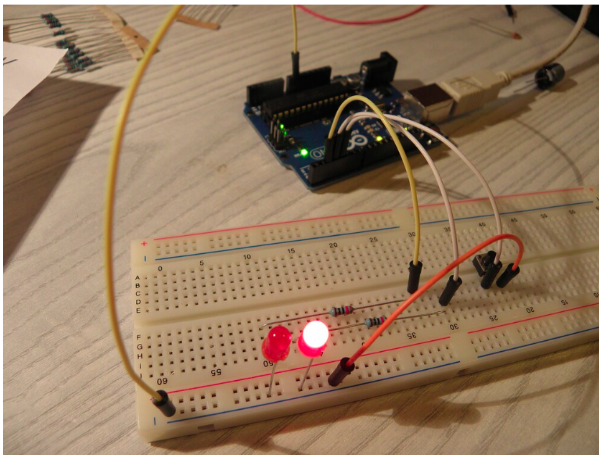
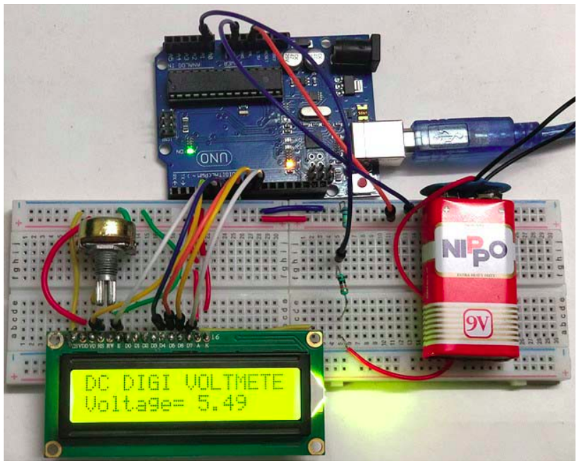
Project Topic: Working of a Capacitor, Capacitance Meter and Digital Voltmeter.





Part 1 (Capacitor & Capacitance)

Introduction

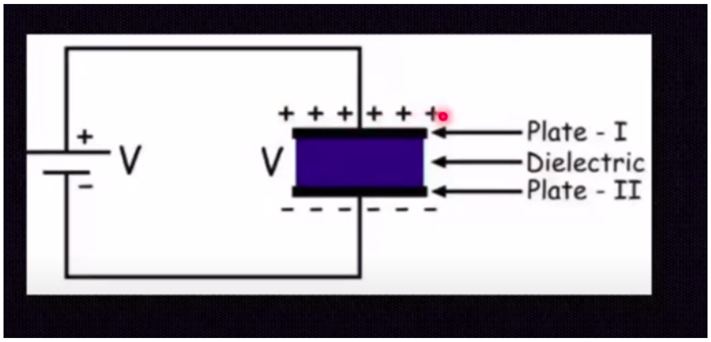
What is Capacitor and Capacitance?

A capacitor is an electrical device that stores electrical charge and this ability to store electric charge is called capacitance.

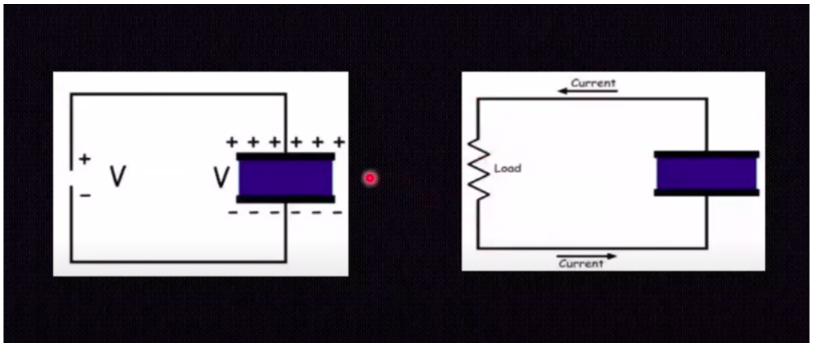
It is different from battery in 3 ways:

a. Charging and discharging is fast in the capacitor.
b. Capacitor has less storage capacity as compared to battery.
c. It uses an electrical field to store charge whereas a battery uses chemical energy.

