AMERICAN INTERNATIONAL UNIVERSITY – BANGLADESH (AIUB)
Faculty of Engineering
Department of Electrical and Electronic Engineering

Course/Lab Name: EEE4103 Microprocessor and Embedded Systems

Semester: Summer 2023-24 **Term**: Final **Quiz**: 02F **Total Marks**: 10 **Time**: 20 Minutes

Question Mapping with Course Outcomes:

Item	COs	POIs	K	P	A	Marks	Obtained Marks
Q1-2	CO1	P.a.4.C.3	K4			2×5	
					Total:	10	

Student Information:

Student Name:	Solve Sheet			Section:	D
Student ID #:	Solve Sheet	Date:	18.09.2024	Department:	

1. **Compute** the duty cycle and **sketch** the PWM waveform obtained at port D of the Arduino. Identify the modes of operation and Timer of the Arduino Microcontroller, and then **compute** the operating frequency of that mode based on the following program segment. The system clock frequency is 16 MHz. **[5]**

```
DDRD |= (1<<PD5);
pinMode(5, OUTPUT);
OCR0B= 175; // 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);
```

Answer:

Here, Timer0 is used whose register setups are as follows for the Timer0:
TCCR0A = 0b00100011
TCCR0B = 0b00000101
Since WGM02:0 bits are set to 011, it will operate in the **Fast PWM mode 3**.
Since COM0B1:0 bits are set to 10, it will produce a **non-inverted PWM signal** at port B (OC0B, PD5) by setting a LOW value to the OC0B pin when during the upcounting the timer-counter register's (TCNT0) count value matches with the output-compare register's (OCR0B) data and a HIGH value to the OC0B pin when the count value of the TCNT0 register reaches its TOP value (0xFF).
Since CS02:0 bits are set to 101, the pre-scaler value is 1024.

The **PWM frequency** of **output port B (OC0B, PD5)** for the **Fast PWM Mode 3** is

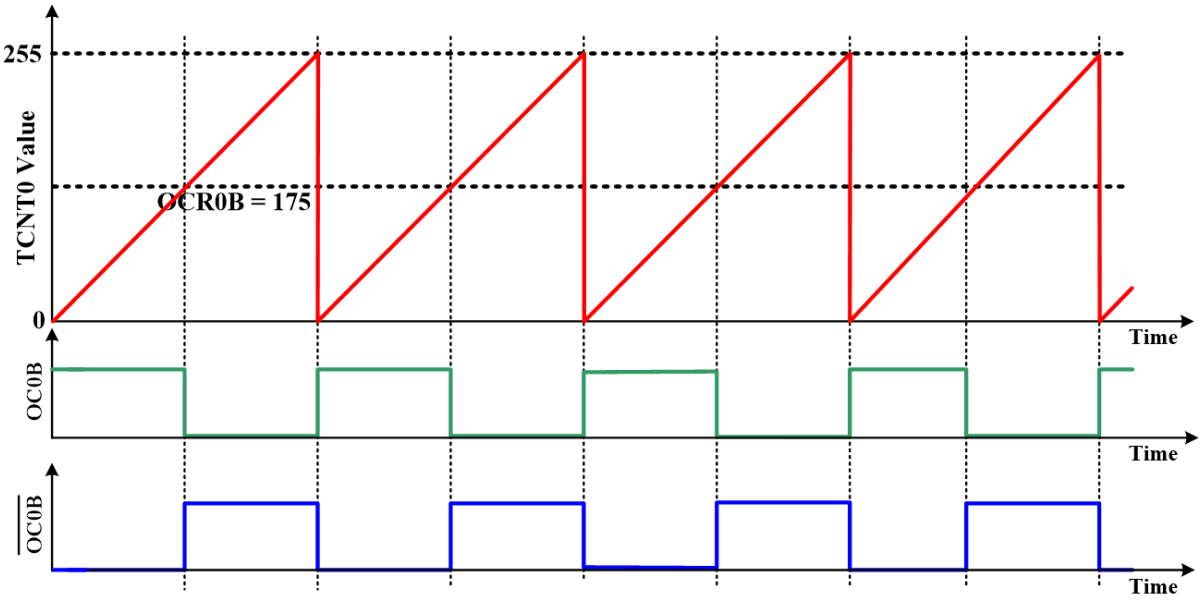
$$f_{OC0BPCPWM} = \frac{f_{clk\_IO}}{N \times 256} = \frac{16 \times 10^6}{1024 \times 256} = 61.04 \text{ Hz}$$

The duty cycle of the **non-inverting mode Fast PWM** is calculated as

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

$$\therefore D = \frac{100 \times (OCR0B + 1)}{256} = \frac{100 \times (175 + 1)}{256} \cong 68.75\%$$

