AMERICAN INTERNATIONAL UNIVERSITY-BANGLADESH
Faculty of Engineering

Lab Report

Experiment # 03

Experiment Title: Familiarization with the Timers of an Arduino Microcontroller Board, the study of LED blink test, and implementation of a simple traffic control system using its Timer0 function.

Date of Perform:	Date Month 2023	**Date of Submission:**	19 June 2023
Course Title:	MICROPROCESSOR AND EMBEDDED SYSTEMS LAB		
Course Code:	COE3104	**Section:**	N/A
Semester:	Summer 2022-23	**Degree Program:**	BSc in CSE/EEE
Course Teacher:	**Prof. Dr. Engr. Muhibul Haque Bhuyan**		

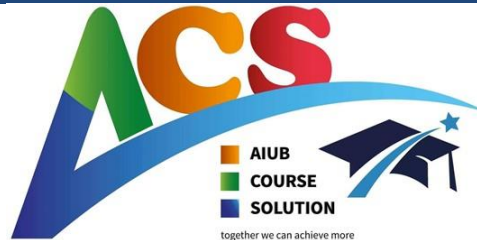**Declaration and Statement of Authorship:**

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	Total Marks	

Table of Contents

Experiment Title: Familiarization with the Timers of an Arduino Microcontroller Board, the study of LED blink test, and implementation of a simple traffic control system using its Timer0 function.

Objectives:
The objectives of this experiment are to-
- Familiarize with the Arduino microcontroller
- Familiarize with Timers in Arduino microcontroller
- Implement Timer0 function in the programing
- Implement a simple circuit to make an LED light blink using the Timer0 function
- Implement a simple traffic control system using the Timer0 function

Equipment List:
1. Arduino IDE (2.0.1 or any recent version)
2. Arduino Microcontroller board
3. LED lights (Red, Green, and Yellow)
4. Three 100 Ω resistors
5. Jumper wires

Circuit Diagram:
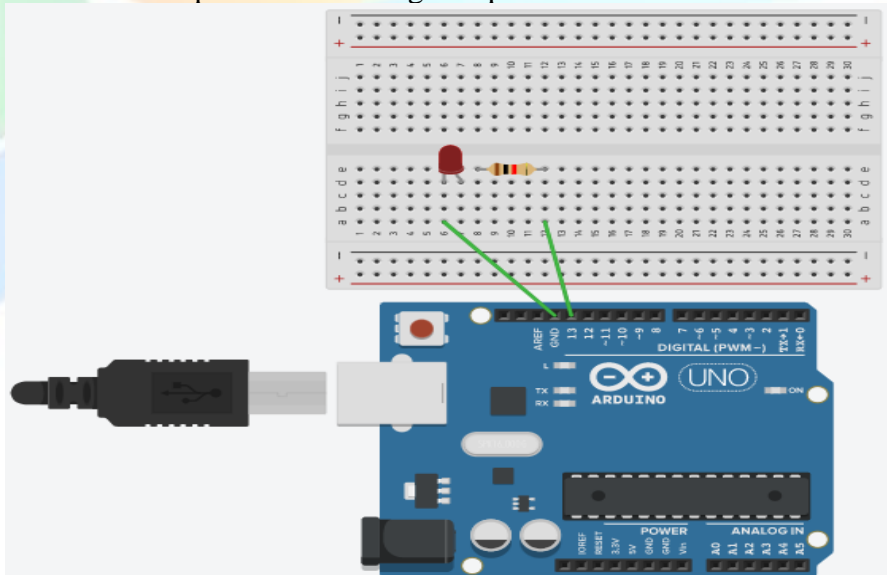The Arduino platform is made up of the following components.