Capacitor is made up of 2 parallel plates separated by an insulating material called dielectric, one such example is ceramic disc.



When the switch is closed, at time=0 sec, current will flow through the resistor and the capacitor will start charging. It will charge till the time Voltage Vc (is the voltage of capacitor) becomes equal to V supply.

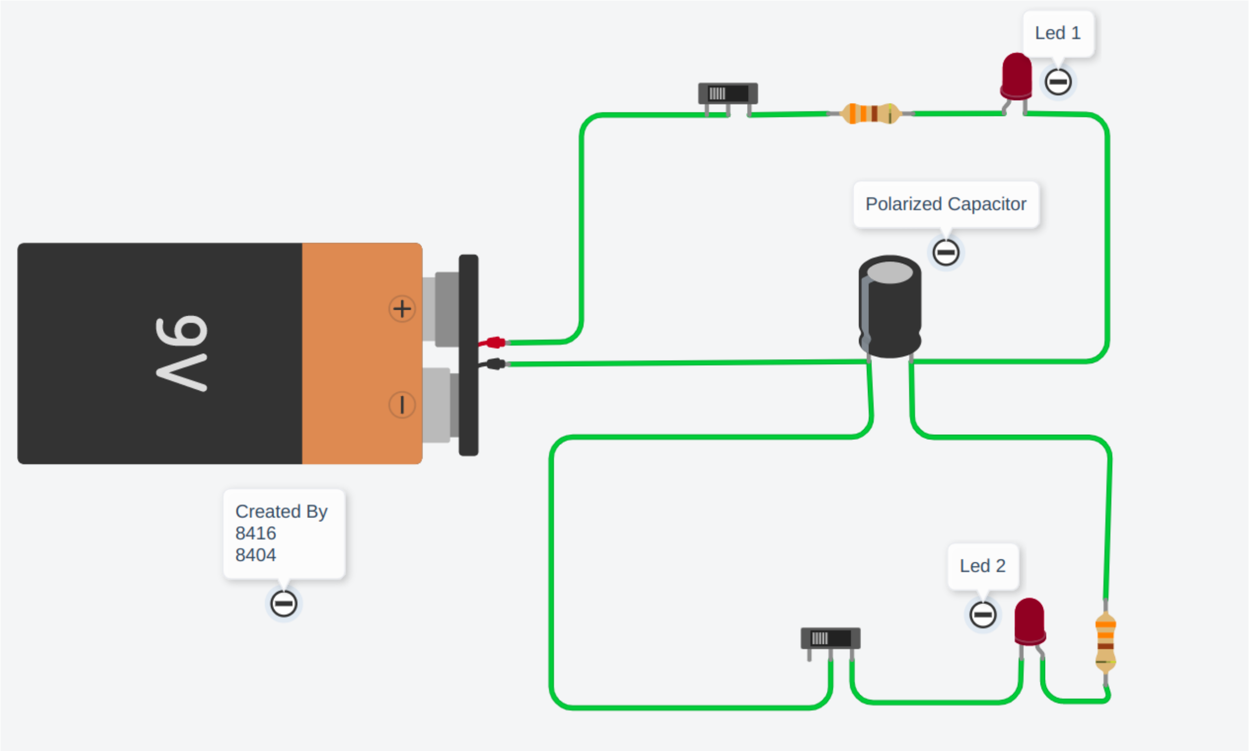


After the battery is taken out, potential is created on the capacitor and it can be used with any load.

What is the use of capacitance ?

In many cases we cannot switch off the current suddenly, this disturbs the changes in the load thus we use capacitor,where there will be gradual discharge of battery and it is used in tube lights, fans.

Lightning and dimming the LED with Battery and Capacitor



Part 2 (Finding Capacitance through Arduino Uno acting as Capacitance Meter)

Introduction

What does a capacitance meter do?

We can measure the rate of charge storage in capacitance.

