on Industrial Internet of Things (IIoT) is designed to provide students with an in depth understanding of how IoT technologies are revolutionizing industrial sectors. By integrating IIoT into industrial processes, industries can achieve greater efficiency, improved productivity, and enhanced safety. This course is structured to focus on different aspects of IIoT, from fundamental concepts to real-world applications

c) Prerequisite

Nil

d) Related Courses

Nil

e) Course Outcomes

On successful completion of the course, student will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Build a foundational understanding of the role of the Internet of Things (IoT) and Industrial Internet of Things (IIoT) in modern industries.	K3
CO2	Identify the roles of microcontrollers and embedded PCs in the deployment of IIoT solutions.	K3
CO3	Construct data analytics and predictive maintenance models utilizing IIoT technology to enhance operational efficiency.	K3
CO4	Infer the cyber physical systems of AR/VR, AI and Bigdata.	K2
CO5	Identify key challenges and opportunities in implementing IIoT solutions across different industries.	K3

f) Correlation of COs with POs and PSOs

	PO1	PO2	PO3	PSO1	PSO2
CO1	H	L	-	L	L
CO2	H	L	-	L	L
CO3	H	L	-	L	L
CO4	H	L	M	M	L
CO5	M	L	M	M	L

g) Course Content

UNIT I FUNDAMENTALS OF IIoT 9

Various Industrial Revolutions, Role of Internet of Things (IoT) & Industrial Internet of Things (IIoT) in Industry, Industry 4.0 revolutions, Support System for Industry 4.0, Smart Factories.

UNIT II SYSTEMS FOR IIoT AND REFERENCE ARCHITECTURE 9

Sensors and Actuators for Industrial Processes, Sensor networks, Process automation and Data Acquisitions on IoT Platform, Microcontrollers and Embedded PC roles in IIoT, Wireless Sensor nodes and Protocols: Bluetooth, WiFi, and LoRa Protocols, IoT Hub systems. Industrial Internet Architecture Framework – Functional Viewpoint – Operational Domain, Information Domain, Application Domain, Business Domain.

UNIT III IIoT DATA MONITORING AND CONTROL INTERNET SYSTEMS 9

IoT Gate way, IoT Edge Systems and It's Programming, Cloud computing, Real Time Dashboard for Data Monitoring, Data Analytics and Predictive Maintenance with IIoT technology. Introduction-Proximity Network Protocols – WSN Edge Node – Legacy Industrial Protocols - Industrial Ethernet – Industrial Gateways

UNIT IV MIDDLEWARE TRANSPORT PROTOCOL AND CYBER PHYSICAL SYSTEMS 9

TCP/IP, UDP, RTP, CoAP –Middleware Software patterns –Software Design patterns – Application Programming Interface (API) – CAN Protocol-Web Services – Middleware IIoT – Securing the IIoT- Identity Access Management - Next Generation Sensors, Collaborative Platform and Product Lifecycle Management, Augmented Reality and Virtual Reality, Artificial Intelligence, Big Data and Advanced Analysis.

UNIT V APPLICATIONS OF INDUSTRIAL IOT 9

Healthcare, Power Plants, Inventory Management and Quality Control, Plant Safety and Security (Including AR and VR safety applications), Facility Management, Real life examples

of IIoT in Manufacturing Sector, Case studies: IIoT application development with Embedded PC based development boards.

. **Total : 45 Hrs**

h) Learning Resources

Text books

1. Alasdair Gilchrist "Industry 4.0: The Industrial Internet of Things" Apress Publications by 2017.
2. Bartodziej, Christoph Jan "The Concept Industry 4.0 An Empirical Analysis of Technologies and Applications in Production Logistics" Springer: Publication in the field of economic science, 2017.

Reference books

1. Dr. OvidiuVermesan, Dr. Peter Friess, "Internet of Things: Converging Technologies for Smart Environments and Integrated Ecosystems", River Publishers, 2013.
2. Rajkamal "Embedded System: Architecture, Programming and Design" , Tata MCGraw Hill 3rd Edition, 2017.