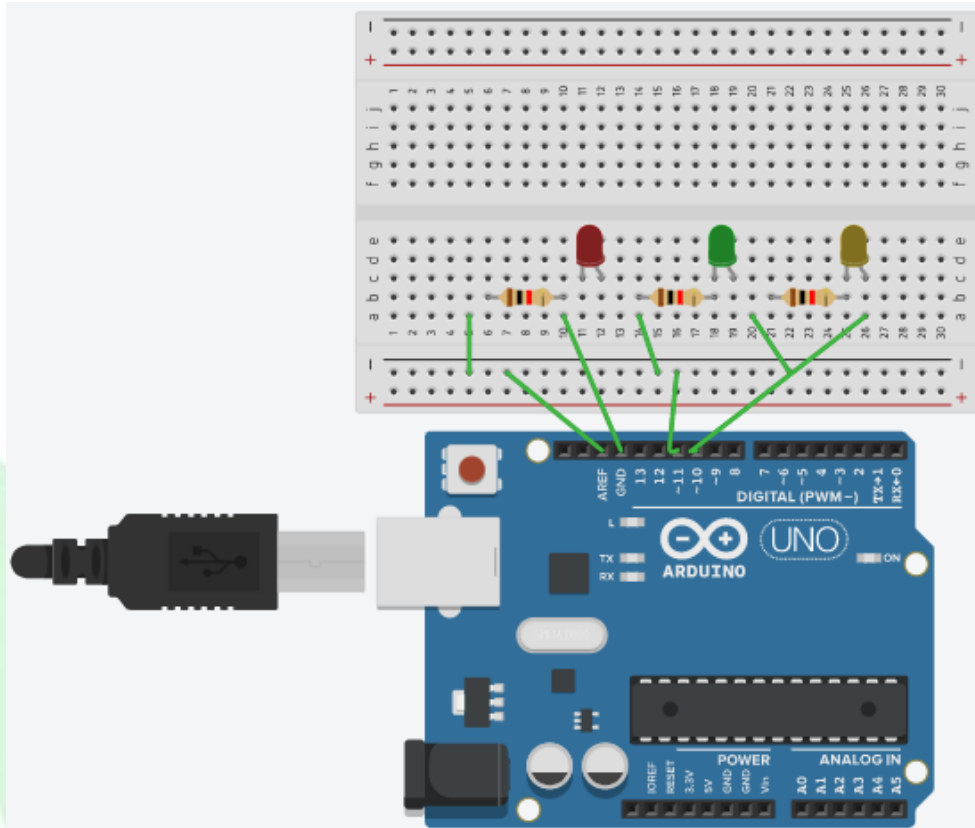Fig. 1 Experimental Setup of Blink Test using an Arduino Microcontroller Board

Fig. 2 Experimental Setup of a Traffic Control System using an Arduino Microcontroller Board

Code/Program:

The following is the code for the implementation of the LED blink test with the necessary code explanation:

```
// Pin numbers are defined by the corresponding LED colors
#define RED_PIN 10
// The delay amounts are declared in ms; 1 s = 1000 ms
int red_on = 2000;
// Declaring the timer function to count 1 ms of delay instead of
calling the delay function
int delay_timer (int milliseconds){
 int count = 0;
 while(1)
 {
 if(TCNT0 >= 16) // Checking if 1 millisecond has passed
 {
TCNT0=0;
 count++;
 if (count == milliseconds) //checking if required milliseconds
delay has passed
 {
 count=0;
```

```
    break; // exits the loop
   }
  }
 }
 return 0;
}
void setup() {
 //define pins connected to LEDs as outputs
 pinMode(RED_PIN, OUTPUT);

 //set up the timer using timer registers
 TCCR0A = 0b00000000;
 TCCR0B = 0b00000101; //setting pre-scaler for timer clock
 TCNT0 = 0;
}
void loop() {
 //to make the red LED turned on
 digitalWrite(RED_PIN, HIGH);
 delay_timer(red_on);

 //turning off the red LED
 digitalWrite(RED_PIN, LOW);
 delay_timer(red_on);
 }
```

The following is the code for the implementation of a simple traffic control system with the necessary code explanation:

```
// Pin numbers are defined by the corresponding LED colors
#define RED_PIN 8
#define YELLOW_PIN 10
#define GREEN_PIN 12
//Define the delays for each traffic light color
int red_on = 6000; //3 s delay
int green_on = 3000; //3 s delay
int yellow_blink = 500; //0.5 s delay
// Declaring the timer function to count 1 ms of delay instead of
calling the delay function
int delay_timer (int milliseconds){
 int count = 0;
 while(1)
 {
  if(TCNT0 >= 16) // Checking if 1 millisecond has passed
  {
   TCNT0 = 0;
   count++;
```

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```
   if (count == milliseconds) //checking if required milliseconds
delay has passed
   {
    count = 0;
    break; // exits the loop
   }
 }
}
return 0;
}

void setup() {
 //Define pins connected to LEDs as outputs
 pinMode(RED_PIN, OUTPUT);
 pinMode(YELLOW_PIN, OUTPUT);
 pinMode(GREEN_PIN, OUTPUT);