What do we do if we want to measure capacitance?

Simple digital measuring meters cannot measure the capacitance.

We can make our own capacitance meter using an Arduino uno board.

To do this we must use an RC circuit (it is a resistor capacitance circuit).

Description

The Aurdiuno will be programmed to time how long it will take for a capacitor to reach 63.2% of its total charge. It will then use the equation, Tau/R =C to calculate the capacitance since the resistance is known .

So it is quite obvious that smaller that capacitor value, less time it will take to charge, so time constant will also be smaller and discharging time will also be less. RC circuit has a property called as Time Constant (τ), which is the time the capacitor takes to be charged by the resistor, to reach 63.2% of the total voltage.

$$\tau = RC$$

The principle used here is that of Time Constant.
We take the known Resistance value, i.e R.

Components

1. Arduino Uno Board:

   Arduino UNO is one of the most popular electronics prototyping boards based on ATmega328P Microcontroller. ATmega328P is an AVR architecture based 8-bit microcontroller.

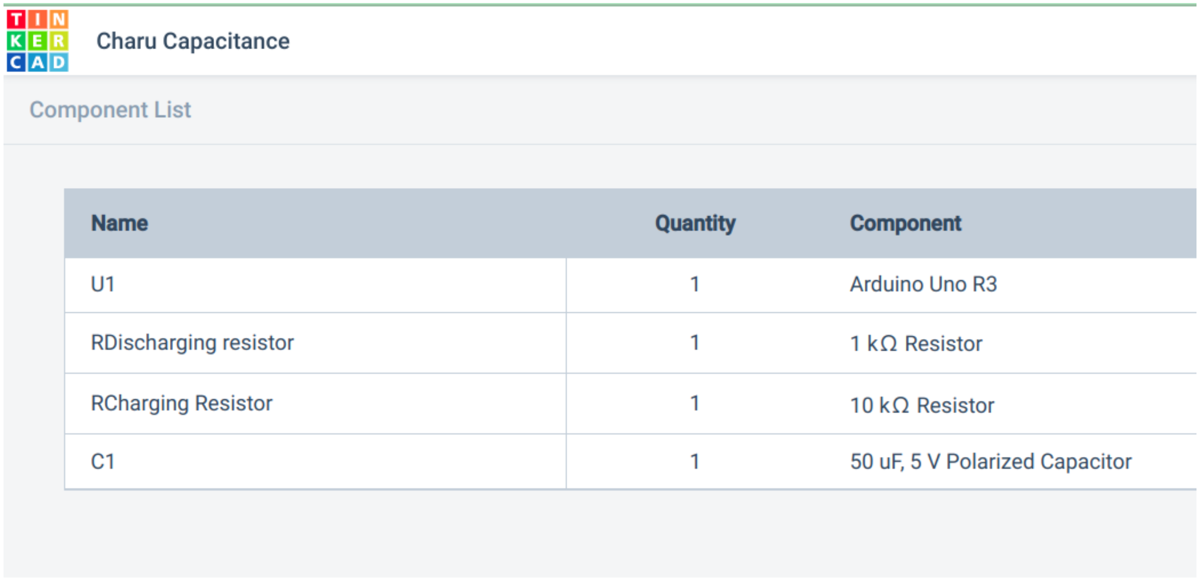
2. Charging & Discharging Resistor:

   The Charging Resistor is of 10k Ohm so that the resistor charges fast and the discharging capacitor is of 1k Ohm.

3. Polarized Capacitor:

   Capacitors with particular positive and negative polarities are known as polarized capacitors. It is critical to ensure that these capacitors are linked in precise polarities when utilizing them in circuits.

