**Centre for Electronic Design and Technology**

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# Electronic Electroscope

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# 1. Synopsis

In the realm of scientific instrumentation, the electroscope has long been an invaluable tool for detecting and measuring electric charges. Traditionally, the electroscope was constructed using metal foils or leaves suspended within an insulated container. When an electric charge was introduced to the electroscope, the leaves would repel each other, providing a visual indication of the presence of the charge.

With enhancements in technology, the classic electroscope has not been an optimal option for the transfer of information. So, we devised an " Electronic Electroscope " which is the second version of this series.

In this variant, the basic design idea for the project is :

- Analog block, that is used for the detection of charge and converting it into the voltage of the same polarity.
- Arduino Nano, which is used to convert analog data into digital data and map the digital data with random values which will then be used to multiplex a certain number of LEDs.
- Bar Graph LEDs, its used to display the multiplexed LEDs according to the magnitude of charge.

# 2. Introduction

In the field of Electronics, charge is a general term used very commonly. So, it's crucial to detect whether a body is charged or not, and if it's charged then identifying the polarity is significant information. Here comes the concept of **ELECTROSCOPE**, which is used to detect charge and its polarity. The block diagram for the implementation of the Electroscope is :

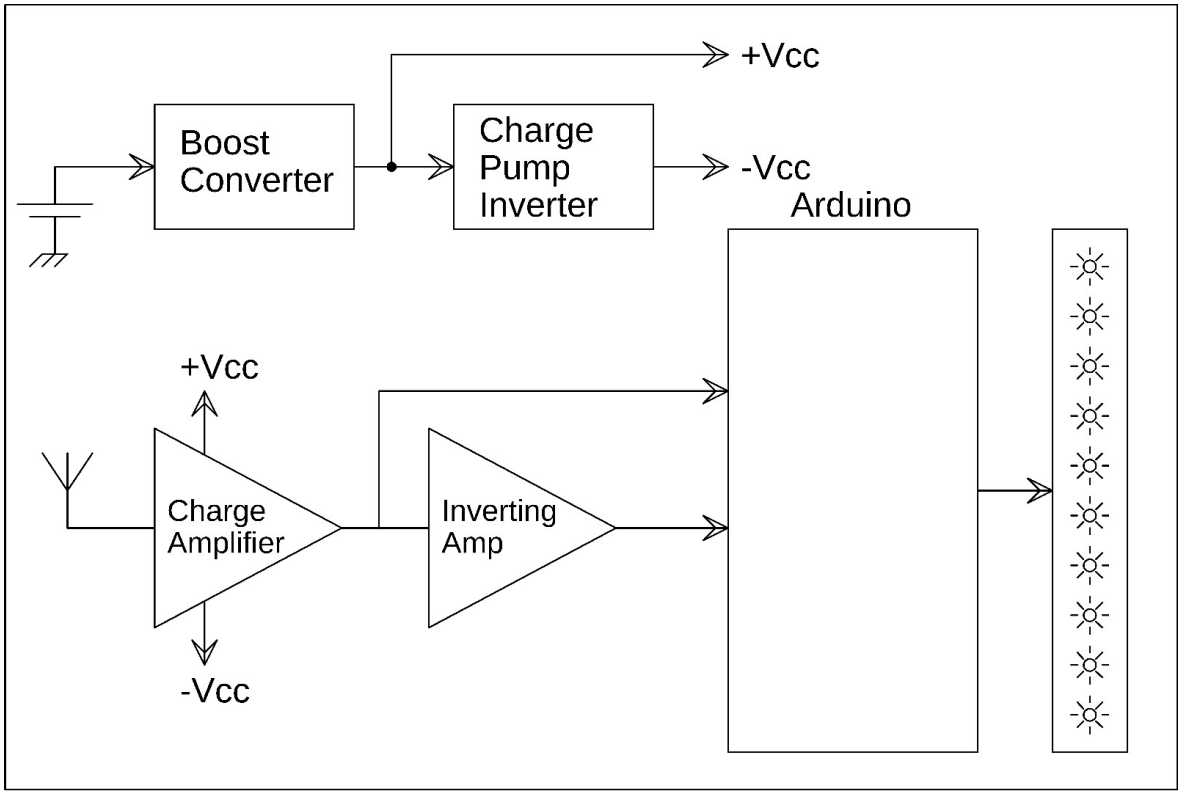


Figure 1: Block Diagram Of Electroscope

# 3. Circuit Schematic

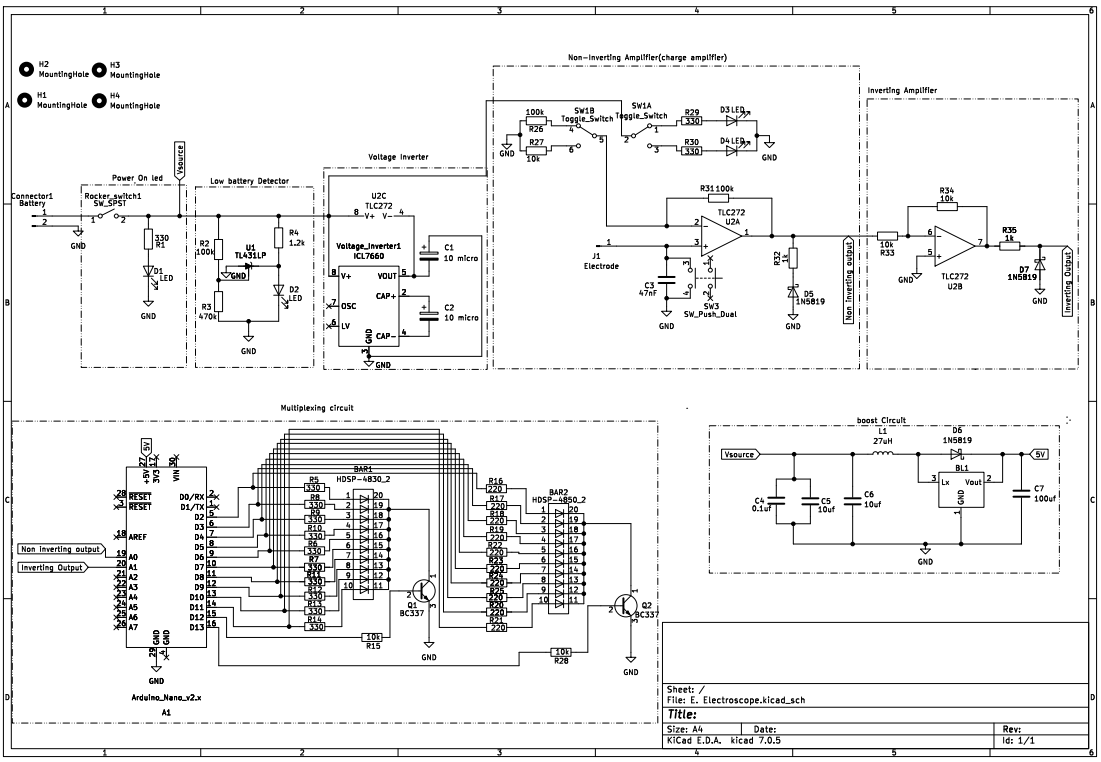


Figure 2: Circuit Schematic

# 4. Building Blocks of the Electroscope

Firstly, we need to be familiar with the major working blocks of the project,

- **4.1 LOW BATTERY DETECTOR**
  - This circuit alerts the user when the battery needs charging. We have chosen the simplest way of determining that the battery capacity is low, and that's using the battery terminal voltage. This circuit lights up a warning LED whenever the voltage drops below a certain value.
  - A circuit was constructed using TLC 431 (Precision Programmable Reference) and a couple of resistors that were used to glow the LED indicating a low battery level.

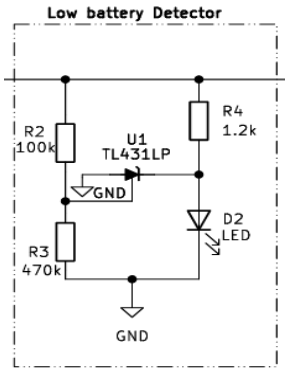


Figure 3: Low Battery Detector

- **4.2 BOOST CIRCUIT**
  - This circuit is a type of DC-DC (direct current to direct current) converter that takes an input voltage and produces a higher output voltage. It's designed to "Boost" or increase the voltage level from the input to the output.
  - The Boost circuit used in this project is;

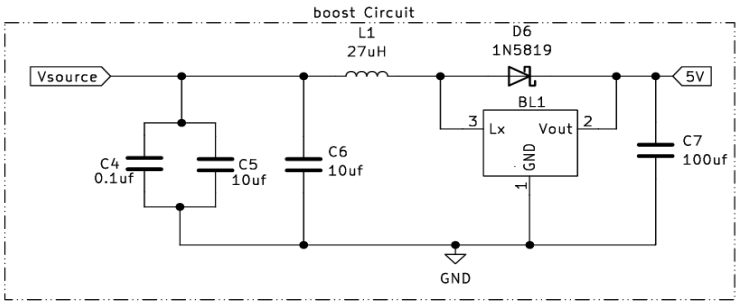


Figure 4: The Boost Circuit

## 4.3 VOLTAGE INVERTER

- – A voltage inverter is a simple circuit that converts the positive voltage into negative voltage and vice versa, this circuit was implemented using TJ7660 IC, 2 X 10 uf capacitors, and a couple of jumpers.