The sketch is given below



2. **Compute** the duty cycle and **sketch** the PWM waveform obtained at port D of the Arduino. **Identify** the modes of operation Timer of the Arduino Microcontroller, and then **compute** the operating frequency of that mode based on the following program segment. The system clock frequency is 16 MHz. **[5]**

```
DDRD |= (1<<PD5);
pinMode(5, OUTPUT);
OCR0A = 210;  // Load a value in the OCR0A register
OCR0B= 150;  // 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);
```

Answer:

Here, Timer0 is used whose register setups are as follows:
TCCR0A = 0b01100011
TCCR0B = 0b00001011
Since WGM02:0 bits are set to **111**, it will operate in the **Fast PWM mode 7**.
Since COM0B1:0 bits are set to 10, it will produce a **non-inverted PWM signal** at port B (OC0B, PD5).
Since COM0A1:0 bits are set to 01 and WGM02 = 1, it will toggle the PWM signal at port B (OC0B, PD5) upon compare match of OCR0B contents (150) with the TCNT0 register. The Output-Compare Register's (OCR0A) value is the TOP value here (210), not 255.
Since CS02:0 bits are set to 011, the pre-scaler value is 64.

The **PWM frequency** of **Output B** for the **Fast PWM Mode 7** is

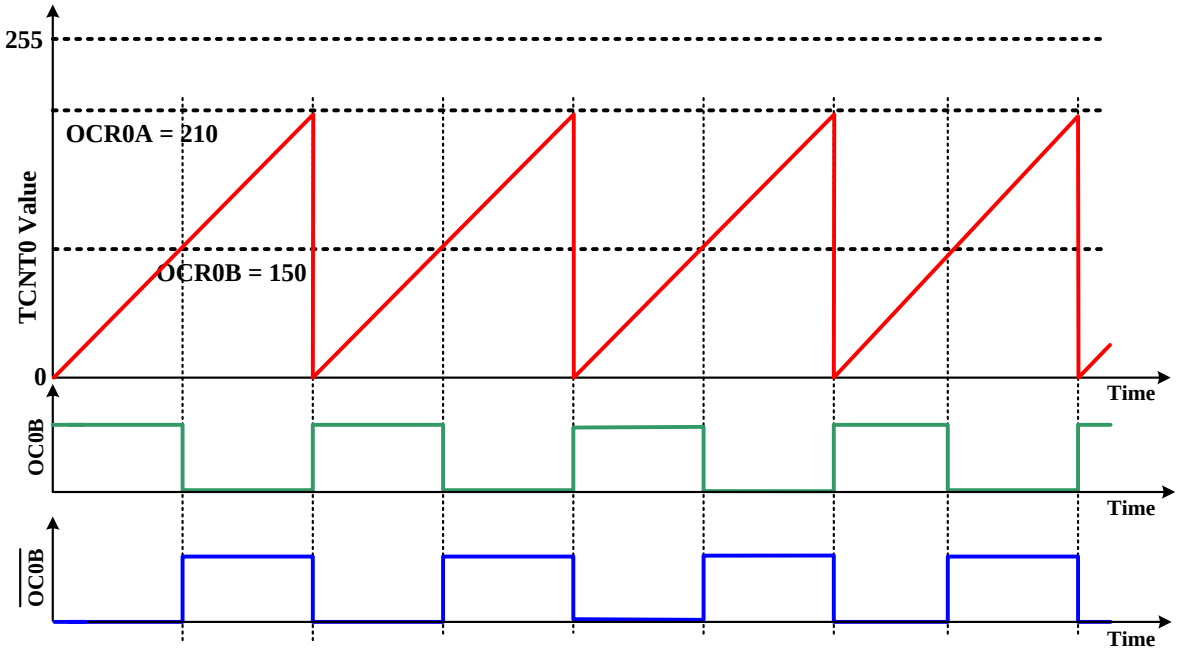
$$f_{OC0BFPWM} = \frac{f_{clk\_IO}}{N\times(1+OCR0A)} = \frac{16\times10^6}{64\times(1+210)} \cong 1185 \text{ Hz}$$

The duty cycle of the **non-inverting mode Fast PWM** is calculated using the formula (for a TOP value of 210 stored in the OCR0A register)

$$OCR0B = \frac{OCR0A \times D}{100} - 1$$

$$\therefore D = \frac{100 \times (OCR0B + 1)}{OCR0A} = \frac{100 \times (150 + 1)}{210} \cong 72\%$$

The sketch is given below


255
OCR0A = 210
OCR0B = 150
TCNT0 Value
0
Time
OC0B
Time
OC0B
Time