Online resources

1. Introduction to Industry 4.0 and Industrial Internet of Things - Course (nptel.ac.in) - Introduction to Industry 4.0 and Industrial Internet of Things - Course (nptel.ac.in) Prof. Sudip Misra
2. Introduction: Sensing and Actuation - Lecture 01: Introduction: Sensing and Actuation (youtube.com) (IIT Kharagpur).
3. IoT Based Smart Electricity Energy Meter using ESP32 & Blynk Application - IoT Based Smart Electricity Energy Meter using ESP32 & Blynk Application (youtube.com)

Course Code	Course Title	L	T	P	C
20232EC110	EMBEDDED REAL TIME SYSTEM WITH FPGA	3	0	0	3

a) Course Category

Program Elective

b) Preamble

This course aims to introduce the fundamentals of real-time system design using Field-Programmable Gate Arrays (FPGAs), theoretical concepts and practical techniques for developing real-time applications with FPGA.

c) Prerequisite

Nil

d) Related Courses

Nil

e) Course Outcomes

On successful completion of the course, student will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Choose appropriate design methodologies and tools based on project requirements and constraints.	K3
CO2	Build modular and cohesive systems that adhere to design quality standards.	K3
CO3	Organize strategies for identifying and managing dependencies in parallelized designs.	K3
CO4	Infer the FPGA-based hardware accelerators for real-time applications.	K2
CO5	Build advanced Fieldbus networks for efficient and reliable low-speed communication in real-time applications.	K3

f) Correlation of COs with POs and PSOs

	PO1	PO2	PO3	PSO1	PSO2
CO1	H	L	-	M	-
CO2	H	L	L	-	L
CO3	H	L	-	M	-
CO4	H	L	L	-	M
CO5	M	L	L	M	-

g) Course Content

UNIT I FUNDAMENTALS OF EMBEDDED SYSTEM DESIGN 9

Overview of embedded system- Design challenges: design life cycle, measures of success, cost- FPGA tool chain- Target FPGA - function generators, storage elements, special purpose function blocks – Xilinx Virtex 5- Creating and generating custom IP.

UNIT II SYSTEMS DESIGN 9

Cellular system, Hexa Principles of system design: design quality, modules and interfaces, cohesion and coupling, designing for reuse- Hardware design – Software design – Partitioning: analytical solution to partitioning, practical issues.

UNIT III SPATIAL DESIGN 9

Principles of parallelism: granularity, degree of parallelism, spatial organizations- Identifying parallelism: ordering, dependence, uniform dependence vectors- Spatial parallelism with platform FPGA: hardware cores and designs – Debugging.

UNIT IV PERFORMANCE OF REAL TIME SYSTEMS 9

Balancing bandwidth technique: Kahn process network, synchronous and asynchronous design – FPGA bandwidth technique: on-chip and off-chip memory, streaming instrument data and its practical issues – Scalable designs: scalable constraints and its solutions.

UNIT V FUTURE VISION ON REAL TIME SYSTEMS 9

Real time hardware: Heterogeneous soft multi-cores, architectural issues with individual soft core, advanced fieldbus networks and simpler distributed nodes, Low speed communication: Generating the hardware base system, testing the design.

Total: 45 Hrs

h) Learning Resources

Text books

1. Ron Sass, Andrew G. Schmidt "Embedded Systems Design with Platform FPGAs Principles and Practices" Elsevier, 2017.
2. Phillip A. Laplante, Seppo J. Ovaska "Real-Time Systems Design and Analysis: Tools for the Practitioner", 4th Edition Wiley, 2012.

Reference books

1. Juan José Rodriguez Andina, Eduardo de la Torre Arnanz, "FPGAs: Fundamentals, Advanced Features, and Applications in Industrial Electronics" CRC Publisher 1st Edition September 2020
2. Peter Athanas, Dionisios Pnevmatikatos "Embedded Systems Design with FPGAs" Springer-Verlag New York Inc.; 2012th Year edition.

Online resources

1. Introduction to Real Time Embedded Systems Part I - Course (nptel.ac.in) - https://nptel.ac.in/courses/108105057 Prof. Rajib Mall, Prof. Amit Patra, Prof. A. Routray
2. Embedded Systems Design Course (nptel.ac.in) - https://onlinecourses.nptel.ac.in/noc22_cs46/preview By Prof. Anupam Basu, IIT Kharagpur .