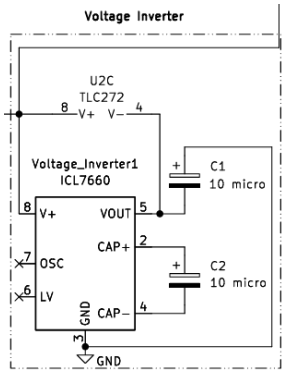


Figure 5: Voltage Inverter

## • 4.4 CHARGE AMPLIFIER

– A charge amplifier is an electronic current integrator that produces a voltage output proportional to the integrated value of the input current, or the total charge injected.

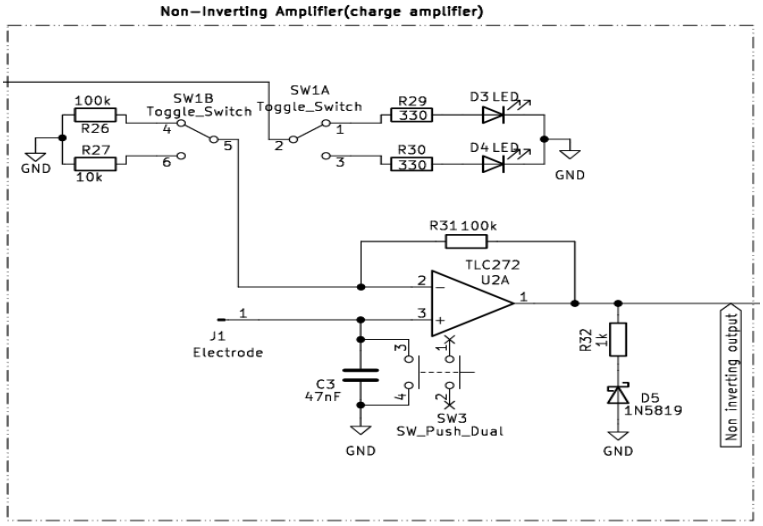


Figure 6: Charge Amplifier Circuit

- **4.5 ARDUINO NANO**
  - The Arduino Nano is a compact and versatile development board that is based on the ATmega328P microcontroller, which is the same chip used in the Arduino Uno board.
  - The Nano is commonly used in various projects due to its small size, ease of use, and versatility. It's ideal for applications where space is limited, and it's used by hobbyists, makers, and professionals for a wide range of electronic projects.
  - In this project, the Arduino Nano is used for multiplexing bar graph LEDs according to the input voltage fed to Arduino Nano.
  - The connection of Arduino Nano With Bar Graph LEDs for multiplexing is;

