CHOICE BASED CREDIT SYSTEM CBCS

M.E. DEGREE EMBEDDED SYSTEM TECHNOLOGIES PROGRAMME

CURRICULUM AND SYLLABI

FOR

I TO IV SEMESTERS

CORE AND ELECTIVE COURSES

FOR THE STUDENTS ADMITTED IN THE

ACADEMIC YEAR 2026-2027 ONWARDS

THIAGARAJAR COLLEGE OF ENGINEERING

(A Government Aided Autonomous Institution affiliated to Anna University)

MADURAI–625015, TAMILNADU

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Department of Electrical and Electronics Engineering

VISION

Transforming the individuals into globally competent electrical engineers to fulfill the technological needs of the society.

MISSION

Establishing world class infrastructure in Electrical Engineering.

Enhancing the knowledge of the faculty in cutting edge technologies through continuous improvement programmes.

Providing well balanced curriculum in graduate, postgraduate and doctoral programmes.

Adopting innovative content delivery, assessment and continuous improvement methods to achieve desired outcomes.

Facilitating industry institution interaction in teaching & learning, consultancy and research activities to accomplish the technological needs of the society.

Encouraging the faculty and students to carry out innovative research work.
Practicing ethical standards by the faculty and students.

Motivating the students for active participation in co-curricular and extracurricular activities.

Programme Educational Objectives (PEOs)

PEO1: Graduates will establish successful professional careers or pursue advanced research in embedded systems, IoT, industrial automation, and cyber-physical systems.

PEO2: Graduates will design and develop innovative embedded solutions for real-world problems in an ethical and sustainable manner.

PEO3: Graduates will exhibit teamwork, communication, and lifelong learning in multidisciplinary professional environments.

Programme Specific Outcomes (PSOs)

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PSO1: Graduates will be able to design and develop embedded systems using embedded controllers, FPGAs/SoCs, and RTOS for industrial and societal applications.

PSO2: Graduates will be able to design and deploy intelligent cyber-physical systems integrating IoT, AI, and security for real-world applications.

M.E. / M.Tech. Programme Structure (CBCS)

Credit Distribution:

S. No.	Category	M.E./M. Tech. Programme Credits	Embedded System Technologies Programme Credits
A	Foundation Course (FC)	03	03
B	Program Core Courses (PCC)	22	22
C	Program Elective Courses (PEC)	18	18
D	Research Methodology and IPR Course (RMC)	03	03
E	Employability Enhancement Course (EEC)	27	27
F	Value Added Courses (VAC) (Non-Credit and not included in CGPA)	4	4
	Minimum Credits to be earned for the award of the Degree	73	73
		Minimum Credits to be earned for the award of the M.E. / M.Tech. Degree Programme	Total credits as per the Curriculum of Embedded System Technologies Programme
		73 (from A to E) and 4 (from F)	73 (from A to E) and 4 (from F)

*TCP and Laboratory courses are mandatory in Programme Core Courses.

Credit Details:
Theory: 3 Credits
Theory cum Practical (TCP): 3 Credits
Laboratory: 2 Credits
Open Elective: 3 Credits
Mini Project: 3 Credits
Project I: 9 Credits
Project II: 15 Credits
Common Core Course: Research Methodology and IPR: 3 Credits.

THIAGARAJAR COLLEGE OF ENGINEERING, MADURAI- 625 015
(A Government Aided Autonomous Institution affiliated to Anna University)

CHOICE BASED CREDIT SYSTEM

Categorization of Courses

Degree: M.E. Programme: Embedded System Technologies Batch: 2026-2027

A. Foundation Courses Total Credits to be earned:03

S. No.	Course Code	Name of the Course	Number of Hours /Week			Credit
			L	T	P	
		THEORY				
1.	26PEFA0	Optimization and Applied Mathematics	2	1	-	3

B. Program Core Courses (PCC) Credits to be earned:22

S. No.	Course Code	Name of the Course	Number of Hours /Week			Credit
			L	T	P	
THEORY						
1	26PECA0	Embedded System Design	3	-	-	3
2	26PECB0	Embedded Processors	3	-	-	3
3	26PECC0	Machine Learning and Deep Learning	3	-	-	3
4	26PECF0	Real Time Operating System	3	-	-	3
THEORY CUM PRACTICAL						
1.	26PECD0	FPGA Based System Design	2	-	2	3
2	26PECG0	IoT Based System Design	2	-	2	3
PRACTICALS						
1.	26PECE0	Embedded Programming Laboratory	-	-	4	2

2.	26PECH0	Embedded Systems Laboratory	-	-	4	2

C. Program Elective Courses (PEC) Credits to be earned: 18

S. No.	Course code	Name of the Course	Number of Hours / Week			Credit
			L	T	P	
1.	26PEPA0	Embedded System Networks	3	-	-	3
2.	26PEPB0	Computer Vision	3	-	-	3
3.	26PEPC0	Embedded Linux	3	-	-	3
4.	26PEPD0	Automotive Systems and Software Architecture	3	-	-	3
5.	26PEPE0	Unmanned Aerial Vehicle	3	-	-	3
6.	26PEPF0	Cloud and Edge Computing	3	-	-	3
7.	26PEPJ0	Embedded Controllers for EV Applications	3	-	-	3
8.	26PEPH0	Cyber Physical Systems	3	-	-	3
9.	26PEPK0	Embedded Systems in Robotics and Automation	3	-	-	3
10.	26PEPL0	Embedded Systems in Smart Grid	3	-	-	3
11.	26PEPM0	Embedded Systems for Biomedical Applications	3	-	-	3
12.	26PEPN0	Entrepreneurship and Embedded Product Development	3	-	-	3
13.	26PEPP0	Embedded Systems Security	3	-	-	3
14.	26PEPQ0	Scripting Languages for Electronic Design Automation	3	-	-	3
15.	26PEPR0	Parallel Processing and Computing	3	-	-	3
16.	26PEPS0	Python Programming for Embedded Systems	3	-	-	3
17.	26PEPT0	Block Chain Technology	3	-	-	3
18.	26PEPU0	Fault Tolerant Systems	3	-	-	3
19.	26PEPV0	Electromagnetic Interference and Compatibility	3	-	-	3

D. Research Methodology and IPR Course (RMC)

S. No.	Course Code	Name of the Course	Number of Hours /Week			Credit	Pre requisite if any
			L	T	P		
1.	26PZRA0	Research Methodology and IPR	3	-	-	3	Nil

E. Mini Project and Dissertation Credits to be earned: 27

Mini Project: 3 Credits
Project I: 9 Credits
Project II: 15 Credits

F. Value added Courses (Not to be included in CGPA)

Credits to be earned: 04 (Mandatory)

S. No.	Course Code	Name of the Course	Number of Hours /Week			Credit	Pre requisite if any
			L	T	P		
1.	26PZVA0	Value Added Course 1	2	-	-	2	Nil
2.	26PZVB0	Value Added Course 2	2	-	-	2	Nil

Minimum credits to be earned for the award of the degree = 73
(From A to E) and 4 from F.

Thiagarajar College of Engineering: Madurai-625 015

Department of Electrical and Electronics Engineering

M.E. - EMBEDDED SYSTEM TECHNOLOGIES

For the students admitted from 2026 - 2027

Scheduling of Courses

Semester	Theory					Theory Cum Practical	Laboratory	VAC	EEC	Credits	
I	26PEFA0 Optimization and Applied Mathematics (3 Credits)	26PECA0 Embedded System Design (3 Credits)	26PECB0 Embedded Processors (3 Credits)	26PECC0 Machine learning and Deep learning (3 Credits)	26PEPX0 Prog. Elective 1 (3 Credits)	26PECD0 FPGA Based System Design (3 Credits)	26PECE0 Embedded Programming Laboratory (2 Credits)		-	A -3 B – 14 C - 3	**20**
II	26PECF0 Real Time Operating Systems (3 Credits)	26PEPX0 Prog. Elective 2 (3 Credits)	26PEPX0 Prog. Elective 3 (3 Credits)	26PZRA0 Research Methodology and IPR (3 Credits)	-	26PECG0 IoT Based System Design (3 Credits)	26PECH0 Embedded Systems Laboratory (2 Credits)	VAC 1	26PEEA0 Mini Project (3 Credits)	B – 8 C – 6 D – 3 E – 3 *F - 2	**20**
III	26PEPX0 Prog. Elective 4 (3 Credits)	26PEPX0 Prog. Elective 5 (3 Credits)	26PEPX0 Prog. Elective 6 (3 Credits)	-	-	-	-	VAC 2	26PEEB0 Project I (9 Credits)	C - 9 E - 9 *F - 2	**18**
IV	-	-	-	-	-	-	-		26PEEC0 Project II (15 Credits)	E - 15	**15**
									Total Credits	73	

A	Foundation Course (FC)
B	Program Core Courses (PCC)
C	Program Elective Courses (PEC)
D	Research Methodology and IPR Course (RMC)
E	Employability Enhancement Course (EEC)
F	Value Added Courses (VAC) (*Non-Credit and not included in CGPA)

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015
M.E (Embedded System Technologies) Degree Programme
COURSES OF STUDY
(For the students admitted in the Academic Year 2026-27 onwards)

FIRST SEMESTER

Course Code	Name of the Course	Category	No. of Hours / Week			Credits
			L	T	P	
THEORY						
26PEFA0	Optimization and Applied Mathematics	FC	2	1	-	3
26PECA0	Embedded System Design	PCC	3	-	-	3
26PECB0	Embedded Processors	PCC	3	-	-	3
26PECC0	Machine learning and Deep learning	PCC	3	-	-	3
26PEPX0	Programme Elective 1	PEC	3	-	-	3
THEORY CUM PRACTICAL						
26PECD0	FPGA Based System Design	PCC	3	-	-	3
PRACTICAL						
26PECE0	Embedded Programming Laboratory	PCC	-	-	4	2
Total						**20**

SECOND SEMESTER

Course Code	Name of the Course	Category	No. of Hours / Week			Credits
			L	T	P	
THEORY						
26PZRA0	Research Methodology and IPR	RMC	3	-	-	3
26PECF0	Real Time Operating Systems	PCC	3	-	-	3
26PEPX0	Programme Elective 1	PEC	3	-	-	3
26PEPX0	Programme Elective 1	PEC	3	-	-	3
THEORY CUM PRACTICAL						
26PECD0	FPGA Based System Design	PCC	3	-	-	3
PRACTICAL						
26PECE0	Embedded Programming Laboratory	PCC	-	-	4	2
PROJECT						
26PEEA0	Mini Project	EEC	-	-	6	3
AUDIT COURSE						
26PZVA0	Value Added Course 1	VAC	2	-	-	0
Total						**20**

L : Lecture   T : Tutorial   P : Practical

Note:
1 Hour Lecture is equivalent to 1 credit
1 Hour Tutorial is equivalent to 1 credit
2 Hours Practical is equivalent to 1 credit

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015
M.E (Communication Systems) Degree Programme
SCHEME OF EXAMINATIONS
(For the candidates admitted from 2026-27 onwards)

FIRST SEMESTER

Course Code	Name of the Course	Duration of End Semester Exam\ in Hrs	Marks			Min. Marks for Pass	
			Conti-nuous Asses-sment	Termi-nal Exam	Max. Marks	Termi-nal Exam	Total
THEORY							
26PEFA0	Optimization and Applied Mathematics	3	40	60	100	27	50
26PECA0	Embedded System Design	3	40	60	100	27	50
26PECB0	Embedded Processors	3	40	60	100	27	50
26PECC0	Machine learning and Deep learning	3	40	60	100	27	50
26PEPX0	Programme Elective 1	3	40	60	100	27	50
THEORY CUM PRACTICAL							
26PECD0	FPGA Based System Design	3	50	50	100	25	50
PRACTICAL							
26PECE0	Embedded Programming Laboratory	3	60	40	100	18	50

SECOND SEMESTER

Course Code	**Name of the Course**	Duration of End Semester Exam\ in Hrs	Marks			Min. Marks for Pass	
			Conti-nuous Asses-sment	Termi-nal Exam	Max. Marks	Termi-nal Exam	Total
THEORY							
26PZRA0	Research Methodology and IPR	3	40	60	100	27	50
26PECF0	Real Time Operating Systems	3	40	60	100	27	50
26PEPX0	Programme Elective 1	3	40	60	100	27	50
26PEPX0	Programme Elective 1	3	40	60	100	27	50
THEORY CUM PRACTICAL							
26PECD0	FPGA Based System Design	3	50	50	100	25	50
PRACTICAL							
26PECE0	Embedded Programming Laboratory	3	60	40	100	18	50
PROJECT							
26PEEA0	Mini Project	-	60	40	100	18	50
AUDIT COURSE							
26PZVA0	Value Added Course 1	-	100	-	100	-	50

26PEFA0	OPTIMIZATION AND APPLIED MATHEMATICS

Category	L	T	P	Credit
BSC	2	1	0	3

1.Preamble:

Optimization and Applied Mathematics course serves as a bridge between foundational mathematics and the robust computational frameworks required in modern engineering, data science, and scientific computing. The curriculum is strategically structured into four core pillars, moving from abstract algebraic structures to practical, high-dimensional numerical optimization.