Course Code	Course Title	L	T	P	C
20232EC113	IN VEHICLE NETWORKING	3	0	0	3

a) Course Category

Program Elective

b) Preamble

This course introduces the networking concept of embedded devices in vehicles. It explains interconnection methods and protocols for embedded systems in the vehicles, leads to connected and autonomous vehicles.

c) Prerequisite

Nil

d) Related Courses

Automotive Embedded System, Embedded Communication Protocol

e) Course Outcomes

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

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Apply knowledge of data communication networks to understand the fundamentals and importance of automotive communication protocols.	K3
CO2	Construct models of the CAN Data Link Layer to validate principles of data exchange, including arbitration, data frames, and remote frames.	K3
CO3	Identify key components of LIN node configuration and identification processes to ensure proper network setup.	K3
CO4	Outline the Medial Oriented System Transport (MOST) protocol and FlexRay used in automotive for multimedia and fault tolerant applications.	K2
CO5	Choose an appropriate communication technologies for vehicular environments, including Intelligent Transport System (ITS) and Wireless Access Vehicle Environments (WAVE).	K3

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PSO 1	PSO 2
CO1	H	L	L	L	-
CO2	H	M	M	L	L
CO3	H	M	L	L	-
CO4	H	M	M	L	L
CO5	H	M	L	L	L

g) Course Content

UNIT I FUNDAMENTALS OF DATA NETWORKS AND PROTOCOLS 9

Basics of data communication networks and automotive communication protocols: Networks- Need for networks- Types of networks- Need for standards- TCP/IP model- Topologies- Error detection and correction mechanisms- Encoding schemes- Serial/parallel transmission- Bits- Baud and bandwidth- Synchronous and asynchronous- Need and benefits of IVN- Classes of IV N protocols.

UNIT II CONTROLLER AREA NETWORK (CAN) PROTOCOL 9

Overview of CAN- CAN Applications- SAE J1939 Protocol- Main characteristics of CAN- CAN in OSI Reference Model- CAN Data Link Layer- Principles of data exchange in CAN- Arbitration- Data Frame- Remote Frame- Error detection and management in CAN- CAN physical Layer- Bit encoding- Bit timing and synchronization- Relationship between data rate and bus length- Single wire and twin wire media- CAN repeaters- Medium to medium gateway- Protocol handlers.

UNIT III LOCAL INTERCONNECT NETWORK (LIN) PROTOCOL 9

Introduction to LIN- LIN consortium- LIN specification- LIN features- Technical overview- Work flow concept- LIN operation- LIN frame format- Scheduling table- Network management of LIN cluster- LIN Transport Layer- LIN node configuration and identification- LIN diagnostics- LIN physical layer- Comparison with other IVN protocols.

UNIT IV DIAGNOSTICS PROTOCOLS FOR VEHICLES 9

Process of Automotive Fault Diagnostics- Fault Codes- Vehicle Systems (open loop and closed loop) - On and Off Board Diagnostics- OBDI- OBDII- Engine Analyzers- Steps taken to diagnose a fault- Diagnostics Protocol KWP2000. MOST overview–data rates–data types–topology. Flex Ray introduction–network topology–ECU sand bus interfaces-application areas.

UNIT V APPLICATIONS AND TECHNOLOGIES 9

Global Positioning Systems (GPS)- Inertial Navigation Systems (INS)- Vehicle Location and Navigation- Bluetooth- UWB- RFID- Intelligent Transportation Systems (ITS) and Wireless Access in Vehicular Environments (WAVE)- Vehicular Ad Hoc Networks (VANETs)- Communications- Air interface- Long and Medium range (CALM)- Real time management and planning of CRDI vehicle operation

Total: 45 Hrs

h) Learning Resources

Text books

1. Dominique Paret, "Multiplexed Networks for Embedded Systems CAN, LIN, FlexRay, Safe by Wire", 1st edition, Wiley, United States, 2014.
2. Chung Ming Huang, YuhShyan Chen, "Telematics Communication Technologies and Vehicular Networks: Wireless Architectures and Application", 1st edition, Information Science Reference, United States, 2010.