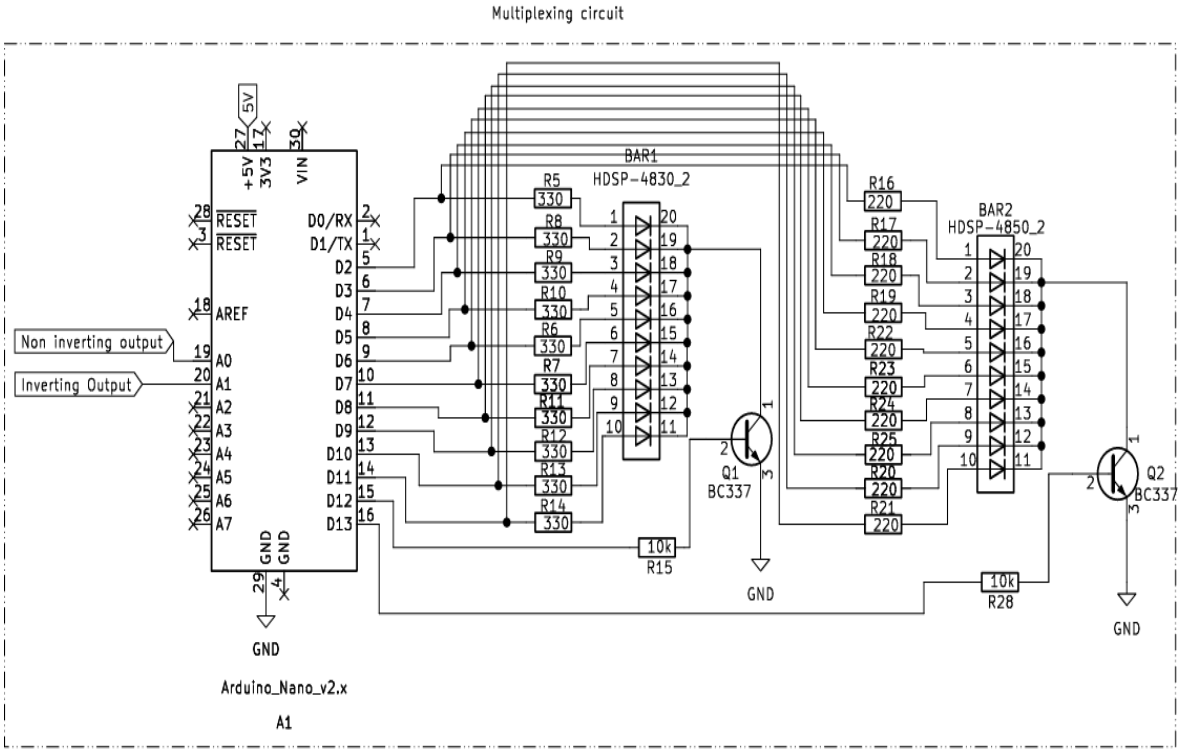


Figure 7: Multiplexing Circuit

# 5. Working

In this Project, we have used a lithium polymer battery to power the circuit. First Current goes into a Power on LED circuit, afterwards the current goes into a Low Battery Detector circuit to detect when the voltage goes below a specific level( Particularly 3.1 V ) to remind the User to recharge the battery. The next step is to boost the voltage using a Boost Voltage regulator circuit designed using IC BL8530, its used to provide supply voltage to Arduino. Furthermore, the voltage is inverted using a Voltage Inverter circuit to provide the biasing voltage across the operational Amplifier (as the operational amplifiers require both positive and negative voltage for biasing to operate ). Now, when the static charge is transferred to the non-inverting pin of the op-amp, the capacitor connected to the same leg gets charged, which provides voltage at the input. after which a voltage is developed at the output of the operational amplifier ( a Non-Inverting amplifier), which is further fed to the Arduino NANO which turns on a specific number of bar graph LEDs of green color when a positive charge is given and LEDs of red color when a negative charge is given. The number of LEDs at the same charge can be altered using the gain Charge Amplifier, which is controlled using a Double Pole Double Throw (DPDT) Toggle switch.

```
void setup() {
  pinMode(buzzerPin, OUTPUT);
}

// here we just incrementally change the number of the LED to beturned on.
void loop()
{

  int analog_read1;
  int analog_read2;
  int value1, value2;
  bool raw;                          // raw variable is used to identify which type of charge is being read at input
  analog_read1 = analogRead(A0);
  analog_read2 = analogRead(A1);
  value1 = (analog_read1 * 4) / 1024;
  value2 = (analog_read2 * 4) / 1024;
  //Mapping for LEDs for specific amount of charge on different Pins of NANO
  int onnA = map(analog_read1, 0, 1023, 0, 10);
  int onnB = map(analog_read2, 0, 1023, 0, 10);


  if (value1 > 0) {
    raw = true;
  }
  else if (value2 > 0) {
    raw = false;
  }

  noTone(buzzerPin);
```

```
  if (raw == true)    // Turning ON LEDs (according to mapping) when
   charge is being read by PIN A0 of NANO
  {

    if (onnA > 0 && onnA < 0.5) {
      tone(buzzerPin, 350);
    }
    else {
      for (int l = 0; l < onnA; l++)
      {
        lightOffB();
        lightOnA(l);
        delay(15 / onnA);
        tone(buzzerPin, 350);
      };
      lightOffA();   // Turning OFF all the LEDs

      noTone(buzzerPin);
    }
  }
  noTone(buzzerPin);
  if (raw == false)     // Turning ON LEDs when charge is being read
   by PIN A1 of NANO
  {

    if (onnB > 0 && onnB < 0.5) {
      tone(buzzerPin, 680);
    }
    else {
      for (int f = 0; f < onnB; f++)
      {
        lightOffA();
        lightOnB(f);
        delay(15 / onnB);
        tone(buzzerPin, 680);
      };
      lightOffB();   // Turning OFF all the LEDs
      noTone(buzzerPin);
    }
  }
  noTone(buzzerPin);
};
```

