American International University-Bangladesh (AIUB)
Faculty of Engineering
Department of Electrical and Electronic Engineering (EEE)

Course Name:	Microprocessor and Embedded Systems	**Course Code:**	EEE 4103
Semester:	Spring 2024-25	**Term:**	Mid
Faculty Name:	Prof. Dr. Engr. Muhibul Haque Bhuyan	**Assignment #:**	01

Course Outcome Mapping with Questions

Item	COs	POIs	K	P	A	Marks	Obtained Marks
Q1	**CO2**	**P.a.4.C3**	**K4**	**P1, P3, P7**		**30**	
					Total:	**30**	

Student Information:

Due Date:	**22 April 2025**	**Submission Date:**		**22 April 2025**	
Student Name:	**Md. Mosharof Hossain Khan**				
Student ID #:	**23-51259-1**	**Department:**	**CSE**	**Section:**	**P**

Marking Rubrics (to be filled by Faculty):

Problem #	Excellent [26-30]	Proficient [21-25]	Good [11-20]	Acceptable [6-10]	Unacceptable [1-5]	No Response [0]	Secured Marks
	Detailed unique response explaining the concept properly and the answer is correct with all works clearly shown.	Responses with no apparent errors and the answer is correct, but the explanation is not adequate/unique.	The response shows an understanding of the problem, but the final answer may not be correct	Partial problem is solved; the response indicates part of the problem was not understood clearly or not solved.	Unable to clarify the understanding of the problem and the method of problem-solving was not correct	No Response/ copied from others/identical submissions with gross errors/image file printed	
Comments						**Total Marks (30)**	

Question # 1: Complete Table 1 after reviewing the specified microcontrollers' datasheet.

Table 1

Specifications	ATMega328PB	STM32F401RET6TR	STM32F446xC/E	ATMega2560	PIC16F628
Architecture Type	8-bit AVR enhanced RISC(Reduced Instruction Set Computer) Architecture	ARM Cortex-M4 32-bit RISC	ARM Cortex-M4 32-bit RISC	8-bit AVR enhanced RISC Architecture	8-bit Harvard RISC (PIC16 family)
Maximum Clock Speed	20MHz	84 MHz	180 MHz	16 MHz	20 MHz
Program Flash Memory (KB)	32 KB	512 KB	512 KB	256 KB	2 KB
SRAM (KB)	2 KB	96 KB	128 KB	8 KB	0.219 KB
EEPROMM (KB)	1 KB	No EEPROM (Use Flash Memory)	No EEPROM (Use Flash Memory)	4 KB	0.125 KB
ADC Resolution	10-bits	12-bits	12-bits	10-bits	Does not have
Operating Voltage Range (V)	1.8 - 5.5V	1.7 – 3.6 V	1.7 – 3.6 V	4.5 - 5.5V	3.0 – 5.5 V
Number of Timers	**5 timers:** two 8-bit timers and Three 16-bit timers	**11 timers** 1.General-purpose 16-bit timers: 6 2.General-purpose 32-bit timers: 2 3.SysTick timer: 1 4.Watchdog timers: 2 (independent and window)	**17 timers** 1.16-bit timers:12 2.32-bit timers:2 3.watchdog timers:2 4.SysTick timer:1	**6 timers:** two 8-bit timers and four 16-bit timer	**3 timers:** One 8-bit timer,one 16-bit timer and an 8-bit timer with a prescaler.
Number of PWM Channels	10 PWM channels	Theoretically 23 PWM but Practically 15-17PWM Channel	Theoretically 23 PWM but Practically 15-17PWM Channel	15 PWM channels	1 PWM channels
Communication Interfaces	2 SPIs, 2 TWIs, 2 USARTs	4 SPIs, 3 TWIs, 3 USARTs	4 SPIs, 4TWIs, 4 USARTs,2SAI, 2CAN	1SPIs,1TWIs, 4 USARTs	1 SPIs, 1 USARTs

The unit prices of the above-mentioned MCUs are as follows: (1 USD = 118 BDT)

	ATMega328PB	**STM32F401RET6TR**	**STM32F446xC/E**	**ATMega2560**	**PIC16F628**
Price	$3.20	$4.12	$3.9	$20	$1.9

XYZ Industry in Bangladesh is trying to develop an affordable shop security system, and they have shortlisted the listed 1000 MCUs as possible candidates for their system CPU. The required minimum specifications for their intended design for the CPU are given below:

Minimum Clock Speed	16 MHz
Minimum SRAM	8 kB
Minimum ADC Resolution	12-bit
Minimum Program Memory	64 kB
Minimum Number of PWM Channels	12
Minimum Number of Timers	10
Required Serial Communication Interfaces	4 SPIs, 2 TWIs, 3 USARTs

Being a design engineer at *XYZ* Industry, you have been given the responsibility of selecting the most suitable IC from the list for the security system design that requires a minimum of 1000 microcontroller ICs.
Select an appropriate IC from the list to design an affordable and efficient system and justify your answer with proper reasoning. **Compute** the total cost of designing the system.

Ans: XYZ Industry in Bangladesh is planning to develop a cost-effective shop security system and has shortlisted five different microcontroller units (MCUs) as potential candidates. To select the most suitable MCU, I have reviewed each one against the system's required minimum specifications in terms of Clock speed, SRAM, ADC Resolution, Memory, PWM, Timers communication interfaces, and cost. Based on this analysis, I will now compare the available options to determine which MCU best meets the criteria while ensuring affordability for a batch of 1000 units.

The required minimum specifications for the project are:

1. Minimum Clock Speed: **16 MHz**
2. Minimum SRAM: **8 KB**
3. Minimum ADC Resolution: **12-bit**
4. Minimum Program Memory: **64 KB**
5. Minimum Number of PWM Channels: **12**
6. Minimum Number of Timers: **10**
7. Required Serial Communication Interfaces: **4 SPIs, 2 TWIs, 3 USARTs**

Now, based on the above requirements, I will compare the shortlisted microcontrollers to determine which one best fits the design criteria for the shop security system.

❖ ATMega328PB

1. Clock Speed: **20 MHz** ; Meets the requirement because the minimum is **16 MHz**.
2. SRAM: **2 KB** ; Does not meet the minimum because the required is **8 KB.**
3. ADC Resolution: **10-bit** ; Does not meet the minimum because the required is **12-bit.**
4. Program Memory: **32 KB** ; Does not meet the minimum because the required is **64 KB.**
5. Number of PWM Channels: **10 Channels**; Does not meet the minimum because the required is **12.**
6. Number of Timers: **5 timers** ; Does not meet the minimum because the required is **10.**
7. Communication Interfaces: **2SPIs, 2TWIs, 2USARTs**; Does not meet the requirement because the required is **4SPIs, 2TWIs, 3USARTs**.

ATMega328PB meets the requirements for Clock speed, but does not fulfill the criteria for others.Therefore, it is not suitable for the intended shop security system design.

❖ STM32F401RET6TR

1. Clock Speed: **84 MHz** ; Meets the requirement because the minimum is **16 MHz.**
2. SRAM: **96 KB** ; Meets the requirement because the minimum is **8 KB.**
3. ADC Resolution: **12-bit** ; Meets the requirement because the minimum is **12-bit.**
4. Program Memory: **512 KB** ; Meets the requirement because the minimum is **64 KB**.
5. Number of PWM Channels: **(15-17) PWM**; Meets the requirement because the minimum is **12.**
6. Number of Timers: **11 timers** ; Meets the requirement because the minimum is **10**.
7. Communication Interfaces: **4SPIs, 3TWIs, 3USARTs**;Meets the requirement because the minimum is **4SPIs, 2TWIs, 3USARTs.**

STM32F401RET6TR meets all the required specifications, including clock speed, SRAM, ADC resolution, program memory, number of timers, PWM channels, and communication interfaces. Therefore, it is suitable choice for the intended shop security system design.

❖ STM32F446xC/E

1. Clock Speed: **180 MHz** ; Meets the requirement because the minimum is **16 MHz.**
2. SRAM: **128 KB** ; Meets the requirement because the minimum is **8 KB**.
3. ADC Resolution: **12-bit** ; Meets the requirement because the minimum is **12-bit**.
4. Program Memory: **512 KB** ; Meets the requirement because the minimum is **64 KB**.
5. Number of PWM Channels**: (15-17) PWM**; Meets the requirement because the minimum is **12**.
6. Number of Timers: **17 timers** ; Meets the requirement because the minimum is **10**.
7. Communication Interfaces: **4SPIs, 4TWIs, 4USARTs**; Meets the requirement because the minimum is **4SPIs, 2TWIs, 3USARTs.**

STM32F4446xC/E also meets all the required specifications, including clock speed, SRAM, ADC resolution, program memory, number of timers, PWM channels, and communication interfaces. Therefore, it is also suitable choice for the intended shop security system design.