Reference books

1. Ronald K Jurgen, "Distributed Automotive Embedded Systems", 4th Edition, SAE International, United States, 2010.
2. Richard Zurawski, "Industrial Communication Technology Handbook", 2nd Edition, CRC press, United States, 2015.
3. Konrad Reif, "Automotive Mechatronics: Automotive Networking, Driving Stability Systems Electronics", 2nd Edition, Springer, United States, 2015.

Online resources

1. Networks and Systems: https://nptel.ac.in/courses/117106116
2. UART to Local Interconnect Network (LIN bus): https://www.udemy.com/course/automotive-networks-foundation-classes/
3. Controller Area Network (CAN bus): https://www.udemy.com/topic/controller-area-network-can-bus/
4. Secure Vehicle and Industrial Networking: https://www.online.colostate.edu/courses/SYSE/SYSE549.dot
5. Introduction to Automotive Cyber security and Vehicle Networks: https://www.careers360.com/courses-certifications/skill-lync-introduction-automotive-cybersecurity-and-vehicle-networks-course

Course Code	Course Title	L	T	P	C
20233EC101	ELECTRIC VEHICLE TECHNOLOGY	3	0	0	3

a) Course Category:

Open Elective

b) Preamble

The major goal of this course is to give students the knowledge and solid foundation on electric vehicle technology. This course, which has been erected to develop student's knowledge on electric and hybrid vehicles for pollution free environment.

c) Prerequisite Courses

Nil

d) Related Courses

Nil

e) Course Outcome:

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

CO Nos.	Course Outcome	Knowledge Level (Based on revised Bloom's Taxonomy)
CO1	Summarize of Electric Systems and Hybrid related Vehicles	K2
CO2	Illustrate an architectural developments of electric vehicles.	K2
CO3	Classify of electric storage batteries for electric and hybrid vehicles.	K2
CO4	Compare on AC and DC motors of electric machines	K2
CO5	Explain on applications and modelling of electric and hybrid vehicles.	K2

f) Correlation of COs with POs:

COs	PO1	PO2	PO3	PSO1	PSO2
CO1	M	L	M	M	L
CO2	M	L	M	M	L
CO3	M	L	L	L	L
CO4	M	-	-	L	L

CO5	M	-	-	L	L

H- High; M-Medium; L-Low

g) Course Content

UNIT I FUNDAMENTALS AND ESSENTIALS OF ELECTRIC VEHICLES 9

Introduction to Electric Vehicles: Brief and History, Electric Vehicles and the Environmental assistances, Usage Patterns for Electric Road Vehicles. Hybrid Electric Vehicles: Components, Electric and Hybrid Vehicles: History and comparison, Roadway Fundamentals: Propulsion and Power, Velocity and acceleration, Electric Vehicle Market - Case Study.

UNIT II ARCHITECHTURES OF ELECTRIC AND HYBRID VEHICLES 9

Electric Vehicles and Hybrid Vehicles: Basic Architectures, Types of Electric Vehicles – EV Architecture: Battery Electric Vehicles, The IC Engine/Electric Hybrid Vehicle, Fuelled EVs, EVs using Supply Lines, EVs which use Flywheels or Supercapacitors, Solar-Powered Vehicles, Vehicles using Linear Motors, EVs for the Future.

UNIT III BATTERY ENERGY STORAGE 9

Introduction: Batteries, Flywheels and Supercapacitors. Battery Parameters: Cell and Battery Voltages, Charge (or Amphour) Capacity and Energy Stored, Battery Geometry, Battery Temperature, Heating and Cooling Needs, Battery Life and Number of Deep Cycles. Batter types: lead acid batteries, nickel-based batteries, and lithium-based batteries. Supercapacitors and Flywheels, Battery charging, Designer choices battery, Use of Batteries in Hybrid Vehicles, Battery modelling: The Purpose of Battery Modelling and Battery Equivalent Circuit, Fuel Cells: Hydrogen Fuel Cells, Efficiency of Fuel cells-Green Energy.