2.Prerequisite:

- Nil

3.Course Outcome

CO	Course Outcomes	TPS Level	PO	CO Weightage	SDG addressed	SDG Level
CO 1	Determine the basis and dimension of vector spaces	TPS3	PO1	15%	SDG4	2
CO 2	Construct orthonormal bases of a vector space using appropriate methods	TPS3	PO1, PO2	15%	SDG4	2
CO 3	Apply diagonalisation and SVD techniques to solve engineering problems	TPS3	PO1, PO2, PO3	20%	SDG4	2
CO 4	Use matrix factorization techniques such as Cholesky decomposition, QR factorization, least-squares methods and pseudo inverse to solve linear systems	TPS3	PO1, PO2, PO4	20%	SDG4	2
CO 5	Apply numerical techniques to classify and solve second order partial differential equations	TPS3	PO1, PO2, PO5	15%	SDG4	2
CO 6	Apply optimization methods to obtain solutions for constrained and unconstrained problems	TPS3	PO1, PO2, PO3, PO4, PO5	15%	SDG4	2

4.Assessment Pattern

CO	CAT1	Assignment 1	CAT2	Assignment 2	Terminal Exam
	% of Marks	% of Marks	% of Marks	% of Marks	% of Marks
CO1	30	30	-	-	15

CO2	30	30	-	-	15
CO3	40	40	-	-	20
CO4	-	-	40	40	20
CO5	-	-	30	30	15
CO6	-	-	30	30	15
Total	100	100	100	100	100

5.Syllabus

Vector Spaces

Definition and Examples– Subspaces–Linear Independence–-Basis and Dimension–Orthogonal Subspaces–Inner Product Spaces–Orthonormal Sets–Gram-Schmidt Orthogonalization Process.

Advanced Matrix Theory

Eigenvalues and Eigenvectors – Diagonalisation – Singular Value Decomposition – Cholesky decomposition – QR factorization – Least Square Problems – Pseudo inverse.

Numerical solution for partial differential equation

Classification of second order partial differential equation-Solution of Laplace equation – Solution of Poisson equation – Solution of heat equation – Solution of wave equation.

Non Linear Programming Methods

Introduction – Kuhn-Tucker Conditions – Unconstrained Optimization – Steepest Descent method – Fletcher Reeves method

6. Learning Resources

6.1 Text Book

1. Steven J. Leon, "Linear Algebra with Applications", Tenth edition, Pearson Education Limited, 2021.

   Module 1: Chapter 3, Sec 3.1-3.4, Chapter 5, Sec 5.2,5.4 - 5.6
   Module 2: Chapter 6, Sec 6.1,6.3,6.5,6.7(Property VI) Chapter 7, Sec 7.6,7.7

2. B.S. Grewal, " Higher Engineering Mathematics" Khanna publishers, 42^{nd} edition, 2012.

   Module 3: Chapter 33, Sec 33.2,33.5-33.10

3. S.S.Rao, "Engineering Optimization - Theory and Practice", John Wiley and Sons Inc, New Jersey, 5^{th} Edition, 2020

   Module 4: Chapter 2, Sec 2.5.1,2.5.2 Chapter 6, Sec 6.1,6.9,6.10

6.2 Reference Books & Web Resources

1. Erwin Kreszig, "Advanced Engineering Mathematics", Wiley, 10 th edition, 2017.
2. Steven C. Chapra, Raymond P. Canale, "Numerical Methods for Engineers", McGrawHill Higher Education,7th Edition, 2016.
3. Bronson,R, " Matrix Operations, Schaum's Outline Series", McGraw Hill, New York, 2nd edition 2011.
4. Richard L Burden and Douglas J Faires, "Numerical Analysis", Thomas Learning, New York, 2017.
5. Ward Cheney and David Kincaid, "Numerical Mathematics and Computing", Cengage Learning, USA, 2018.

7. Course Contents and Lecture Schedule

Module No.	Topics	No. of Periods
1.	**Vector Spaces**	
1.1	Definition and Examples– Subspaces	2
	Tutorial	1
1.2	Linear Independence–Basis and Dimension	2
	Tutorial	1
1.3	Orthogonal Subspaces–Inner Product Spaces	2
	Tutorial	1
1.4	Orthonormal Sets–Gram-Schmidt Orthogonalization Process.	2
	Tutorial	1
2.	**Advanced Matrix Theory**	
2.1	Eigenvalues and Eigenvectors	2
	Tutorial	1
2.3	Diagonalisation	1
2.4	Singular Value Decomposition	1
	Tutorial	1
2.5	Cholesky decomposition	1
2.6	QR factorization	1
	Tutorial	1
2.7	Least Square Problems	1
2.8	Pseudo inverse	1
	Tutorial	1
3.	**Numerical solution for partial differential equation**	
3.1	Classification of second order partial differential equation & Solution of Laplace equation	1
3.2	Solution of Poisson equation	1
	Tutorial	1
3.3	Solution of heat equation	1
3.4	Solution of wave equation	1
	Tutorial	1
4.	**Non Linear Programming Methods**	
4.1	**Introduction - Kuhn-Tucker Conditions**	1

Module No.	Topics	No. of Periods
4.2	**Unconstrained Optimization**	1
	Tutorial	1
4.3	Steepest Descent method	1
4.4	Fletcher-Reeves method	1
	Tutorial	1
	Total	**36**

8.Course Designer(s):

1. Dr. L. Muthusubramanian Assistant Professor Mathematics lmsmat@tce.edu
2. Dr. I. Pradeepa Assistant Professor Mathematics ipamat@tce.edu
3. Dr. A. Muneesh Kumar Assistant Professor Mathematics amkmat@tce.edu

26PECA0	EMBEDDED SYSTEM DESIGN

Category	L	T	P	Credit
PCC	3	-	-	3

1.Preamble:

Embedded systems are application-specific computing systems used in industrial automation, consumer electronics, automotive systems and IoT applications. Designing embedded systems requires understanding processor architecture, hardware components, firmware development, communication interfaces and optimization techniques. This course covers embedded system characteristics, hardware platforms such as microcontrollers, DSPs, SoCs and ASICs, embedded software design, communication protocols including UART, SPI, I2C, CAN and USB, and design methodologies involving hardware/software partitioning, reliability and power-aware optimization. The course enables students to design efficient and optimized embedded solutions for practical applications.

2.Prerequisite:

- Nil

3.Course Outcome

CO	Course Outcomes	TPS Level	PO	CO Weightage	SDG addressed	SDG Level
CO1	Explain the architecture and design metrics of embedded systems.	TPS2	PO1	10	NC	0
CO2	Describe hardware and software components used in embedded system design.	TPS2	PO1, PO2,	20	NC	0
CO3	Develop embedded system specifications based on application requirements.	TPS3	PO1, PO2, PO3, PO5	20	9	1
CO4	Design interfacing circuits using sensors, actuators and communication peripherals.	TPS3	PO1, PO2, PO3, PO5	20	9	1
CO5	Apply real-time constraints, power and performance trade-offs in embedded systems.	TPS3	PO1, PO2, PO4, PO5	15	7	1
CO6	Analyze design alternatives and propose optimized embedded solutions for practical applications.	TPS4	PO1, PO2, PO3, PO4, PO5, PO6	15	11	1

4.Assessment Pattern

CO	CAT1	Assignment 1	CAT2	Assignment 2	Terminal Exam
	% of Marks	% of Marks	% of Marks	% of Marks	% of Marks
CO1	20				10
CO2	40				20
CO3	40	100			20

CO4			40	40	20
CO5			30	30	15
CO6			30	30	15
Total	100	100	100	100	100

5.Syllabus

Introduction to Embedded Systems

Definition and characteristics of embedded systems – Classification – Design metrics – Application domains – Processor, memory and I/O organization.

Embedded Hardware Design

Microcontrollers, DSPs, SoCs and ASICs – Memory devices – Sensors and actuators – ADC, DAC, timers, watchdog timers – Communication interfaces.

Embedded Software Design

Firmware architecture – Device drivers – Interrupt handling – Scheduling concepts – State machine based design – Embedded C programming.

Communication Protocols

UART, SPI, I2C, CAN, USB, Ethernet – Protocol selection and implementation.

Design Methodology and Optimization

Requirement specification – Hardware/software partitioning – Power-aware design – Reliability and fault tolerance – Case studies.

6. Learning Resources

6.1 Text Book

1. Frank Vahid and Tony Givargis, *Embedded System Design: A Unified Hardware/Software Introduction*, Wiley.
2. Tammy Noergaard, *Embedded Systems Architecture*, Elsevier.
3. Raj Kamal, *Embedded Systems: Architecture, Programming and Design*, McGraw Hill.

6.2 Reference Books & Web Resources

1. Steven W.Smith,"The Scientist and Engineers Guide for Digital Signal Processing", Elsevier 2019.
2. Lyla B Das," Embedded Systems-An Integrated Approach", Pearson 2013
3. Elicia White, "Making Embedded Systems",O'Reilly Series,SPD,2011
4. Bruce Powel Douglass, "Real-Time UML Workshop for Embedded Systems,Elsevier,2011
5. Advanced Computer architecture , By Rajiv Chopra, S Chand , 2010
6. Jorgen Staunstrup, Wayne Wolf, Hardware / Software Co- Design Principles and Practice, Springer, 2009.

7. Shibu.K.V, “Introduction to Embedded Systems”, Tata McGraw Hill,2009
8. Tammy Noergaard, ”Embedded System Architecture, A comprehensive Guide for Engineers and Programmers”, Elsevier, 2006
9. Peckol, “Embedded system Design”,JohnWiley&Sons,2010

7. Course Contents and Lecture Schedule

Module No.	Topics	No of Periods
1	Introduction to Embedded Systems	
1.1	Definition and characteristics of embedded systems	1
1.2	Classification – Design metrics	1
1.3	Application domains – Processor	1
1.4	Memory and I/O organization.	1
2	Embedded Hardware Design	
2.1	Microcontrollers, DSPs	2
2.2	SoCs and ASICs – Memory devices	1
2.3	Sensors and actuators – ADC, DAC, timers, watchdog timers	1
2.4	Communication interfaces.	1
3	Embedded Software Design	
3.1	Firmware architecture – Device drivers	1
3.2	Interrupt handling – Scheduling concepts	1
3.3	State machine based design	1
3.4	Embedded C programming	1
4	Communication Protocols	
4.1	UART	1
4.2	SPI,-I2C	1
4.3	CAN- USB- Ethernet	2
4.4	Protocol selection and implementation	1
5	Design Methodology and Optimization	
5.1	Requirement specification	2
5.2	Hardware/software partitioning	1
5.3	Power-aware design	1
5.4	Reliability and fault tolerance – Case studies	1
	Total Periods	36

8.Course Designer(s):

1. Dr. P.S.Manoharan, Professor, Dept. of EEE, psmeee@tce.edu
2. Dr. D. Kavitha , Associate Professor, Dept. of EEE, dkavitha@tce.edu
3. Dr. P.M.Devie, Assistant Professor, Dept. of EEE , pmdeee@tce.edu

26PECB0	EMBEDDED PROCESSORS

Category	L	T	P	Credit
PCC	3	-	-	3

1.Preamble:

Embedded processors form the computational core of modern embedded systems used in automation, communication, consumer electronics and smart devices. Different processor architectures such as ARM Cortex, AVR, PIC and RISC-V offer varying performance, power and interfacing capabilities for embedded applications. This course introduces embedded processor types, ARM Cortex architecture, registers, instruction sets, interrupts, NVIC, RISC-V architecture and processor interfacing techniques including GPIO, timers, PWM and ADC. The course also covers pipelining, cache memory, benchmarking and power management to help students analyze processor performance and select suitable embedded processors for specific applications.

