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

Final Assignment			
Course Name:	Microprocessor and Embedded Systems	**Course Code:**	COE 3104
Semester:	Fall 2024-25	**Section:**	R
Faculty Name:	**Niloy Goswami**		

Assignment No:	1F **(individual submission consisting of 30 marks)**

Submission Date:	**25/01/2025**	**Due Date:**	**25/01/2025**

Student Information:

Student Name:	MD. Tanvir Rahman Molla											**Section:**	R
Student ID #:	2	2		4	6	0	5	2		1	**Assigned Date:** **25.01.2025**	**Department:**	CSE
	p	**q**	**-**	**a**	**b**	**c**	**d**	**e**	**-**	**r**			

Special Instruction: Questions may be copied from here through copy-paste. Online submission via TEAMS is allowed.

Assessment Rubrics:

COs-POIs	Excellent [28-30]	Proficient [22-28]	Good [16-21]	Acceptable [9-15]	Unacceptable [1-8]	No Response [0]	Secured Marks
CO3 P.a.4.C.3	All the problems are solved correctly. The results are generated by combining all possible input patterns with appropriate outcomes. All necessary drawings and computations are shown correctly.	All the problems are solved correctly. The results are generated by combining all possible input patterns with appropriate outcomes. A few necessary drawings and computations are missing but no wrong drawing.	All the problems are solved correctly. The results are generated by combining all possible input patterns with appropriate outcomes. A few necessary drawings and computations are missing or wrong.	All the problems are not solved correctly. The results are generated by combining several wrong or less no of input patterns with in/appropriate outcomes. Some necessary drawings and computations are missing or wrong.	All the problems are not solved correctly. The results are generated by combining mostly wrong input patterns with inappropriate outcomes. Almost all the necessary drawings and computations are missing or wrong.	No responses at all or copied from others	
Comments					**Total Marks (30)**		

1. Find the baud rate for the three operating modes when the oscillator frequency, f_{OSC} = ac MHz (put side-by-side), and register data is, UBRRn = 010110101110. Calculate the baud error and comment on whether there will be any communication errors or not. Standard Baud rates are 300, 600, 1200, 2400, 4800, 9600, 14400,19200, 38400, 57600, 115200, 230400, ... bps.

2. Compute the duty cycle and sketch the waveform obtained at port D of the Arduino. Identify the modes of
operation and compute the operating frequency of that mode based on the following program segment. Identify the Timer of the Arduino Microcontroller. The system clock frequency is rq MHz. Draw the relevant
circuit diagram using Proteus and show its timing diagram.

```
DDRD |= (1<<PD5);
pinMode(5, OUTPUT);
OCR0A = (200+ a + b + c); // Load a value in the OCR0A register
OCR0B= (100 + d + e); // Load a value in the OCR0B register
// Configure TCCR0A and TCCR0B registers for the mode and pre-scaler
TCCR0A |= (1 << COM0B1) | (1 << COM0A0) | (1<<WGM01) | (1<<WGM00);
TCCR0B |= (1<<WGM02) | (1<<CS01) | (1<<CS00);
```

3. Compute the duty cycle and sketch the waveform obtained at port D of the Arduino. Identify the modes of operation and compute the operating frequency of that mode based on the following program segment. Identify the Timer of the Arduino Microcontroller. The system clock frequency is pq MHz.

```
DDRD |= (1<<PD5);
pinMode(5, OUTPUT);
OCR0B= (150+a+b); // Load OCR0B for setting its duty cycle
// Configure TCCR0A and TCCR0B registers for the mode and pre-scaler
TCCR0A |= (1 << COM0B1) | (1<<WGM01) | (1<<WGM00);
TCCR0B |= (1<<CS02) | (1<<CS00);
```

4. Design an ***a***-bit shifter circuit for the listed shift functions provided in Table 1. Explain its operation for variouscases of select inputs.

