American International University- Bangladesh (AIUB)
Faculty of Engineering

Course Name:	Microprocessor and Embedded Systems	**Course Code:**	EEE 4103
Semester:	Spring 2023-24	**Term:**	Mid
Total Marks:	20	**Submission Date:**	**11-03-2024**
Instructor Name:	Protik Parvez Sheikh	**Assignment:**	02

Course Outcome Mapping with Questions

Item	COs	POIs	K	P	A	Marks	Obtained Marks
Q1 to Q5	**CO1**	**P.a.4.C3**	**K4**	**P1, P3, P7**		**4x5**	
					Total:	**20**	

Student Information:

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Section:	**E**	**Department:**	**BSc CSE**

Marking Rubrics (to be filled by Faculty):

Problem #	Excellent [4]	Good [3]	Acceptable [2]	Unacceptable [1]	No Response [0]	Secured Marks
	Detailed unique response explaining the concept properly and answer is correct with all works clearly shown.	Response shows understanding of the problem, but the final answer may not be correct	Partial problem is solved; response indicates part of the problem was not understood clearly.	Unable to clarify the understanding of the problem and method of the problem solving was not correct	No Response/(Copied/identical submissions will be graded as 0 for all parties concerned)	
1				=		
2						
3						
4						
5						
Comments					Total marks (20)	

1. A TV remote control 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 **5 ms**. Design a circuit using the **74HC14** Schmitt trigger IC along with the **resistance** and **capacitance** and calculate the **hysteresis voltage**. The worst-case Vth of 74HC14 for a signal going low is **2.2 V** and that of when going high is **0.8 V**. Consider that the CMOS device leakage current is **15 μA** and the gate's best-case switching point is of the order of **0.4 V.** Also, consider that a Si diode is connected in the circuit and its forward voltage drop, V_D **= 0.7 V**. The supply voltage of the IC is V_{CC} **= 5 V**.

Ans:

Here,
For discharging(without diode),
t = 5 ms = $5 * 10^{-3}$ s
C = $1 * 10^{-6}$ F
$R_2 = \frac{-t}{Cln\left(\frac{VthH}{Vfinal}\right)} = -5 * 10^{-3}/1 * 10^{-6} \ln\left(\frac{2.2}{5}\right)$ = 6.09 Kohm

V = $IR_2 = 15 * 10^{-6} * 6.09 * 10^{3}$ = 0.09 V which is close to the gates best case switching point of 0.5v.
Now,
C_{new} = 10μF and $R_{2new} = \frac{6.09}{10}$ = 0.609 Kohm
For charging(without diode),

$$R = \frac{-t}{Cln\left(1-\frac{VthL}{Vfinal}\right)}$$

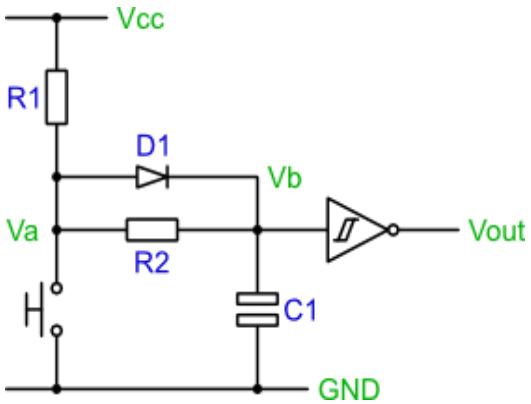
$$= -10 * 10^{-3}/10 * 10^{-6} \ln\left(1 - \frac{0.8}{5}\right) = 5.73\text{Kohm}$$

We know ,
$R = R_1 + R_{2new}$
$R_1 = R - R_{2new}$
= 5.73-0.609
= 5.121
For charging(with diode),
Vcc = 5 – 0.7 = 4.3

$$R_1 = -5 * 10^{-3}/10 * 10^{-6} \ln\left(1 - \frac{0.8}{4.3}\right)$$

= 2.43Kohm.