UNIT IV ELECTRIC MACHINES 9

Electric Machines: Electric Motors and its types, principle of AC and DC motors, Electric Motors as Brakes, Single-Phase Inverters, Three Phase. Brushless Electric Motors: Switched Reluctance Motors, Induction Motor, Motor Cooling, Efficiency, Size and Mass.

UNIT V ELECTRIC VEHICLE MODELLING AND APPLICATIONS 9

Tractive Effort, Rolling Resistance Force, Aerodynamic Drag, Modelling Vehicle Acceleration, Modelling Electric Vehicle Range, Driving Cycles, Range Modelling of Battery Electric Vehicles, Range Modelling of Fuel Cell Vehicles, Range Modelling of Hybrid Electric Vehicles, Electric Vehicles and the Environment, Recent Electric Vehicles, Future of Electric Vehicles, Case study: Testla Model, Honda, Toyota Prius, Renault cars and Electric Road – Rail Systems.

Total: 45 Hrs

i) Learning Resources

Text books

1. James Laminae and John Lowry, "Electric Vehicle Technology Explained" John Wiley & Sons Ltd, second edition, 2012.
2. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, 2nd edition CRC Press, 2011.

References

1. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.
2. Ehsani, M, “Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design”, CRC Press, 2005.

Online Resources

1. Electric Vehicles and Renewable Energy: https://onlinecourses.nptel.ac.in/noc21_ee112/preview
2. Fundamentals of Electric vehicles: Technology & Economics: https://nptel.ac.in/courses/108106170
3. Electric Vehicles : https://onlinecourses.nptel.ac.in/noc22_ee53/preview
4. eMobility and Electric Vehicle Engineering: https://elearn.nptel.ac.in/shop/iit-workshops/completed/e-mobility-and-electric-vehicle-engineering/

Course Code	Course Title	L	T	P	C
20233EC102	MEDICAL ROBOTICS	3	0	0	3

a) Course Category:

Open Elective

b) Preamble

This advanced course in Robotics in Medicine is designed to provide students with a comprehensive understanding of robotics principles and their applications in the field of medicine. It covers foundational robotics concepts, sensors, actuators, manipulators, surgical robots, rehabilitation and assistive robots, and wearable robots. Students will gain theoretical knowledge and practical skills to navigate the evolving landscape of medical robotics.

c) Prerequisite Courses

Nil

d) Related Courses

Nil

e) Course Outcome:

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

CO Nos.	Course Outcome	Knowledge Level (Based on revised Bloom's Taxonomy)
CO1	Explain robotics fundamentals: grasp core robotics principles and apply them effectively in healthcare contexts.	K2
CO2	Design and analyze: proficiently design and analyze robotic systems tailored for medical applications, optimizing their performance.	K3
CO3	Apply robotics in medicine: explore diverse medical uses of robotics, from surgery to rehabilitation, and identify suitable solutions.	K3
CO4	Illustrate ethical and safety awareness: gain insight into ethical and safety aspects of medical robotics, enabling informed ethical decision-making.	K2
CO5	Infer wearable tech competence: investigate cutting-edge wearable robotics, gaining hands-on experience and understanding human-robot interaction nuances.	K2

f) Correlation of COs with POs:

COs	PO1	PO2	PO3	PSO1	PSO2
CO1	M	-	-	-	L
CO2	M	M	M	L	-
CO3	M	-	M	L	L
CO4	L	-	-	L	L
CO5	M	-	M	-	L

H- High; M-Medium; L-Low

g) Course Content:

UNIT I INTRODUCTION TO ROBOTICS 9

Historical context of robotics, Overview of robot subsystems, Degrees of freedom, configurations, workspace Dynamic Stabilization, Sensors and Actuators: Types, controllers, internal and external sensors, position, velocity, and acceleration sensors, proximity sensors, force sensors, Pneumatic and hydraulic actuators, Stepper motor control circuits, End effectors and various types of grippers, PD and PID feedback actuator models.