 //Set up the Timer0
 TCCR0A = 0b00000000;
 TCCR0B = 0b00000101; //setting pre-scaler for timer clock
 TCNT0 = 0;
}

void loop() {
 //to make the green LED turned on
 digitalWrite(GREEN_PIN, HIGH);
 delay_timer(green_on);
 //to make the green LED turned off
 digitalWrite(GREEN_PIN, LOW);

//for turning the yellow LED on and off for 4 times
 for(int i = 0; i < 4; i = i+1)
  {
    digitalWrite(YELLOW_PIN, HIGH);
    delay_timer(yellow_blink);
    digitalWrite(YELLOW_PIN, LOW);
    delay_timer(yellow_blink);
 }

 //to make the red LED turned on
 digitalWrite(RED_PIN, HIGH);
 delay_timer(red_on);
 //to make the red LED turned off
 digitalWrite(RED_PIN, LOW);
 }
```

Hardware Output Results:
Here is the hardware implementation of the LED blink test and implement simple traffic control system test and the necessary explanation of the implementation:
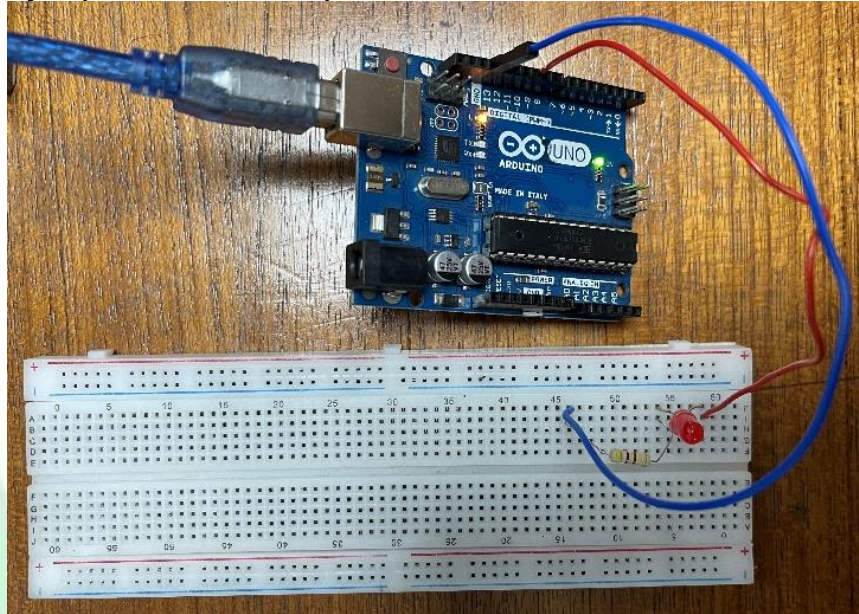

Fig.3 Hardware implementation for the blink test

Explanation: In the following implementation, a jumper wire was connected at the pin 8 of the Arduino Uno board. The wire was then connected on the breadboard. The anode of an LED light was connected with the wire connected with pin 8. The cathode of the LED light was connected with a 100 Ω resistor. The following resistor was then connected with the Ground (GND) of the Arduino Uno board. The Arduino Uno board was connected with a PC to compile and import necessary codes.

Here is the hardware implementation of Traffic Light System and the necessary explanation of the implementation:
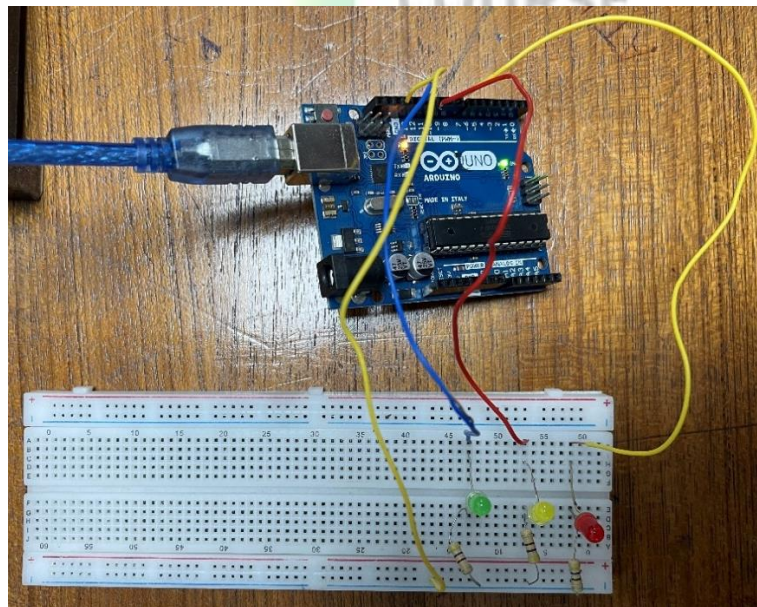