Component List



Charu Capacitance

Component List

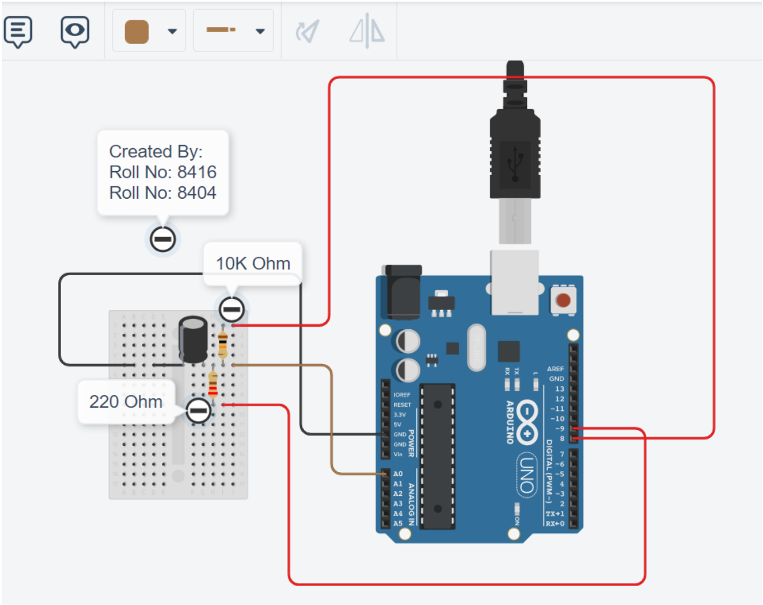
Name	Quantity	Component
U1	1	Arduino Uno R3
RDischarging resistor	1	1 kΩ Resistor
RCharging Resistor	1	10 kΩ Resistor
C1	1	50 uF, 5 V Polarized Capacitor

Code

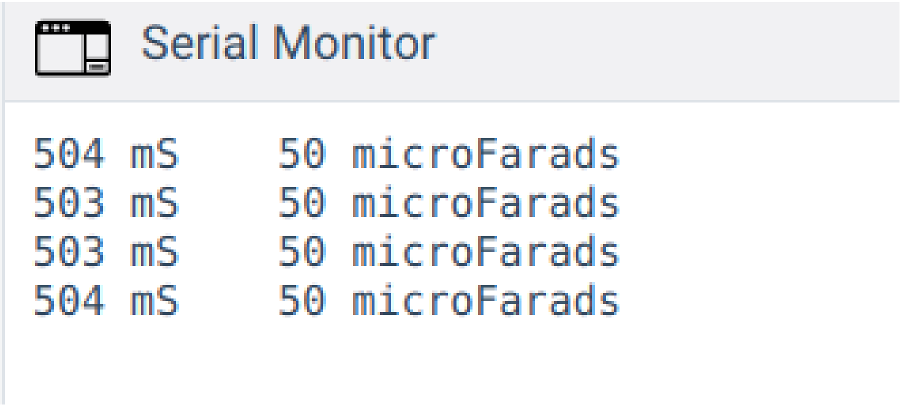
```
// Initialize Pins
int analogPin = 0;
int chargePin = 8;
int dischargePin =9; //speeds up discharging process, not necessary though

// Initialize Resistor
int resistorValue = 10000;

// Initialize Timer
unsigned long startTime;
unsigned long elapsedTime;

// Initialize Capacitance Variables
float microFarads;
float nanoFarads;

void setup()
{
  pinMode(chargePin, OUTPUT);
  digitalWrite(chargePin, LOW);
  Serial.begin(9600); // Necessary to print data to serial monitor over USB
}
```

```
void loop()
{
  digitalWrite(chargePin, HIGH); // Begins charging the capacitor
  startTime = millis(); // Begins the timer

  while(analogRead(analogPin) < 648)
  {
    // Does nothing until capacitor reaches 63.2% of total voltage
  }

  elapsedTime= millis() - startTime; // Determines how much time it took to charge
capacitor
  microFarads = ((float)elapsedTime / resistorValue) * 1000;
  Serial.print(elapsedTime);
  Serial.print(" mS    ");

  if (microFarads > 1) // Determines if units should be micro or nano and prints
accordingly
  {
    Serial.print((long)microFarads);
    Serial.println(" microFarads");
  }

  else
  {
    nanoFarads = microFarads * 1000.0;
    Serial.print((long)nanoFarads);
    Serial.println(" nanoFarads");
    delay(500);
  }

  digitalWrite(chargePin, LOW); // Stops charging capacitor
  pinMode(dischargePin, OUTPUT);
  digitalWrite(dischargePin, LOW); // Allows capacitor to discharge
  while(analogRead(analogPin) > 0)
  {
    // Do nothing until capacitor is discharged
  }

  pinMode(dischargePin, INPUT); // Prevents capacitor from discharging
}
```