2. Prerequisite:

- Nil

3.Course Outcome

CO	Course Outcomes	TPS Level	PO	CO Weightage	SDG addressed	SDG Level
CO1	Explain the architecture of modern embedded processors and controllers.	TPS2	PO1	10	NC	0
CO2	Compare ARM, AVR, PIC and RISC-V processor architectures.	TPS2	PO1, PO2	20	NC	0
CO3	Develop assembly and C programs for embedded processors.	TPS3	PO1, PO2, PO3, PO5	20	9	1
CO4	Interface memories and peripherals with embedded processors.	TPS3	PO1, PO2, PO3, PO5	20	9	1
CO5	Analyze processor performance and pipeline behavior.	TPS4	PO1, PO2, PO4, PO5	15	7	2
CO6	Evaluate suitable processors for specific embedded applications.	TPS5	PO1, PO2, PO3, PO4, PO5, PO6	15	11	1

4.Assessment Pattern

CO	CAT1	Assignment 1	CAT2	Assignment 2	Terminal Exam
	% of Marks	% of Marks	% of Marks	% of Marks	% of Marks
CO1	20				10
CO2	40				20
CO3	40	100			20
CO4			40	40	20
CO5			30	30	15

CO6			30	30	15
Total	100	100	100	100	100

5.Syllabus

Embedded Processor Overview
General purpose processors- Microcontrollers - DSP processors - Application specific processors
ARM Cortex Architecture
Architecture - Registers- Instruction set - Assembly programming - Memory map - Exceptions and interrupts - Nested Vectored Interrupt Controller (NVIC)
RISC-V and Advanced Processor Architectures
Architecture - Reduced Instruction Set Computer-V - Instruction Set Architecture (ISA) - Comparison with ARM - Open-source ecosystem
Processor Interfacing
GPIO - Timers - PWM - Analog to Digital Converter - communication peripherals - Programming
Performance Optimization
Pipelining - Cache - Power management - Benchmarking

6. Learning Resources

6.1 Text Book

1. Joseph Yiu, *The Definitive Guide to ARM Cortex-M Processors*, Elsevier.
2. Steve Furber, *ARM System-on-Chip Architecture*, Addison-Wesley.
3. David Patterson and Andrew Waterman, *The RISC-V Reader*, Strawberry Canyon

6.2 Reference Books & Web Resources

1. Shibu K V, ‘Introduction to Embedded Systems’, Second Edition. Tata McGraw Hill Education Pvt.Ltd.,2017.
2. D.P.Kothari, Shriram K.Vasudevan, Embedded Systems, New Age International Publishers, 2012.

7. Course Contents and Lecture Schedule

Module No.	Topics	No of Periods
1	**Embedded Processor Overview**	
1.1	General purpose processors	1
1.2	Microcontrollers	1
1.3	DSP processors	1
1.4	Application specific processors	1
2	**ARM Cortex Architecture**	
2.1	Architecture - Registers	2
2.2	Instruction set - Memory map	1
2.3	Exceptions and interrupts	1
2.4	NVIC	1
3	**RISC-V and Advanced Processor Architectures**	
3.1	Architeture - RISC-V	1
3.2	ISA	1

Module No.	Topics	No of Periods
3.3	Comparison with ARM	1
3.4	Open-source ecosystem	1
4	**Processor Interfacing**	
4.1	GPIO	1
4.2	Timers	1
4.3	PWM - Analog to Digital Converter	2
4.4	communication peripherals	1
5	**Performance Optimization**	
5.1	Pipelining	2
5.2	Cache	1
5.3	Power management	1
5.4	Benchmarking	1
	Total Periods	**36**

8.Course Designer(s):

1 Dr. P.S.Manoharan, Professor, Dept. of EEE psmeee@tce.edu
2. Dr. D. Kavitha , Associate Professor, Dept. of EEE, dkavitha@tce.edu
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26PECC0	MACHINE LEARNING AND DEEP LEARNING

Category	L	T	P	Credit
PCC	3	-	-	3

1.Preamble:

Machine Learning and Deep Learning techniques are widely used in modern engineering applications such as smart grids, electric vehicles, robotics, healthcare, industrial automation and intelligent monitoring systems. These technologies enable systems to learn patterns from data, perform intelligent decision-making and improve automation efficiency. This course introduces fundamental concepts of machine learning, supervised and unsupervised learning techniques, neural networks, deep learning architectures and practical AI model implementation using Python frameworks. The course also emphasizes engineering applications including predictive maintenance, fault diagnosis, computer vision and intelligent control systems.

2.Prerequisite:

- Fundamentals of Mathematics and Statistics

3.Course Outcome

CO	Course Outcomes	TPS Level	PO	CO Weightage	SDG addressed	SDG Level
CO 1	Explain the fundamentals of machine learning and deep learning techniques.	TPS2	PO1	10	9	1
CO 2	Apply data preprocessing and feature engineering techniques for AI model development.	TPS3	PO1, PO2	20	9	1
CO 3	Develop supervised and unsupervised machine learning models for engineering applications.	TPS3	PO1, PO2, PO3	20	9	1
CO 4	Design deep learning architectures using neural networks for intelligent systems.	TPS3	PO1, PO2, PO3, PO5	20	9	1
CO 5	Evaluate the performance of AI models using suitable metrics and optimization techniques.	TPS4	PO2, PO4, PO5	15	11	1
CO 6	Analyze and propose AI-based solutions for real-world industrial and smart system applications.	TPS4	PO1, PO2, PO3, PO4, PO5, PO6	15	9	1

4.Assessment Pattern

CO	CAT1	Assignment 1	CAT2	Assignment 2	Terminal Exam
	% of Marks	% of Marks	% of Marks	% of Marks	% of Marks
CO1	20				10
CO2	40				20

CO3	40	100			20
CO4			40	40	20
CO5			30	30	15
CO6			30	30	15
Total	100	100	100	100	100

5.Syllabus

Introduction to Machine Learning
Artificial Intelligence and Machine Learning concepts – Types of learning – Data preprocessing – Feature engineering – Training and testing datasets – Model evaluation basics.

Supervised Learning Techniques
Linear regression – Logistic regression – Decision trees – Support Vector Machines – Random Forest – Classification and regression applications.

Unsupervised Learning Techniques
Clustering – K-means algorithm – Principal Component Analysis (PCA) – Dimensionality reduction – Association rule mining. Reinforcement learning

Deep Learning Fundamentals
Artificial Neural Networks – Activation functions – Backpropagation – Convolutional Neural Networks (CNN) – Recurrent Neural Networks (RNN) – LSTM networks.

AI Applications and Case Studies
Computer vision – Natural Language Processing – Predictive maintenance – Fault diagnosis in electric vehicles – Smart grid analytics – Industrial AI applications.

6. Learning Resources

6.1 Text Book

1. Ian Goodfellow, Yoshua Bengio and Aaron Courville, Deep Learning, MIT Press.
2. Tom Mitchell, Machine Learning, McGraw Hill Education.
3. Aurélien Géron, Hands-On Machine Learning with Scikit-Learn, Keras and TensorFlow, O'Reilly Publications.

6.2 Reference Books & Web Resources

1. Simon Haykin, Neural Networks and Learning Machines, Pearson Education.
2. Ethem Alpaydin, Introduction to Machine Learning, MIT Press.
3. Christopher Bishop, Pattern Recognition and Machine Learning, Springer.
4. François Chollet, Deep Learning with Python, Manning Publications.
5. NPTEL Online Courses on Machine Learning and Deep Learning.
6. TensorFlow Documentation and Tutorials.
7. Scikit-Learn Official Documentation.
8. Python Libraries Documentation – NumPy, Pandas, Matplotlib.

7. Course Contents and Lecture Schedule

Module No.	Topics	No of Periods
1	**Introduction to Machine Learning**	
1.1	AI and Machine Learning concepts	1
1.2	Types of learning techniques	1
1.3	Data preprocessing and feature engineering	2
1.4	Training, testing and evaluation basics	1
2	**Supervised Learning Techniques**	
2.1	Linear and Logistic Regression	2
2.2	Decision Trees and Random Forest	1
2.3	Support Vector Machines	1
2.4	Classification and regression applications	1
3	**Unsupervised Learning Techniques**	
3.1	Clustering and K-means	2
3.2	Principal Component Analysis	1
3.3	Dimensionality reduction methods	1
3.4	Association rule mining	1
4	**Deep Learning Fundamentals**	
4.1	Artificial Neural Networks	1
4.2	Activation functions and backpropagation	1
4.3	CNN architectures	2
4.4	RNN and LSTM networks	1
5	**AI Applications and Case Studies**	
5.1	Computer vision and NLP	1
5.2	Predictive maintenance and fault diagnosis	2
5.3	Smart grid and EV applications	1
5.4	Industrial AI case studies	1
	Total Periods	**36**

8.Course Designer(s):

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26PECF0	REAL TIME OPERATING SYSTEMS

Category	L	T	P	Credit
PCC	3	-	-	3

Preamble:

Real-Time Operating Systems (RTOS) are widely used in embedded applications that require deterministic timing, multitasking and reliable resource management. RTOS supports efficient task scheduling, synchronization and communication in applications such as robotics, industrial control, automotive electronics and IoT systems. This course covers hard and soft real-time systems, RTOS architecture, task and thread management, scheduling algorithms, priority inversion, semaphores, mutexes, event flags, queues and memory management techniques. The course also introduces software timers, tickless kernels and RTOS platforms such as FreeRTOS, Zephyr, VxWorks and QNX for developing and analyzing real-time embedded applications.

2.Prerequisite:

- Nil

3.Course Outcome

CO	Course Outcomes	TPS Level	PO	CO Weightage	SDG addressed	SDG Level
CO1	Explain the concepts and architecture of real-time operating systems.	TPS2	PO1	10	NC	0
CO2	Describe task management, synchronization and inter-task communication.	TPS2	PO1, PO2	20	NC	0
CO3	Develop multitasking applications using RTOS APIs.	TPS3	PO1, PO2, PO3, PO5	20	9	1
CO4	Implement scheduling, semaphores, queues and timers.	TPS3	PO1, PO2, PO3, PO5	20	NC	0
CO5	Analyze timing behavior and schedulability of real-time systems.	TPS4	PO1, PO2, PO4, PO5	15	7	1
CO6	Select suitable RTOS kernels for embedded applications.	TPS3	PO1, PO2, PO3, PO4, PO5, PO6	15	11	1

4.Assessment Pattern

CO	CAT1	Assignment 1	CAT2	Assignment 2	Terminal Exam
	% of Marks	% of Marks	% of Marks	% of Marks	% of Marks
CO1	20				10
CO2	40				20
CO3	40	100			20
CO4			40	40	20

CO5			30	30	15
CO6			30	30	15
Total	100	100	100	100	100

5.Syllabus

Introduction to Real-Time Systems

Hard and soft real-time systems – Timing constraints – RTOS architecture.

Task Management

Tasks, threads, context switching – Scheduling algorithms – Priority inversion.

Synchronization and Communication

Semaphores, mutexes, event flags, mailboxes, queues.

Memory and Time Management

Dynamic and static memory allocation – Software timers – Tick and tickless kernels.

