American International University - Bangladesh (AIUB)
Faculty of Engineering

Course Name:	Microprocessor and Embedded System	**Course Code:**	EEE 4103
Semester:	Spring 2023-24	**Term:**	Mid
Faculty Name:	**Md. Shaoran Sayem**	**Assignment #:**	02/02

Course Outcome Mapping with Questions

Item	COs	POIs	K	P	A	Marks	Obtained Marks
Q1-4	CO1	P.a.4.C3	K4	P1, P3, P7		5×4	
					Total:	20	

CO/ CLO Number	CO/CLO Statement	K	P	A	Assessed Program Outcome Indicator	BNQF Indicator	Teaching-Learning Strategy	Assessment Strategy
CO1	Apply knowledge of microprocessors and microcontrollers to configure different modules of a microprocessor or microcontroller-based system as per given specifications and perform in-depth analysis to optimize the performance of the designed system utilizing the basic concepts and properties of a microcontroller.	K4	P1, P3, P7		P.a.4.C.3	FS.2	Lecture/ Discussion/ Q&A	Midterm Assignment 2

Student Information:

Due Date:	05/03/2024									**Submission Date:**		6/3/24	
Student Name:	MD. ABU TOWSIF												
Student ID #:	2	2	-	4	7	0	1	9	-	1	**Department:** CSE	**Section:**	J
	p	q	-	a	b	c	d	e	-	r			

Marking Rubrics (to be filled by Faculty):

Problem #	Excellent [5]	Proficient [4]	Good [3]	Acceptable [2]	Unacceptable [1]	No Response [0]	Secured Marks
	Detailed unique response explaining the concept properly and the answer is correct with all works clearly shown.	Response 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	The 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 method of the problem solving was not correct	No Response/ copied from others/identical submissions with gross errors/ image file printed	
1							
2							
3							
4							
Comments						Total marks (20)	

1. In a biscuit factory, a control system has been designed based on an Arduino Uno microcontroller.This system transfers the biscuit packets at a regular time interval to the conveyor belt from the biscuit-making machine. It was found that the Timer modules in the Arduino microcontroller are perfect candidates to count the number of biscuit packets being transferred to the conveyor belt correctly and appropriately. Compute the number of biscuit packets being transferred using the Timers within the following time intervals (Timer0 or Timer1 may be used as needed).
   a) r0 ms
   b) abc ms

   Assume that the Arduino system clock has been set at 1q MHz and the available pre-scalers of the system are 1, 8, 64, 256, 512, and 1024. Comment on why and how the required counts are possibleto implement using Timer0 or Timer1. Write down the program codes for the Arduino board.

2. (a) A TV remote controller is to be designed for the selection of channels. The channel selection buttons are required to be debounced, that is, one press must cause the remote to change to the subsequent channel. It was observed that the switches exhibit bounce times well under b ms and the duty cycle is 50%. Design a circuit using the 74HC14 Schmitt trigger IC along with the resistance and capacitance. The worst-case V_{th} of 74HC14 for a signal going LOW is 2.r V and that of when going high is 0.pq V. Also, consider that the CMOS device leakage current is pa μA and the gate's best-case switching point is of the order of 0.r V. What is the hysteresis voltage?

   (b) Write a software code for the Arduino to read the status of a switch connected to pin number p by avoiding the bouncing problem of the switch and then display that switch status in the LED connected to pin number 1r. If the switch status is HIGH/LOW the LED will be turned ON/OFF respectively. It was observed that the switches exhibit bounce times well under q0 ms and the dutycycle is 50%. Use the Timer0 or Timer1 function of the Arduino to compute this delay. Also, drawthe flow chart of this program.

