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وزارة التعليم العالي والبحث العلمي
MINISTRY OF HIGHER EDUCATION AND SCIENTIFIC RESEARCH

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Report
Measurement Project

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Introduction

This project aims to design and implement a digital multimeter using Arduino. A digital multimeter is an essential tool for measuring electrical parameters such as voltage, current, and resistance. With the help of an Arduino microcontroller, we can build a low-cost and easy-to-use multimeter that can accurately measure different electrical quantities.

The main goal of this project is to provide an affordable and efficient solution for measuring electrical parameters. In addition, the project will give us a better understanding of how to use an Arduino and different sensors to build an electronic measuring device.

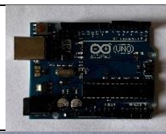
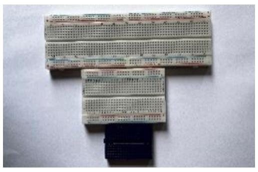
In this report, we will describe the components used in the project, the procedures followed, the results obtained, and the discussion of the findings. We will also provide a conclusion that summarizes the project's objectives and the lessons learned during the implementation of the multimeter.

Objectives

- To design and implement a digital multimeter using Arduino.
- To measure various electrical quantities such as voltage, current, and resistance accurately using the multimeter.
- To provide an easy-to-use and low-cost solution for measuring electrical quantities.
- To incorporate user-friendly features such as an LCD display.
- To explore the capabilities of Arduino in designing and implementing electrical measurement instruments.
- To gain practical experience in circuit design, programming, and testing.
- To design and build a reliable and accurate multimeter capable of measuring voltage, current, and resistance in DC circuits.
- To incorporate safety features such as overload protection and isolation to ensure the safety of the user and the device.
- To use high-quality components to ensure the durability and longevity of the multimeter.
- To make the multimeter user-friendly and easy to operate with a clear and intuitive display.
- To ensure the multimeter meets industry standards for accuracy and reliability, and to calibrate the device accordingly.
- To provide a cost-effective solution for professionals and hobbyists in need of a versatile and reliable multimeter.
- To educate users on the principles and techniques of multimeter operation and measurement and provide instructions on the proper use and maintenance of the device.

Components

The following components were used in the construction of the multimeter:

Component	Description	Photo
Arduino UNO board	The main control unit for the multimeter	
I2C Module	Control the LCD display	
16x2 LCD Display	The interface of the multimeter	
Breadboards	Connect the components together	
Jumper wires	Connect the components together	

Procedures

First of all, we gathered the necessary components:

1. Arduino uno Board.
2. I2C LCD.
3. Jumper wires, breadboard, and resistors.

1st: I2C LCD connection:

1. First, we connect the I2C LCD to the Arduino board using the following pinout table:

I2C LCD Pin	Arduino Pin
VCC	5v
GND	GND
SDA	A4
SCL	A5

2. Match the I2C address of the LCD with the address in the code *(which is 0×27)*.
3. Connect the breadboard to the Arduino Uno board and add the resistors.

2nd: Voltmeter:

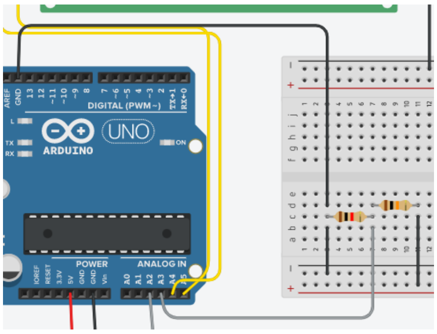


Figure 2

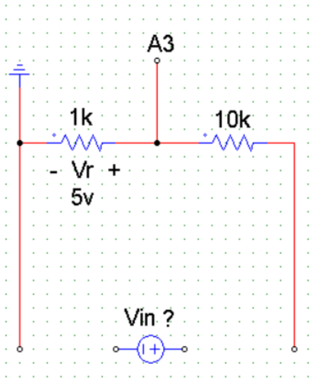


Figure 1

Connect the circuit as shown in figure 1 and 2.