Code extraction 1: Multipexing

# 6. Bill Of Material[BOM]

The list of components required for producing the Electroscope is given in the figure below,

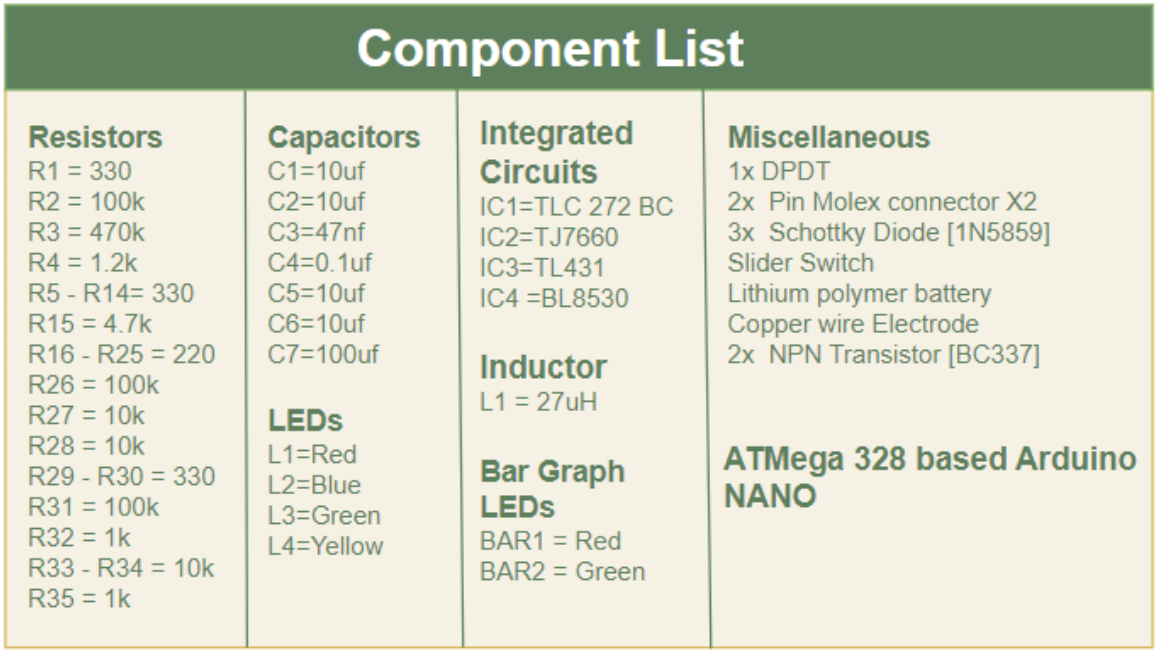


Figure 8: Bill Of Material

# 7. End Result

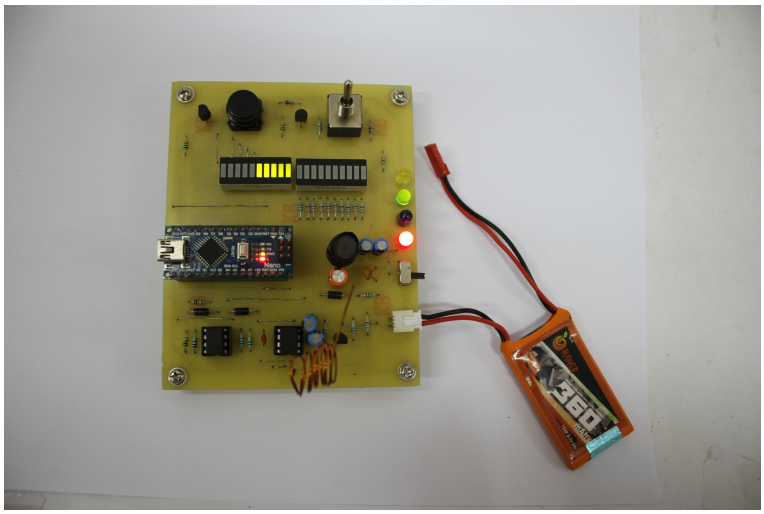

Figure 9: Electroscope with a positive charge in LOW gain Mode

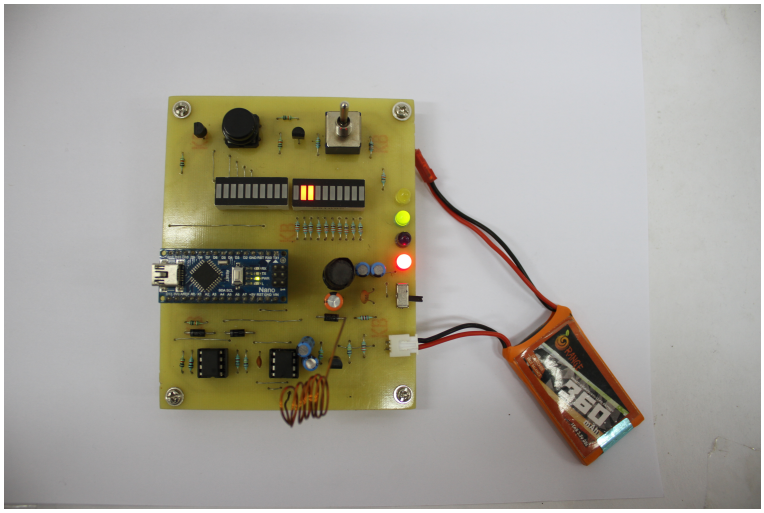

Figure 10: Electroscope with a negative charge in LOW gain Mode

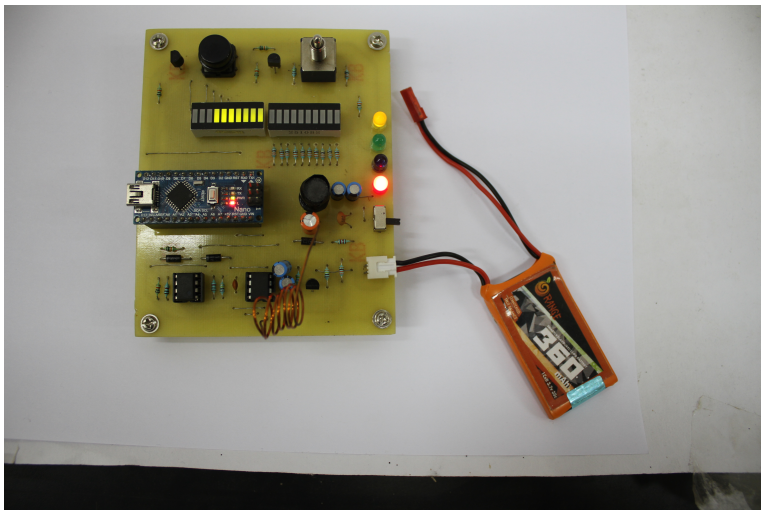