Diagram



Output



```
504 mS    50 microFarads
503 mS    50 microFarads
503 mS    50 microFarads
504 mS    50 microFarads
```

Part 3: Digital Voltmeter

Introduction

A voltmeter, also known as a voltage meter, is an instrument used for measuring the potential difference, or voltage, between two points in an electrical or electronic circuit.

A digital voltmeter (DVM) **measures an unknown input voltage by converting the voltage to a digital value and then displays the voltage in numeric form**. DVMs are usually designed around a special type of analogue-to-digital converter called an integrating converter.

What is use of Digital Voltmeter

To overcome the defects of analog voltmeters, Digital Voltmeters are introduced.

Analog Voltmeters generally have an error percentage of 5% and the parallax error is often an issue.

Description

This is a voltage divider circuit

Voltage dividers are one of the most fundamental circuits in electronics.

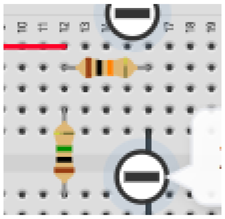
Using just two series resistors and an input voltage, we can create an output voltage that is a fraction of the input.
I have constructed the circuit to **maximize voltage reading range.**

In a digital voltmeter, the voltages to be measured, which are in analog form, are converted to digital form with the help of Analog to Digital Converters (ADC).

Hence, the ADC feature of the Arduino UNO is utilized in this project.
The ADC in Arduino UNO is of *10-bit resolution*. Hence, the **input voltage** is calculated by multiplying the *analog value at the analog pin with 5 and dividing the value with 210 i.e. 1024*.

An Arduino based Digital Voltmeter is designed in this project which can be used to measure different ranges of DC voltages.

When I am constructing a digital voltmeter, I want my voltages to be read. To maximize the ranges of voltages, this voltage divider circuit is created. The range of voltages for Arduino UNOs analog input is 0V to 5V. Hence, in order to increase this range, a voltage divider circuit must be used.



- **The disadvantage of using a voltage divider based voltmeter is the error of measurement. Hence, we need multiple ranges of voltmeters.**

Components.

1. Arduino UNO

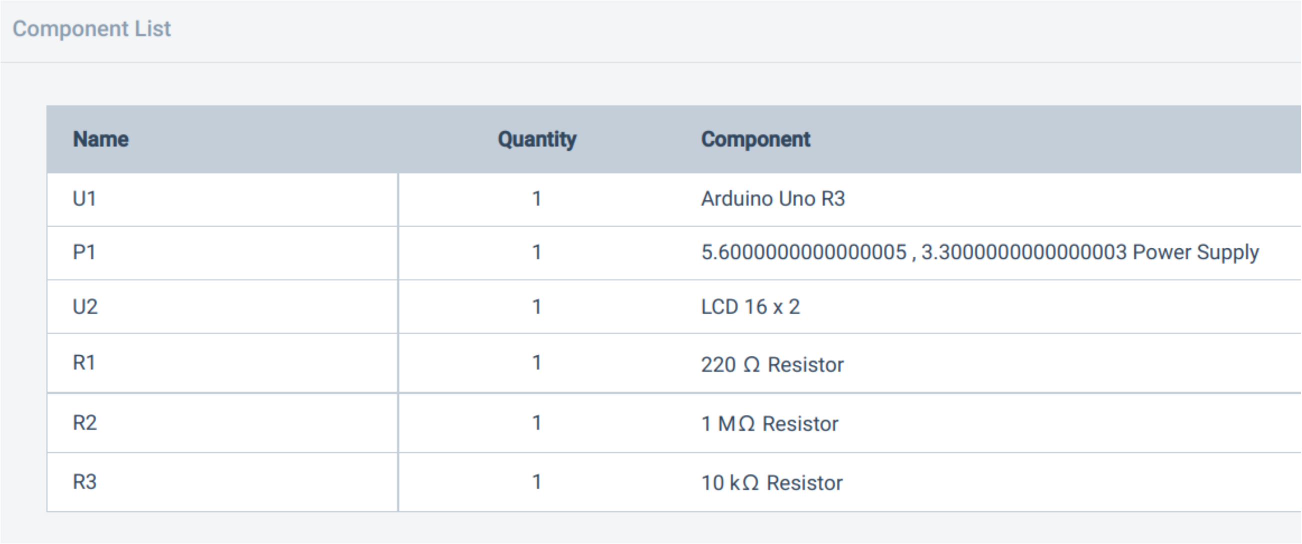
Arduino UNO is one of the most popular electronics prototyping boards based on ATmega328P Microcontroller. ATmega328P is an AVR architecture based 8-bit microcontroller.

