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

Course/Lab Name: EEE4103 Microprocessor and Embedded Systems

Semester: Fall 2023-23 **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:	B
Student ID #:	Solve Sheet	Date:	27.11.2023	Department:	

1. 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 16 MHz. **[5]**

```
DDRD |= (1<<PD5);
pinMode(5, OUTPUT);
OCR0B= 185; // 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 the LOW value to the OC0B pin while upcounting and the HIGH value to the OC0B pin while downcounting.
Since CS02:0 bits are set to 101, the pre-scaler value is 1024.
The PWM frequency of **Output B** for the Phase-Correct PWM Mode is:

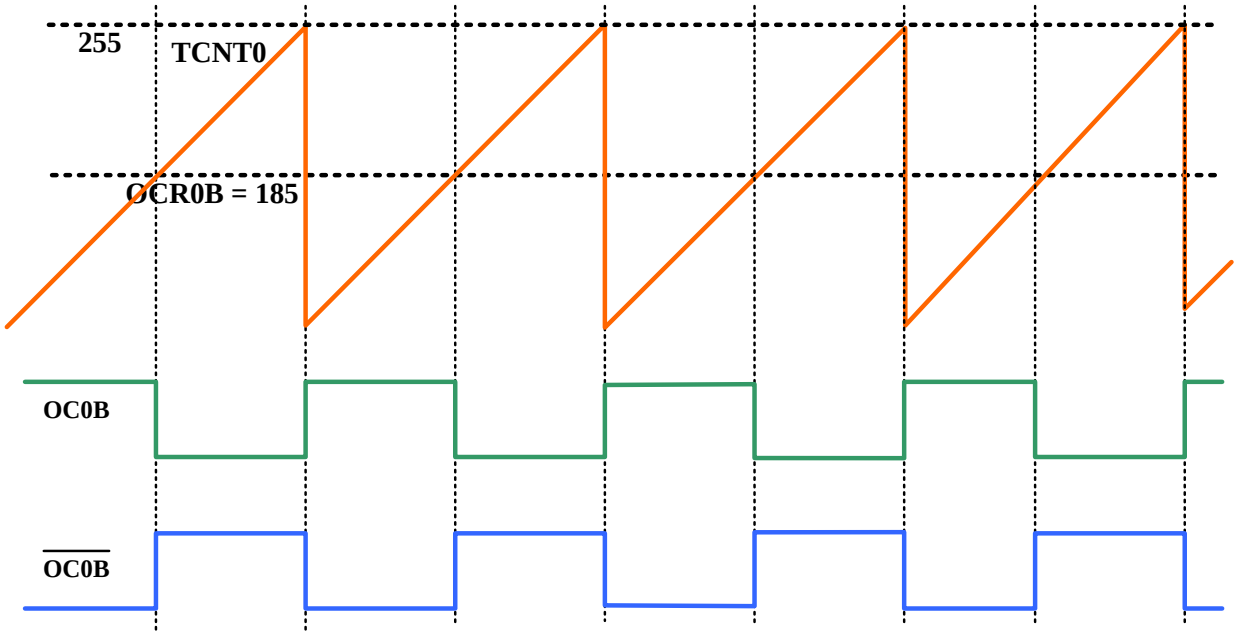
$$f_{OC0BPCPWM} = \frac{f_{clk\_IO}}{2N\times(1+OCR0B)} = \frac{16\times10^6}{2\times1024\times(1+185)} = 42 \text{ Hz}$$

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

$$OCR0B = \frac{255D}{100} - 1$$

$$\therefore D = \frac{100\times(OCR0B+1)}{255} = \frac{100\times(185+1)}{255} \cong 73\%$$

The sketch is given below:



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 16 MHz. **[5]**

```
DDRD |= (1<<PD5);
pinMode(5, OUTPUT);
OCR0A = 220;  // Load a value in the OCR0A register
OCR0B= 155;  // Load a value in the OCR0A 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 with the TCNT0 register. OCR0A of port D (PD6) value is the TOP value here (220).
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:

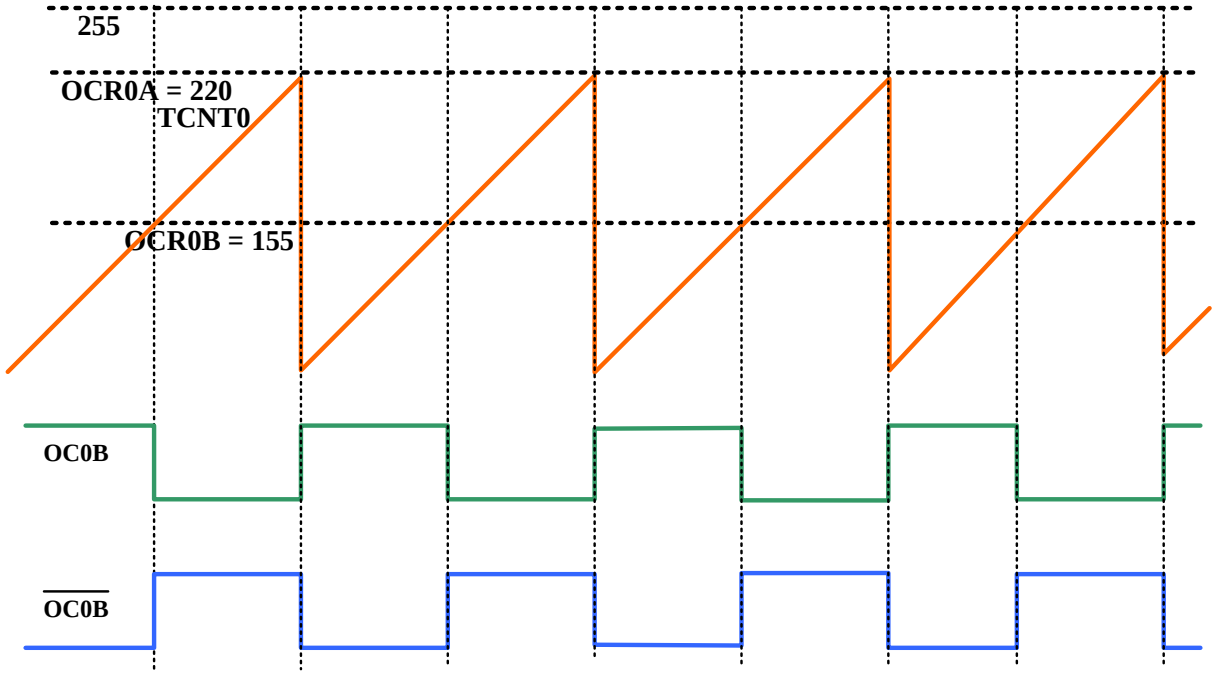
$$f_{OC0BFPWM} = \frac{f_{clk\_IO}}{2N\times(1+OCR0A)} = \frac{16\times10^6}{2\times64\times(1+220)} = 565.6 \text{ Hz}$$

The duty cycle of the **non-inverting mode Fast PWM** is calculated using the formula (for a TOP value of 220 stored in the OCR0A register)-

$$OCR0B = \frac{OCR0AD}{100} - 1$$

$$\therefore D = \frac{100 \times (OCR0B + 1)}{OCR0A} = \frac{100 \times (155 + 1)}{220} \cong 71\%$$

The sketch is given below:


255
OCR0A = 220
TCNT0
OCR0B = 155
OC0B
$\overline{OC0B}$