RTOS Case Studies
Free RTOS, Zephyr, VxWorks and QNX- POSIX – Schedulability analysis

6. Learning Resources

6.1 Text Book

1. Qing Li and Caroline Yao, *Real-Time Concepts for Embedded Systems*, CMP Books.
2. Richard Barry, *Mastering the FreeRTOS Real Time Kernel*, Real Time Engineers Ltd.
3. Jean Labrosse, MicroC/OS-II: The Real-Time Kernel, CMP Books

6.2 Reference Books & Web Resources

1. Silberschatz, Galvin, Gagne “Operating System Concepts”, 6th ed,John Wiley,2003
2. Charles Crowley, “Operating Systems - A Design Oriented approach” McGraw Hill,1997
3. Mukesh Sighal and N G Shi, “Advanced Concepts in Operating System”, McGraw Hill,2000

7. Course Contents and Lecture Schedule

Module No.	Topics	No of Periods
1	**Introduction to Real-Time Systems**	

Module No.	Topics	No of Periods
1.1	Hard real time systems	1
1.2	Soft real time System	1
1.3	Timing constraints	1
1.4	RTOS architecture	1
2	**Task Management**	
2.1	Tasks, threads	2
2.2	context switching	1
2.3	Scheduling algorithms	1
2.4	Priority inversion	1
3	**Synchronization and Communication**	
3.1	Semaphores	1
3.2	, mutexes	1
3.3	event flags	1
3.4	Mailboxes-, queues	1
4	**Memory and Time Management**	
4.1	Dynamic memory allocation	1
4.2	Static memory allocation	1
4.3	Software timers–	2
4.4	Tick and tickless kernels	1
5	**RTOS Case Studies**	
5.1	Free RTOS	1
5.2	Zephyr	1
5.3	VxWorks and QNX, POSIX	2
5.4	Schedulability analysis	1
	Total Periods	**36**

8. Course Designer(s):

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26PECD0	FPGA BASED SYSTEM DESIGN (THEORY CUM PRACTICAL - T)

Category	L	T	P	Credit
PCC	2	-	2	3

1.Preamble:

Field Programmable Gate Arrays (FPGAs) provide reconfigurable hardware platforms for implementing digital systems, communication interfaces and hardware accelerators. FPGA-based systems are extensively used in signal processing, embedded computing, automation and high-speed digital applications. This course covers FPGA architecture, logic blocks, routing resources and FPGA design flow using HDL-based development. The course introduces Verilog/VHDL programming concepts, combinational and sequential circuit design, finite state machines, UART, SPI, PWM and memory interfacing. It also discusses soft-core processors and hardware/software co-design concepts to enable students to implement and evaluate FPGA-based embedded systems.

2.Prerequisite:

- Nil

3.Course Outcome

CO	Course Outcomes	TPS Level	PO	CO Weightage	SDG addressed	SDG Level
CO1	Explain FPGA architecture and design flow.	TPS3	PO1,	15	NC	0
CO2	Describe HDL constructs and synthesis concepts.	TPS3	PO1, PO2,	15	NC	0
CO3	Develop combinational and sequential logic using Verilog/VHDL.	TPS3	PO1, PO2, PO3, PO5	20	9	1
CO4	Implement digital systems and interfaces on FPGA.	TPS3	PO1, PO2, PO3, PO5	15	9	1
CO5	Analyze timing reports and resource utilization.	TPS4	PO1, PO2, PO4, PO5	15	7	1
CO6	Compute FPGA-based solutions for embedded applications.	TPS3	PO1, PO2, PO3, PO4, PO5, PO6	20	11	1

Assessment Pattern

CO	Theory		Practical		Terminal Exam (Theory)
	CAT1	CAT2	OCR/Continuous Assessment	Model Test CO-wise	
	% of Marks	% of Marks	% of Marks	% of Marks	% of Marks
CO1	30				**15**
CO2	30				**15**
CO3	40		30	30	**20**
CO4		30	30	30	**15**
CO5		30	10	10	**15**

CO6		40	30	30	**20**
Total	100	100	100	100	100

Assessment Pattern: Practical Component

Type of Assessment	Component	Marks	Remarks
Continuous Assessment	Pre-lab, In-lab, Post-lab	75	Conducted throughout the semester
Model Test	CO-wise (Cognitive, Psychomotor, Affective)	25	Rubrics covering all Domains of learning
Total Internal Marks		**100**	

5.Syllabus

Programmable Logic to ASICs:

Programmable Read Only Memories (PROMs), Programmable Logic Arrays (PLAs), Programmable Array Logic (PALs), the Masked Gate Array ASIC, CPLDs and FPGAs.

Complex Programmable Logic Devices (CPLDs):

CPLD Architectures, Function Blocks, I/O Blocks, Clock Drivers, Interconnect CPLD Technology and Programmable Elements.

FPGA Architecture and Design Flow:

FPGA-Based System: Design, Goals & techniques, Hierarchical design, Design abstraction, Methodologies.

FPGA Fabrics:
FPGA Architectures, SRAM-Based FPGAs, Characteristics of SRAM-Based FPGAs, Characteristics of SRAM-Based FPGAs, Logic elements & Interconnections networks, Chip I/O, Circuit Design of FPGA Fabrics.

HDL Fundamentals

Modules, operators, data types, procedural statements, test benches.

Sequential and FSM Design

Registers, counters, finite state machines.

SoC and Hardware Acceleration

Soft-core processors – SoC interconnect - Hardware/software co-design.

Tentative List of Experiments (24 Hours)

1. Construct digital circuits such as,

   a. Synchronous Counters
   b. Ripple counters
   c. 4 –Bit adder and Subtractor
   d. Code Converters
   e. MUX, DEMUX, Encoder and decoder
2. Design FPGA based real time application such as,
   a. Digital signal processing
   b. Motor Control

6. Learning Resources

6.1 Text Book

1. Pong P. Chu, *FPGA Prototyping by Verilog Examples*, Wiley.
2. Stephen Brown and Zvonko Vranesic, *Fundamentals of Digital Logic with Verilog Design*, McGraw Hill.
3. Clive Maxfield, *The Design Warrior's Guide to FPGAs*, Elsevier

6.2 Reference Books & Web Resources

1. Michael D. Ciletti, "Advanced Digital Design with Verilog HDL", Second Edition, Pearson Higher Education, 2011.
2. Stephen Brown and Zvonko Vranesic, "Fundamental of Digital Logic with VHDL Design", Third Edition, McGraw Hill, 2009

7. Course Contents and Lecture Schedule

Module No.	Topics	No of Periods
1	**Programmable Logic to ASICs:**	
1.1	Programmable Read Only Memories (PROMs),	1
1.2	Programmable Logic Arrays (PLAs), Programmable Array Logic (PALs),	2
1.3	Masked Gate Array ASIC, CPLDs and FPGAs.	1
2	**Complex Programmable Logic Devices (CPLDs):**	
2.1	CPLD Architectures, Function Blocks	2
2.2	/O Blocks, Clock Drivers	1
2.3	Interconnect CPLD Technology and Programmable Elements.	1
3	**FPGA Fabrics:**	
3.1	FPGA Architectures, SRAM-Based FPGAs, Characteristics of SRAM-Based FPGAs	1
3.2	, Logic elements & Interconnections networks, Chip I/O	2
3.3	Circuit Design of FPGA Fabrics.	2
4	**HDL Fundamentals**	
4.1	Modules, operators, data types,	2
4.2	procedural statements	2
4.3	test benches.	1

5	**Sequential and FSM Design**	
5.1	Registers	1
5.2	Counters	1
5.3	finite state machines	1
6	**SoC and Hardware Acceleration**	
6.1	Soft-core processors	2
6.2	SoC interconnect ,	1
6.3	Hardware software co-design	1
		24

List of Experiments with CO Mapping

Sl. No.	Name of the Experiment	Level of Experimen t	Objective(s)	COs Addressed
1	Modeling and Simulation of Basic Combinational Circuits (Half Adder, Full Adder, Multiplexer, Decoder) using Verilog/VHDL	Level 1	Instrumentation, Models, Experimentation, Psychomotor Skills	CO3
2	Design and Simulation of Sequential Circuits (D Flip-Flop, Register, Counter) using Verilog/VHDL	Level 2	Models, Experimentation, Data Analysis, Learn from Failure	CO3
3	FPGA Implementation of Combinational Logic with LED and Switch Interface	Level 2	Design, Psychomotor Skills, Safety, Communication	CO4
4	FPGA-Based Seven-Segment Display Interface for Counter Application	Level 2	Design, Experimentation, Communication, Creativity	CO4
5	UART Interface Design and FPGA Implementation	Level 3	Design, Teamwork, Communication, Ethics & Integrity	CO4
6	Timing Analysis and Resource Utilization Study using Synthesis Reports	Level 2	Data Analysis, Models, Communication	CO5
7	Optimization of Logic Design to Reduce Delay and Resource Usage	Level 3	Creativity, Learn from Failure, Data Analysis, Design	CO5
8	Mini Project: FPGA-Based Embedded Application (Traffic Light Controller / Digital Clock / Sensor Interface)	Level 3	Design, Creativity, Teamwork, Communication, Ethics & Integrity, Safety	CO6

8.Course Designer(s):

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26PECG0	IOT BASED SYSTEM DESIGN (THEORY CUM PRACTICAL - P)

Category	L	T	P	Credit
PCC	2	-	2	3

1.Preamble:

Internet of Things (IoT) enables interconnected devices to sense, process and exchange data through wireless communication and cloud platforms for intelligent monitoring and control applications. IoT systems are widely used in smart homes, industrial automation, healthcare, agriculture and smart city applications. This course covers IoT architecture, edge, fog and cloud computing, sensor interfacing and communication technologies such as Wi-Fi, BLE, LoRa and Zigbee. The course also introduces application protocols including MQTT, CoAP, HTTP and WebSockets, cloud integration using ThingSpeak, AWS IoT and Azure IoT, and security concepts such as authentication and encryption for industrial IoT applications.

2.Prerequisite:

- Nil

3.Course Outcome

CO	Course Outcomes	TPS Level	PO	CO Weightage	SDG addressed	SDG Level
CO1	Explain IoT architecture, protocols and enabling technologies.	TPS2	PO1, PO2, PO5	15	NC	0
CO2	Describe sensor networks, cloud platforms and edge computing concepts.	TPS2	PO1, PO2, PO5	15	NC	0
CO3	Develop embedded IoT nodes using sensors and wireless modules.	TPS3	PO1, PO2, PO3, PO5	20	9	1
CO4	Implement data acquisition, visualization and remote control applications.	TPS3	PO1, PO2, PO3, PO5	15	NC	0
CO5	Analyze communication performance, power and security issues.	TPS4	PO1, PO2, PO4, PO5	15	7	1
CO6	Design IoT solutions for industrial and smart applications.	TPS3	PO1,PO2, PO3,PO4, PO5, PO6	20	9	1

Assessment Pattern

CO	Theory		Practical		Terminal Exam (Practicals)
	CAT1	CAT2	OCR/Continuous Assessment	Model Test CO-wise	
	% of Marks	% of Marks	% of Marks	% of Marks	% of Marks
CO1	**30**				
CO2	**30**				

CO3	**40**		**30**	**30**	**30**
CO4		**30**	**30**	**30**	**30**
CO5		**30**	10	10	10
CO6		**40**	30	30	30
Total	100	100	100	100	100

Assessment Pattern: Practical Component

Type of Assessment	Component	Marks	Remarks
Continuous Assessment	Pre-lab, In-lab, Post-lab	75	Conducted throughout the semester
Model Test	CO-wise (Cognitive, Psychomotor, Affective)	25	Rubrics covering all Domains of learning
Total Internal Marks		**100**	
End Semester Examination	CO-wise (Cognitive, Psychomotor, Affective)	100	Rubrics covering all Domains of learning

5.Syllabus

IoT Fundamentals

Architecture – Edge, fog and cloud computing – IoT applications.

Sensors and Connectivity

Sensor interfacing – Wi-Fi, BLE, LoRa, Zigbee.

Application Protocols

MQTT, CoAP, HTTP, WebSockets.

Cloud Integration

ThingSpeak, AWS IoT, Azure IoT, Node-RED dashboards.

Security and Case Studies

Authentication, encryption and industrial IoT applications

List of Experiments: (24 hours) (Arduino, ESP32, Raspberry pi based)

1 Interfacing Temperature and Humidity Sensor with ESP32/NodeMCU and Displaying Data Locally
2 Wireless Transmission of Sensor Data using Wi-Fi/Bluetooth and MQTT
3 IoT Node Development with Multiple Sensors (DHT11 + LDR + PIR)
4 Data Acquisition and Upload to Cloud Platform (e.g., ThingSpeak)
5 Real-Time Data Visualization Dashboard and Alert Generation
6 Remote Control of LED/Relay using Mobile App or Web Interface
7 Measurement of Communication Performance (Latency, Packet Loss, Throughput)
8 Secure IoT Communication using Authentication and API Keys
9 Mini Project

6. Learning Resources

6.1 Text Book

1. Arshdeep Bahga and Vijay Madisetti, *Internet of Things: A Hands-On Approach*, Universities Press.
2. Olivier Hersent, David Boswarthick and Omar Elloumi, *The Internet of Things*, Wiley.
3. Raj Kamal, *Internet of Things*, McGraw Hill.

