GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3151107
Semester – V
Subject Name: Advance Microcontroller

Type of course: Professional Elective Course

Prerequisite: Microprocessor & Microcontroller

Rationale: This course will provide an opportunity to the students to learn ARM architecture, instruction set and programming. ARM is very popular for portable applications because of its high performance with low power consumption. Students will learn architecture, assembly language and C programming for ARM microcontroller in this course.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	2	4	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs	% Weight age
1	**ARM Introduction** Types of computer Architectures, ISA's and ARM, Difference between RISC and CISC, RISC Design philosophy, ARM Design Philosophy, History of ARM microprocessor, ARM processor family, Embedded System Software and Hardware	6	10%
2	**ARM Architecture and pipeline structure** The Acorn RISC Machine, ARM Core data flow model, Architectural inheritance, The ARM7TDMI programmer's model: General purpose registers, CPSR, SPSR, ARM memory map, data format, load and store architecture, ARM 3 stage Pipeline, ARM 5 stage Pipeline, Pipeline Hazards, Data forwarding - a hardware solution, Stack implementation in ARM, Endianness, condition codes. Processor core Vs CPU core, ARM7TDMI Interface signals	8	20%
3	**ARM7TDMI assembly language instructions and programming** Different Types of Instructions, ARM Instruction set, data processing instructions. Shift Operations, shift Operations using RS lower byte, Immediate value encoding. Data processing Instructions. Addressing modes with examples. Instruction Timing, Swap Instructions, Swap Register related Instructions, Loading Constants. Program Control Flow, Control Flow Instructions, B & BL instructions, BX instruction. Interrupts and Exceptions, Exception Handlers, Reset	10	25%

	Handling. Aborts, software Interrupt Instruction, undefined instruction exception. Interrupt Latency, Multiply Instructions,. Thumb state, Thumb Programmers model, Thumb Implementation, Thumb Applications. Thumb Instructions, Interrupt processing. Interrupt Handling schemes, Examples of Interrupt Handlers, Co-processor instructions		
4	**Embedded C Programming for ARM:** ARM Development Environment Embedded Software, Overview of C compiler and optimization, Basic C data types, C Looping structures, Register allocations, function calls, pointer aliasing, structure arrangement, bit-fields, unaligned data and Endianness, Division, floating point, Inline functions and inline assembly, Portability issues. C programs for General purpose I/O, general purpose timer, PWM Modulator, UART, I2C Interface, SPI Interface, ADC, DAC	10	20%
5	**Cache and Memory Management and Protection** Memory Technologies, Need for memory Hierarchy, Hierarchical Memory Organization, Virtual Memory. Cache Memory, Mapping Functions. Cache Design, Unified or split cache, multiple level of caches, ARM cache features, coprocessor 15 for system control. Processes, Memory Map, Protected Systems, ARM systems with MPU, memory Protection Unit (MPU). Physical Vs Virtual Memory, Paging, Segmentation. MMU Advantage, virtual memory translation, Multitasking with MMU, MMU organization, Tightly coupled Memory (TCM).	6	15%
6	**ARM Peripherals and versions** AMBA Overview, Typical AMBA Based Microcontroller, AHB bus features, AHB Bus transfers, APB bus transfers, APB bridge. Overview of ARM Versions: ARMv5, ARMv6, ARM v7 (Cortex family R: Real time A: Application and M: Microcontroller), ARM big.LITTLE® Technology, ARMv8.	5	10%

Suggested Specification table with Marks (Theory): (For BE only)

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
20	**20**	**25**	**15**	**10**	**10**

Legends: 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 above table.

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Reference Books:

[1] ARM Assembly Language Programming & Architecture By. Muhammad Ali Mazidi, Kindle edition
[2] Arm Assembly Language, Fundamentals and Techniques, 2nd edition, William Hohl, Christppher Hinds, CRC Press.
[3] Arm System Developer's Guide, Designing and Optimizing Software, Andrew N. Sloss, Dominic Symes, Chris Wwight, Elsevier
[4] Arm System-on-chip Architecture, 2nd Edition, Steve Furber, Pearson publication
[5] Embedded Systems By. Lyla Das, Pearson publication
[6] Manuals and Technical Documents from the ARM Inc, web site.

Course Outcomes:

Sr. No.	CO statement	Marks % weightage
CO-1	Explain architecture and programming model of ARM 7TDMI	20
CO-2	Learn and analyse assembly language programs for ARM microcontroller	25
CO-3	Develop Embedded C language program for interfacing I/O devices with ARM microcontroller and use it	25
CO-4	Exemplify memory management system of ARM and different versions of ARM	15
CO-5	Design ARM based system to solve real life challenges	15

Suggested List of Experiments:
1. To write and simulate ARM assembly language programs for data transfer, arithmetic and logical operations.
2. To write and simulate C Programs for ARM microprocessor in KEIL
3. To interface LED with ARM microprocessor and write program to blink LED at the interval of 1 second
4. To interface switch with ARM microprocessor and write program in C language to read status of the switch
5. To interface LCD with ARM microprocessor. Write and execute programs in C language for displaying text messages and numbers on LCD.
6. To interface DC motor with ARM microprocessor. Write program to rotate DC motor in clockwise and anticlockwise direction with different speed
7. To interface Stepper motor with ARM microprocessor. Write program to rotate motor in half step and full step mode

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8. Programming NodeMCU with Arduino IDE or Micropython. Write and execute programs for device control using Android App and NodeMCU

9. Write program to control devices using webpage and NodeMCU.

10. Write program to read analog value from sensors (light, temperature, humidity etc.) using NodeMCU and upload data on cloud.

11. Student mini project based on ARM microprocessor/NodeMCU

List of Open Source Software/learning website:

- NPTEL Video lecture on https://nptel.ac.in/courses/117106111/

- Energia Software for Texas Tiva Board

- Micropython