DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING,
FACULTY OF ECE,
Rajshahi University of Engineering & Technology, Bangladesh

EEE - 4210– Embedded System Design Sessional

Student Sessional Report

Submitted to

Md. Razon Chowdhury
Assistant Professor
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Submitted by

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Session: 2018-2019
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Rajshahi University of Engineering and Technology

Department of Electrical & Electronic Engineering

PROJECT

Course no. EEE 4210

Course title: Embedded System Design Sessional

Project Title: Design and implementation of an induction motor drive system using Arduino Uno and single-phase H-Bridge inverter.

Submitted to

Md. Razon Chowdhury

Assistant Professor

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PROJECT WORK

❖ Project Title

Design and implementation of an induction motor drive system using Arduino Uno and single-phase H-Bridge inverter.

❖ Objectives

- To get a better understanding of single-phase H-bridge inverter
- To understand the designing process of single-phase H-bridge inverter
- To get familiar with the practical implication of single-phase H-bridge inverter along with Arduino UNO

❖ Apparatus

Driver A3120 Optocoupler (2 pcs)	LED (2 pcs)
MOSFET IRF 240N (2 pcs)	Diode (2 pcs)
Two pin connector (2 pcs)	Capacitor (100µF; 2 pcs)
Three pin connector (2 pcs)	Resistor (1kΩ 4 pcs; 470Ω 2pcs)
8 pin IC holder (2 pcs)	Flexible wire

❖ Experimental connection

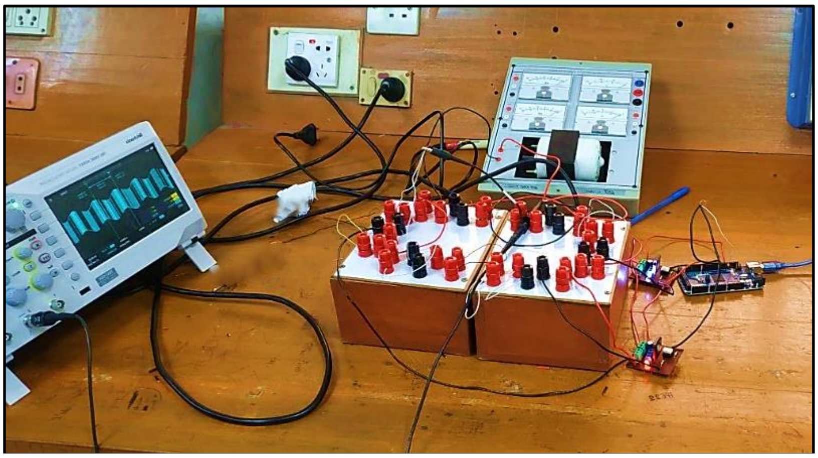

Fig. 1: Experimental connection

❖ Arduino Code

```
int angle =0;
int dr=10;
void setup()
{
pinMode(11, OUTPUT);  // Timer 2
pinMode(3, OUTPUT);  // Timer 2
TCCR2A = B10110001;
TCCR2B = B00000101;
TIMSK2 = B00000001;
}
ISR(TIMER2_OVF_vect)
{
  int duty = (255*sin(angle*3.1416/180)+255)/2;
  OCR2A = duty;
if (duty==0){
     dr=0;
    }else{
       dr=10;
    }
  int y= duty+dr;
```

```
      if (y>=255){
       y=255;
       }
           else{
         y=y;
       }
     OCR2B=y;
     angle = angle +5;
     if (angle >360)
     {
       angle =0;
     }
   }
   void loop()
   {
   }
```

❖ **Waveform**

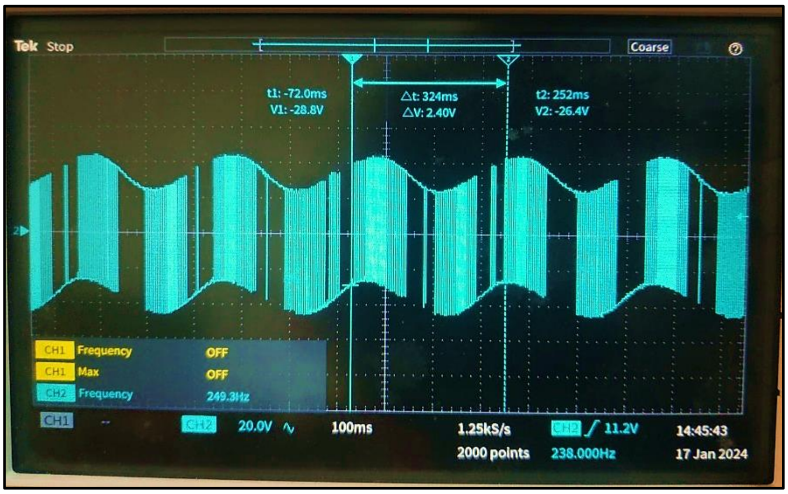

Fig. 2: The output waveform of induction motor

❖ **Discussion & Conclusion**

In this experiment, we successfully carried out the design and implementation of single-phase H-bridge inverter using an Arduino Uno. Our approach involved meticulous programming of the Arduino Uno to align with the project requirements. The induction motor, originally rated at 110V AC, exhibited an RMS voltage significantly below its rated voltage. To initiate motor activation, we adjusted the frequency accordingly. Thus, the induction motor operates at a lower frequency than its rating when the voltage falls below the rated frequency. Thus, the desired project output was obtained.