6.2 Reference Books & Web Resources

1. Donald Norris, “The Internet of Things-Do -It-Yourself at Home Projects for Arduino, Raspberry Pi, and BeagleBone Black”, MC Graw Hill Education,2015.
2. Dragan Ibrahim, The complete ESP32 Projects Guide, Elektor Publishers, 2019.
3. Peter Waher “Learning Internet of Things”, PacktPublishing,UK, 2015.
4. Miguel de Sousa ”,Internet of Things with Intel Galileo” ”, PacktPublishing,UK, 2015
5. Marco Schwartz, “Internet of Things with the Arduino Yun”, Packt Publishing, 2014.
6. Adrian McEwen, Hakim Cassimally “Designing the Internet of Things”,WileyPublishing, 2015

7. Course Contents and Lecture Schedule

Module No.	Topics	No of Periods
1	**IoT Fundamentals**	
1.1	Architecture	1
1.2	Edge	1
1.3	Fog and cloud computing	1
1.4	IoT applications	1
2	**Sensors and Connectivity**	
2.1	Sensor interfacing	2
2.2	Wi-Fi	1
2.3	BLE	1
2.4	LoRa	1
2.5	Zigbee	1
3	**Application Protocols**	
3.1	MQTT	1
3.2	CoAP	1
3.3	HTTP	1
3.4	WebSockets	1
4	**Cloud Integration**	
4.1	ThingSpeak	1
4.2	AWS IoT	1
4.3	Azure IoT	1
4.4	Node-RED dashboards	2
5	**Security and Case Studies**	
5.1	Authentication	2
5.2	Encryption	1
5.3	Industrial IoT applications	1
	Tutorial	1
	Total Periods	**24**

List of Experiments with CO Mapping

S. No.	Name of the Experiment	Level of Experiment	Objective(s)	COs Addressed
1	Interfacing Temperature and Humidity Sensor with ESP32/NodeMCU and Displaying Data Locally	Level 1	Instrumentation, Experimentation, Psychomotor Skills, Safety	CO3
2	Wireless Transmission of Sensor Data using Wi-Fi/Bluetooth and MQTT	Level 2	Models, Experimentation, Communication, Design	CO3
3	IoT Node Development with Multiple Sensors (DHT11 + LDR + PIR)	Level 2	Design, Data Analysis, Creativity, Learn from Failure	CO3
4	Data Acquisition and Upload to Cloud Platform (e.g., ThingSpeak)	Level 2	Experimentation, Communication, Data Analysis	CO4
5	Real-Time Data Visualization Dashboard and Alert Generation	Level 2	Data Analysis, Communication, Design	CO4
6	Remote Control of LED/Relay using Mobile App or Web Interface	Level 3	Design, Teamwork, Communication, Ethics & Integrity	CO4
7	Measurement of Communication Performance (Latency, Packet Loss, Throughput)	Level 2	Data Analysis, Models, Communication	CO5
8	Secure IoT Communication using Authentication and API Keys	Level 3	Ethics & Integrity, Communication, Learn from Failure	CO5
9	Mini Project: Smart Industrial/Smart City IoT Application (e.g., Smart Energy Meter, Smart Agriculture, Smart Parking)	Level 3	Design, Creativity, Teamwork, Communication, Safety, Ethics & Integrity	CO6

8.Course Designer(s):

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26PECE0	EMBEDDED PROGRAMMING LABORATORY

Category	L	T	P	Credit
PCC	0	0	4	2

1.Preamble:

Embedded programming is essential for implementing real-time control, sensing and communication functions in embedded systems. Practical knowledge of embedded C programming, peripheral interfacing and debugging techniques is necessary for developing reliable embedded applications. This laboratory course provides hands-on experience in IDE setup, GPIO programming, timer and interrupt handling, ADC interfacing, PWM generation, UART, SPI and I2C communication, display interfacing and motor control applications. The course also includes data logging and mini project development, enabling students to design, debug and evaluate embedded firmware solutions for real-world application

2.Prerequisite:

- Nil

3.Course Outcome

CO	Course Outcomes	TPS Level	PO	CO Weightage	SDG addressed	SDG Level
CO1	Analyze 8 bit microcontroller based assembly language programs and embedded 'C' programs to implement basic operations by software tools.	TPS4	PO1, PO2, PO5	10	NC	0
CO2	Analyze embedded 'C' programs of 8 -bit microcontroller for accessing on-chip hardware units such as timer/counter, interrupts and serial communication.	TPS4	PO1, PO2, PO5	15	9	1
CO3	Interface keypad, sensors, actuators and displays.	TPS4	PO1, PO2, PO3, PO5	20	9	1
CO4	Implement interrupt-driven and communication-based applications.	TPS4	PO1, PO2, PO3, PO5	20	9	1
CO5	Interface ADC/DAC for data conversion.	TPS4	PO1, PO2, PO5	15	9	1
CO6	Develop complete microcontroller based solutions for real-world applications.	TPS4	PO1, PO2, PO3, PO4, PO5, PO6	20	9	1

Assessment Pattern: Cognitive Domain

Type of Assessment	Component	Marks	Remarks
Continuous Assessment	Pre-lab, In-lab, Post-lab	75	Conducted throughout the semester
Model Test	CO-wise (Cognitive, Psychomotor, Affective)	25	Mid/End semester internal test
Total Internal Marks		**100**	
End Semester Examination	CO-wise (Cognitive, Psychomotor, Affective)	100	As directed by COE or as per curriculum

List of Experiments with CO Mapping

S. No.	Name of the Experiment	Level of Experiment	Objective(s)	COs Addressed
1.	Study of Integrated Development Environment (IDE) and Basic Assembly Language Programming of 8-bit microcontroller	Level 1	Instrumentation, Experimentation, Psychomotor Skills, Safety	CO1
2.	Embedded C Program for Arithmetic and Logical Operations	Level 1	Models, Experimentation, Communication	CO1
3.	LED Interfacing and Pattern Generation	Level 1	Instrumentation, Psychomotor Skills, Safety	CO1
4.	Push Button and Switch Interfacing	Level 1	Experimentation, Sensory Awareness, Learn from Failure	CO1
5.	Timer/Counter Programming for Delay Generation and Event Counting	Level 2	Models, Data Analysis, Experimentation	CO2
6.	Interrupt Programming for External Event Handling	Level 2	Models, Learn from Failure, Communication	CO2
7.	UART Serial Communication with PC	Level 2	Instrumentation, Communication, Ethics & Integrity	CO2
8.	Matrix Keypad Interfacing and Debounce Analysis	Level 2	Experimentation, Data Analysis, Creativity	CO3
9.	LCD Interfacing for Dynamic Message Display	Level 2	Psychomotor Skills, Communication, Design	CO3

S. No.	Name of the Experiment	Level of Experiment	Objective(s)	COs Addressed
10.	Seven-Segment Display Interfacing and Multiplexing	Level 2	Models, Experimentation, Communication	CO3
11.	Sensor Interfacing (LM35/LDR) and Data Acquisition	Level 2	Instrumentation, Data Analysis, Design	CO3
12.	Relay/Buzzer/DC Motor Interfacing	Level 2	Design, Psychomotor Skills, Safety	CO3
13.	Interrupt-Driven Real-Time Counter or Alarm System	Level 3	Design, Learn from Failure, Communication	CO4
14.	Serial Communication Based Embedded System (PC-to-MCU Command Processing)	Level 3	Design, Communication, Teamwork	CO4
15.	ADC Interfacing for Analog Signal Measurement	Level 2	Instrumentation, Data Analysis, Sensory Awareness	CO5
16.	DAC/PWM Interfacing for Waveform Generation and Actuator Control	Level 2	Models, Experimentation, Creativity	CO5
17.	Mini Project: Real-Time Microcontroller-Based Application Development	Level 3	Design, Creativity, Teamwork, Communication, Ethics & Integrity	CO6

Course Designer(s):

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26PECH0	EMBEDDED SYSTEMS LABORATORY

Category	L	T	P	Credit
PCC	0	0	4	2

Preamble

An embedded system is a computer system with a dedicated function present within a larger electrical or electronics or mechanical system, often with real-time computing constraints. An embedded system is some combination of computer hardware and software, either fixed in capability or programmable, that is specifically designed for a particular function. Industrial machines, automobiles, medical equipments, digital cameras, household appliances, airplanes, vending machines, toys, cellular phone and PDA are among the numerous possible hosts of an embedded system. Embedded systems that are programmable are provided with programming interfaces. In order to meet real time constraints, most of the embedded systems use a real-time operating system (RTOS). This course introduces the architecture, design and development process of embedded systems. The architecture and programming of ARM Cortex M4 microcontrollers (STM32407xx, TM4C123) are covered in this course.

Prerequisite

26PE170 – Embedded Programming laboratory

Course Outcomes

CO	Course Outcomes	TPS Level	PO	CO Weightage	SDG addressed	SDG Level
CO1	Develop Embedded C programs for interfacing LED, LCD, Keyboard, 7-segment display with STM32407xx Microcontroller	TPS 4	PO1, PO2, PO5	20	9 - Resilient infrastructure and innovation	1
CO2	Develop Embedded C programs for interfacing ADC, DAC with STM32407xx Microcontroller	TPS 4	PO1, PO2, PO5	15	9	1
CO3	Develop Embedded C programs for interfacing Sensor modules with TM4C123 Microcontroller.	TPS 4	PO1, PO2, PO3, PO5	15	9	1
CO4	Develop Embedded C programs for interfacing Bluetooth, Zigbee, with TM4C123 Microcontroller.	TPS 4	PO1, PO2, PO3, PO5	20	9	2
CO5	Simulate RTOS for Creation of Simple Task, Priority Assignment, Queues, Mutex and Semaphore and Software Timers	TPS 4	PO1, PO2, PO4, PO5	20	NC	0
CO6	Develop embedded systems applications to solve real time problems	TPS 4	PO1, PO2, PO3, PO4, PO5, PO6	10	9	2

Assessment Pattern: Cognitive Domain

Type of Assessment	Component	Marks	Remarks
Continuous Assessment	Pre-lab, In-lab, Post-lab	75	Conducted throughout the semester
Model Test	CO-wise (Cognitive, Psychomotor, Affective)	25	Mid/End semester internal test
Total Internal Marks		**100**	
End Semester Examination	CO-wise (Cognitive, Psychomotor, Affective)	100	As directed by COE or as per curriculum

List of Experiments with CO Mapping

S. No.	Name of the Experiment	Level of Experiment	Objective(s)	COs Addressed
1	LED Interfacing and Pattern Generation using STM32F407xx	Level 1	Instrumentation, Experimentation, Psychomotor Skills, Safety	CO1
2	7-Segment Display Interfacing for Decimal Counter and Multiplexing	Level 1	Models, Experimentation, Data Analysis, Communication	CO1
3	Matrix Keyboard Interfacing and Debounce Analysis	Level 2	Instrumentation, Models, Learn from Failure, Creativity	CO1
4	LCD Interfacing for Dynamic Message Display and Sensor Data Visualization	Level 2	Experimentation, Communication, Psychomotor Skills	CO1
5	ADC Interfacing for Potentiometer and Analog Signal Measurement	Level 2	Instrumentation, Data Analysis, Sensory Awareness	CO2
6	DAC Interfacing for Waveform Generation and Verification	Level 2	Models, Experimentation, Data Analysis, Creativity	CO2
7	Temperature Sensor (LM35/TMP36) Interfacing with TM4C123	Level 2	Instrumentation, Data Analysis, Design	CO3
8	Ultrasonic Sensor Interfacing for Distance Measurement	Level 2	Experimentation, Models, Learn from Failure	CO3
9	Bluetooth Communication with Smartphone for Device Control	Level 2	Design, Communication, Teamwork	CO4
10	Zigbee-Based Wireless Data Transmission	Level 3	Design, Communication,	CO4

S. No.	Name of the Experiment	Level of Experiment	Objective(s)	COs Addressed
			Creativity, Ethics & Integrity	
11	FreeRTOS Task Creation and Scheduler Observation	Level 1	Models, Experimentation, Communication	CO5
12	Priority Assignment and Task Preemption Analysis	Level 2	Data Analysis, Learn from Failure, Design	CO5
13	Inter-Task Communication using Queues	Level 2	Design, Teamwork, Communication	CO5
14	Synchronization using Mutexes and Binary Semaphores	Level 2	Learn from Failure, Ethics & Integrity, Teamwork	CO5
15	Software Timers for Periodic Task Execution	Level 2	Models, Experimentation, Creativity	CO5
16	Mini Project: Real-Time Embedded System Application Development	Level 3	Design, Creativity, Communication, Teamwork, Safety, Ethics & Integrity	CO6

Course Designer(s):

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26PEPE0	UNMANNED AERIAL VEHICLE

Category	L	T	P	Credit
PCC	3	-	-	3

1. Preamble:

Unmanned Aerial Vehicles (UAVs) have emerged as an important technology in applications such as surveillance, agriculture, mapping, disaster management, inspection, logistics and defense systems. UAV systems integrate aerodynamics, embedded control, communication systems, sensors and intelligent navigation technologies for autonomous operation. This course introduces UAV architecture, flight dynamics, propulsion systems, embedded flight controllers, navigation techniques, communication systems and autonomous drone applications. The course enables students to understand and develop intelligent UAV systems for modern engineering applications.