Table 1: Functions of control variables

Binary Code	**Functions of selection variables**					
	A	***B***	***D***	***F* with C_{in} = 0**	***F* with C_{in} = 1**	***H***
0 0 0	Input Data	Input Data	None	A-1	A	1's to the output Bus
0 0 1	R1	R1	R1	A+B	A+B+1	Shift Left with I_L = 0
0 1 0	R2	R2	R2	A-B-1	A-B	No Shift
0 1 1	R3	R3	R3	A	A+1	Circulate Left with Carry
1 0 0	R4	R4	R4	$\bar{A}$	X	0's to the output Bus
1 0 1	R5	R5	R5	AX**OR** B	X	0's & 1's to the lower and upper nibbles
1 1 0	R6	R6	R6	A **AND** B	X	Circulate-Right with Carry
1 1 1	R7	R7	R7	A **OR** B	X	Shift Right with I_R = 0

5. Develop the control words in binary and hexadecimal formats using the information provided in Table 1 for thefollowing micro-operations:

i.	Re←Ra+Rb	ii.	Rd←3(Re – 0)/3
iii.	Rq←SHL Rp	iv.	Output←Rc
v.	Rd←Rc	vi.	Rb←0
vii.	Rq←Input	viii.	Rq←Rp-Ra
ix.	Rr←SHR Rb	x.	Rc←CRC Rd

** If any value of a-e goes above 7 then it should be assumed as 7.*

The necessary bits for the control word are presented in Table 2.

Table 2: 16-bit control word sequence

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
A			*B*			*D*			*F*			C_{in}	*H*		

One example is shown as follows:

Micro-operation	*A*	*B*	*D*	*F*	C_{in}	*H*	In Hex
R5← CRC (R3+R4)	011	100	101	001	0	110	7296h

6. Prepare a flow chart that will count the number of 1's in a register, R4 and then store the counts in register R6.
   Determine the outputs of the R6 (in binary) and R4 (in decimal) registers as well as of the carry flag (C) after each clock cycle or timing state.

Timing States	R4								C	R6
	1	1	0	1	0	0	1	1	0	0
T1										
T2										
T3										
T4										
T5										
T6										
T7										
T8										

Solution-1

My ID: 22-46052-1

12-abede-n.

f_{osc} = ac MHz

= 40 MHz

= 40×10^6 Hz

UBRRn = 0101101011110

= 1454

For Asynchronous Normal Mode:

Band rate = $\frac{40 \times 10^6}{16(1454+1)}$ = 1719 bps

Error = $\frac{1200 - 1719}{1200} \times 100\%$

= -43.25% > ±2%

So, there will be communication error.

For Asynchronous double speed mode,

Band rate = $\frac{40 \times 10^6}{8(1454+1)}$ = 3437 bps

Error = $\frac{2400 - 3437}{2400} \times 100\%$

= -43.20% > ±2%

So, there will be communication error

For synchronous master mode

Band rate = $\frac{40 \times 10^6}{2(1454+1)}$ = 13746

Error = $\frac{9600 - 13746}{9600} \times 100\%$ = -43.18% > ±2%

So, there will be communication error.

Solution:2

ID: 22-46052-1
P2-akde-n

Given,

$WGM01 = WGM00 = WGM02 = 1$

$OCR0A = (200+a+b+c) = (200+4+6+0) = 210$

$OCR0B = (100+d+e) = (100+5+2) = 107$

∴ This is Fast PWM with mode 7 (111).