❖ ATMega2560

1. Clock Speed: **16 MHz** ; Meets the requirement because the minimum is **16 MHz**.
2. SRAM: **8 KB** ; Meets the requirement because the minimum is **8 KB**.
3. ADC Resolution: **10-bit** ; Does not meet the minimum because the required is **12-bit**.
4. Program Memory: **256 KB** ; Meets the requirement because the minimum is **64 KB.**
5. Number of PWM Channels: **15 PWM**; Meets the requirement because the minimum is **12**.
6. Number of Timers: **6 timers** ; Does not meet the minimum because the required is **10**.
7. Communication Interfaces: **1SPIs, 1TWIs, 4USARTs**; Does not meet the minimum because the required is **4SPIs, 2TWIs, 3USARTs**.

ATMega2560 meets the requirements for Clock speed, SRAM, Memory, PWM but does not fulfill the criteria for others. Therefore, it is not suitable for the intended shop security system design.

❖ PIC16F628

1. Clock Speed: **20 MHz** ; Meets the requirement because the minimum is **16 MHz.**
2. SRAM: **0.219 KB** ; Does not meet the minimum because the required is **8 KB**.
3. ADC Resolution: **No ADC**; Does not meet the minimum because the required is **12-bit.**
4. Program Memory: **2 KB** ; Does not meet the minimum because the required is **64 KB**.
5. Number of PWM Channels: **1 PWM**; Does not meet the minimum because the required is **12**.
6. Number of Timers: **3 timers** ; Does not meet the minimum because the required is **10**.
7. Communication Interfaces: **1SPIs, 1USARTs**; Does not meet the minimum because the required is **4SPIs, 2TWIs, 3USARTs**.

PIC16F628 meets the requirements for Clock speed but does not fulfill the criteria for others. Therefore, it is not suitable for the intended shop security system design.

From the comparison, it is observed that both **STM32F401RET6TR** and **STM32F446xC/E** meet all the minimum required specifications for the shop security system. Therefore, the final selection will be based on cost efficiency. The total cost for 1000 units of each microcontroller will be calculated to determine the more economical choice.

Cost Calculation: **(**1 USD = 118 BDT)

- ***For STM32F401RET6TR:***

Given,

- **Unit Price**: $4.12
- **Total Cost in USD**:
  (4.12×1000)= 4120 USD
- **Total Cost in BDT**:
  (4120×118)=486,160 BDT

So,this IC requires a total cost of **486,160 BDT** for 1000 pieces.

- ***For STM32F4446xC/E:***

Given,

- **Unit Price**: $3.9
- **Total Cost in USD**:
  3.9×1000=3900USD
- **Total Cost in BDT**:
  3900×118=460,200BDT

So, this IC requires a total cost of **460,200 BDT** for 1000 pieces.

After a detailed comparison of the shortlisted microcontroller units (MCUs) based on the specified requirements of XYZ Industry's shop security system, it has been observed that only STM32F401RET6TR and STM32F446xC/E meet all the minimum required specifications, including clock speed, SRAM, ADC resolution, program memory, number of timers, PWM channels, and communication interfaces.Among the two, both are technically capable, but the STM32F446xC/E stands out due to its higher performance specifications and lower overall cost for 1000 units. While **STM32F401RET6TR** would cost **486,160 BDT**, **STM32F446xC/E** would cost **460,200 BDT**, saving 25,960 BDT in total without compromising any of the system requirements.

Conclusion:

Eventually based on performance, compliance with minimum requirements and cost-efficiency the **STM32F446xC/E** is the most suitable and practical choice for implementing the security system design for XYZ Industry.

References:

[1] **ATMega328PB:** **https://ww1.microchip.com**
[2] **STM32F401RET6TR:** **https://www.st.com/resource/en/datasheet/stm32f401re**
[3] **STM32F446xC/E:** **https://www.st.com/resource/en/datasheet/stm32f446mc**
[4] **ATMega2560:** **https://ww1.microchip.com/downloads/en/devicedoc/atmel**
[5] **PIC16F628:** **https://www.alldatasheet.com/datasheet-pdf/pdf/574755**