UNIT II MANIPULATORS AND BASIC KINEMATICS 9

Construction of manipulators, Manipulator dynamic and force control, Electronic and pneumatic manipulators, forward kinematic problems, Inverse kinematic problems and solutions, Navigation and treatment planning, Variable speed arrangements, Path determination using machinery vision, laser, acoustic, magnetic, fiber optic, and tactile sensors.

UNIT III SURGICAL ROBOTS 9

Da Vinci Surgical System, Image-guided robotic systems for focal ultrasound-based surgical applications, Robotic tele-surgical system for off-pump CABG surgery, Urologic, cardiac, neuro, pediatric and general surgery applications, Gynecologic surgery and nanorobotics, Case study.

UNIT IV REHABILITATION AND ASSISTIVE ROBOTS 9

Pediatric rehabilitation, Robotic therapy for upper extremity and walking, Clinical-based gait rehabilitation robots, Motion correlation, tracking, prediction, and replication, Portable robots for tele-rehabilitation, Robotic exoskeletons: Design considerations and hybrid assistive limbs, Case study.

UNIT V WEARABLE ROBOTS 9

Augmented reality in wearable robots, Kinematics and dynamics for wearable robots, Wearable robot technology: Sensors, actuators, portable energy storage, Human-robot cognitive interaction (cHRI) and physical interaction (pHRI), Wearable robotic communication, Case study.

Total:45 Hrs

h) Learning Resources

Text books

1. Nagrath and Mittal, “Robotics and Control”, Tata McGraw Hill, First edition, 2003.
2. Spong and Vidhyasagar, “Robot Dynamics and Control”, John Wiley and Sons, First edition, 2008.
3. Fu.K.S, Gonzalez. R.C., Lee, C.S.G, “Robotics, control, sensing, Vision and Intelligence”, Tata McGraw Hill International, First edition, 2008.
4. Shane (S.Q.) Xie , "Robotics for Medical Applications" Springer International, 2017.

References

1. Bruno Siciliano, Oussama Khatib, “Handbook of Robotics”, 1st Edition, Springer, 2008
2. Shane (S.Q.) Xie, “Advanced Robotics for Medical Rehabilitation - Current State of the Art and Recent Advances”, Springer, 2016
3. Sashi S Kommu, “Rehabilitation Robotics”, I-Tech Education and Publishing, 2007
4. Jose L. Pons, “Wearable Robots: Biomechatronic Exoskeletons”, John Wiley & Sons Ltd, England, 2008
5. Howie Choset, Kevin Lynch, Seth Hutchinson, “Principles of Robot Motion: Theory, Algorithms, and Implementations”, Prentice Hall of India, First edition, 2005
6. Philippe Coiffet, Michel Chirouze, “An Introduction to Robot Technology”, Tata McGraw Hill, First Edition, 1983
7. Jacob Rosen, Blake Hannaford & Richard M Satava, “Surgical Robotics: System Applications & Visions”, Springer 2011
8. Jocelyn Troccaz, “Medical Robotics”, Wiley, 2012
9. Achim Schweikard, Floris Ernst, “Medical Robotics”, Springer, 2015

Online Resources

1. Introduction to Biomedical Imaging Systems, https://onlinecourses.nptel.ac.in/noc21_bt50/preview
2. Electronic Systems for Cancer Diagnosis: https://onlinecourses.nptel.ac.in/noc22_ee77/preview
3. Biomedical Signal Processing: https://onlinecourses.nptel.ac.in/noc24_ee49/preview
4. Medical Image Analysis: https://onlinecourses.nptel.ac.in/noc24_ee57/preview

Course Code	Course Title	L	T	P	C
20233EC103	MODERN AUTOMOTIVE ELECTRICAL AND ELECTRONICS SYSTEMS	3	0	0	3

a) Course Category:
Open Elective

b) Preamble
The major goal of this course expose to the fundamentals and building of Electronic Engine Control systems.

c) Prerequisite Courses
NIL

d) Related Courses
Electric Vehicle Technology

e) Course Outcome:
Upon the successful completion of the course, students will be able to:

