GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3161009
EMBEDDED SYSTEM
SEMESTER-VI

Type of course: Programme Elective Course

Prerequisite: Knowledge of microprocessor/microcontroller hardware, programming concept in assembly and C.

Rationale: Embedded System plays crucial role in today's industry, where automation is generally achieved by microcontroller based system. Some of higher end multi-processing application requires OS/RTOS level programming to achieve real time requirements. Also, Internet of Thing (IOT) gives basic idea of future trends, application area and challenges.

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	30	30	20	150

Content:

Sr. No.	Content	Total Hrs	% Weightage
1	**Introduction to Embedded Systems** Embedded Systems, Processor Embedded into a System, Embedded Hardware Units and Devices In a System, Embedded Software in a system, Examples of Embedded Systems, Embedded System-on-chip (SOC) and Use of VLSI Circuit Design Technology, Complex Systems Design and Processors, Design Process in Embedded System, Formulization of System Design, Design Process and Design Examples, Classification of Embedded Systems, Skills Required for an Embedded System Designer	3	5%
2	**Device and Communication Buses** Timer and Counting Devices: Watch dog timer, Real time clock, Brown Out Reset, Serial Communication protocols : UART, I2C, SPI, SDIO, CAN, SDIO, USB, JTAG, Spy-Bi-Wire Parallel Communication protocols : ISA, AMBA, PCI, PCI-X, Wireless Communication Protocols : IrDA, Bluetooth, WiFi, Zigbee	6	15%
3	**Device Drivers and Interrupt Services Mechanism** Programmed-I/O Busy-wait Approach without Interrupt Services Mechanism, ISR Concept, Interrupt Sources, Interrupt Servicing(Handling) Mechanism, Multiple Interrupts, Context and the Periods for Context Switching, Interrupt Latency and Deadline, Classification of Processor Interrupt Service Mechanism from Context-Saving Angle, Direct Memory	5	5%

	Access, Device Driver Programming		
4	**Inter-process Communication:** Multiple process in an application, Multiple Threads in an application, Task and Task state, Task and Data, Clear-cut Distinction between Functions, ISRS and Tasks by their Characteristics, Concept of Semaphores, Shared Data, Inter process Communication, Signal Function, Semaphore Functions, Message Queue Functions, Mailbox Functions, Pipe Functions, Socket Functions, RPC Functions	**8**	**20%**
5	**Introduction to OS and Real Time Operating System:** Overview of OS: Multirate Systems, Processes and Threads, Context Switching, Multi tasking, Cooperative Multi-tasking, Pre-emptive Operating Systems structure, Operating system function, Timing requirements on processes, Features of an Operating System, Features of RTOS, Case studies: FreeRTOS. µCOS, RTx51 TinyOS, Benchmarking RTOS, VxWorks.	**7**	**20%**
6	**Software architectures and Real Time Task Scheduling:** Requirements of Embedded Software, Interrupts- Basics, latency, Process state and scheduling, Clock driven and Event driven scheduling, Rate-Monotonic Scheduling, Earliest-Deadline First Scheduling, Fault-Tolerant Scheduling, Round Robin, Round robin with interrupt, function queue scheduling.	**6**	**20%**
7	**MSP430 (Case Study):** Motivation for MSP 430 Microcontrollers, MSP430 RISC CPU architecture, Compiler-friendly features, On-chip peripherals and programming for - Watchdog Timer, Basic Timer, Real Time Clock (RTC), ADC, Universal Serial Communication Interface (USCI), Low-power features of MSP430	**7**	**15%**

Suggested Specification table with Marks (Theory):

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

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Reference Books:

[1] Embedded System: Architecture, Programming and Design by Raj Kamal, 2nd Edition, TMH Publication
[2] Embedded Software Premier David Simon (Pearson)
[3] Computers as Components Principles of Embedded Computing System Design by Wayne Wolf, Morgan Kaufman
[4] Real Times Systems Theory and Practice by Rajib Mall (Pearson Education)
[5] Embedded Real-time Systems Programming Sri Ram Iyer and Pankaj Gupta (TMH)
[6] The Linux Programming Interface , Michael Kerrisk
[7] MSP430 Microcontroller Basics by John H. Davies, 1st Edition, Elsevier

Course Outcome:

After learning the course the students should be able to:

- Understand the differences between the general computing system and the embedded system, also recognize the classification of embedded systems.
- Recognize basics of various embedded hardware and protocol standards.
- Learn and analyze basics of operating system fundamentals and real-time operating systems concepts.
- Analyze Inter-Process Communication methods.
- Learn programming using POSIX concept.
- Design software for embedded computer systems using a real-time operating system.

List of Experiments:

(General guidelines.. Institute may change list of experiments based on laboratory set up available)

- GPIO Programming with MSP430 – LED, Switches, seven-segment, 16x2 LCD
- MSP430 – Timer, UART, SPI, I2C Programming
- Watch Dog Timer, Brown-out reset design using MSP430
- MSP430 with RTOS programming
- POSIX pthread : create, delete, merge
- Tiny RTx51, uCOS , VxWork (study and/or basic programming)
- Raspberry Pi based OS controlled IO programming.

Design based Problems (DP)/Open Ended Problem:

1. Design of microcontroller application based on RTOS.
2. Design of petrol-pump system with/without RTOS.
3. Design Air-bag system with/without RTOS.

Major Equipment:

1. MSP430 Hardware Boards or Proteous based environment

2. LINUX System
3. Switches, LEDs, Relay, Solenoid valves, motor drivers
4. WiFi, Bluethooth boards.
5. Robot for demonstration