2. 16 x 2 LCD Display 10KΩ POT

A 16 x 2 LCD display is the most commonly used display unit for microcontroller based applications.It supports 16 characters in a row with two such rows. It also supports special characters and even custom characters.

3. 100KΩ
4. 10KΩ
5. Connecting Wires

Component List



Component List

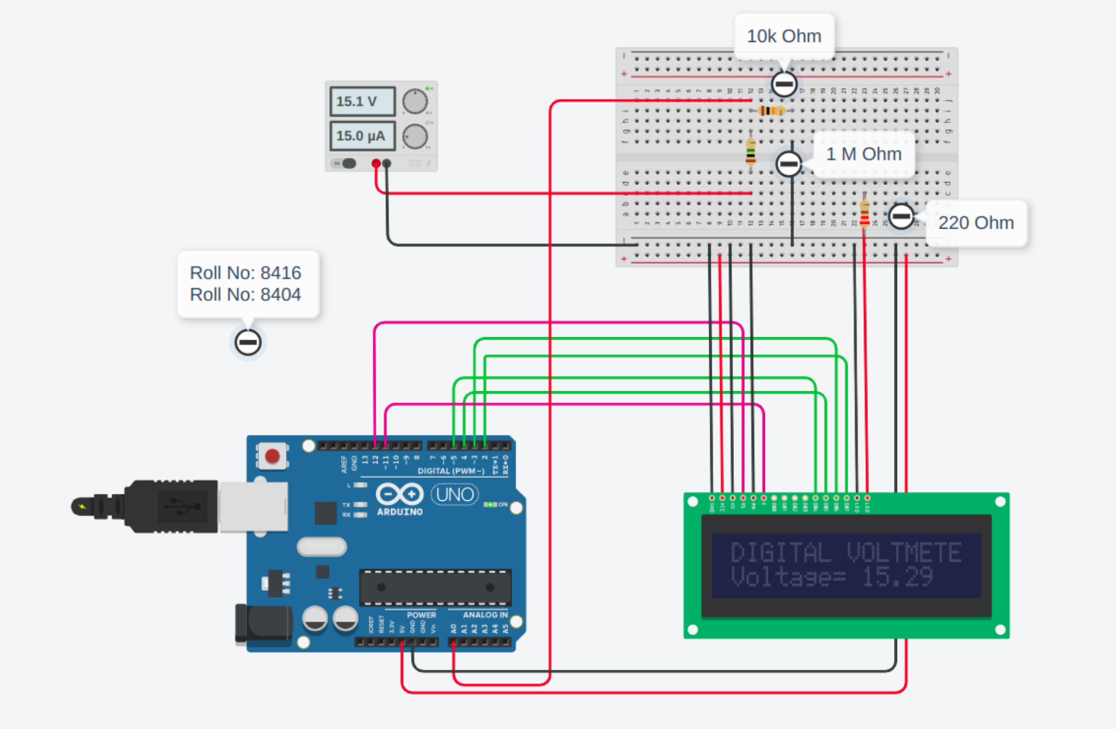
Name	Quantity	Component
U1	1	Arduino Uno R3
P1	1	5.6000000000000005 , 3.3000000000000003 Power Supply
U2	1	LCD 16 x 2
R1	1	220 Ω Resistor
R2	1	1 MΩ Resistor
R3	1	10 kΩ Resistor