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Department of Electrical & Electronic Engineering

Course no. EEE 4210

Course title: Embedded System DesignSessional

Experiment no. 1

Experiment name: Introduction to PLC Ladder Diagram in Siemens LOGO! Soft Comfort Platform & OMRON CP1E 40 I/O PLC Trainer Kit

Date of experiment: September 26, 2023

Date of submission: October 10, 2023

Submitted to:	Submitted by:
Md. Razon Chowdhury **Assistant Professor** Dept. of Electrical & Electronic Engineering, Rajshahi University of Engineering and Technology.	**Ashraf Al- Khalique** **Roll:** 1801171 **Session:** 2018-2019 Dept. of Electrical & Electronic Engineering, Rajshahi University of Engineering and Technology.

Experiment No. 01

1.1 Experiment Name

Introduction to PLC Ladder Diagram in Siemens LOGO! Soft Comfort Platform & OMRON CP1E 40 I/O PLC Trainer Kit

1.2 Objectives

- To get a better understanding of PLC hardware and Ladder diagram
- To get familiar with the design and simulation procedure of PLC in LOGO! Soft Comfort Platform
- To get familiar with the procedure of PLC trainer kit OMRON CP1E 40 I/O

1.3 Apparatus

- ❖ LOGO! Soft Comfort Platform
- ❖ OMRON CP1E 40 I/O

1.4 Theory

1.4.1 Programmable logic controller (PLC)

Programmable logic controller (PLC) is specialized computerized device commonly used in industrial automation system. They are used to control and monitor various process and machinery. They were originally modified from relay logic, as troubleshooting and maintenance was challenging in relay logic.

PLC consists of components like input module, output module, CPU, memory, power supply, programming device, and communication interface.

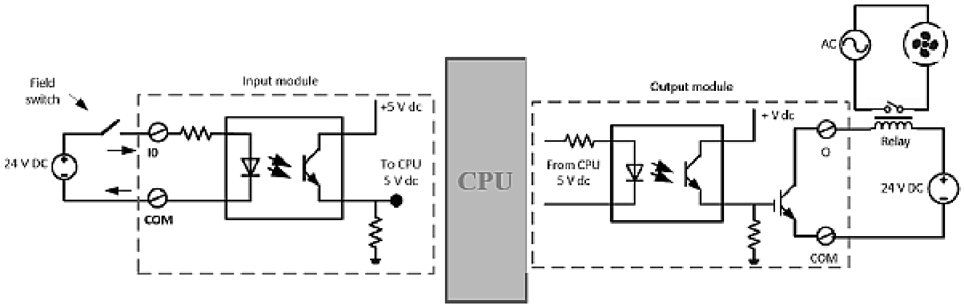

Figure 1.1: Input module & output module internal connection (sink type)

PLC can be displayed by hardware and ladder diagram. This ladder diagram contains positive and negative power rail along with rung, and rung inputs and outputs. Here the power flow direction of the ladder diagram is from left to right and top to bottom. Moreover, the input or output coils may be closed or open contacts.

1.4.2 OMRON CP1E 40 I/O trainer kit

The OMRON CP1E 40 I/O is a PLC trainer kit that supports both sink type and source type PLC connections. The are multiple channels on the input or output side. The input and output ports are respectively defined as X and Y.

These ports are identified as following format, X.0.02 where this identifies as the input from port 2 of channel 0. In the same way, Y.100.03 identifies as output to port 3 of channel 100. The inputs are not grouped but the outputs are grouped. As external devices, there are lamp, motor and a buzzer.

The PLC is connected to the computer by ethernet cable. There is an internal power supply unit for the PLC.

1.5 Problem and necessary diagram

1.5.1 Problem 1

Input: One start push button (normally open)
Output: Induction motor
Operation: The push button is pressed, the motor starts. Push button is released, remains running
Hardware diagram:

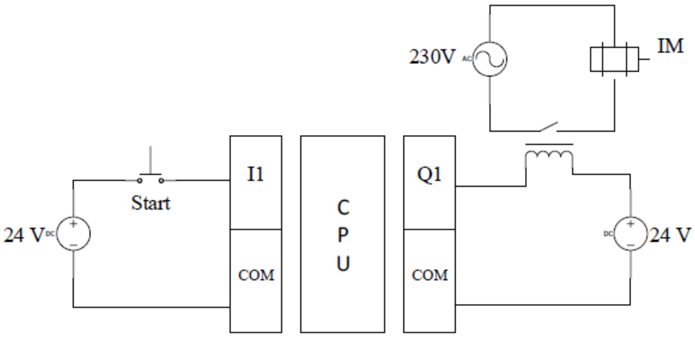

Figure 1.2: Hardware diagram for problem 1.5.1

Ladder diagram:

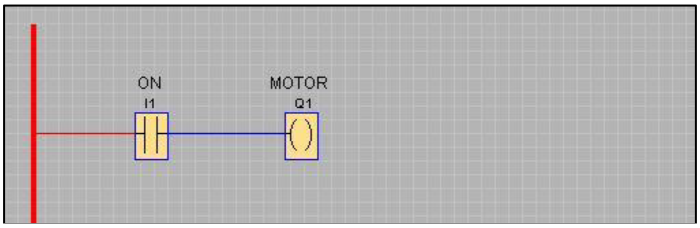

Figure 1.3: Ladder Diagram of problem 1.5.1

1.5.2 Problem 2

Input: One start push button (normally open) for clockwise rotation,
One start push button (normally open) for anti-clockwise rotation
One stop push button (normally open)
Output: Induction motor
Operation:

*The clockwise start button is pressed; the motor rotates clockwise.
*The anti-clockwise start button is pressed; the motor rotates anti-clockwise
*The stop button is pressed, the motor stops
*During clockwise rotation, anti-clockwise rotation circuit will be inactive and vice-versa

Hardware diagram:

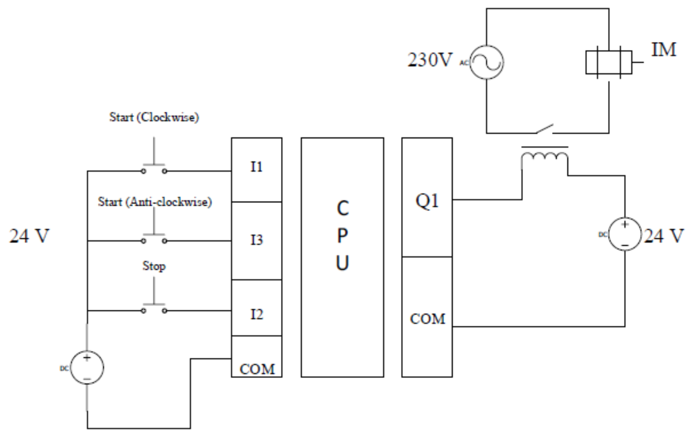

Figure 1.4: Hardware diagram for problem 1.5.2

Ladder diagram:

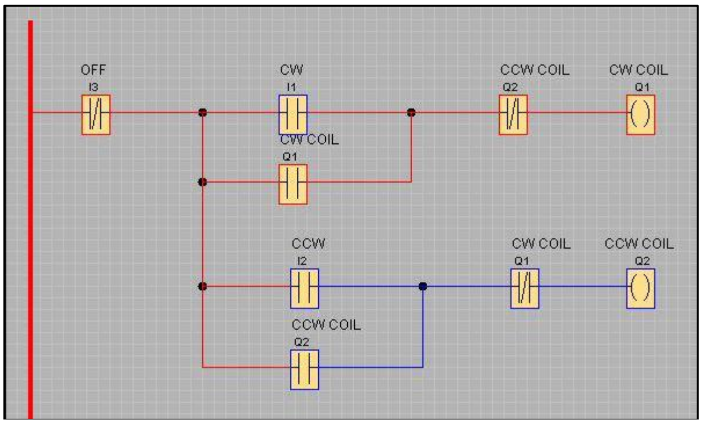

Figure 1.5: Ladder Diagram of problem 1.5.2

1.5.3 Problem 3

Input: One start push button (normally open) for clockwise rotation,
One start push button (normally open) for anti-clockwise rotation
One stop push button (normally open)

Output: Induction motor

Operation:

*The clockwise start button is pressed; the motor rotates clockwise.
*The anti-clockwise start button is pressed; the motor rotates anti-clockwise
*The stop button is pressed, the motor stops
*During clockwise rotation, anti-clockwise rotation circuit will be inactive and vice-versa

Hardware diagram:

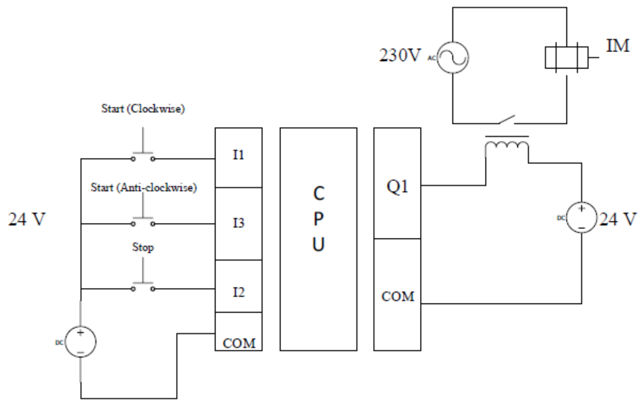

Figure 1.6: Hardware diagram for problem 1.5.3

Ladder diagram:

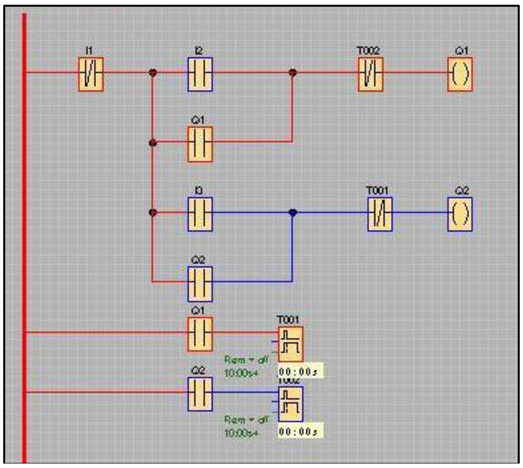

Figure 1.7: Ladder Diagram of problem 1.5.3

1.6 Hardware connection to OMRON CP1E 40 I/O

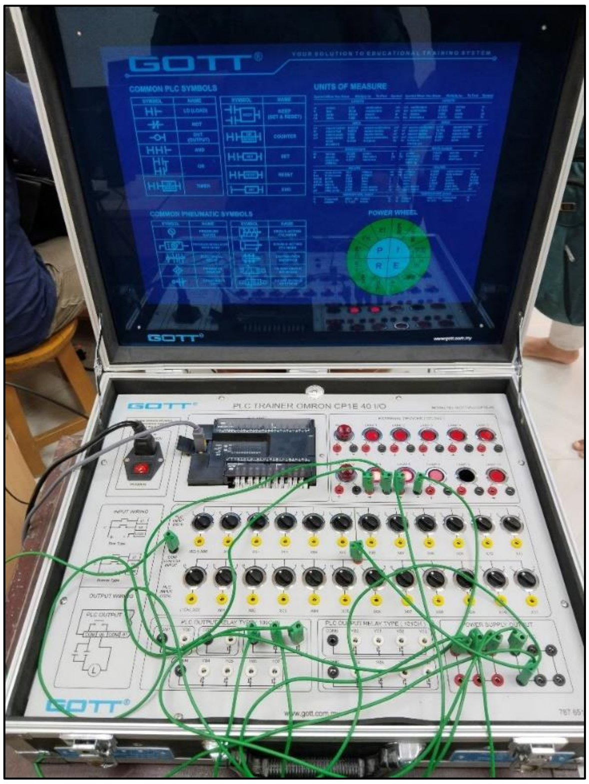

Figure 1.8: Experimental setup of OMRON CP1E 40 I/O

1.7 Discussion & Conclusion

In this experiment, we designed, implemented, and observed various practical problem. Among them problem 1.5.1, when NO push button is pressed the output is in ON state. In problem 1.5.2 and 1.5.3, the system was quite practical and the concept of interlocking was introduced. Interlocking means the state of one output will affect the other outputs. Here, as the motor was run in clockwise direction it wouldn't start in anti-clockwise direction. To turn it in anti-clockwise direction it's required to turn off the motor first.