2.Prerequisite:

- Basics of Embedded Systems
- Fundamentals of Control Systems

3.Course Outcome

CO	Course Outcomes	TPS Level	PO	CO Weightage	SDG addressed	SDG Level
CO1	Explain the architecture and operating principles of UAV systems.	TPS2	PO1	10	9	1
CO2	Describe UAV components, sensors and propulsion systems.	TPS2	PO1, PO2	20	9	1
CO3	Develop embedded control and navigation systems for UAV applications.	TPS3	PO1, PO2, PO3	20	9	1
CO4	Design communication and autonomous flight systems for UAVs.	TPS3	PO1, PO2, PO3, PO5	20	9	1
CO5	Apply UAV technologies for industrial and smart monitoring applications.	TPS3	PO1, PO2, PO4, PO5	15	11	1
CO6	Analyze UAV system performance and propose intelligent drone solutions for real-world applications.	TPS4	PO1, PO2, PO3, PO4, PO5, PO6	15	9	1

4.Assessment Pattern

CO	CAT1	Assignment 1	CAT2	Assignment 2	Terminal Exam
	% of Marks	% of Marks	% of Marks	% of Marks	% of Marks
CO1	20				10
CO2	40				20
CO3	40	100			20

CO4			40	40	20
CO5			30	30	15
CO6			30	30	15
Total	100	100	100	100	100

5.Syllabus

Introduction to UAV Systems

History and evolution of UAVs – Types of UAVs – UAV architecture – Applications of UAVs – Regulatory and safety aspects.

UAV Components and Propulsion Systems

Frames and structures – Motors and ESCs – Propellers – Batteries – Power systems – Sensors and actuators – Flight controllers.

Flight Dynamics and Navigation

Aerodynamics of UAVs – Stability and control – PID control – Sensor fusion – GPS navigation – Path planning techniques.

Communication and Autonomous Systems

Telemetry systems – Wireless communication – RF communication – Autonomous flight control – Obstacle avoidance – Ground control stations.

UAV Applications and Case Studies

Agriculture drones – Surveillance systems – Mapping and inspection – Disaster management – AI-enabled drones – Industrial case studies.

6. Learning Resources

6.1 Text Book

1. Randal W. Beard and Timothy W. McLain, Small Unmanned Aircraft: Theory and Practice, Princeton University Press.
2. Kimon P. Valavanis and George J. Vachtsevanos, Handbook of Unmanned Aerial Vehicles, Springer.
3. Paul Fahlstrom and Thomas Gleason, Introduction to UAV Systems, Wiley.

6.2 Reference Books & Web Resources

1. Austin Reg, Unmanned Aircraft Systems: UAV Design, Development and Deployment, Wiley.
2. Robert C. Nelson, Flight Stability and Automatic Control, McGraw Hill.

3. Raj Kamal, Embedded Systems: Architecture, Programming and Design, McGraw Hill.
4. NPTEL Courses on UAVs and Drone Technology.
5. PX4 and ArduPilot Open Source Documentation.
6. DGCA UAV Regulations and Drone Guidelines.
7. IEEE Journals on UAV Systems and Autonomous Navigation.
8. MATLAB and Simulink UAV Toolbox Documentation.

7. Course Contents and Lecture Schedule

Module No.	Topics	No of Periods
1	**Introduction to UAV Systems**	
1.1	History and evolution of UAVs	1
1.2	Types and architecture of UAVs	1
1.3	UAV applications and classifications	2
1.4	Regulatory and safety aspects	1
2	**UAV Components and Propulsion Systems**	
2.1	UAV frames and structures	1
2.2	Motors, ESCs and propellers	2
2.3	Batteries and power systems	1
2.4	Sensors, actuators and flight controllers	1
3	**Flight Dynamics and Navigation**	
3.1	Aerodynamics of UAVs	1
3.2	Stability and control systems	2
3.3	PID control and sensor fusion	1
3.4	GPS navigation and path planning	1
4	**Communication and Autonomous Systems**	
4.1	Telemetry and RF communication	1
4.2	Wireless communication systems	1
4.3	Autonomous flight control	2
4.4	Obstacle avoidance and ground control stations	1
5	**UAV Applications and Case Studies**	
5.1	Agriculture and surveillance drones	1
5.2	Mapping and inspection applications	2
5.3	Disaster management systems	1
5.4	AI-enabled UAV case studies	1
	Total Periods	**36**

8.Course Designer(s):

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26PEPF0	CLOUD AND EDGE COMPUTING

Category	L	T	P	Credit
PCC	3	-	-	3

1. Preamble:

Cloud and Edge Computing are transforming modern computing infrastructures by enabling scalable data processing, intelligent analytics, low-latency communication and distributed application deployment. Cloud platforms provide centralized computing, storage and service-oriented architectures, while edge computing brings computational intelligence closer to devices and users for real-time applications. These technologies play a vital role in IoT systems, smart cities, autonomous systems, industrial automation and AI-enabled applications. This course introduces cloud computing architectures, virtualization, edge and fog computing, containerization, distributed systems, security and real-world applications. Students will gain knowledge to design and deploy intelligent cloud-edge solutions for modern engineering applications.

2.Prerequisite:

- Basics of Computer Networks

3.Course Outcome

CO	Course Outcomes	TPS Level	PO	CO Weightage	SDG Addressed	SDG Level
CO1	Explain cloud computing architecture, services and deployment models.	TPS2	PO1	15	9	1
CO2	Describe virtualization, containerization and distributed computing concepts.	TPS2	PO1, PO2	20	9	1
CO3	Develop cloud-based applications and storage solutions for IoT systems.	TPS3	PO1, PO2, PO3	20	9	1
CO4	Design edge and fog computing architectures for real-time applications.	TPS3	PO1, PO2, PO3, PO5	20	9	1
CO5	Apply security, privacy and resource management techniques in cloud-edge environments.	TPS3	PO1, PO2, PO4, PO5	10	11	1
CO6	Analyze and propose intelligent cloud-edge solutions for industrial and smart infrastructure applications.	TPS4	PO1, PO2, PO3, PO4, PO5, PO6	15	9	1

4.Assessment Pattern

CO	CAT1	Assignment 1	CAT2	Assignment 2	Terminal Exam
	% of Marks	% of Marks	% of Marks	% of Marks	% of Marks
CO1	30				15
CO2	30	50			20

CO3	40	50			20
CO4			40	40	20
CO5			30	30	10
CO6			30	30	15
Total	100	100	100	100	100

5.Syllabus

Introduction to Cloud Computing

Cloud computing concepts – Evolution of cloud computing – Cloud architecture – Service models (IaaS, PaaS, SaaS) – Deployment models – Virtualization and hypervisors.

Distributed and Virtualized Computing

Distributed systems – Virtual machines – Containerization using Docker – Kubernetes basics – Resource management – Cloud storage and databases.

Edge and Fog Computing

Edge computing architecture – Fog computing concepts – Edge devices and gateways – Real-time analytics – Latency-sensitive applications – Edge AI.

Cloud-Edge Integration and IoT

IoT-cloud integration – Data acquisition and streaming – Big data processing – Serverless computing – Smart applications using cloud-edge platforms.

Security and Applications of Cloud-Edge Systems

Cloud security and privacy – Authentication and access control – Reliability and fault tolerance – Smart city applications – Industrial IoT – Autonomous systems and healthcare applications.

6. Learning Resources

6.1 Text Book

1. Kai Hwang, Geoffrey Fox and Jack Dongarra, *Distributed and Cloud Computing*, Morgan Kaufmann.
2. Rajkumar Buyya, Christian Vecchiola and S. Thamarai Selvi, *Mastering Cloud Computing*, McGraw Hill.
3. Perry Lea, *Internet of Things for Architects*, Packt Publishing.

6.2 Reference Books & Web Resources

1. David E. Y. Sarna, *Implementing and Developing Cloud Computing Applications*, CRC Press.

2. Flavio Bonomi et al., *Fog Computing and Its Role in the Internet of Things*, ACM Publications.
3. Michael J. Kavis, *Architecting the Cloud*, Wiley.
4. NPTEL Courses on Cloud Computing and Edge Computing.
5. AWS, Microsoft Azure and Google Cloud Documentation.
6. Docker and Kubernetes Official Documentation.
7. IEEE Journals on Cloud and Edge Computing.

8. Course Contents and Lecture Schedule

Module No.	Topics	No. of Periods
1	Introduction to Cloud Computing	
1.1	Evolution and concepts of cloud computing	1
1.2	Cloud architecture and service models	2
1.3	Deployment models and virtualization	1
1.4	Hypervisors and cloud platforms	1
2	Distributed and Virtualized Computing	
2.1	Distributed computing concepts	1
2.2	Virtual machines and storage systems	2
2.3	Containerization and Docker	1
2.4	Kubernetes and orchestration basics	1
3	Edge and Fog Computing	
3.1	Edge computing architecture	1
3.2	Fog computing frameworks	1
3.3	Real-time analytics and edge AI	2
3.4	Resource optimization techniques	1
4	Cloud-Edge Integration and IoT	
4.1	IoT-cloud communication	1
4.2	Data streaming and processing	1
4.3	Serverless computing concepts	2
4.4	Smart applications and case studies	1
5	Security and Applications	
5.1	Security and privacy in cloud-edge systems	1
5.2	Reliability and fault tolerance	1
5.3	Industrial IoT and smart city applications	2
5.4	AI-enabled cloud-edge applications	1
	Total Periods	**36**

8.Course Designer(s):

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26PEPH0	CYBER PHYSICAL SYSTEMS

Category	L	T	P	Credit
PCC	3	-	-	3

1. Preamble:

Cyber Physical Systems (CPS) integrate computation, communication, networking and physical processes to enable intelligent automation and real-time control in modern engineering systems. CPS technologies are widely used in smart grids, industrial automation, healthcare systems, autonomous vehicles, robotics and smart infrastructure. This course introduces CPS architecture, embedded computing, sensing and actuation, communication networks, real-time control, IoT integration and cybersecurity aspects. The course enables students to develop intelligent and reliable CPS solutions for industrial and smart system applications.

2.Prerequisite:

- Basics of Embedded Systems
- Fundamentals of Communication Networks

3.Course Outcome

CO	Course Outcomes	TPS Level	PO	CO Weightage	SDG addressed	SDG Level
CO1	Explain the architecture and components of Cyber Physical Systems.	TPS2	PO1	10	9	1
CO2	Describe sensing, actuation and embedded computing techniques used in CPS.	TPS2	PO1, PO2	20	9	1
CO3	Develop communication and networking systems for CPS applications.	TPS3	PO1, PO2, PO3	20	9	1
CO4	Design real-time monitoring and control systems for cyber physical applications.	TPS3	PO1, PO2, PO3, PO5	20	9	1
CO5	Apply cybersecurity and reliability concepts in CPS environments.	TPS3	PO1, PO2, PO4, PO5	15	11	1
CO6	Analyze and propose intelligent CPS solutions for industrial automation and smart infrastructure applications.	TPS4	PO1, PO2, PO3, PO4, PO5, PO6	15	9	1

4.Assessment Pattern

CO	CAT1	Assignment 1	CAT2	Assignment 2	Terminal Exam
	% of Marks	% of Marks	% of Marks	% of Marks	% of Marks
CO1	20				10
CO2	40				20
CO3	40	100			20

CO4			40	40	20
CO5			30	30	15
CO6			30	30	15
Total	100	100	100	100	100

5.Syllabus

Introduction to Cyber Physical Systems

Definition and characteristics of CPS – CPS architecture – Embedded intelligence – Physical and cyber interaction – Applications of CPS.

Sensors, Actuators and Embedded Computing

Sensors and signal conditioning – Actuators and control elements – Embedded processors – Data acquisition systems – Edge computing.