Then, take the reading of A3 (Vr) and measure the value of Vin using voltage divider:

Vr = Vin × [1/ (1+10)]

∴Vin = Vr × 11

Then write the following lines in our code:

```
// calculate the voltage value based on the reading from A3
  //Voltmeter
  float temp_V = voltage_value3*(5.0/1023.0) ;
  float Vin =  11*temp_V ;
```

3rd: Ohmmeter:

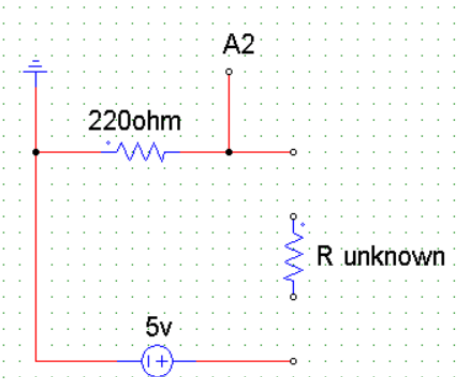


Figure 3

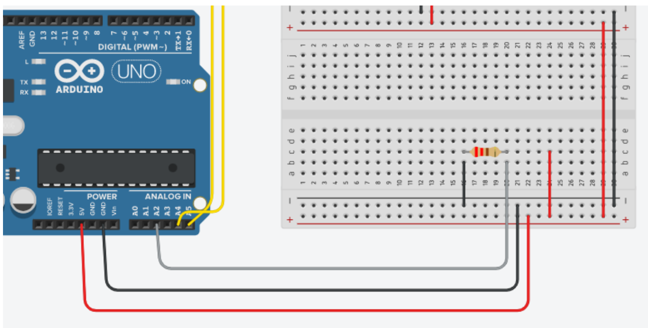


Figure 4

Connect the circuit as shown in figure 3 and 4.

From voltage divider:

Voltage of A2= $\frac{5\times220}{220+Rx}$

$\therefore$ V of A2×(220+Rx)=1100

$\therefore$Rx=$\frac{1100}{A2}$ - 200

Then write the following lines in our code:

```
// calculate the resistance value based on the voltage reading from A2
//ohmmeter
float Rx = (1100.0/(voltage_value2*(5.0/1023.0)))-220.0;
```

4th: ammeter:

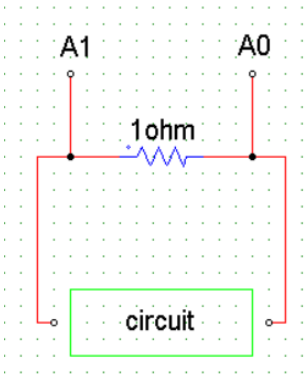


Figure 5

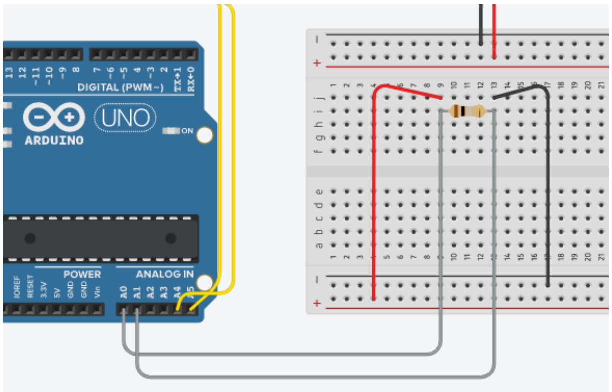


Figure 6

Connect the circuit as shown in figure 1 and 2.

I = Potential difference between A0 and A1 *(as the resistance = 1Ω).*

Then write the following lines in our code:

```
// calculate the current value based on the voltage difference between A0 and A1
//Ammeter


float current_value = abs((voltage_value0 - voltage_value1)*(5.0/1023.0));
```

Results and Discussion

1st: Voltmeter:

Test plan:

Figure 7: actual value of battery voltage

The volt of battery (1.5V) was measured using AVO Meter to measure its actual value, as shown in figure ().

After that, the volt of the battery was measured using the prototype, as shown in figure ().