In reality, if the motor was stopped from clockwise motion, it would not be able to instantly start its anti-clockwise motion because of its inertia. So, there should be some time gap between the stop and start. The time gap was provided by the timer block. Two OFF delay timers of 10 second count were used here. OFF delay timer would follow the rising edge instantly and start the timing action with the falling edge of the timer input signal.

Later on, these were implemented in the PLC trainer kit OMRON CP1E 40 I/O and the results were observed.

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RUET

Department of Electrical & Electronic Engineering

Course no.	EEE 4210
Course title:	Embedded System DesignSessional
Experiment no.	2
Experiment name:	Speed control of a DC motor using temperature sensor
Date of experiment:	October 10, 2023
Date of submission:	October 30, 2023

Submitted to:	Submitted by:
Md. Razon Chowdhury **Assistant Professor** Dept. of Electrical & Electronic Engineering, Rajshahi University of Engineering and Technology.	**Ashraf Al- Khalique** **Roll:** 1801171 **Session:** 2018-2019 Dept. of Electrical & Electronic Engineering, Rajshahi University of Engineering and Technology.

RUET

Experiment No. 02

2.1 Experiment Name

Speed control of a DC motor using temperature sensor

2.2 Objectives

- To get a better understanding of PLC hardware and the ladder diagram
- To get familiar with the speed control of DC motors and their PLC implementation
- To understand the generation of PWM signal using an Arduino Uno
- To get familiar with the use of the driver circuit and BJT for varying the duty cycle

2.3 Theory

2.3.1 Speed control of a DC motor with Arduino UNO code

A DC motor's speed can be controlled using a variety of methods and by modifying a number of factors such as, power supply, armature resistance, field winding control, pulse width modulation (PWM), and electronic control circuits.

The PWM signal was generated and used to control the speed of the DC motor. Here, the Arduino Uno microcontroller played an integral part for the generation of the PWM signal. The duty cycle of the PWM was adjusted by adjusting the potentiometer. The Arduino detected the resistance and calculated the duty cycle. Then this signal is fed to the DC motor and speed was controlled.

2.4 Apparatus

- ❖ DC motor
- ❖ Oscilloscope
- ❖ Potentiometer
- ❖ Driver Circuits
- ❖ Probe
- ❖ Arduino UNO
- ❖ Voltmeter
- ❖ Ammeter
- ❖ center-taped transformer
- ❖ Power Diode
- ❖ Software
  - ✓ Arduino software
  - ✓ MATLAB Simulink software

2.5 Connection diagram

2.5.1 Driver Circuit connection

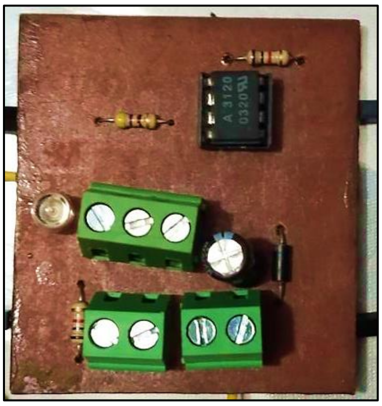


Figure 2.1: PCB connection of Driver Circuit

2.5.2 DC motor connection

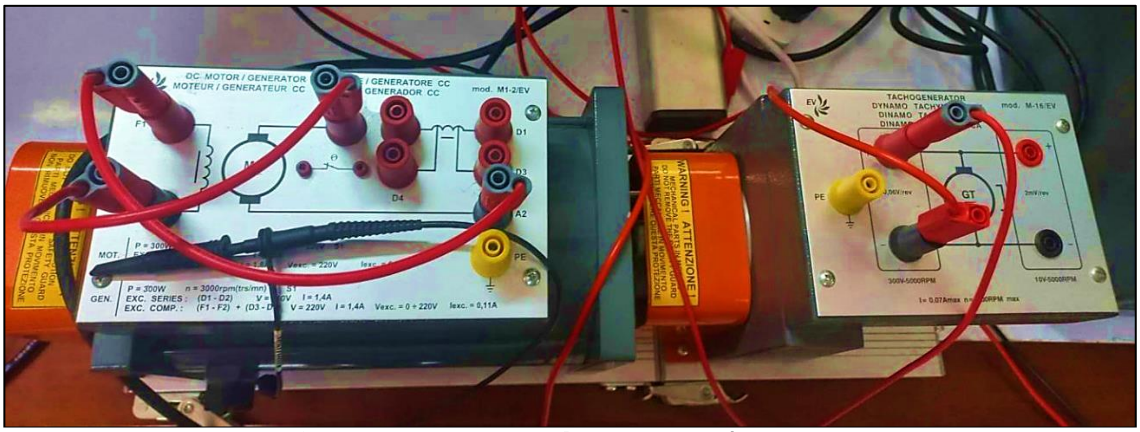
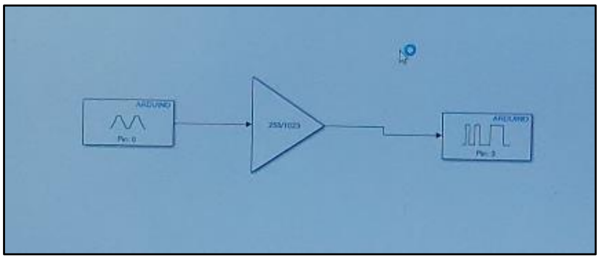