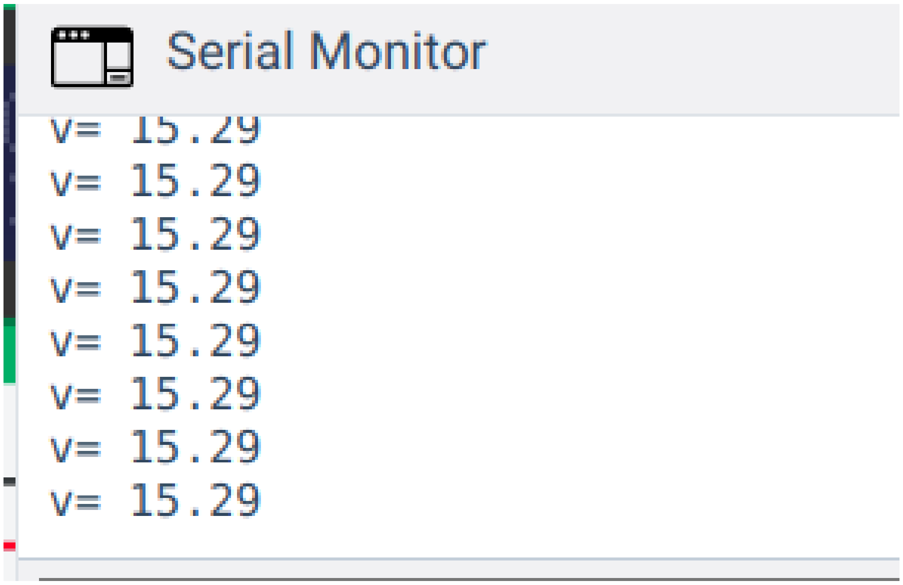
Code

```
#include "LiquidCrystal.h"
LiquidCrystal lcd(12,11,5,4,3,2);
float input_voltage = 0.0;
float temp=0.0;
float r1=100000.0;//1Mohm
float r2=1000.0;//10Kohm
void setup()
{
   Serial.begin(9600);     //  opens serial port, sets data rate to 9600 bps
   lcd.begin(16, 2);       //// set up the LCD's number of columns and rows:
   lcd.print("DIGITAL VOLTMETER");
}
void loop()
{
//Conversion formula for voltage

   float analog_value = analogRead(A0);
   temp = (analog_value * 5.0) / 1024.0;
  input_voltage=temp/(r2/(r2+r1));
 if (input_voltage < 0.1)
   {
     input_voltage=0.0;
  }
   Serial.print("v= ");
   Serial.println(input_voltage);
   lcd.setCursor(0, 1);
   lcd.print("Voltage= ");
   lcd.print(input_voltage);
   delay(1000);
}
```