CO Nos.	Course Outcome	Knowledge Level (Based on revised Bloom's Taxonomy)
CO1	Insight into the significance of the basic electrical and electronic technology incorporated with automotive technology	K2
CO2	Illustrate the need, selection of sensors and actuators and interfacing with ECU.	K2
CO3	Comprehend engine management system and various Ignition and Injection systems	K2
CO4	Explain the automotive control mechanisms	K2
CO5	Acquire knowledge about Bus system in automotive electronics systems	K2

f) Correlation of COs with POs:

COs	PO1	PO2	PO3	PSO1	PSO2
CO1	M	L	M	-	M
CO2	M	L	M	-	L
CO3	L	L	L	L	L
CO4	M	-	-	L	M

CO5	M	-	-	L	M

H- High; M-Medium; L-Low

g) Course Content:

UNIT I BASICS OF ELECTRICAL AND ELECTRONIC PRINCIPLES 9

Safe working practices, Basic electrical principles, Electronic components and circuits, Digital electronics, Microprocessor systems, Measurement, New developments, Diagnostics – electronics, sensors and actuators, Open loop and closed loop control system, New developments in electronic systems.

UNIT II SENSORS AND ACTUATORS 9

Voltage sensor, current sensor, pressure sensor, temperature sensor, air quality measurement sensors, crash sensors, motors, Micromechanical bulk silicon acceleration sensors ,Piezoelectric acceleration sensors,iBolt™ force sensor, Torque sensor, Rain/light sensor, Two-step Lambda oxygen sensors,LSU4 planar wide-band lambda oxygen sensor

UNIT III ENGINE MANAGEMENT SYSTEMS, IGNITION SYSTEMS 9

Introduction - components for engine management system -– Engine cranking and warm up control –Acceleration, deceleration and idle speed control. Advantage of electronic ignition systems–Types of solid state ignition systems and their principles of operation –Electronic spark timing control, Exhaust emission control engineering, Electric vehicles –Components-Plug in Electrical vehicle

UNIT IV AUTOMOTIVE ELECTRONICS SYSTEMS CONTROL MECHANISM 9

Active suspension system Keyless entry system and Electronic power steering system, Electronic controls - lighting design - Horn – Warning systems – Brake actuation warning systems, Infotainment, Electronic management of chassis systems, Vehicle motion control, anti – lock braking system, Tyre pressure monitoring system, Collision avoidance system, Traction control system

UNIT V BUS SYSTEM 9

CAN bus-Applications, Topology, Data transmission system, CAN protocol. LIN bus-Overview, Applications, Data transmission system, LIN protocol. MOST bus- Introduction, Features of the MOST bus. FlexRay,- Overview, Areas of application, Topology, Diagnosis interfaces- Application protocols

Total-45 Hrs

h) Learning Reources

Text books

1. Tom Denton, Automobile Electrical and Electronic Systems, 4th Edition, Butter Worth Heinemann, United States, 2012.
2. Bosch Automotive Electrics and Automotive Electronics, 5th Edition, Springer Vieweg, United States, 2014.
3. Beckwith, T.G, Roy D.Marangoni, John H.Lienhard, Mechanical Measurements, 6th Edition, Addison Wesley, United States, 2011.

References

1. Ernest O Doeblin, Measurement Systems, Application and design, 5th Edition McGraw Hill Book Co., United States, 2013.

2. Holman, J.P, Experimental methods for Engineers, McGraw Hill Book Co., 8th Edition, United States, 2011.
3. Robert Bosch Gmph, Automotive Hand Book, 9th Edition, Wiley, United States, 2014.
4. William, B. Ribbens, Understanding Automotive Electronics, 8th Edition Butter Worth Heinemann, United States, 2014.

Online Resources

1. Open loop and closed loop systems: https://www.electricalengineeringinfo.com/2023/01/closed-loop-control-system.html#google_vignette.
2. Sensors and Actuators: https://managerplus.iofficecorp.com/blog/sensors-actuators
3. Engine Management Systems: https://carbiketech.com/engine-management-system-ems/
4. Automotive Electronics: https://www.edibon.com/en/electronics/automotive-electronics
5. CAN Bus : https://www.csselectronics.com/pages/can-bus-simple-intro-tutorial