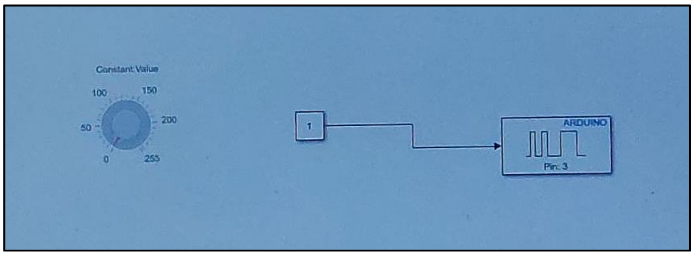
Figure 2.2: Experimental connection of DC motor

2.5.3 Experimental connection

Figure 2.3: Experimental setup

2.5.4 MATLAB Simulation





(i) PWM generation

(ii) Speed control

2.6 Waveform

Figure 1.8: Experimental setup of OMRON CP1E 40 I/O

2.7 Discussion & Conclusion

In this experiment, we designed, implemented, and observed a practical problem, Speed control of a DC motor.

A potentiometer was used to simulate a temperature sensor, with the goal to change the resistance of the potentiometer and the speed of the DC motor. The Arduino was used to generate the desired PWM signal, and the duty cycle was adjusted by changing the potentiometer. This PWM modulated the input signal, and the speed was controlled by feeding the signal to the motor. This worked because the average value of the input signal decreased as the duty cycle decreased, and vice versa.

There were few limitations such as, the potentiometer's response time to resistance changes is relatively slow compared to dedicated temperature sensors. Moreover, the relationship between temperature and resistance is not linear. Real temperature sensors, like thermistors, exhibit a more predictable and accurate response to temperature changes.

As a result, the experiment was a success. This experiment is a basic demonstration of how analog components can be utilized for control. Because of the limits of the potentiometer, it is not a realistic approach for accurate temperature-dependent control.

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Department of Electrical & Electronic Engineering

Course no. EEE 4210

Course title: Embedded System Design Sessional

Experiment no. 3

Experiment name: Study of fast and phase correct PWM generation using microcontroller

Date of experiment: October 30, 2023

Date of submission: , 2023

Submitted to:	Submitted by:
Md. Razon Chowdhury **Assistant Professor** Dept. of Electrical & Electronic Engineering, Rajshahi University of Engineering and Technology.	**Ashraf Al- Khalique** **Roll:** 1801171 **Session:** 2018-2019 Dept. of Electrical & Electronic Engineering, Rajshahi University of Engineering and Technology.

Experiment No. 03

3.1 Experiment Name

Study of fast and phase correct PWM generation using microcontroller.

3.2 Objectives

- To get a better understanding of Pulse Width Modulation (PWM) technique
- To understand the generation of PWM signal using an Arduino Uno
- To get familiar with the timer/counter and observe output waveform using oscilloscope

3.3 Theory

Pulse Width Modulation (PWM) is a technique used to generate an analog signal using a digital signal. PWM is employed in microcontroller applications to regulate motor speed, dim LEDs, and adjust the power supply to loads, among other tasks. The duty cycle of the PWM signal is controlled by changing the time that the output pin is high. This method, while simple to implement, lacks resolution and may not be suitable for high-frequency applications. Thus, modified techniques like fast PWM and phase-correct PWM provide a better solution to these traditional limitations.

In the fast PWM technique, the microcontroller rapidly alternates between high and low states, resulting in a high-frequency PWM signal. To be more precise, in fast PWM mode, the counter counts up to its maximum value and then resets to 0. The output at the output pin toggles every time the timer value equals the value of the OCR register. As a result, it offers more precise control over the duty cycle, ensuring high-speed modulation. In contrast, in phase-correct PWM mode, the counter starts counting down from its maximum upon reaching it before resetting back to 0. This cycle repeats. Here also, the output at the output pin toggles every time the timer value equals the value of the OCR register, resulting in a symmetric waveform. This helps minimize errors in certain control scenarios.

3.4 Apparatus

- ❖ Arduino Uno (for ATmega328 microcontroller)
- ❖ Oscilloscope
- ❖ Jumper wires
- ❖ Laptop
- ❖ Power supply