Hysteresis voltage (V_h) is the difference between the high-going (V_{thL}) and low-going (V_{thH}) threshold voltages.
Given that V_{thH} is 2.2 V and V_{thL} is 0.8 V, we can calculate V_h as follows:
$V_h = V_{thH} - V_{thL}$
V_h = (2.2 V – 0.8 V)
V_h = 1.4 V
So, the hysteresis voltage is 1.4 V.



R_1 =2.43Kohm,R_{2new} = 0.609KOhm, C = 10µF, hysteresis voltage=1.4V

2. Prepare a program that triggers Timer interrupt every **10 µs** to blink an LED light.
Ans:

Calculation for 10 µs :

Pulse time = 1/16 MHz = 62.5 ns
Count up to = 10µs/62.5 = 160

```
Bool LED_STATE = true;
void setup()
{
Pin MODE(13,output);
cli();
TCCR0A = 0;
TCCR0B = 0;
TCCR0B | = 0B00000001;
TIMSK0 | =  0B00000010;
OCR0A = 160;
sei ();
}
void loop()
{
}
ISR(TIMER0_COMPA_VECT)
{
TCNT0 = 0;
LED_STATE =! LED_STATE;
digital Write(13,LED_STATE);
}
}
```

3. For the processor ATmega328P, state the contents of registers R26, R25, and the data memory locations at 0xFA50 and 0xFA51 after the following program is executed:

```
LDI R25, 4;
LDI R26, 20;
SUB R26, R25;
STS 0xFA50, R26;
ADD R25, R26;
STS 0xFA51, R25;
```

Ans:

LDI R25, 4;	R25=4
LDI R26, 20;	R26=20
SUB R26, R25;	R26= (20-4)=16
STS 0xFA50, R26;	0xFA50= 16
ADD R25, R26;	R25= (16+4) =20
STS 0xFA51, R25;	0xFA51=20

Now, R25=20, R26=16, 0xFA50=16, 0xFA51=20

4. Determine the output of the following programs:

a)
```
#include "LowPower.h"

void setup () {
pinMode(12, OUTPUT);
}
void loop () {
digitalWrite(12, HIGH);
delay (5000);
digitalWrite(12, LOW);
LowPower.powerDown(SLEEP_2S, ADC_OFF, BOD_OFF);
}
```

b)
```
volatile boolean var_b;

void isr_f() {
var_b = false.
digitalWrite(7, HIGH); }

void setup () {
attachInterrupt (digitalPinToInterrupt(2), isr_f, CHANGE);
pinMode(7, OUTPUT);
digitalWrite(7, LOW); }

void loop () {
if (var_b) {
// interrupt has occurred}
}
```

NB. Consider an LED is connected to pin 7 and a switch is connected to pin 2

Ans:

(a) The LED connected to pin 12 will turn on for 5 seconds due to delay(5000)
The LED will then turn off for 2 seconds due to digitalWrite(12, LOW)
During this 2-second off period, the Arduino board will enter a low-power sleep mode (using LowPower.powerDown) to conserve energy.
This cycle (LED on for 5 seconds, LED off with sleep for 2 seconds) will repeat continuously as the code runs in an infinite loop void loop().

(b) The LED lights up whenever the switch connected to pin 2 changes state. (press or release)
It remains on until another switch press/release.

5. a) Prepare a C++ program for an Arduino UNO to configure the Sleep Mode Control Register (SMCR) so that the system enters **power-save mode** and powers down Timer0, Timer1, and SPI peripherals using power reduction register (PRR).

b) Develop an assembly program for an Arduino UNO to set the Sleep Mode Control Register (SMCR) to enter the **power-down mode** while keeping Timer0 and Timer1 active using power reduction register (PRR).

Ans:

(a)

```
void setup ()
{
}
void loop ()
{
  PRR |= (1 << PRTIM0) | (1 << PRTIM1) | (1 << PRSPI);
  set_sleep_mode(SLEEP_MODE_PWR_DOWN);

  sleep_enable();
  sleep_bod_disable();
  sleep_mode();
}
```

(b)

```
.globl main
main:
  cli
  out PRR0, 0b00000011
  out SMCR, SLEEP_MODE_PWR_DOWN
  sei
  sleep
  rjmp main
```