Fig.4 Hardware circuit diagram for the traffic light system

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Explanation: In the following experiment, jumper wires were connected from pin 8, 10 and 12 of the Arduino Uno board to the anodes of the RED, YELLOW and GREEN LED consecutively. Three 100 Ω resistors were connected at each cathode of all the LEDs. Jumper wires were then connected at the negative common row of the breadboard. A jumper wire was connected then with the Ground (GND) of the Arduino Uno board from the common negative of the breadboard. The Arduino Uno board was connected with a PC to compile and import necessary codes.

Experimental Output Results:
Here are results of the light blink test and the necessary explanation of the results:
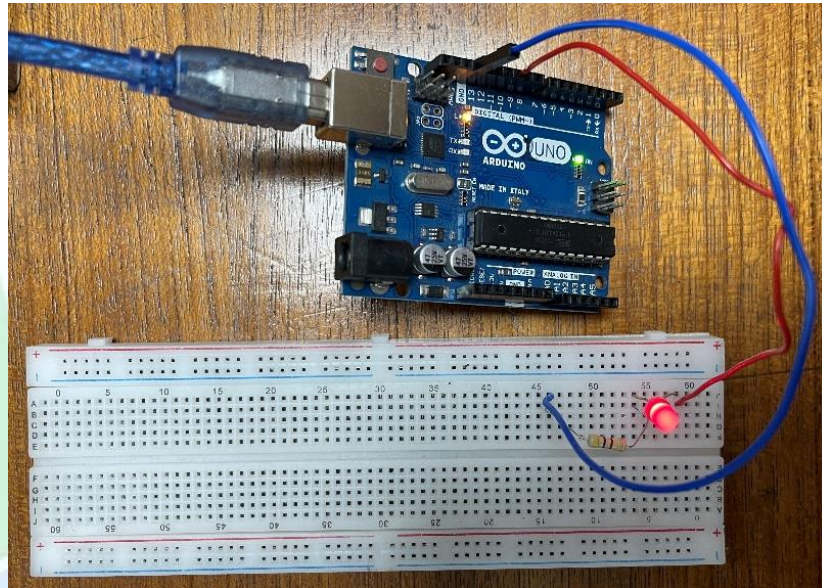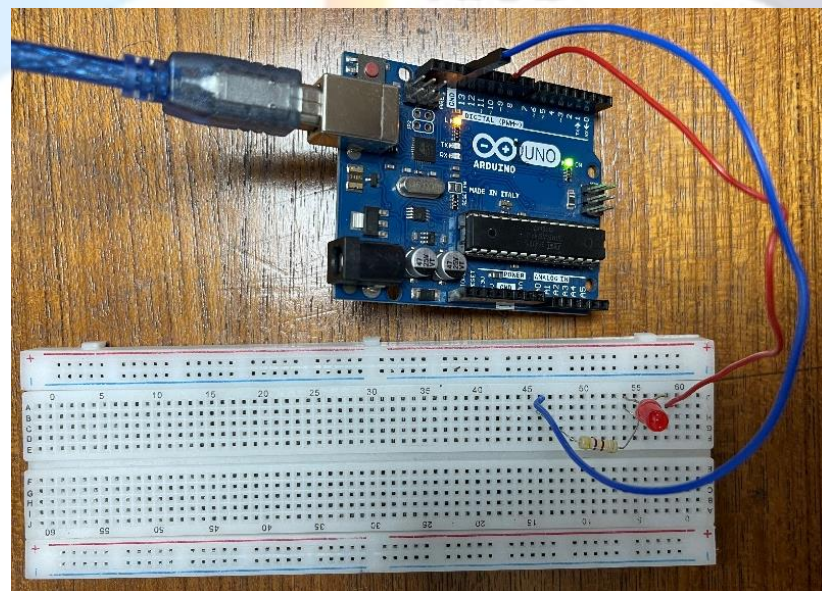

Fig.5 LED is ON in Light Blink Test

Fig.6 LED is OFF in Light Blink Test

Explanation: When the code is implemented and the loop () function starts, the code implements a digital write operation on the microcontroller and provides a high voltage at the pin 8 as output. Hence, the LED

that was connected at pin 8 turns ON (Fig,5). A delay occurs afterwards for a certain time. This time was defined in milliseconds. According to the code that was implemented, a 2000 millisecond delay occurs after the light is turned ON. Then, another digital write operation occurs and the pin 8 was set to LOW as output. Therefore, the LED turns OFF (Fig. 6). Another 2000 milliseconds delay occurs after the LED was set to low. The delay operation was executed by using delay_timer () function in the loop () function. Thus, these results were happening one by one until the microcontroller was turned off or removed from the power source.