3.5 Connection diagram

3.5.1 Experimental connection

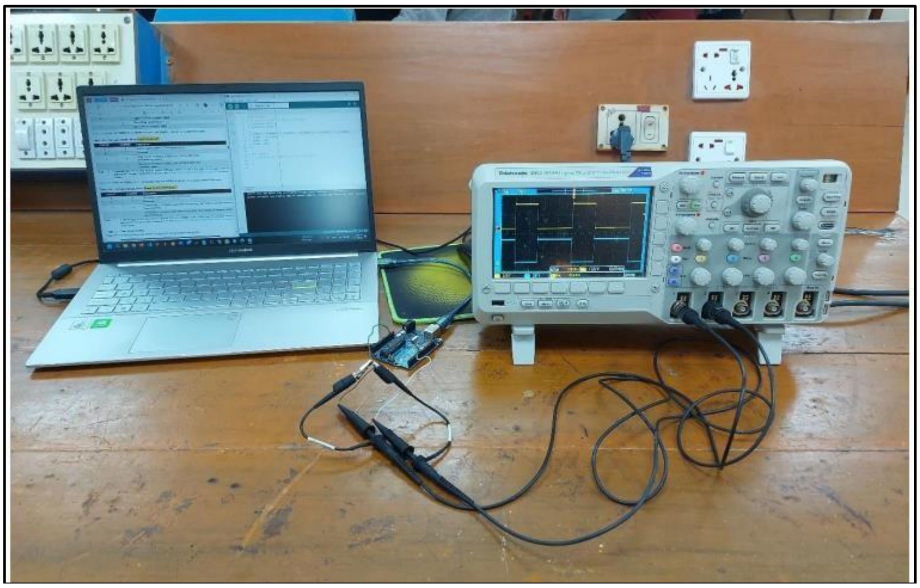

Figure 3.1: Experimental setup

3.6 Waveform

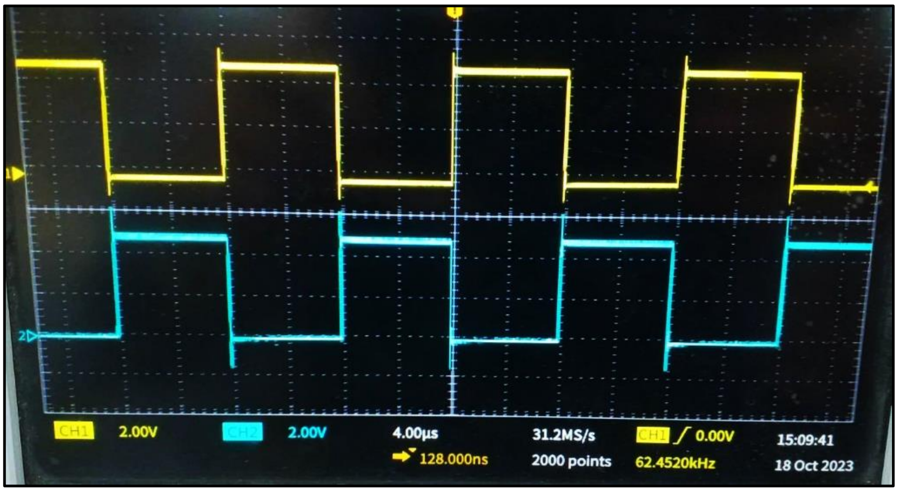

Figure 3.2: Fast PWM waveform

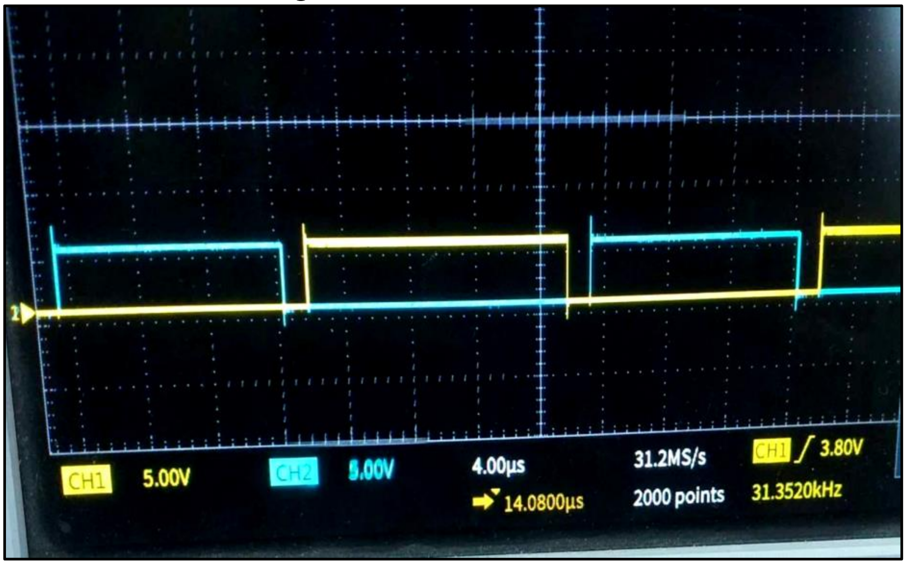

Figure 3.3: Phase Correct PWM waveform

3.7 Discussion & Conclusion

In this experiment, we successfully carried out the generation of a PWM signal using an Arduino Uno. Our approach involved meticulous programming of the Arduino Uno to align with the experimental requirements.

For the generation of fast PWM, we strategically configured digital pins 6 and 5 as the outputs for the PWM signal. Additionally, we tailored the settings of Timer 0 to operate in fast PWM mode. This entailed activating the WGM00 and WGM01 bits to enable fast PWM. Further customization was achieved by configuring COM0A1, COM0B1, and COM0B0 to dictate the behavior of the PWM outputs on pins 6 and 5. To fine-tune the duty cycle, we set the values in the Output Compare Registers (OCR0A and OCR0B) to 127 and 130, respectively. Conversely, in the case of phase-correct PWM generation, achieving our desired waveform was simplified. We only needed to set the values in the Output Compare Registers (OCR0A and OCR0B) to 127 and 150, respectively. These modifications effectively realized the desired waveform characteristics. The experiment conclusively demonstrated the successful generation of PWM signals with the Arduino Uno, showcasing the adaptability and precision achievable through careful configuration. The obtained results affirm the effectiveness of our programmed settings in producing the intended waveforms, marking the experiment as a success.

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Rajshahi University of Engineering and Technology

RUET

Department of Electrical & Electronic Engineering

Course no. EEE 4210

Course title: Embedded System Design Sessional

Experiment no. 4

Experiment name: Study of R-2R ADC & generation of different signals using Arduino microcontroller & designing PLL block

Date of experiment: December 13, 2023

Date of submission: January 03, 2023

Submitted to:	Submitted by:
Md. Razon Chowdhury **Assistant Professor** Dept. of Electrical & Electronic Engineering, Rajshahi University of Engineering and Technology.	**Ashraf Al- Khalique** **Roll:** 1801171 **Session:** 2018-2019 Dept. of Electrical & Electronic Engineering, Rajshahi University of Engineering and Technology.