3. A biomedical engineer is to design a new laboratory where biologically hazardous materials arebeing used for experimental research works. As such, during the experimental works are ongoing, no one is allowed to remain inside the laboratory. To display the message that hazardous materials are being used in the laboratory, 2 lights with green and red colors are installed at the entrance door of the laboratory. When the green light is turned on, it indicates that anybody can enter the laboratory but when the red light is turned on then none can enter the laboratory. It is to be ensured that both lights can't remain turned on at the same time and these 2 lights should be controlled using a single mechanical switch inside the laboratory, and they can only light up alternatively when the switch is pressed or depressed. The switch has already been debounced using a hardware circuit. Draw a flowchart to show the logical flow of the program and then write a program for the Arduino Uno microcontroller to operate the door lights based on the switch conditions as per the given constraints.

4. Write an Arduino microcontroller code for an acd ms interval LED blinking system using Timer$x$ (x = 0-2) interrupts and a pre-scalar value of 1024. LED is connected to the pin r of the board. Compute the value to be loaded into the OCR(r-1)A register.

ANSWER TO THE QUESTION NO - 1

(A)

ID:

2	2	-	4	7	0	1	9	-	1
p	q	-	a	b	c	d	e	-	r

Here,
Required Delay = r0 =10ms
Pre-scalar value = 1024
Clock = 12MHz
System clock period = 1÷12000000 = 83.3ns
Timer clock period = 83.3ns ×1024 = 85µs
Timer count = (10ms ÷ 85µs) -1 = 116.65
Counts required = 116.65 ≈ 117.
With the 10ms time the possible number of biscuit packets that can be counted is 117. Here Timer0 can be used as the maximum count for Timer0 is 255.

Code:

```
#define PIN_USED 8
int milisec = 10;
int prescaler = 1024;
float clock_freq = 12000000.0 / prescaler;
float clock_period = 1.0 / clock_freq;
int count = (milisec * 0.001 / clock_period) - 1;
void setup() {
pinMode(PIN_USED, OUTPUT);
// Configure Timer0
TCCR0A = 0b00000000;
TCCR0B = 0b00000101;
TCNT0 = 0;
}
void loop() {
if (TCNT0 >= count) {
TCNT0 = 0; // Reset the counter
digitalWrite(PIN_USED, !digitalRead(PIN_USED));
}
    }
```

(B)

Required Delay = abc = 470ms
Pre-scaler value = 1024
System clock period = 1÷12000000 = 83.3ns
Timer clock period = 83.3ns ×1024 = 85µs
Timer count = (470ms /85µs) – 1 = 5529.411
Counts required = 5529.411 ≈ 5529

With the 462ms time the possible number of biscuit packets that can be counted is 5529. Here Timer0 cannot be used as it can only count up to 255. Whereas Timer1 can count up to 65535. So Timer1 is used here.

Code:

```
#define PIN_USED 8
int milisec = 470;
int prescaler = 1024;
float clock_freq = 12000000.0 / prescaler;
float clock_period = 1.0 / clock_freq;
int count = (milisec * 0.001 / clock_period) - 1;
void setup() {
pinMode(PIN_USED, OUTPUT);
// Configure Timer1
TCCR1A = 0b00000000;
TCCR1B = 0b00000101;
TCNT1 = 0;
}
void loop() {
if (TCNT1 >= count) {
TCNT1 = 0;
digitalWrite(PIN_USED, !digitalRead(PIN_USED));
}
    }
```

ANSWER TO THE QUESTION NO - 2

(A)

