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Vellore Institute of Technology
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CHENNAI

Reg. No 22BBS1085

Final Assessment Test(FAT) - Apr/May 2025

Programme	B.Tech.	Semester	Winter Semester 2024-25
Course Code	BCSE305L	Faculty Name	Prof. Satheesh Kumar T
Course Title	Embedded Systems	Slot	G2+TG2
		Class Nbr	CH2024250501701
Time	3 hours	Max. Marks	100

Instructions To Candidates

- Write only your registration number in the designated box on the question paper. Writing anything elsewhere on the question paper will be considered a violation.

Course Outcomes

CO1: Identify the challenges in designing an embedded system using various microcontrollers and interfaces.
CO2: To summaries the functionality of any special purpose computing system, and to propose smart solutions to engineering challenges at the prototype level.
CO3: To examine the working principle and interface of typical embedded system components, create programme models, apply various optimization approaches including simulation environment and demonstration using debugging tools.
CO4: To evaluate the working principle of serial communication protocols and their proper use, as well as to analyze the benefits and drawbacks of real-time scheduling algorithms and to recommend acceptable solutions for specific challenges.

Answer all Questions (10 × 10 Marks)

01. (a) Describe the primary functionalities of the 8051 microcontroller. How do its core components, such as the CPU, memory (RAM and ROM), I/O ports, and serial communication interface, support typical embedded applications? (5 Marks)

(b) You are tasked with designing an automated water level monitoring system for a small water tank using the 8051 microcontroller. The system should measure the water level using a sensor, display the level on an LCD, and activate a water pump if the water level drops below a set threshold.
Based on the above task, answer the following questions:

(i) Which features of the 8051 microcontroller would you utilize to read the sensor data, control the LCD, and activate the water pump ? (2.5 Marks)

(ii) Describe how you would set up the 8051's I/O ports, timers, and interrupts to handle these tasks efficiently. (2.5 Marks)

[10] (CO1/K1)

02. (a) Given a 10-bit Analog-to-Digital Converter (ADC) to measure an input voltage ranging from 0V to 3.3V, calculate the resolution of this 10-bit ADC in terms of voltage per step. If the input voltage is 2.45V, calculate the digital output value that the ADC would produce. (5 Marks)

(b) Imagine you are designing an embedded system to monitor and respond to rapid voltage fluctuations in a high-speed sensor signal. You have the option to use either a successive approximation ADC (SAR ADC) or a flash ADC.

(i) Evaluate which type of ADC would be more suitable for this application and explain why. (2.5 Marks)

(ii) Analyze the trade-offs in terms of speed, resolution, complexity, and power consumption between the SAR ADC and flash ADC. If cost is also a factor in your design, how might this affect your choice? (2.5 Marks)

[10] (CO2/K4)

03. You are an embedded engineer working for a company developing a next-generation digital camera for wildlife photographers. The camera must capture high-speed action shots in various lighting conditions, from bright daylight to low-light forest environments. Your task is to design an efficient image-capturing system that delivers high-quality images under these challenging conditions.

(a) Explain the architecture of the digital camera you would design for this application. Describe the roles of the lens, image sensor, processor, storage, and other key components, and how they work together to capture and process high-speed images effectively. (5 Marks)

(b) Wildlife photography often involves capturing subjects in harsh lighting conditions, such as bright sunlight, deep shadows, or nighttime environments. Analyze the key requirements for high-quality image capture, including resolution, sensor sensitivity (ISO), and dynamic range. How do these factors impact the camera's performance in these different lighting scenarios? (5 Marks)

[10] (CO2/K2)

04. You are designing a real-time traffic management system for a smart city. The system must process critical tasks in real-time, such as:

Task A: Detecting emergency vehicles and clearing traffic (Execution time = 2ms, Deadline = 6ms)

Task B: Managing traffic light signals dynamically (Execution time = 3ms, Deadline = 10ms)

Task C: Monitoring and analyzing vehicle congestion data (Execution time = 1ms, Deadline = 4ms)

To ensure smooth traffic operations, the system implements the Earliest Deadline First (EDF) scheduling algorithm to prioritize and execute tasks efficiently.