RUET

Experiment No. 04

4.1 Experiment Name

Study of R-2R ADC & generation of different signals using Arduino microcontroller & designing PLL block

4.2 Objectives

- To get a better understanding of R-2R ADC Circuit
- To understand the function of R-2R ADC using an Arduino Uno
- To get familiar with the generation of different signals using Arduino Uno

4.3 Theory

A Digital to Analog Converter (DAC) serves to transform digital signals into corresponding analog signals, while an Analog-to-Digital Converter (ADC) does the opposite. DAC finds applications in various fields, including audio, video, mechanical, and communication, with a primary focus on audio applications. The effectiveness of a DAC is evaluated based on parameters such as resolution and sampling frequency, and various DAC architectures exist. In this project, the R-2R Ladder DAC, known for its simplicity and versatility, is explored. Utilizing only two resistor values, it can be extended to any bit number, maintaining a consistent output impedance of R, simplifying filtering and circuit design.

On a different note, a Phase-Locked Loop (PLL) is a closed-loop feedback control system extensively used in electronics for diverse applications. Its principal function is to generate an output signal synchronized with the phase of an input signal, typically referred to as the reference signal, in various electronic systems.

4.4 Apparatus

- ❖ Arduino Uno (for ATmega328 microcontroller)
- ❖ Oscilloscope
- ❖ Resister (1kΩ; 24 pcs)
- ❖ Jumper wires
- ❖ Laptop
- ❖ Power supply

4.5 Connection diagram

4.5.1 Experimental connection of R-2R ADC

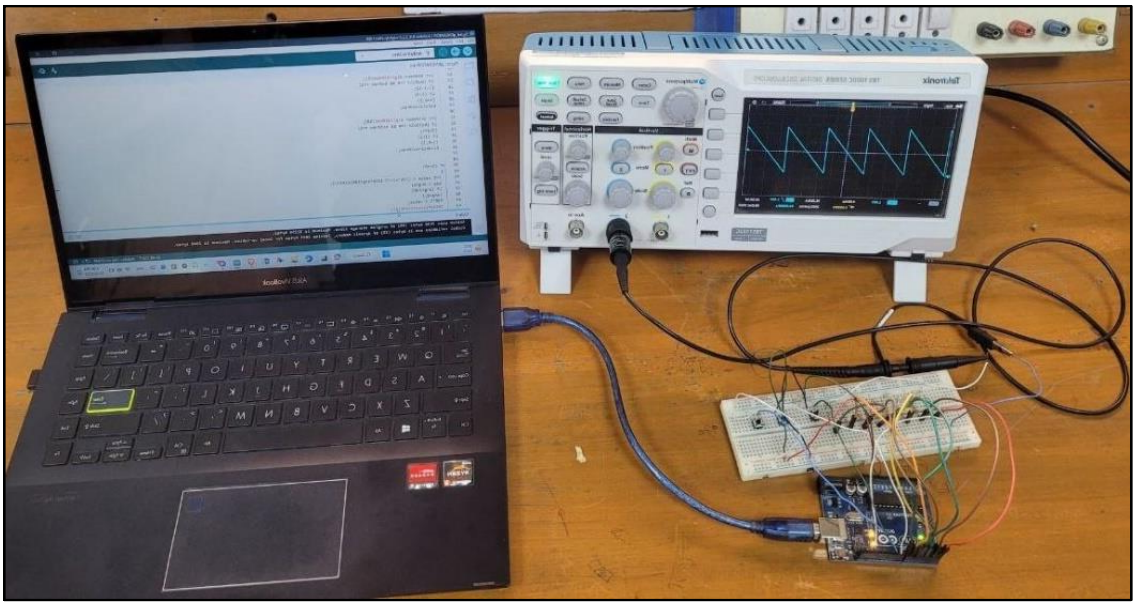


Fig. 4.1: Experimental setup of R-2R ADC

4.5.2 Experimental connection of PLL

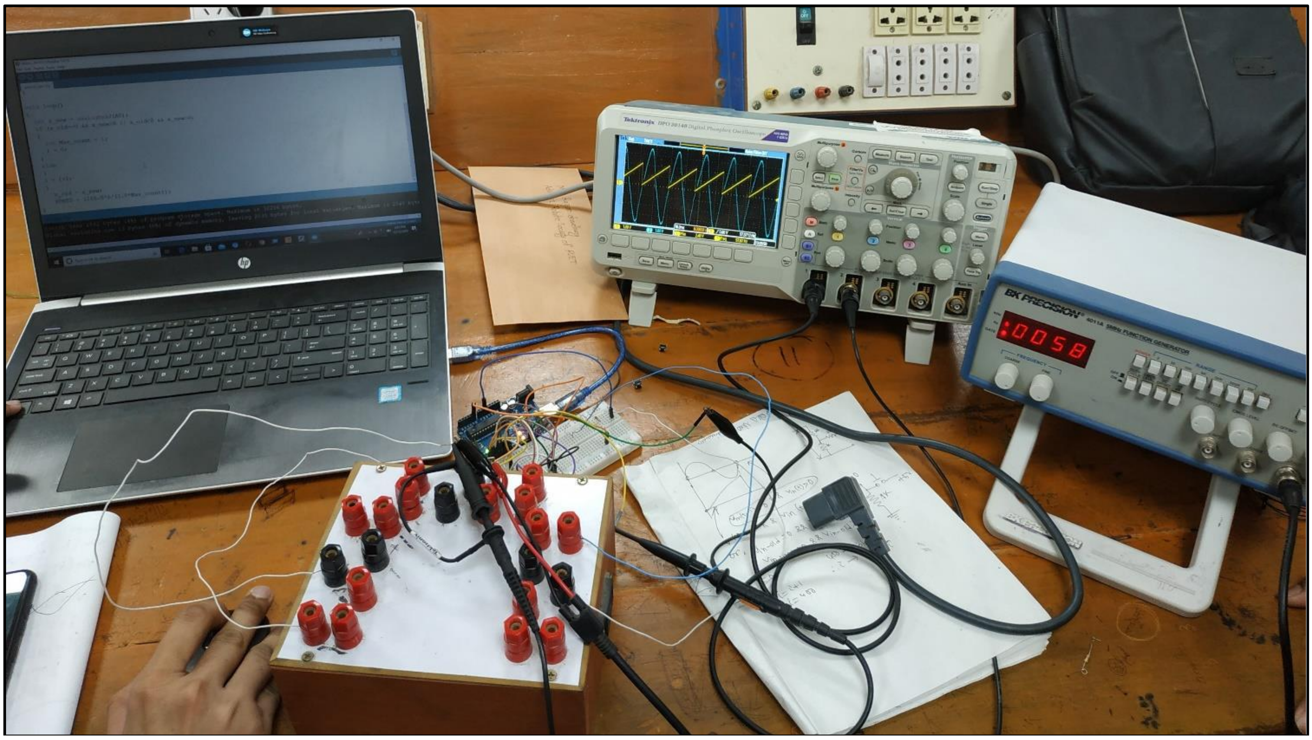
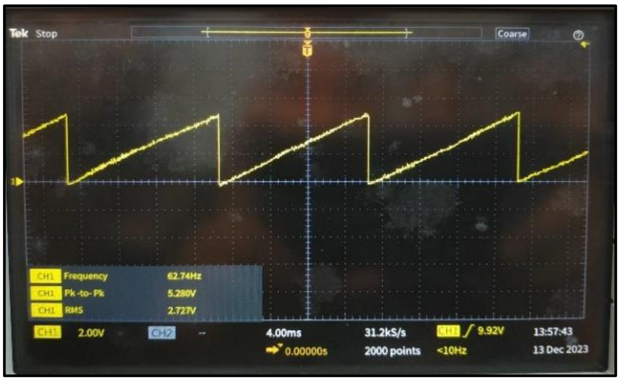


