



# GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering

Level: UG

Branch: Power Electronics

Subject Code: BE05024011

Subject Name: Microcontrollers And Its Applications

w.e.f. Academic Year:	2026-27
Semester:	5
Category of the Course:	Professional Core Course

<b>Prerequisite:</b>	<b>Digital Electronics</b>
<b>Rationale:</b>	<p>Microcontrollers, the brain of modern embedded systems used across automation, consumer electronics, industrial control, and real-time applications. A strong understanding of microcontroller architecture, interfacing, programming, and system-level design helps students build intelligent and efficient electronic systems. This course builds upon foundational knowledge of Digital Electronics in earlier semesters and extends into modern architectures—particularly the ARM Cortex family, widely used in power electronics control systems.</p> <p>Microcontroller-based PWM generation, ADC/DAC interfacing, sensor acquisition, inverter and converter control, and protection logic are central to today’s power-electronic systems, making this course highly relevant for advanced study in Power Electronics, Drives, Renewable Energy control, and embedded power converters.</p>

### Course Outcomes:

Sr. No.	CO statement	Marks% weightage
CO-1	Explain the architecture and functional features of popular microcontroller families, including 8085/8051 and ARM Cortex.	35
CO-2	Develop embedded programs using assembly language and C for microcontroller-based systems.	15
CO-3	Interface microcontrollers with I/O devices, sensors, ADC/DAC modules, and communication peripherals.	15
CO-4	Analyze timing, interrupts, and real-time control behaviour of microcontroller-based systems.	25
CO-5	Design application-oriented embedded solutions for industrial automation and power electronics systems.	10

### Teaching and Examination Scheme:

Teaching / Learning Scheme (in Hours per semester)					Total Credits	Assessment Pattern and Marks					Total Marks
L	T	P	PBL *	Total no of hours per semester		Theory		Tutorial / Practical			
						ESE (E)	PA / CA (M)	PA/C A (I)	PBL (I)	ESE (V)	
45	0	30	45	120	4	70	30	20	30	50	200

\* *Problem-Based Learning (PBL) aims to accommodate learning beyond the syllabus as per clause 9.4 of NBA manual.*

Where L = Lecture, T= Tutorial, P= Practical, TW/SL = Term-Work / Self-Learning, TH = Total Hours, ESE = End Semester Examination, PA = Progressive Assessment.



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## Content:

Sr. No.	Content	Total Hrs
1	<b>Introduction to Microcontrollers:</b> Microprocessor vs Microcontroller, Von Neumann vs Harvard architecture, CISC vs RISC (overview), Application areas: embedded systems, power electronics, automotive, IoT, Overview of popular microcontroller families (8051, AVR, PIC, ARM Cortex)	4
2	<b>8085 &amp; 8051 Architecture:</b> 8085 and 8051 internal architecture, Registers, Flags, ALU, Bus structure, Memory organization, SFRs, I/O ports, Pin diagram & functions, Oscillator, clock circuit, reset circuit, only (conceptual and architectural review)	6
3	<b>ARM Architecture (Cortex-M Series):</b> ARM evolution, RISC characteristics, ARM Cortex-M0/M3/M4 architecture, Programmer's model, registers, stack, memory map, Pipeline basics, NVIC, SysTick timer, GPIO, ADC, timers, USART, SPI, I <sup>2</sup> C, PWM modules, ARM instruction set overview, Embedded C programming model	10
4	<b>Interfacing &amp; Peripherals</b> Digital I/O interfacing, LCD, keypad, LED, stepper motor, DC motor interfacing, ADC/DAC interfacing concepts, Serial communication: UART, SPI, I <sup>2</sup> C, Interrupts: ARM NVIC, priority levels, Timer/counter programming, Sensor interfacing (temperature, current, voltage, IR, Hall sensors), Power Electronics relevance: Microcontroller-based PWM generation for converters, triggering of MOSFET/IGBT drivers, and measurement through ADC.	10
5	<b>Embedded System Applications</b> Real-time control, PWM generation for DC-DC converters & inverters, Motor control basics using ARM microcontrollers, Protections in power-electronic systems, Event capture, compare, and high-resolution PWM, Introduction to industrial communication protocols (CAN, MODBUS)	8
6	<b>Development Tools &amp; Debugging</b> IDEs: Keil $\mu$ Vision, STM32CubeIDE, MPLAB X, Arduino IDE, Assemblers, compilers, linkers, Debugging tools: J-Link, ST-Link, logic analyzers, protocol analyzers, Embedded code optimization, Introduction to RTOS (FreeRTOS basics)	7
<b>TOTAL</b>		<b>45</b>

## Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
15	25	25	15	10	10

**R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate; C: Create and above Levels (Revised Bloom's Taxonomy)**

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from the above table.

The Microcontroller and Its Applications course demonstrate direct alignment with SDGs 7 and 9 through energy-efficient control and automation, and indirectly supports SDGs 8, 11, 12, and 13 by enabling intelligent, resource-efficient, and sustainable embedded system solutions.



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SDG 7	Affordable & Clean Energy – direct alignment PWM generation, ADC sensing, and microcontroller-based control of converters/inverters support efficient energy management in renewable systems, battery charging, and power electronics applications.
SDG 8	Decent Work and Economic Growth — Indirect Alignment Knowledge of microcontroller families (8051, AVR, ARM), development tools (Keil, STM32CubeIDE), and embedded applications builds skills for industries like automation, IoT, automotive, and electronics manufacturing.
SDG 9	Industry, Innovation & Infrastructure -direct alignment PWM generation, ADC sensing, and microcontroller-based control of converters/inverters support efficient energy management in renewable systems, battery charging, and power electronics applications.
SDG 11	Sustainable Cities & Communities -indirect alignment Applications of IoT systems, sensor interfacing, communication protocols (UART, SPI, I <sup>2</sup> C), and automation contribute to smart homes, traffic systems, and urban energy management.
SDG12	Responsible Consumption & Production -indirect alignment Concepts like embedded code optimization, efficient peripheral usage, and hardware-software co-design promote energy-efficient devices, reduced resource consumption, and longer system life cycles.
SDG 13	Climate Action -indirect alignment Efficient control using real-time embedded systems, sensor interfacing (temperature, current, voltage), and optimized firmware (RTOS, debugging tools) reduces energy wastage and enables low-carbon technologies like EVs and smart grids.

## Reference Books:

1. Architecture, Programming, and Applications with the 8085 — R. Gaonkar
2. ARM System Developer's Guide Designing and Optimizing System Software - Andrew N. Sloss  
Dominic Symes Chris Wright, Elseweir
3. The Definitive Guide to ARM Cortex-M3 and M4 – Joseph Yiu - Newens
4. Embedded Systems with ARM Cortex-M Microcontrollers – Jonathan Valvano -
5. The 8051 Architecture, Programming and Applications, Kenneth J Ayala – West Publishing Company
6. Research Papers on IEEE/IET/Science Direct etc.

## List of Experiments:

### Part A: 8051/Basic Microcontroller Labs (10 Hours)

1. Study of 8051 trainer kit/simulation tools
2. Study of Basic data transfer, arithmetic, and logical programs
3. Delay generation using timers
4. LED, switch, buzzer interfacing
5. ADC/DAC interfacing basics

### Part B: ARM Cortex-M Labs (20 Hours) (Using STM32 or equivalent board)

6. GPIO programming and on-board LED control
7. Timer-based square wave & PWM generation
8. ADC reading of analog sensors
9. UART/SPI/I<sup>2</sup>C communication
10. Interrupt handling using NVIC
11. LCD/Seven-segment interfacing



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- Motor control (DC or stepper)
- Real-time application demo (e.g., digital voltmeter using ADC)
- PWM-based control for a DC-DC buck converter (simulation allowed)
- Mini project: Any embedded application (preferably power-electronics related)

### Major Equipment:

- Microcontroller trainer kits/ development boards
- Logic Analyzer
- Digital Storage Oscilloscope (DSO)
- IDE software for various microcontrollers.