Communication and Networking in CPS

Wireless sensor networks – IoT protocols – Cloud integration – Real-time communication – Industrial communication systems.

Real-Time Monitoring and Control

Real-time operating systems – Feedback control systems – Distributed control – Monitoring and automation systems – Human-machine interaction.

Cybersecurity and CPS Applications

CPS security challenges – Data protection and privacy – Reliability and fault tolerance – Smart manufacturing – Smart grids – Autonomous systems – Healthcare CPS applications.

6. Learning Resources

6.1 Text Book

1. Raj Rajkumar, Dionisio de Niz and Mark Klein, Cyber-Physical Systems, Addison-Wesley.
2. Edward A. Lee and Sanjit A. Seshia, Introduction to Embedded Systems: A Cyber-Physical Systems Approach, MIT Press.
3. Raj Kamal, Embedded Systems: Architecture, Programming and Design, McGraw Hill.

6.2 Reference Books & Web Resources

1. Houbing Song and Danda B. Rawat, *Cyber Physical Systems: Foundations, Principles and Applications*, Elsevier.
2. K. J. Astrom and Richard M. Murray, *Feedback Systems: An Introduction for Scientists and Engineers*, Princeton University Press.

3. Jean-Philippe Vasseur and Adam Dunkels, *Interconnecting Smart Objects with IP*, Morgan Kaufmann.
4. NPTEL Courses on Cyber Physical Systems and IoT.
5. IEEE CPS Resource Center and Technical Journals.
6. IoT Protocol Documentation – MQTT, CoAP and ZigBee.
7. Industrial Automation and SCADA Technical Manuals.

8. Course Contents and Lecture Schedule

Module No.	Topics	No. of Periods
1	Introduction to Cyber Physical Systems	
1.1	Definition and characteristics of CPS	1
1.2	CPS architecture and components	1
1.3	Physical and cyber interaction	2
1.4	Applications of CPS	1
2	Sensors, Actuators and Embedded Computing	
2.1	Sensors and signal conditioning	1
2.2	Actuators and control systems	2
2.3	Embedded processors and data acquisition	1
2.4	Edge computing concepts	1
3	Communication and Networking in CPS	
3.1	Wireless sensor networks	1
3.2	IoT communication protocols	1
3.3	Real-time communication systems	2
3.4	Industrial communication networks	1
4	Real-Time Monitoring and Control	
4.1	Real-time operating systems	1
4.2	Feedback and distributed control	1
4.3	Automation and monitoring systems	2
4.4	Human-machine interaction	1
5	Cybersecurity and CPS Applications	
5.1	CPS security challenges	1
5.2	Data privacy and reliability	1
5.3	Smart manufacturing and smart grids	2
5.4	Healthcare and autonomous CPS applications	1
	Total Periods	**36**

8.Course Designer(s):

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26PEPJ0	EMBEDDED CONTROLLERS FOR EV APPLICATIONS

Category	L	T	P	Credit
PCC	3	-	-	3

1. Preamble:

Embedded controllers play a crucial role in Electric Vehicle (EV) systems for intelligent monitoring, energy management, motor control and vehicle automation. Modern EVs require efficient real-time embedded systems for battery management, propulsion control, charging systems, safety monitoring and communication networks. This course introduces embedded controller architectures, EV electronic subsystems, motor control techniques, battery management systems, communication protocols and real-time implementation strategies used in electric mobility applications. The course enables students to design intelligent embedded solutions for next-generation EV systems.

2.Prerequisite:

- Basics of Embedded Systems

3.Course Outcome

CO	Course Outcomes	TPS Level	PO	CO Weightage	SDG addressed	SDG Level
CO1	Explain the architecture, components, and operation of embedded control systems used in electric vehicle applications.	TPS2	PO1	10	7	1
CO2	Describe automotive communication protocols and software architectures for data exchange and control in electric vehicle subsystems.	TPS2	PO1, PO2	20	9	1
CO3	Design battery management system for monitoring, protection of electric vehicle battery systems.	TPS3	PO1, PO2, PO3	20	7	2
CO4	Develop embedded control strategies for electric drives, power electronic converters, and regenerative braking systems in electric vehicles.	TPS3	PO1, PO2, PO3, PO5	20	9	1
CO5	Apply real-time programming concepts for intelligent EV applications.	TPS3	PO1, PO2, PO4, PO5	15	11	1
CO6	Apply energy management and charging control techniques for enhancing the performance and reliability of electric vehicle systems.	TPS3	PO1,PO2, PO3, PO4, PO5, PO6	15	7	1

4.Assessment Pattern

CO	CAT1	Assignment 1	CAT2	Assignment 2	Terminal Exam

	% of Marks	% of Marks	% of Marks	% of Marks	% of Marks
CO1	20				10
CO2	40				20
CO3	40	100			20
CO4			40	40	20
CO5			30	30	15
CO6			30	30	15
Total	100	100	100	100	100

5.Syllabus

Fundamentals of Electric Vehicle Embedded Systems
Introduction to Electric Vehicles (EVs), Hybrid Electric Vehicles (HEVs), and Plug-in Hybrid Electric Vehicles (PHEVs); architecture of electric vehicles; powertrain components and their functions; role of embedded controllers in EV subsystems; Vehicle Control Unit (VCU), Electronic Control Units (ECUs), sensors and actuators; embedded hardware platforms for automotive applications; design requirements and challenges of EV embedded systems.

Automotive Communication and Software Architecture
Automotive communication requirements; Controller Area Network (CAN) and CAN FD protocols; Local Interconnect Network (LIN), FlexRay, and Automotive Ethernet; communication scheduling and data exchange in EVs; diagnostic protocols and Unified Diagnostic Services (UDS); AUTOSAR architecture, software layers, and middleware concepts; functional safety requirements based on ISO 26262.

Battery Management System Controllers
Battery technologies and characteristics for electric vehicles; Battery Management System (BMS) architecture; battery monitoring and protection functions; State of Charge (SOC), State of Health (SOH), and State of Power (SOP) estimation methods; cell balancing techniques; thermal management and fault diagnosis; communication interfaces and embedded control strategies for battery management systems.

Embedded Control of Electric Drives and Power Electronics
Electric traction motors for EV applications; BLDC and PMSM motor characteristics; power electronic converters and inverter systems; pulse-width modulation techniques; motor speed and torque control strategies; field-oriented control (FOC); regenerative braking control; embedded implementation of drive control algorithms and performance optimization techniques.

Real-Time Control and Advanced EV Applications
Real-time operating systems (RTOS) for automotive embedded systems; task scheduling, synchronization, and interrupt management; model-based design and code generation; energy management strategies for EVs; onboard charger control, charging standards, and vehicle-to-grid (V2G) concepts; validation and verification of embedded controllers; emerging trends in software-defined vehicles, connected EVs, and intelligent transportation systems.

6. Learning Resources

6.1 Text Book

1. Iqbal Husain, Electric and Hybrid Vehicles: Design Fundamentals, Third Edition, CRC Press, 2021.
2. Nicolas Navet and Francoise Simonot-Lion (Eds.), Automotive Embedded Systems Handbook, CRC Press, 2009.

6.2 Reference Books & Web Resources

1. Gregory L. Plett, Battery Management Systems, Volume I: Battery Modeling, Artech House, 2015.
2. R. Krishnan, Permanent Magnet Synchronous and Brushless DC Motor Drives, CRC Press, 2010.
3. L. Ashok Kumar & S. Albert Alexander, Power Converters for Electric Vehicles, CRC Press, 2024.
4. Peter Marwedel, Embedded System Design: Embedded Systems Foundations of Cyber-Physical Systems, 4th Edition, Springer, 2021.
5. Qing Li and Caroline Yao, Real-Time Concepts for Embedded Systems, CMP Books, 2003.
6. Ronald K. Jurgen, Automotive Electronics Handbook, McGraw-Hill Education, 1999.
7. Sheldon S. Williamson, Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles, Springer, 2013.
8. National Programme on Technology Enhanced Learning (NPTEL) – Embedded Systems and Electric Vehicle Courses: https://nptel.ac.in
9. MathWorks Automotive and Electric Vehicle Resources: https://www.mathworks.com/solutions/automotive.html
10. AUTOSAR Official Documentation: https://www.autosar.org
11. ISO 26262 Functional Safety Overview: https://www.iso.org
12. Battery University: https://batteryuniversity.com

7. Course Contents and Lecture Schedule

Module No.	Topics	No of Periods
1	**Fundamentals of Electric Vehicle Embedded Systems**	
1.1	Introduction to Electric Vehicles (EVs), Hybrid Electric Vehicles (HEVs), and Plug-in Hybrid Electric Vehicles (PHEVs);	1
1.2	Architecture of electric vehicles; powertrain components and their functions; role of embedded controllers in EV subsystems;	1
1.3	Vehicle Control Unit (VCU), Electronic Control Units (ECUs), sensors and actuators; embedded hardware platforms for automotive applications;	2
1.4	Design requirements and challenges of EV embedded systems.	1
2	**Automotive Communication and Software Architecture**	
2.1	Automotive communication requirements; Controller Area Network (CAN) and CAN FD protocols;	1
2.2	Local Interconnect Network (LIN), FlexRay, and Automotive Ethernet; communication scheduling and data exchange in EVs;	2
2.3	Diagnostic protocols and Unified Diagnostic Services (UDS); AUTOSAR architecture, software layers, and middleware concepts;	1
2.4	Functional safety requirements based on ISO 26262.	1
3	**Battery Management System Controllers**	
3.1	Battery technologies and characteristics for electric vehicles; Battery Management System (BMS) architecture;	1
3.2	Battery monitoring and protection functions; State of Charge (SOC), State of Health (SOH), and State of Power (SOP) estimation methods; cell balancing techniques;	2
3.3	Thermal management and fault diagnosis;	1
3.4	Communication interfaces and embedded control strategies for battery management systems.	1
4	**Embedded Control of Electric Drives and Power Electronics**	

4.1	Electric traction motors for EV applications; BLDC and PMSM motor characteristics; power electronic converters and inverter systems;	2
4.2	Pulse-width modulation techniques; motor speed and torque control strategies;	1
4.3	Field-oriented control (FOC); regenerative braking control;	1
4.4	Embedded implementation of drive control algorithms and performance optimization techniques.	1
5	**Real-Time Control and Advanced EV Applications**	
5.1	Real-time operating systems (RTOS) for automotive embedded systems;	1
5.2	Task scheduling, synchronization, and interrupt management; model-based design and code generation; energy management strategies for EVs;	2
5.3	Onboard charger control, charging standards, and vehicle-to-grid (V2G) concepts; validation and verification of embedded controllers;	1
5.4	Emerging trends in software-defined vehicles, connected EVs, and intelligent transportation systems.	1
	Total Periods	**36**

8.Course Designer(s):

1. Dr. P.S.Manoharan, Professor, Dept. of EEE, psmeee@tce.edu
2. Dr. S.Charles Raja, Professor, Dept. of EEE, charlesrajas@tce.edu
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26PEPL0	EMBEDDED SYSTEMS IN SMART GRID

Category	L	T	P	Credit
PCC	3	-	-	3

1. Preamble:

Smart Grid technology integrates advanced communication, automation and intelligent monitoring systems to improve the efficiency, reliability and sustainability of modern power systems. Embedded systems play a significant role in smart metering, substation automation, distributed energy management, renewable energy integration and real-time grid monitoring. This course introduces embedded platforms, communication protocols, intelligent monitoring systems, automation techniques and cybersecurity aspects used in smart grid applications. The course enables students to design embedded solutions for intelligent power and energy management systems.