Here are results of the Traffic Light System and the necessary explanation of the results:
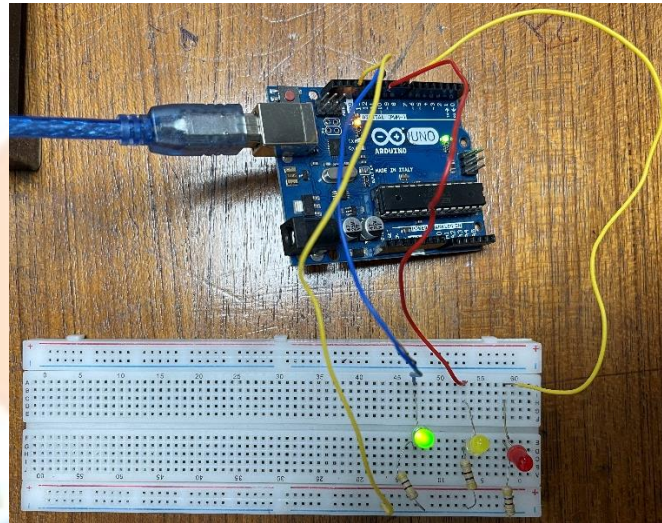

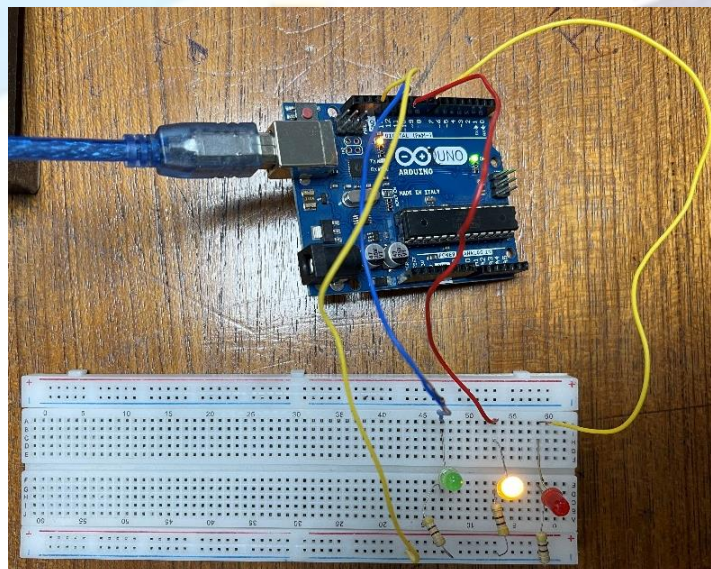Fig.7 GREEN LED is ON in Traffic Light System

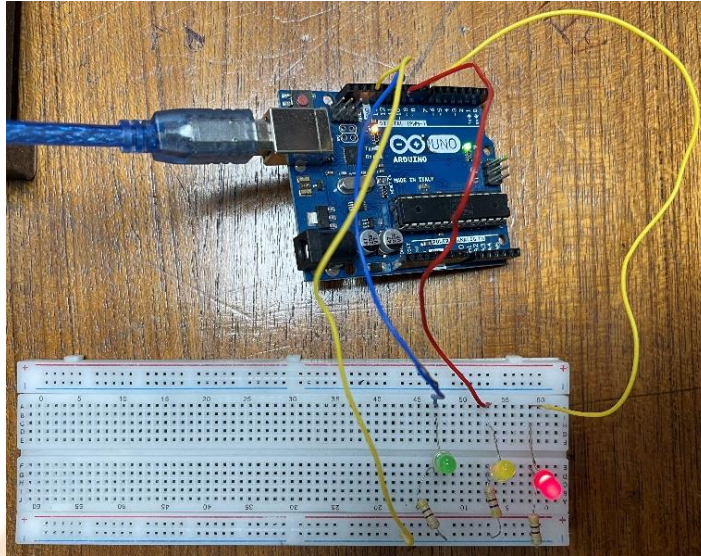Fig.8 YELLOW LED is ON in Traffic Light System

Fig.9 RED LED is ON in Traffic Light System

Explanation: When the code is implemented and the loop () function starts, the code implements a digital write operation on the microcontroller and provides a high voltage at the pin 12 as output. As a result, the green light turns ON (Fig.7). Then the light stayed on for 3000 milliseconds due to the delay function called 'green_on'. After that, the light turned off as a digital write was performed on the microcontroller and output at 12 was low. Then, a for loop was introduced in the code which made the microcontroller blink the yellow loght 4 times with an interval of 500 milliseconds (Fig.8) for the delay caused by the value set on 'yellow_blink'. When the yellow LED blinked for 4 times, then the red LED turns ON (Fig.9). It turned off after 6000 millisecond which was set in the 'red_on' variable and was used a delay function. All the operations kept occurring as all of the codes were performed in a loop.

Simulation Output Results:
Here are the simulation output results of Light Blink Test on Proteus simulation and explanation:
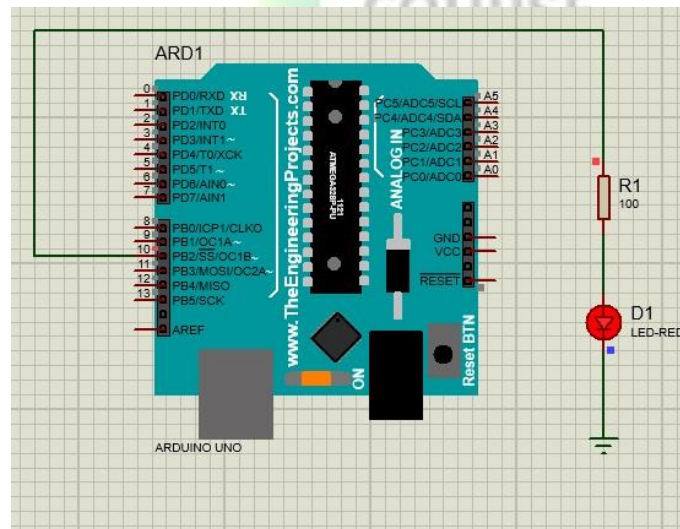

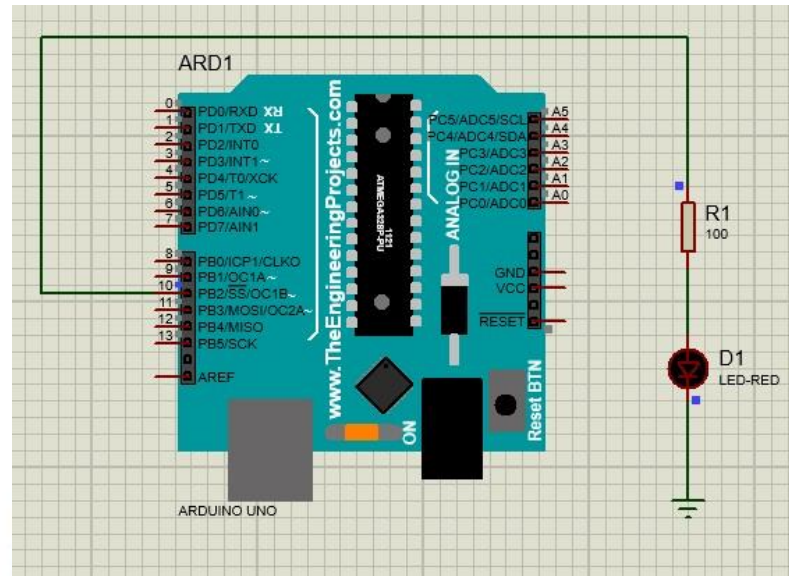Fig.10 LED is ON in Light Blink Test on Proteus Simulation

Fig.11 LED is OFF in Light Blink Test on Proteus Simulation

Explanation: In this simulation, an Arduino Uno Board, Resistor and LED was configured according to the hardware implementation that was performed. The program was made in the Arduino IDE was verified. As a result, a HEX file was generated. The following HEX file was implemented in the Proteus simulation for operation related instructions of the simulation. Afterwards, the simulation was performed and the results that were obtained were noted and compared with the hardware results.

Here are the simulation output results of Traffic Light System on Proteus simulation and explanation:
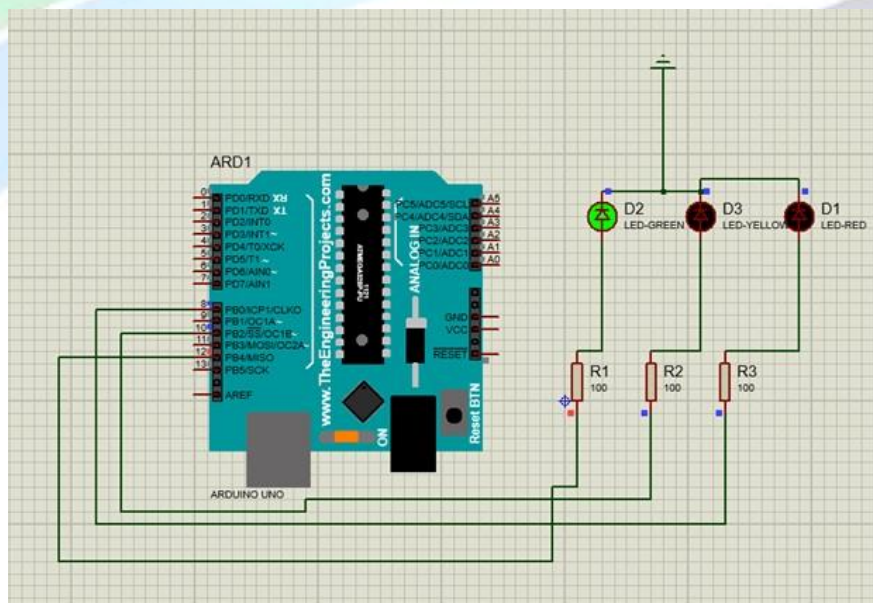

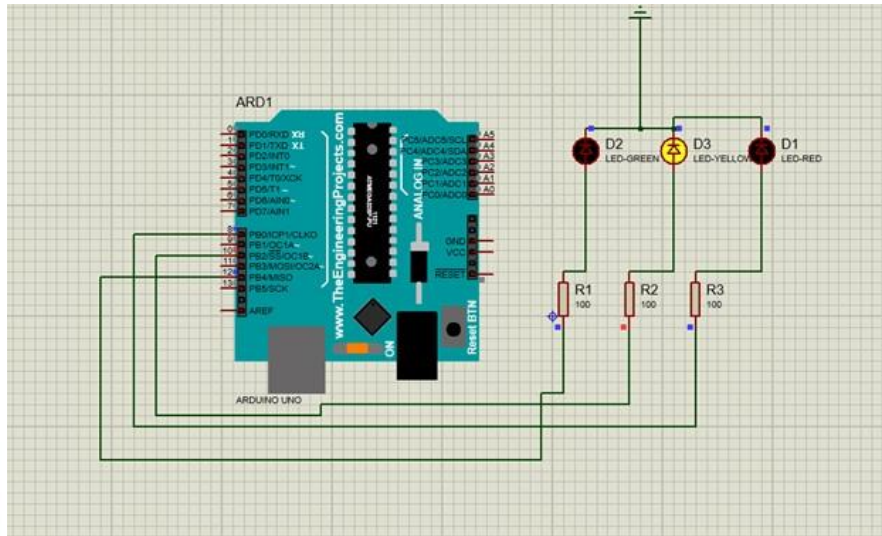Fig.12 Green LED is ON in Traffic Light System on Proteus Simulation

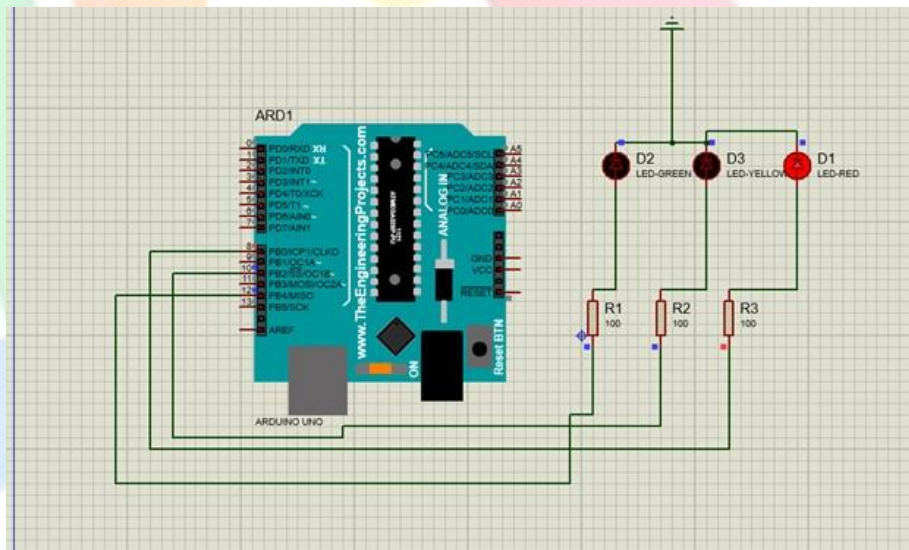Fig.13 Yellow LED is ON in Traffic Light System on Proteus Simulation

Fig.14 Red LED is ON in Traffic Light System on Proteus Simulation

Explanation: In this simulation, an Arduino Uno Board, Resistor, RED, GREEN and YELLOW LEDs were configured according to the hardware implementation that was performed. The program was made in the Arduino IDE was verified. As a result, a HEX file was generated. The following HEX file was implemented in the Proteus simulation for operation related instructions of the simulation. Afterwards, the simulation was performed and the results that were obtained were noted and compared with the hardware results.