And, $CS01 = CS00 = 1$

∴ Prescaler = 64

And,

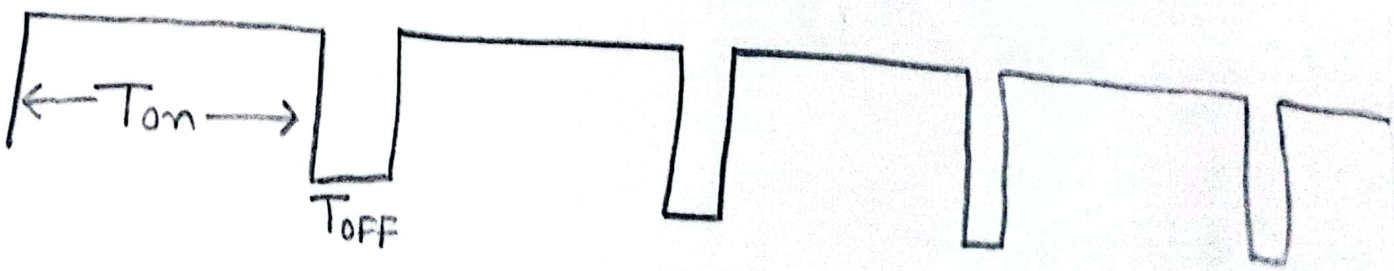
$COM0B1 = 1$

∴ Non-Inverting mode

Duty cycle for OCR0A,

$$OCR0A = \frac{256D}{100} - 1$$

$$D = \frac{(210+1)100}{256} = 82.42\%$$



82.42% duty cycle

For OCR0B,

$$OCR0B = \frac{256D}{100} - 1$$

$$\Rightarrow D = \frac{(107+1)\times 100}{256} = 42.19\%$$

42.19%

Given,

$$f_{clk\_IO} = 12\ MHz$$
$$= 12\ MHz$$

$$\therefore f_{OCnxPWM} = \frac{f_{clk\_IO}}{N \times 256}$$

$$= \frac{12 \times 10^6}{64 \times 256}$$

$$= 732.42\ Hz$$

Operation frequency = 732.42 Hz

Solution: 3

ID: 22-46052-1

P2 - abcde - n

$$OCR0B = (150 + a + b)$$

$$= (150 + 9 + 6)$$

$$= 160$$

$WGM01 = WGM00 = 1$

∴ Mode of operation is Fast PWM Mode 3 (011)

$CS01 = CS00 = 1$

∴ Prescaler = 64

$COM0B1 = 1$

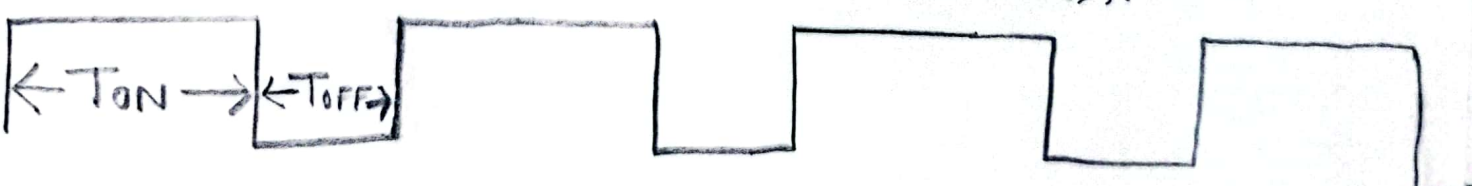
∴ Non-inverting Mode

Now,

Duty cycle,

$$D = \frac{(OCR0B + 1) \times 100}{256} = \frac{(160 + 1) \times 100}{256}$$

$$= 62.89\%$$



62.89% duty cycle

$$f_{clk\_IO} = 22\,MHz$$

$$= 22\,MHz$$

$$f_{ocm\,pwm} = \frac{f_{clk\_IO}}{N \times 256} = \frac{22 \times 10^6}{64 \times 256}$$