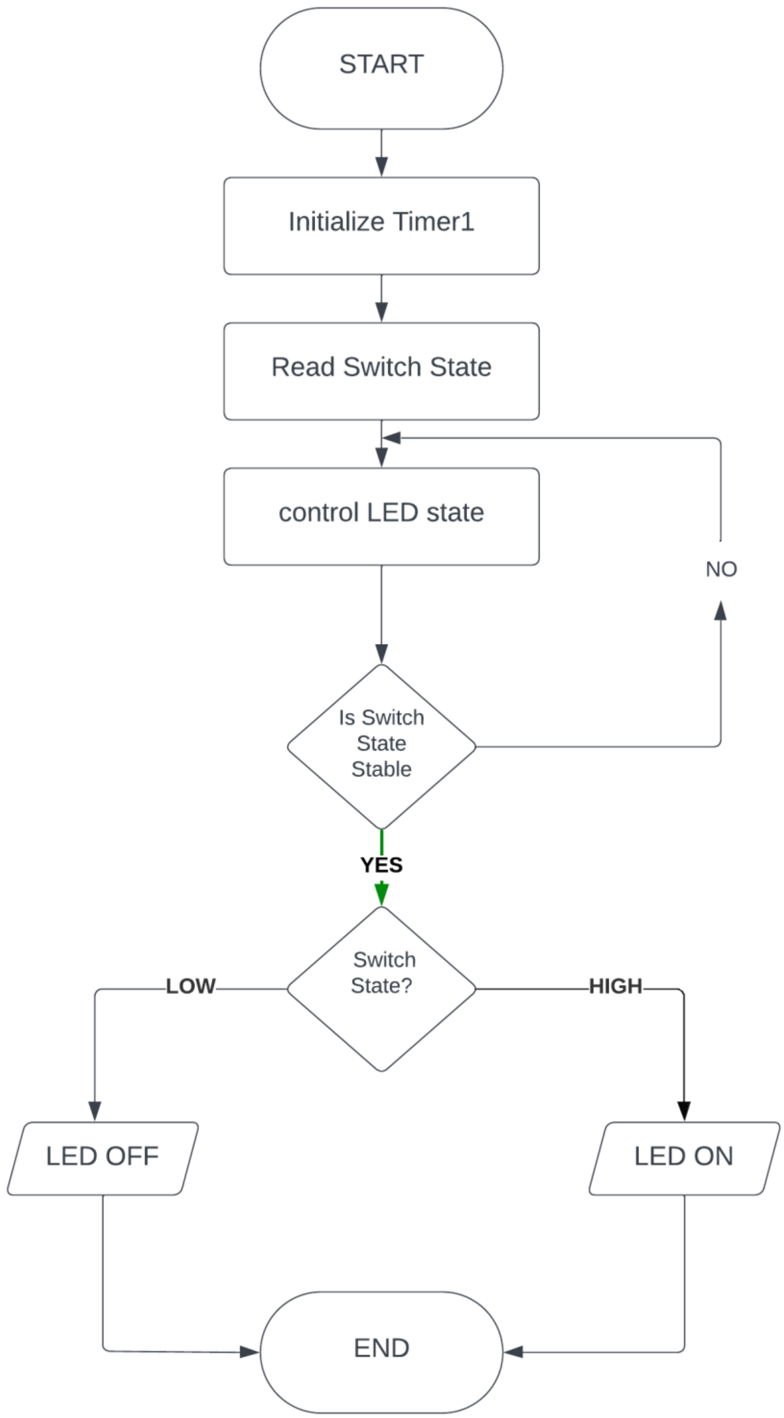
Determining the Hysteresis Voltage (Vh):
Hysteresis voltage (Vh) is the difference between the high-going (Vth+) and low-going (Vth-) threshold voltages. Here,
Vth+ = 0.22 V and Vth- I = 2.1 V, we can calculate Vh as follows:
Vh = Vth+ - Vth-
Vh = (0.22 V - 2.1 V)
Vh = -1.88 V
However, hysteresis voltage should be a positive value,
So,Vh = 1.88 V
So, the hysteresis voltage is 1.88 V.

