GUJARAT TECHNOLOGICAL UNIVERSITY

BE - Semester 6
Minor Degree : Electrical and Computer
Subject Code : 116AK01
Subject Name : Embedded Systems with RTOS

Prerequisite : Knowledge of microprocessor/microcontroller hardware, programming concept in assembly and C, Knowledge of Op amp amplifiers, analog low pass filters, ADC, FIFO queues, digital filters, knowledge of Open loop and closed loop & Linear and Nonlinear control system

Objective :

On successful completion of this course, students will have an in depth understanding of real-time operating systems, real-time debugging, and embedded systems. After the successful conclusion of students should be able to design real-time embedded systems, such as motor controllers, data acquisition systems, data communication systems and robotic systems.

Teaching and Examination Scheme :

Teaching Scheme			Credits	Examination Marks				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	2	4	70	00	30	00	100

Sr. No.	Content	Total Hrs.
1	**32 BIT ARM CORE ARCHITECTURE :** ARM Cortex-M Processors cores, Thumb-2 ISA (Instruction Set Architecture), Memory organization, on-core buses (D-BUS, I-BUS, SYSTEM BUS), core peripherals like system tick timer, NVIC etc., bus matrix.	04
2	**EMBEDDED C PROGRAMMING FOR 32 BIT MCUS :** Introduction to Embedded C programming, Data types, loops, logic statements, functions, arrays, pointers, structures, pointer to structure and pointer to functions.	04
3	**INTRODUCTION TO STM32 FAMILY OF MCUS :** STM32F407(MCU) architecture, MCU buses, bus- matrix , memory organization, AHB and APB buses, Introduction to STM32 programming tool chain,STM32CubeMX(auto generated initialization C-code for STM32 MCUs.), STM32CubeIDE(compiler, linker , de-bugger), methods of hardware de-bugging(break points and single stepping), programming of ISRs and final infinite loop, Introduction to **HAL** library.	04

4	**GPIO , NVIC AND TIMERS ON STM32 :** Overview, Input Mode, Output Mode, GPIO Registers, GPIO HAL Libraries, GPIO programming, NVIC Overview: Nested Interrupt Vector Table, GPIO as External Interrupts, interrupt priorities, basic timers , advanced motor controller timers, general purpose timers, PWM wave form generation programming examples.	**08**
5	**ADC ON STM32 :** ADC architecture on STM 32, ADC registers, ADC HAL library, ADC Configuration and programming, Various Interrupts Associated with ADC, Analog Sensor Interfacing using ADC, introduction to DMA.	**04**
6	**EMBEDDED SOFTWARE ARCHITECTURE and RTOS :** Concept of real time systems, concept of real-time task scheduling, scheduling methods, round robin scheduler, round robin with interrupt scheduler, Function queue scheduler, RTOS scheduler, co-operative and preemptive RTOS. Foreground and bade ground process, task and task state, Semaphores and shared data, multitasking situations, static and dynamic priority, message queens, timer function, memory management ISR in RTOS, Embedded system design using RTOS.	**10**
7	**DATA COMUNICATION PERIPHERALS ON STM32 AND INTEFACING :** UART on STM32, SPI, I2C synchronous serial communication ports, programming of UART, SPI and I2C, seven segment LED display, LCD display, push button keys .	**08**

Suggested Specification table with Marks (Theory) :

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
25	**25**	**25**	**15**	**10**	**5**

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 the above table.

Reference Books :

1) STM32F407 Data sheet and STM32F407 user reference manual (www.st.com).
2) An Embedded Software Primer by David Simon.
3) Discovering the STM32 Microcontroller by Geoffrey Brown.

4) The Insider's Guide to STM32 (www.hitex.com).
5) Jean J. Labrosse, µC/OS-III: The Real-time Kernel for Texas Instruments Stellaris, Micrium. (available in electronic format).
6) Joseph Yiu, The Definitive Guide to the ARM Cortex-M3 and Cortex-M4 Processors, Third Edition, 2013, ISBN: 978-012408082.
7) For programming in C, see the EE312 text, or the Embedded Software in C online reference by Jon Valvano and Ramesh Yerraballi.

Course Outcomes :

Sr. No.	CO STATEMENT	Bloom's taxonomy level	Marks % weightage
CO1	To introduce the architecture of ARM Cortex-M core and STM32 microcontroller.	**Remember L1 , Understand L2, Evaluate L5,**	**10 %**
CO2	To introduce Embedded C programming and STM32 programming tool chain.	**Remember L1 , Understand L2, Evaluate L5,**	**20 %**
CO3	To educate GOIO and TIMERS and ADC peripherals on STM32 with programming exercise.	**Remember L1 , Understand L2, Evaluate L5**	**25 %**
CO4	To learn embedded software architecture and Real Time operating system.	**Remember L1 , Understand L2, Evaluate L5 Create L6**	**25 %**
CO5	To learn communication ports on STM32 like UART, SPI, I2C and interfacing with programming exercise.	**Remember L1 , Understand L2, Evaluate L5 Create L6**	**20 %**

MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES :

1 : Slight (Low) 2 : Moderate (Medium) 3 : Substantial (High) : None

Suggestive List of Experiments :

1) Introduction to STM32CubeMX and STM32CubeIDE with STM32F4 Nucleo or Discovery boards.
2) GPIO programming and LED blinking with software delay.
3) Basic Timer programming and delays, generation of square wave using timer interrupts.
4) Programming of advanced timer for PWM waveforms.

5) Programming of LCD interfaced with STM32.
6) Programming of push button keys and key de bounce.
7) Programming of ADC for analog signals.
8) Programming of UART for serial communication.
9) SPI programming exercise.

List of Software / learning website : www.st.com/programming examples.