Fig. 4.2: Experimental setup of PLL

4.6 Waveform

4.6.1 R-2R ADC Waveform



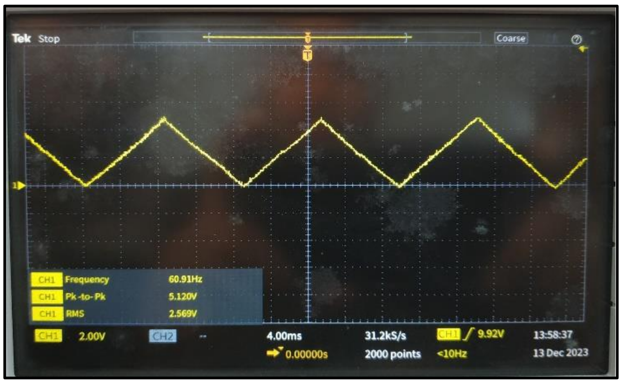


Fig. 4.3: Sawtooth waveform **Fig. 4.4:** Triangular waveform

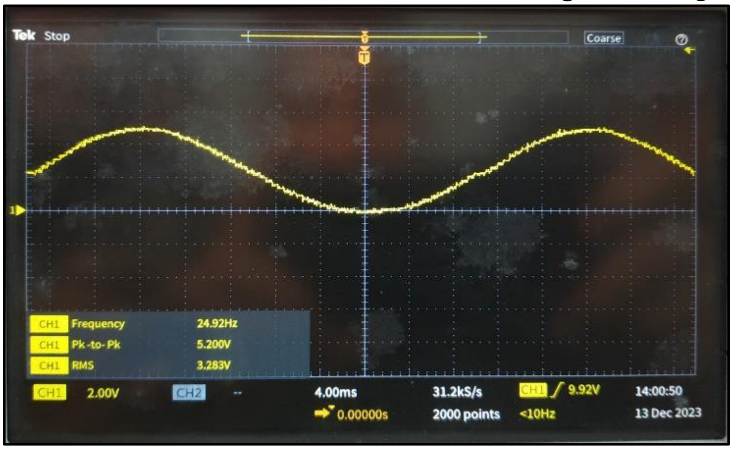


Fig. 4.5: Sinusoidal waveform

4.6.2 PLC Waveform

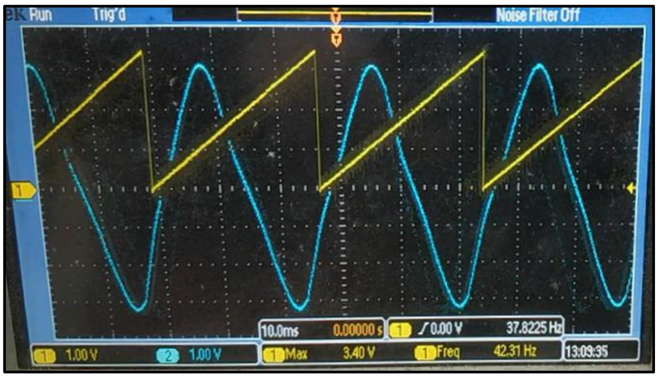


Fig. 4.6: Triangular signal representing the phase of the sinusoidal wave

4.7 Discussion & Conclusion

In this experiment, we successfully carried out the generation of different signals using an Arduino Uno designing PLL block and carried out an comprehensive study on R-2R ADC. Our approach involved meticulous programming of the Arduino Uno to align with the experimental requirements.

In this experiment, an Arduino-based function generator was constructed using an R-2R ADC circuit, generating sawtooth, triangular, and sinusoidal signals as depicted in figures 4.3, 4.4, and 4.5, respectively. In the subsequent phase of the experiment, a Phase-Locked Loop (PLL) was successfully implemented to accurately read the phase of a sinusoidal signal, as evident in figure 4.6. The overall experiment proved to be successful and yielded fruitful results.