(B)

```
#include <avr/io.h>
#include <avr/interrupt.h>
const int switchPin = 2;
const int ledPin = 11;
volatile bool switchState = LOW; // Initial state of the switch
void setup() {
```

```
pinMode(switchPin, INPUT);
pinMode(ledPin, OUTPUT);
// Configure Timer1
cli(); // Disable global interrupts
TCCR1A = 0; // Set Timer1 control register A to default values
TCCR1B = 0; // Set Timer1 control register B to default values
TCNT1 = 0; // Initialize Timer1 counter value to 0
OCR1A = 156; // Set the compare value to generate a 10 ms interrupt (12 MHz clock)
TCCR1B |= (1 << WGM12); // Enable CTC mode
TCCR1B |= (1 << CS11); // Set prescaler to 8
TIMSK1 |= (1 << OCIE1A); // Enable Timer1 output compare match A interrupt
sei(); // Enable global interrupts
}
void loop() {
// Read the switch state
switchState = digitalRead(switchPin);
// Control the LED based on the debounced switch state
digitalWrite(ledPin, switchState);
}
// Timer1 compare match A interrupt service routine
ISR(TIMER1_COMPA_vect) {
static bool previousSwitchState = LOW;
static int debounceCounter = 0;
// Read the current switch state
bool currentSwitchState = digitalRead(switchPin);
// Check for a stable switch state for 5 consecutive timer interrupts (50 ms)
if (currentSwitchState == previousSwitchState) {
if (debounceCounter < 5) {
debounceCounter++;
} else {
switchState = currentSwitchState;
debounceCounter = 0;
}
} else {
debounceCounter = 0;
}
previousSwitchState = currentSwitchState;
    }
```

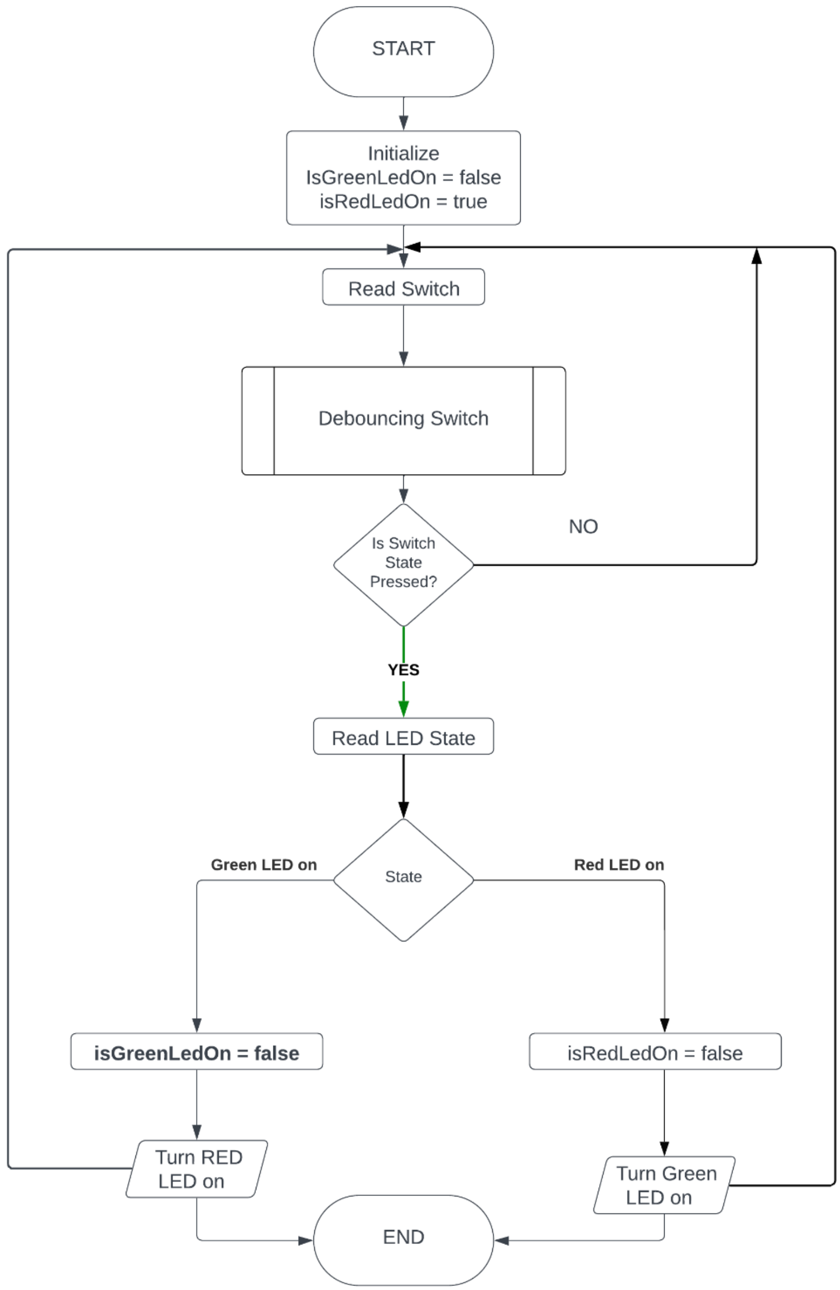
Flow Chart:


START
Initialize Timer1
Read Switch State
control LED state
NO
Is Switch State Stable
YES
Switch State?
LOW
HIGH
LED OFF
LED ON
END

ANSWER TO THE QUESTION NO – 3

```
const int greenLightPin = 2;
const int redLightPin = 3;
const int switchPin = 4;
bool isGreenLightOn = false;
bool isRedLightOn = true;
void setup() {
pinMode(greenLightPin, OUTPUT);
pinMode(redLightPin, OUTPUT);
pinMode(switchPin, INPUT_PULLUP);
// Initialize with the green light on
digitalWrite(greenLightPin, HIGH);
digitalWrite(redLightPin, LOW);
}
void loop() {
int switchState = digitalRead(switchPin);
if (switchState == LOW) {
// Switch is now pressed
if (isGreenLightOn) {
// Green light is now on, turn it off and red light on
digitalWrite(greenLightPin, LOW);
digitalWrite(redLightPin, HIGH);
isGreenLightOn = false;
} else {
// Red light is now on, turn it off and green light on
digitalWrite(greenLightPin, HIGH);
digitalWrite(redLightPin, LOW);
isGreenLightOn = true;
}
// Debouncing the  delay to prevent rapid toggling due to mechanical noise
delay(200);
}
    }
```

Flow Chart


START
Initialize
IsGreenLedOn = false
isRedLedOn = true
Read Switch
Debouncing Switch
Is Switch State Pressed?
NO
YES
Read LED State
State
Green LED on
Red LED on
isGreenLedOn = false
isRedLedOn = false
Turn RED LED on
Turn Green LED on
END

ANSWER TO THE QUESTION NO - 4

Here,
acd = 401
r = 1
So,
OCR(r-1)A= OCR(1-1)A= OCR0A

Timer Frequency = Frequency ÷ Prescaler = 12 MHz ÷ 1024 = 11.718 kHz
Timer Period = 401ms = 0.401 seconds
Time period needed for an 401ms or 0.401 s interval:
OCR1A = (Timer Frequency × Timer Period) - 1
OCR1A = (11.718 kHz × 0.401 s) - 1
OCR1A = 4698.918 - 1
OCR1A = 4997.918

Here,
Timer1 is used as the maximum count for Timer0 and Timer2 is 255 whereas maximum count for Timer1 is 65535. And the value to be loaded in OCR1A register is 4997.918.

Code:

```
#include <avr/io.h>
#include <avr/interrupt.h>
const int ledPin = 1;
void setup() {
pinMode(ledPin, OUTPUT);
noInterrupts();
TCCR1A = 0;
TCCR1B = 0;
TCCR1B |= (1 << CS12) | (1 << CS10);
OCR0A = 4997.918;
interrupts();
}
void loop() {
}
ISR(TIMER1_COMPA_vect) {
digitalWrite(ledPin, !digitalRead(ledPin));
    }
```