Figure 11: Electroscope with a positive charge in HIGH gain Mode

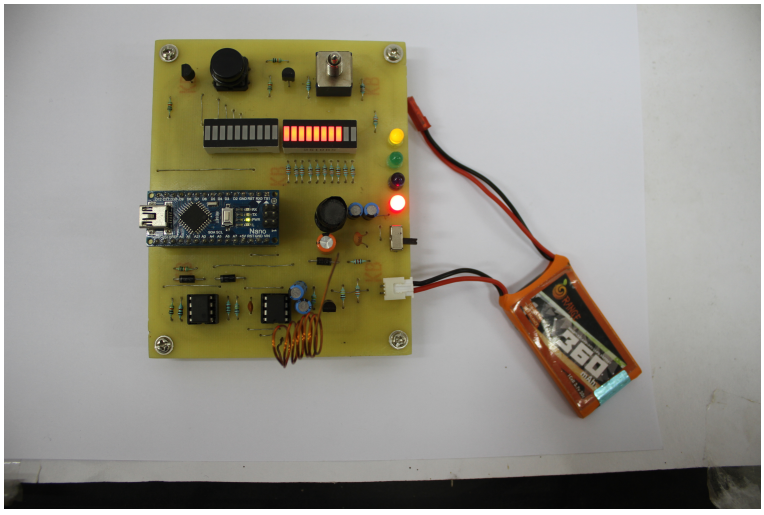

Figure 12: Electroscope with a negative charge in HIGH gain Mode

# 8. Bibliography


- Datasheet of TLC 272 BC
  https://www.ti.com/lit/ds/symlink/tlc272.pdf?ts=1690783846438&ref_url=https%253A%252F%252Fwww.google.com%252F

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- Arduino NANO
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- An Electronic Electroscope
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