$$= 1342.77\,Hz$$

∴ Operating frequency is 1342.77 Hz

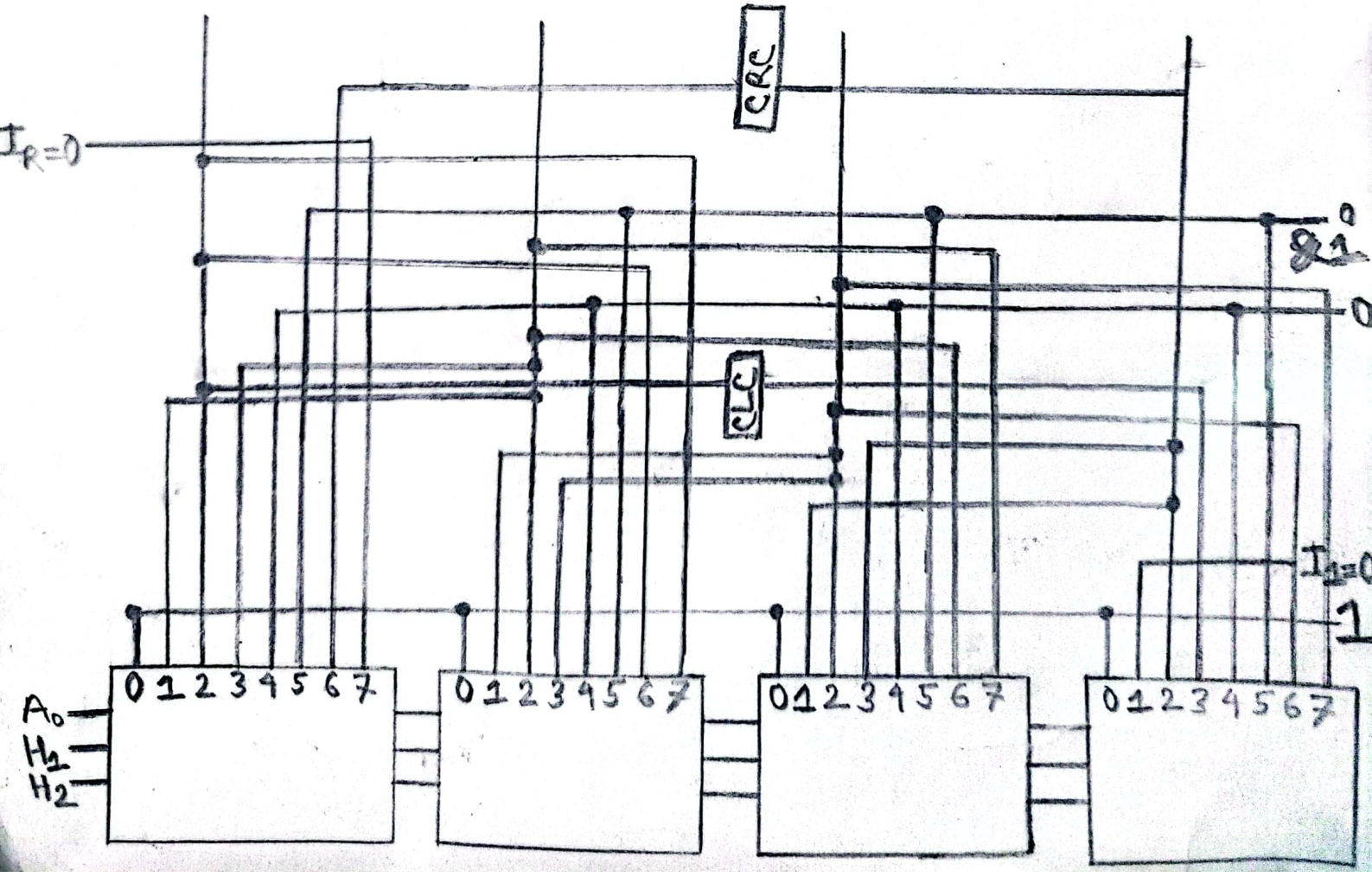
Solution: 4

ID: 22-46052-1

pg_abede-n

a-bit shifter

4-bit shifter



Solution: 05

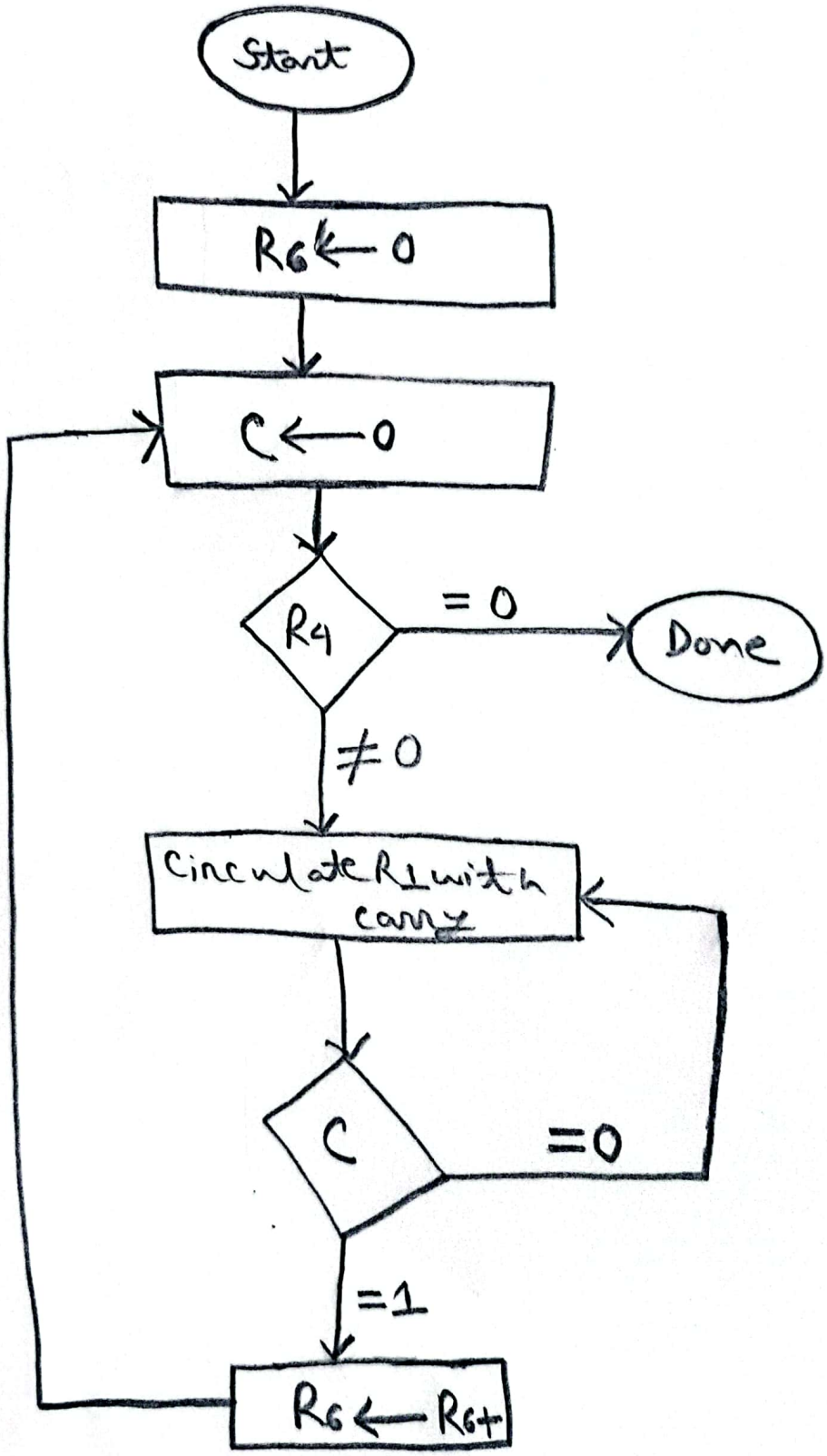
ID: 22-46052-1

P2 - abcde-n

Microoperation	A	B	D	F	Cin	H
$R_2 \leftarrow R_4 + R_6$	100	110	010	001	0	000
$R_5 \leftarrow 3(R_2 - 0)/3$	010	000	101	010	0	000
$R_2 \leftarrow SHL\ R_2$	010	000	010	011	0	000
Output $\leftarrow R_0$	000	000	000	100	0	001
$R_5 \leftarrow R_0$	000	000	101	000	0	000
$R_6 \leftarrow 0$	000	000	110	101	0	000
$R_2 \leftarrow$ Input	000	000	010	110	0	001
$R_2 \leftarrow R_2 - R_4$	010	100	010	010	0	000
$R_1 \leftarrow SHR\ R_6$	110	110	001	111	0	000
$R_0 \leftarrow CRC\ R_5$	101	101	000	100	0	000

Solution: 6

Flowchart:



Timing states	R4								C	R6
	1	1	0	1	0	0	1	1	0	0
T_1	0	1	1	0	1	0	0	1	1	1
T_2	0	0	1	1	0	1	0	0	1	2
T_3	0	0	0	1	1	0	1	0	0	2
T_4	0	0	0	0	1	1	0	1	0	2
T_5	0	0	0	0	0	1	1	0	1	3
T_6	0	0	0	0	0	0	1	1	0	3
T_7	0	0	0	0	0	0	0	1	1	4
T_8	0	0	0	0	0	0	0	0	1	5