SEMESTER S5

MICROCONTROLLERS

(Common to CS/CC)

Course Code	**PBCST504**	**CIE Marks**	60
Teaching Hours/Week (L:T:P:R)	3:0:0:1	**ESE Marks**	40
Credits	4	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Theory

Course Objectives:

1. To introduce the ARM architecture and ARM-based microcontroller architecture.
2. To impart knowledge on the hardware and software components to develop embedded systems using STM32 microcontrollers.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to ARM Cortex-M Architecture:-** Overview of Embedded Systems, Applications of Embedded Systems, Introduction to Embedded C, Microcontrollers vs. Microprocessors, Classification of processors, Overview of ARM Cortex-M Series, Introduction to the Cortex-M23 and Cortex-M33 processors and the Armv8-mArchitecture, ARM Core Features: Registers, Memory, and Bus Architecture, Comparison with previous generations of Cortex-M processors.	**9**
2	**STM32 Microcontroller Overview and Peripheral Programming:-** Introduction to STM32 Family, STM32U575 Features and Specifications, Power Management and Low-Power Features Libraries, Introduction to Integrated Development Environment and HAL, Writing, and Debugging Your First Program(LED Interfacing), Interfacing Seven-Segment Display, LCD Display, and Matrix Keypad, Relay Interfacing, Analog to Digital Conversion: Potentiometer, temperature sensor, LDR, Microphone, Digital to Analog Conversion: Simple DAC Output Generation, Generating a Sine Wave, Audio	**11**

	Signal Generation, Interrupt Handling, Timer and Counter Applications: Basic Timer Configuration, Timers as Counters, Timer-Based Real-Time Clock (RTC)	
3	**Communication Protocols and USB:-** Serial port terminal Application, Serial communication (USART, I2C, SPI, CAN), Interfacing an I2C Temperature Sensor and Displaying Data on an LCD, writing to and Reading from an SPI-based EEPROM, Configuring and Implementing CAN Communication between Multiple STM32U575 Microcontrollers, Creating a USB HID Device for Keyboard / Mouse Emulation	**10**
4	**IoT, Wireless Communication, and RTOS:-** Introduction to IoT, IoT Architecture, Protocols (MQTT, CoAP), IoT Security Principles and Common Threats Wireless Communication: Interfacing GSM (Call, SMS, Internet), Bluetooth Communication Basics, LoRa Communication Basics and Applications, Designing an IoT-Based Home Automation System, Introduction to RTOS Concepts, FreeRTOS with STM32: Task Creation, Scheduling, and Management, RTOS Timers, Delays, and RTC Integration, Inter-task Communication: Queues and Semaphores **Trust Zone Technology:** Introduction to ARM Trust Zone, Trust Zone Architecture and Features, Secure and Non-Secure Worlds: Configuration and Management, Implementing Trust Zone in STM32U575, Advanced Debugging and Optimization: Code and Memory Optimization Techniques, Debugging Strategies and Tools	**14**

Suggestion on Project Topics

- Identify real world problems requiring hardware solutions and develop them using peripheral devices. Some of the examples would be - Home automation, Small home/office security system, ARM based voice response system etc.

Course Assessment Method

(CIE: 60 marks, ESE: 40 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Project	Internal Ex-1	Internal Ex-2	Total
5	30	12.5	12.5	60

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 2 marks **(8x2 =16 marks)**	2 questions will be given from each module, out of which 1 question should be answered. Each question can have a maximum of 2 subdivisions. Each question carries 6 marks. **(4x6 = 24 marks)**	**40**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Explain the architectural features and instructions of the ARM microcontrollers.	**K2**
CO2	Develop applications involving interfacing of external devices and I/O with ARM microcontroller.	**K3**
CO3	Use various communication protocols of interaction with peer devices and peripherals.	**K3**
CO4	Demonstrate the use of a real time operating system in embedded system applications.	**K3**
CO5	Apply hardware security features of ARM in real world applications.	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3									3
CO2	3	3	3									3
CO3	3	3	3	3	3							3
CO4	3	3	3	3	3							3
CO5	3	3	3	3								3

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	The Definitive Guide to ARM Cortex-M3 and Cortex-M4 Processors	Joseph Yiu	Newnes - Elsevier	3/e, 2014
2	Mastering STM32	Carmine Noviello	Learnpub	2/e, 2022

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	ARM System Developer's Guide	Andrew N. Sloss, Dominic Symes, Chris Wright	Morgan Kaufman	1/e, 2008
2	Embedded System Design with Arm Cortex-M Microcontrollers	Cem Ünsalan, Hüseyin Deniz Gürhan Mehmet Erkin Yücel	Springer	1/e, 2022
3	Introduction to ARM ® Cortex-M Microcontrollers	Jonathan W. Valvano	Self-Published	5/e, 2014

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/106/105/106105193/
2	https://www.st.com/resource/en/datasheet/

PBL Course Elements

L: Lecture	**R: Project (1 Hr.), 2 Faculty Members**		
(3 Hrs.)	**Tutorial**	**Practical**	**Presentation**
Lecture delivery	Project identification	Simulation/ Laboratory Work/ Workshops	Presentation (Progress and Final Presentations)
Group discussion	Project Analysis	Data Collection	Evaluation
Question answer Sessions/ Brainstorming Sessions	Analytical thinking and self-learning	Testing	Project Milestone Reviews, Feedback, Project reformation (If required)
Guest Speakers (Industry Experts)	Case Study/ Field Survey Report	Prototyping	Poster Presentation/ Video Presentation: Students present their results in a 2 to 5 minutes video

Assessment and Evaluation for Project Activity

Sl. No	Evaluation for	Allotted Marks
1	Project Planning and Proposal	5
2	Contribution in Progress Presentations and Question Answer Sessions	4
3	Involvement in the project work and Team Work	3
4	Execution and Implementation	10
5	Final Presentations	5
6	Project Quality, Innovation and Creativity	3
Total		**30**

1. **Project Planning and Proposal (5 Marks)**

    - Clarity and feasibility of the project plan
    - Research and background understanding
    - Defined objectives and methodology

2. **Contribution in Progress Presentation and Question Answer Sessions (4 Marks)**

    - Individual contribution to the presentation
    - Effectiveness in answering questions and handling feedback

3. **Involvement in the Project Work and Team Work (3 Marks)**

    - Active participation and individual contribution
    - Teamwork and collaboration

4. **Execution and Implementation (10 Marks)**

    - Adherence to the project timeline and milestones
    - Application of theoretical knowledge and problem-solving
    - Final Result

5. **Final Presentation (5 Marks)**

    - Quality and clarity of the overall presentation
    - Individual contribution to the presentation
    - Effectiveness in answering questions

6. **Project Quality, Innovation, and Creativity (3 Marks)**

    - Overall quality and technical excellence of the project
    - Innovation and originality in the project

Creativity in solutions and approaches