2.Prerequisite:

- Basics of Embedded Systems

3. Course Outcome:

CO	Course Outcomes	TPS Level	PO	CO Weightage	SDG addressed	SDG Level
CO1	Explain the fundamental concepts of smart grids and embedded systems, and their integration for efficient power management and monitoring.	TPS2	PO1	10	7	1
CO2	Discuss embedded hardware architectures and communication protocols used in smart grid applications for reliable data exchange.	TPS2	PO1, PO2	20	9	1
CO3	Develop advanced smart grid technologies including metering infrastructure and distribution automation to enhance grid performance.	TPS3	PO1, PO2, PO3	20	7	2
CO4	Develop the Smart Transmission system using synchrophasor technology.	TPS3	PO1, PO2, PO3, PO5	20	9	1
CO5	Design and implement cybersecurity measures and real-time operating systems within embedded platforms for robust smart grid operations.	TPS3	PO1, PO2, PO4, PO5	15	11	1
CO6	Explain the fundamental concepts of smart grids and embedded systems, and their integration for efficient power management and monitoring.	TPS4	PO1, PO2, PO3, PO4,	15	7	2

			PO5, PO6			

4.Assessment Pattern

CO	CAT1	Assignment 1	CAT2	Assignment 2	Terminal Exam
	% of Marks	% of Marks	% of Marks	% of Marks	% of Marks
CO1	20				10
CO2	40				20
CO3	40	100			20
CO4			40	40	20
CO5			30	30	15
CO6			30	30	15
Total	100	100	100	100	100

5. Syllabus

INTRODUCTION TO SMART GRID
Smart grid definition, development, initiatives and solutions; Old grid versus new grid, Stakeholders in smart grid development, Role of embedded systems in smart grid architecture, Concept of Resilient & Self Healing Grid, Present development & International policies in Smart Grid, Smart Grid Roadmap for India.

EMBEDDED HARDWARE AND COMMUNICATION PROTOCOLS IN SMART GRID
Embedded hardware platforms for smart grid applications, Communication protocols: Modbus, IEC 60870-5-101/104, DNP3, Power line communication, wireless sensor networks, and IoT integration, Role of intelligent electronic devices (IEDs) and smart sensors, Data acquisition and real-time monitoring systems.

SMART DISTRIBUTION SYSTEM AND DEMAND SIDE MANAGMENT
Subsystems in a distribution control center, DMS framework: Integration with subsystems, DMS application functions, Introduction –Smart metering: Evolution - Key components – Smart meters: overview of the hardware used. Demand-side management and demand response, Time of Use Tariff, Distributed energy resource and energy storage - battery, Smart homes with home energy management systems, Plugged hybrid electric vehicles, Microgrids, Case studies in smart grid.

SMART TRANSMISSION SYSTEM
PMU Technologies: importance, Operation, applications and advantages, Algorithms for PMU Placement, Wide Area Monitoring, Protection and Control: Drivers, Benefits Roles, needs and major activities of WAMPAC in a Smart Grid, Indian Blackout 2012 case study.Operating states of the power system and sources of grid vulnerability, Energy control centers, EMS framework, Future trends in EMS and DMS with WAMS, Case studies in EMS and WAMS

CYBERSECURITY AND REAL-TIME OPERATING SYSTEMS FOR SMART GRID EMBEDDED APPLICATIONS
Cybersecurity threats and vulnerabilities in smart grid systems, Security architecture, standards, and best practices, Secure communication protocols and data management, Real-time operating systems for

embedded platforms, Case studies on secure smart grid deployments and incident response, Analytics for smart grid security and resiliency, Cyber attacks and Privacy Concerns of smart grid, Security models of smart grid.

6. Learning Resources

6.1 Text Book

1. Thomas, Mini S., and John Douglas McDonald. Power System SCADA and smart grids. CRC press, 2015.
2. Janaka Ekanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama, “Smart Grid: Technology and Applications”, Wiley & Sons Ltd., February 2012.
3. Grimm, Christoph, Peter Neumann, and Stefan Mahlknecht, eds. *Embedded systems for smart appliances and energy management*. Vol. 3. Springer Science & Business Media, 2012.
4. “Smart Grid primer”, Published by Power grid Corporation of India limited, September 2013

6.2 Reference Books & Web Resources

1. Stuart Borlase, “Smart Grid: Infrastructure, Technology and Solutions”, CRC Press 2012.
2. James Momoh, “Smart Grid Fundamentals of Design and Analysis”, IEEE Press, 2012.
3. Tony Flick, Justin more house, “Securing the smart grid: Next generation power grid security”, Elsevier, 2010.
4. K S K Weranga, D P Chandima,"Smart Meter Design and Application", Springer, 2014.
5. MOOCs course link: https://www.edx.org/course/smart-grids-electricity-future-ieeex-smartgrid-x-0.
6. Al-Shaer, Ehab, Rahman and Mohammad Ashiqur, “Security and Resiliency Analytics for Smart Grids’, Springer Intr., 1st Edition, 2016.
7. Eric D. Knapp, Raj Samani, 'Applied Cyber Security and the Smart Grid - Implementing Security Controls into the Modern Power Infrastructure ',Syngress, 2013. doi: https://doi.org/10.1016/C2012-0-01113-1

7. Course Contents and Lecture Schedule

Module No.	Topics	No of Periods
1	**INTRODUCTION TO SMART GRID**	
1.1	Smart grid definition, development, initiatives and solutions	1
1.2	Old grid versus new grid, Stakeholders in smart grid development	1
1.3	Role of embedded systems in smart grid architecture, Concept of Resilient & Self-Healing Grid	2
1.4	Present development & International policies in Smart Grid, Smart Grid Roadmap for India.	1
2	**EMBEDDED HARDWARE AND COMMUNICATION PROTOCOLS IN SMART GRID**	
2.1	Embedded hardware platforms for smart grid applications	2
2.2	Communication protocols: Modbus, IEC 60870-5-101/104, DNP3, Power line communication, wireless sensor networks	1
2.3	IoT integration, Role of intelligent electronic devices (IEDs)	1
2.4	smart sensors, Data acquisition and real-time monitoring systems	1
3	**SMART DISTRIBUTION SYSTEM AND DEMAND SIDE MANAGMENT**	
3.1	Subsystems in a distribution control center, DMS framework: Integration with subsystems, DMS application functions	1

3.2	Introduction – Smart metering: Evolution - Key components, Smart meters: overview of the hardware used.	1
3.3	Demand-side management and demand response, Time of Use Tariff, Distributed energy resource and energy storage - battery	2
3.4	Smart homes with home energy management systems, Plugged hybrid electric vehicles, Microgrids, Case studies in smart grid.	1
4	**SMART TRANSMISSION SYSTEM**	
4.1	PMU Technologies: importance, Operation, applications and advantages, Algorithms for PMU Placement, Wide Area Monitoring	1
4.2	Protection and Control: Drivers, Benefits Roles, needs and major activities of WAMPAC in a Smart Grid	1
4.3	Indian Blackout 2012 case study. Operating states of the power system and sources of grid vulnerability, Energy control centers, EMS framework	2
4.4	Future trends in EMS and DMS with WAMS, Case studies in EMS and WAMS	1
5	**CYBERSECURITY AND REAL-TIME OPERATING SYSTEMS FOR SMART GRID EMBEDDED APPLICATIONS**	
5.1	Cybersecurity threats and vulnerabilities in smart grid systems, Security architecture, standards, and best practices	1
5.2	Secure communication protocols and data management, Real-time operating systems for embedded platforms	1
5.3	Case studies on secure smart grid deployments and incident response, Analytics for smart grid security and resiliency	2
5.4	Cyber-attacks and Privacy Concerns of smart grid, Security models of smart grid	1
	Total Periods	**36**

8. Course Designer(s):

1. Dr. S.Charles Raja, Professor, Dept. of EEE, charlesrajas@tce.edu
2. Dr. D. Kavitha , Associate Professor, Dept. of EEE, dkavitha@tce.edu
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26PEPS0	PYTHON PROGRAMMING FOR EMBEDDED SYSTEMS

Category	L	T	P	Credit
PCC	3	-	-	3

1. Preamble:

Python has become a powerful programming language for embedded systems, IoT applications, automation and intelligent hardware interfacing due to its simplicity, portability and extensive library support. Embedded Python platforms such as Raspberry Pi, MicroPython and CircuitPython enable rapid development of smart monitoring and control systems. This course introduces Python programming fundamentals, object-oriented programming, hardware interfacing, communication protocols and embedded application development using Python-based embedded platforms. The course enables students to develop intelligent embedded solutions for real-time monitoring, automation and IoT applications.

2.Prerequisite:

- Basics of Embedded Systems
- Basic of Python Programming

3.Course Outcome

CO	Course Outcomes	TPS Level	PO	CO Weightage	SDG addressed	SDG Level
CO1	Explain Python programming fundamentals and embedded Python environments.	TPS2	PO1	10	9	1
CO2	Apply Python programming concepts for embedded application development.	TPS3	PO1, PO2	20	9	1
CO3	Develop hardware interfacing applications using sensors and actuators.	TPS3	PO1, PO2, PO3	20	9	1
CO4	Design communication and networking applications using embedded Python.	TPS3	PO1, PO2, PO3, PO5	20	9	1
CO5	Apply IoT and automation concepts using Raspberry Pi and MicroPython platforms.	TPS3	PO1, PO2, PO4, PO5	15	11	1
CO6	Analyze and propose Python-based embedded solutions for smart monitoring and automation systems.	TPS4	PO1, PO2, PO3, PO4, PO5, PO6	15	7	1

4.Assessment Pattern

CO	CAT1	Assignment 1	CAT2	Assignment 2	Terminal Exam
	% of Marks	% of Marks	% of Marks	% of Marks	% of Marks
CO1	20				10
CO2	40				20

CO3	40	100			20
CO4			40	40	20
CO5			30	30	15
CO6			30	30	15
Total	100	100	100	100	100

5.Syllabus

Python Fundamentals

Introduction to Python – Variables and data types – Operators – Conditional statements – Loops – Functions – File handling – Exception handling.

Object Oriented Programming in Python

Classes and objects – Constructors – Inheritance – Polymorphism – Modules and packages – Python libraries.

Embedded Python Platforms

Introduction to Raspberry Pi – MicroPython and CircuitPython – GPIO programming – Sensor and actuator interfacing – ADC and PWM control.

Communication and Networking

Serial communication – UART, SPI and I2C interfacing – Socket programming – MQTT protocol – IoT communication.

Embedded Applications using Python

Data acquisition systems – Home automation – Smart monitoring systems – IoT-based applications – Mini projects and case studies.

6. Learning Resources

6.1 Text Book

1. Charles Severance, *Python for Everybody*, Shroff Publishers, 2016.
2. Simon Monk, *Programming the Raspberry Pi: Getting Started with Python*, McGraw Hill Education, 2016.
3. Dogan Ibrahim, *Python Programming for Embedded Systems*, Wiley, 2022.

6.2 Reference Books & Web Resources

1. Allen B. Downey, *Think Python: How to Think Like a Computer Scientist*, 2nd Edition, O'Reilly Media, 2015.
2. Mike McGrath, *Python in Easy Steps*, 7th Edition, In Easy Steps Limited, 2021.
3. Eben Upton and Gareth Halfacree, *Raspberry Pi User Guide*, 4th Edition, Wiley, 2016.
4. Simon Monk, *Programming Raspberry Pi in Python: Getting Started with Python*, McGraw Hill Education, 2016.
5. MicroPython Official Documentation – https://docs.micropython.org
6. Raspberry Pi Documentation and Tutorials – https://www.raspberrypi.com/documentation

7. NPTEL Courses on Python Programming and Embedded Systems – https://nptel.ac.in
8. MQTT Official Documentation – https://mqtt.org
9. Eclipse Mosquitto MQTT Documentation – https://mosquitto.org/documentation

7. Course Contents and Lecture Schedule

Module No.	Topics	No of Periods
1	**Python Fundamentals**	
1.1	Introduction to Python and data types	1
1.2	Operators and control statements	1
1.3	Functions and file handling	2
1.4	Exception handling	1
2	**Object Oriented Programming in Python**	
2.1	Classes and objects	2
2.2	Constructors and inheritance	1
2.3	Polymorphism and modules	1
2.4	Python libraries and packages	1
3	**Embedded Python Platforms**	
3.1	Raspberry Pi architecture	1
3.2	MicroPython and CircuitPython	1
3.3	GPIO programming and interfacing	2
3.4	Sensor and actuator control	1
4	**Communication and Networking**	
4.1	Serial communication basics	1
4.2	UART, SPI and I2C interfacing	2
4.3	Socket programming and MQTT	1
4.4	IoT communication systems	1
5	**Embedded Applications using Python**	
5.1	Data acquisition systems	1
5.2	Home automation applications	2
5.3	Smart monitoring systems	1
5.4	IoT mini projects and case studies	1
	Total Periods	**36**

8.Course Designer(s):

1. Dr. S.Charles Raja, Professor, Dept. of EEE, charlesrajas@tce.edu
2. Dr. D. Kavitha , Associate Professor, Dept. of EEE, dkavitha@tce.edu
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