(a) Using the Earliest Deadline First (EDF) scheduling algorithm, determine the order in which these tasks will be scheduled. Explain how EDF prioritizes tasks based on deadlines and discuss how the algorithm responds if the system becomes overloaded with tasks exceeding available CPU time. (5 Marks)
(b) In a real-time traffic management system, timing constraints, task scheduling, and predictability are crucial for ensuring safety and efficiency. Analyze the importance of these factors and identify potential challenges, such as task prioritization conflicts, resource contention, and the risk of missing deadlines in high-traffic conditions. (5 Marks)

[10] (CO4/K3)

05. You are developing an embedded system for a smart home device where multiple sensors (temperature, humidity, light) and actuators (LEDs, motors) communicate with a central microcontroller using the I2C protocol. The system needs to transmit data efficiently between various components while ensuring minimal wiring and proper device addressing.

(a) In this smart home system, several devices are connected on a shared I2C bus. Analyze how the I2C protocol facilitates data transmission between devices on the same bus, considering aspects like bus arbitration and data integrity. (5 Marks)
(b) In your system, the microcontroller acts as the master, and the sensors and actuators are the slaves. Evaluate the roles of the master and slave devices in terms of addressing and how each device knows when to send or receive data. (2 Marks)
(c) The I2C communication involves two primary lines: SDA (Serial Data) and SCL (Serial Clock). Explain the purpose of these two lines in the context of your smart home system and how they ensure synchronized data transfer. (3 Marks)

[10] (CO3/K3)

06. a) Design an embedded C program for the 8051 microcontroller to transmit the string "VIT CHENNAI" via serial communication using UART at a baud rate of 9600. (5 Marks)

b) Explain role of the SCON register in setting up the UART mode and how do you configure Timer 1 to generate the baud rate for UART communication. (5 Marks)

Note: Assume the crystal frequency is 11.0592 MHz. Initialize the serial port appropriately and ensure continuous transmission of the string with a delay of 1 second between each transmission.

[10] (CO1/K3)

07. You are tasked with setting up a Wi-Fi network for a medium-sized office environment with around 50 employees. The office has multiple floors and several conference rooms, and the network must support various devices, including laptops, smartphones, and IoT devices such as smart printers and security cameras.

Based on the above scenario, answer the below questions.

a) Design an efficient Wi-Fi network for this office and consider factors like access point placement, frequency bands, and channel selection. (5 Marks)

b) How would you ensure that the network can handle high traffic during peak usage times while maintaining optimal performance for all devices? (5 Marks)

[10] (CO3/K4)

08. You are tasked with optimizing the following Embedded C code for the 8051 microcontroller. The code is responsible for reading the value of a sensor connected to Port 1 Pin 0 and turning on a corresponding LED on Port 2 Pin 1 if the sensor value exceeds a threshold.

```
#include <reg51.h>

void main() {
 unsigned char sensor_value;
 while (1) {
  sensor_value = P1 & 0x01; // Read sensor value from Port 1 Pin 0
  if (sensor_value > 0) {  // If sensor value is greater than threshold
   P2 = 0x02;      // Turn on LED on Port 2 Pin 1
  } else {
   P2 = 0x00;      // Turn off LED on Port 2 Pin 1
  }
 }
}
```

(a) Identify the areas where the code can be optimized for speed and memory usage on the 8051 microcontroller. Explain why these optimizations are necessary for an embedded system. (5 Marks)
(b) Refactor the given code to implement the optimizations. Provide the optimized Embedded C code. (5 Marks)

[10] (CO3/K4)

09. You are designing an embedded system for an automated industrial control system that manages critical processes such as temperature control, pressure monitoring, and motor operation. The system must operate continuously and reliably, with minimal downtime, to avoid production losses or safety hazards.

(a) Explain the functioning of a watchdog timer in the context of this industrial control system. Discuss its role in monitoring system operations and ensuring the system remains responsive, even in the event of software failures or system crashes. (5 Marks)
(b) In your system, if the watchdog timer fails or is not properly implemented, it could result in critical processes becoming unmonitored or stuck, leading to potential safety risks or system failure. Provide an example scenario where the absence or failure of a watchdog timer could lead to such unsafe conditions. How would implementing a properly configured watchdog timer prevent these situations from occurring? (5 Marks)

[10] (CO2/K1)

10. You are tasked with designing a 4-to-2 priority encoder for a digital system. The encoder has 4 input lines (I0, I1, I2, I3) and two output lines (Y1, Y0) along with a valid output (V) to indicate whether any input is active.

(a) Write the Boolean equations for the output lines (Y1, Y0) and the valid output (V) based on the priority encoding rules. (5 Marks)
(b) Explain how the priority encoder works and how the priority of inputs is determined for generating the output values. (5 Marks)

[10] (CO1/K1)