Finally, the percentage error was measured by the following rule:

$$\%e = \frac{|Measured - actual|}{actual} \times 100$$

Calculations:

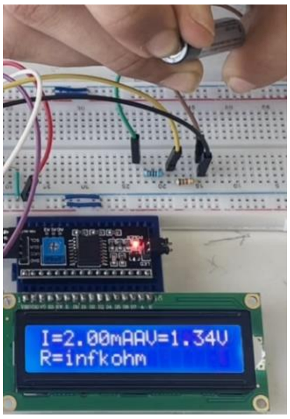


Figure 8: measured value of battery voltage

The actual value of battery volt = 1.46 V

The measured value of battery volt = 1.34 V

Percentage error = $\frac{|1.34-1.46|}{1.46} \times 100 \approx 8.22\%$

2nd: Ohmmeter:

Test plan:

The resistance was measured using AVO Meter to measure its actual value, as shown in figure ().

After that, the resistance was measured using the prototype, as shown in figure ().

Figure9: actual value of resistance

Finally, the percentage error was measured by the following rule:

$$\%e = \frac{|Measured - actual|}{actual} \times 100$$

Calculations:

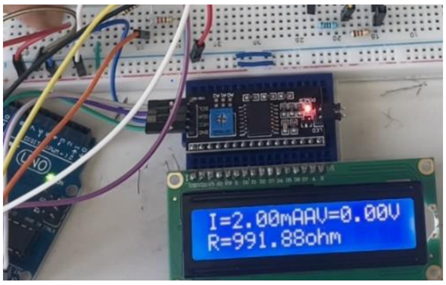


Figure 10: measured value of resistance

The actual value of resistance = 970 Ω

The measured value of resistance = 991.88 Ω

Percentage error = $\frac{|991.88 - 970|}{970} \times 100 \approx 2.26\%$

3rd: Ammeter:

Test plan:

The resistance, where the current pass through is required, used in the circuit was measured using AVO Meter to measure its actual value, as shown in figure (). The volt used in the circuit was the 5V of the Arduino.

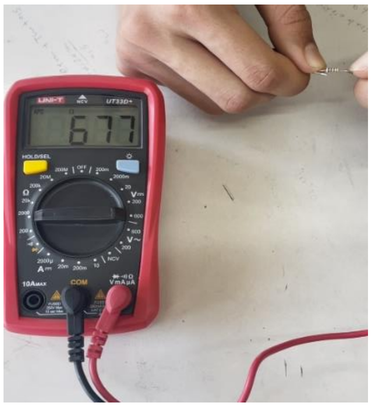


Figure 11: resistance used in the circuit

The actual value of the current was calculated by:

I = 5/R

After that, the current was measured using the prototype, as shown in figure ().

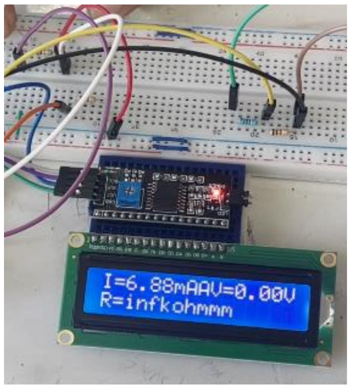


Figure 12: measured value of current

Finally, the percentage error was measured by the following rule:

$$\%e = \frac{|Measured - actual|}{actual} \times 100$$

Calculations:

The actual value of current = 5v / 677 Ω = 7.38 mA

The measured value of current = 6.88mA

Percentage error = $\frac{|6.88-7.38|}{7.38} \times 100 \approx 6.77\%$

Conclusion

In conclusion, the Arduino multimeter is a versatile and customizable tool that can be used for a wide range of measurement tasks. It combines the functionality of a multimeter with the flexibility and programmability of an Arduino microcontroller, making it a useful tool for hobbyists, students, and professionals alike.

The multimeter can be further improved by making modifications to the circuit and code, which can increase its range of measurement and improve its accuracy as well as its ability to measure different types of signals such as AC and DC voltages, currents, and resistances.

Overall, the project was a valuable learning experience and provided insight into the practical applications of electronics.

Simulation Vs. Hardware