### List of Open-Source Software:

- IDE from device manufacturers
- MIDE-51 Studio
- Gpsim
- MCU 8051 IDE
- Yagarto
- freeRTOS

### List of learning websites:

- MIT Open Course Ware (<https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/>)
- Circuit Lab (Free with limited access) (<https://www.circuitlab.com/>) – Web-based circuit simulator
- Virtual Labs by IITs (Government of India Initiative) (<https://vlab.co.in/>)
- Reputed Research Journal Website

### List of suggested activities for Problem-based Learning (PBL):

Sr.No.	PBL Category	Name of the activity	No. of hours	Evaluation Criteria
1	Industry / Research Laboratory Visit	Industry/Research laboratory Visit (electronics/ power electronics manufacturing industry)	Visit = 5hrs, Report preparation = 5hrs Total = 10hrs	Based on the report submitted. The report should contain observations and calculations based on industry/ lab data.
2	Video Based Learning	Technical Video-based learning related to the subject (MOOC/ NPTEL Video)	Duration of video = 5hrs Report preparation = 5hrs Total = 10hrs	Report /presentation based on the video learning outcomes.
		Self-learning online course	Minimum duration of the course should be 10 hours.	Examination-based assessment at the end of the course. Based on the certificate produced.
		Annotated Video Explanation of Concept/Problem	10hrs (Preparation + Recording + Submission)	Based on the accuracy of explanation, clarity, and presentation style.
3	Assignment/ Technical Writing / Research Writing	Assignment writing. Numerical-based assignment is preferable.	5 assignments of 2hrs each. Total = 10hrs	Based on the assignment submitted.
		Blog or Technical Article Writing	10hrs (Research – 6hrs, Writing – 4hrs)	Based on originality, technical content, references cited, and clarity of communication.
4	Complex Problem-Solving	Complex problem solving	Maximum 2 problems. Study of the problem and	Based on the depth of the solution submitted.



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Sr.No.	PBL Category	Name of the activity	No. of hours	Evaluation Criteria
	targeting relevant SDGs. / Mini Project		solution finding, Total = 15 hrs	
5	Research Paper Review / Analysis	Discussion on a research paper based on a relevant subject (SCOPUS Index/ any reputed Journal)	5 research paper = 20 hrs	Summarize the research paper and evaluation of critical parameters
6	Poster/ Chart/ Power point presentation	Poster/chart/power point preparation on technical topics	Duration = 6 hrs	Based on poster/chart preparation and presentation skills
7	Micro Project	Working/non-working model on technical topics	Working = 10hrs non-working = 10hrs	Based on inter-department/external evaluation
8	Group Discussion / Quiz / Simulation	Group Discussion on emerging/trending technical topics based on the subject	Duration = 1 hrs each	Based on performance in group discussion, technical depth, knowledge etc.
		Online Technical Quizzes/Simulations	Multiple quizzes summing up to 10 hours	Based on quiz scores and the reflection report after each quiz.
9	Case Study Analysis / Seminar	Real-world case studies-based learning	Duration of data collection/study = 5hrs Report preparation = 5hrs Total = 10hrs	Based on an in-depth study, technical depth, data collected, fact-finding, etc.
10	Other	Patent Search and Innovation Gap Identification	10hrs (Search + Report)	Based on the number of relevant patents analyzed and the identification of innovation scope.

## Note:

1. In alignment with Outcome-Based Education (OBE) and NBA accreditation requirements, the subject **Microcontrollers and Their Applications** incorporates;

- Mini Project – 10 Marks
- Micro Project – 5 Marks

These activities are incorporated as integral Project-Based Learning (PBL) components. These activities are designed to foster experiential learning, encourage innovation, and strengthen problem-solving skills by engaging students in practical applications of power converter design, simulation, and analysis. The inclusion of PBL ensures that learners develop higher-order cognitive abilities mapped to Bloom's taxonomy, while simultaneously enhancing teamwork, communication, and research competencies essential for professional engineering practice.

2. The hours allocated to specific activities should be proportionate to the total no. of PBL hours and marks.

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