Output

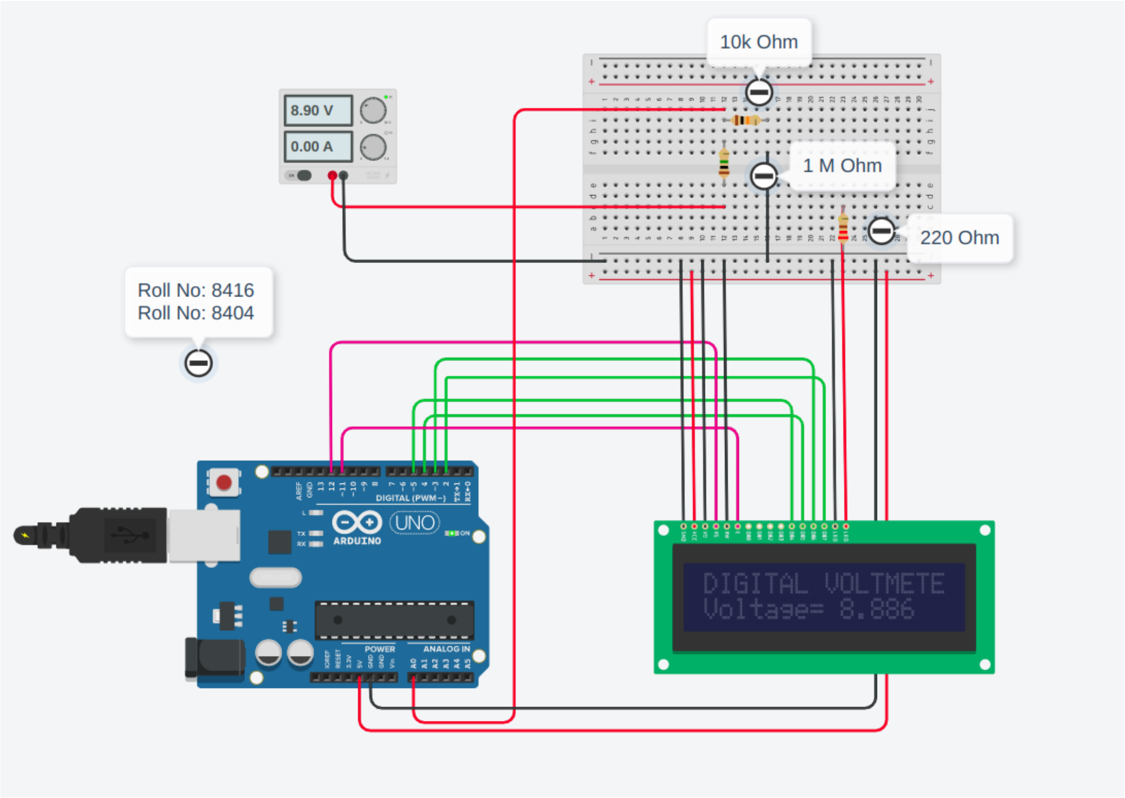
When voltage is around 15.1 v, it is shown as 15.29 nearly (due to some difference in voltage divider circuit).

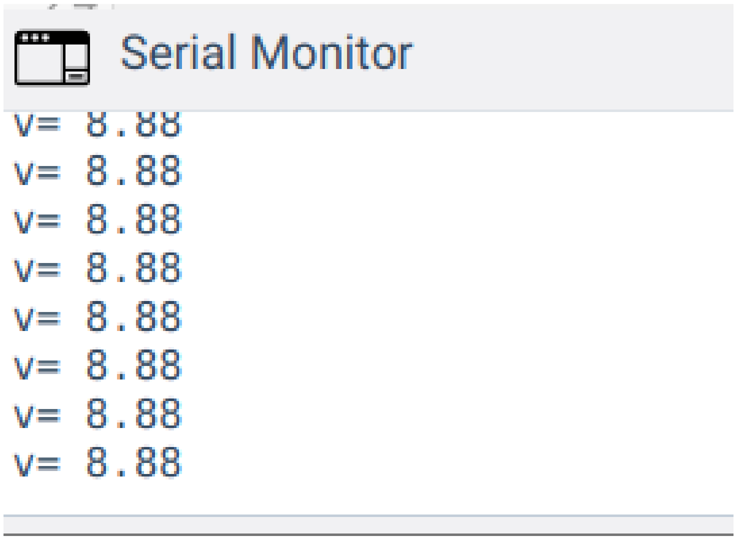




```
v= 15.29
v= 15.29
v= 15.29
v= 15.29
v= 15.29
v= 15.29
v= 15.29
v= 15.29
```

When voltage is around 8.90 v, it is shown as 8.886 nearly (due to some difference in voltage divider circuit).





```
v= 8.88
v= 8.88
v= 8.88
v= 8.88
v= 8.88
v= 8.88
v= 8.88
v= 8.88
```

This is how we can find the voltage of an unknown input voltage, with very little percentage of error.

THANKYOU