Answers to the Questions in the Lab Manual:
3) Configure the system to have delays for outputs according to your ID. Consider the last three digits from your ID (if your ID is XY-PQABC-Z then consider A s delay for the RED LED, B s delay for the YELLOW LED, and C s delay for GREEN LED). In case any digit is zero then use Z s delay by default. Include the program and results within your lab report.

Discussion:

In following experiment, various simple and complex systems were designed like in the previous experiments that were observed. In the previous experiment, a delay() function was used to initiate a pause in the program to generate certain behaviors in the designed systems. But according to various documentation and discussion that observed, this function has some drawbacks. This function causes a halt in the microcontroller which pauses all the operation in a controller. Hence, various operation that might need to run as a certain delay was happening may get interrupted. Timers in the microcontroller was the solution to this problem. Although there are multiple timers that are available in a microcontroller, Timer0 was observed in this experiment. According to various documentations and sources, Timers in Arduino microcontroller boards are hardware components that allow precise timing and synchronization of events. They provide a way to generate interrupts or trigger actions at specific intervals. By understanding the related topics regarding timers, the ways and methods of leveraging their capabilities to control the timing of various projects effectively were observed. This Timer0 function was used in the LED blink test and Traffic Control System. The results of using this Timer0 function were observed and noted down. The methodology of writing the code using this function were also observed and implemented accordingly in the systems that were developed in this experiment. Overall it can be said that, we got to familiarize ourself with timers, observe LED blink tests and a simple traffic control system using the Timer0 function provide a solid foundation for using timers effectively in future Arduino projects. Thus, this experiment would help to control timing, synchronize events and create more advanced applications that require precise timing control. Therefore, it can be said that the objectives of this experiment were observed and achieved.

References:

1) Circuit Digest Website, [Online: March 21, 2022], [Cited: June 10, 2023] Available: https://circuitdigest.com/article/everything-you-need-to-know-about-arduino-uno-board-hardware

2) All About Circuits, *Introduction to Microcontroller Timers: Periodic Timers* [Online: June 15, 2022], [Cited: June 17, 2023] Available: https://www.allaboutcircuits.com/technical-articles/introduction-to-microcontroller-timers-periodic-timers/

3) Arduino CC Website, [Online] [Cited: June 10, 2023] Available: https://docs.arduino.cc/hardware/uno-rev3

4) Microchip Developer, *Timer0* [Online: 2021], [Cited: 18 June, 2023] Available: https://microchipdeveloper.com/8bit:timer0

3) AIUB Microprocessor and Embedded Systems Lab Manual 3