

EE 3140: Measurements and Instrumentation Laboratory

Mini Project

Presented By

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Topic

Hand Gesture Recognition Using Flex Sensor

Objective

- **Design and Implement a circuit to measure the amount of bending/deflection.**
- **Using the same implement the system for recognition of Hand gestures.**

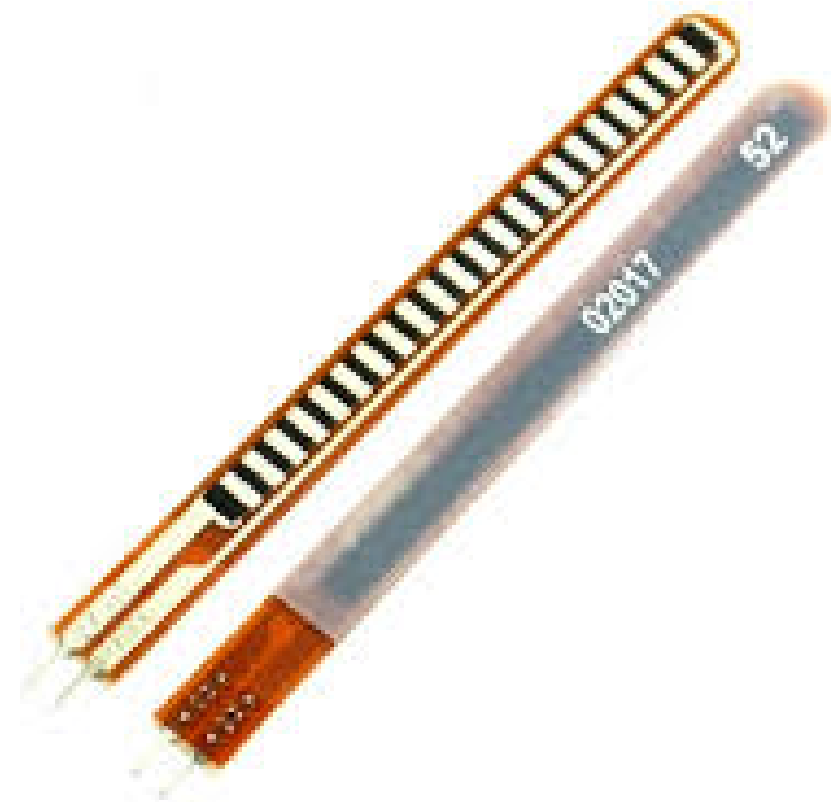


Relevance

The significance of a hand gesture detection circuit utilizing flex sensors resides in its capacity to facilitate novel modes of interaction between humans and computers. They possess various applications, a few of which include:

- Gesture Control Interfaces
- Prosthetic Limbs and Rehabilitation
- Sign Language Recognition
- Biometric Authentication

What is a Flex sensor?



Flex sensors change resistance when bent or flexed. It uses resistance changes to monitor bending on a flexible substrate with conductive materials. Flex sensors accurately sense human movements in gesture control interfaces, prosthetics, and robotics, providing intuitive engagement and inventive solutions.

sensors used

FS-L-0095-103-ST

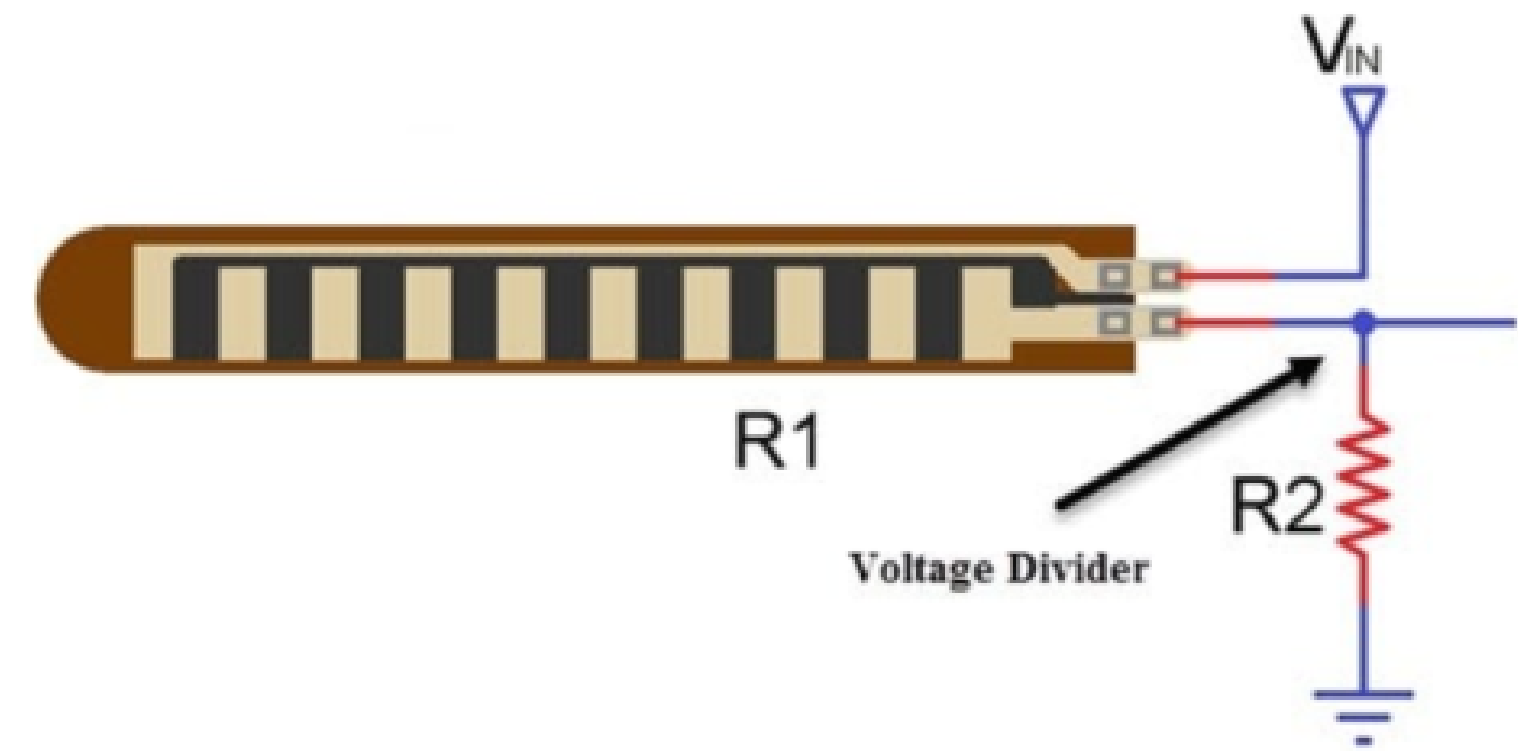
- Flat resistance-10k Ω
- Resistance tolerance- $\pm 30\%$
- Bend resistance range-20k Ω to 110k Ω
- Power rating-0.50 Watts continuous. 1 Watt Peak



How can a flex sensor be used to measure bending?

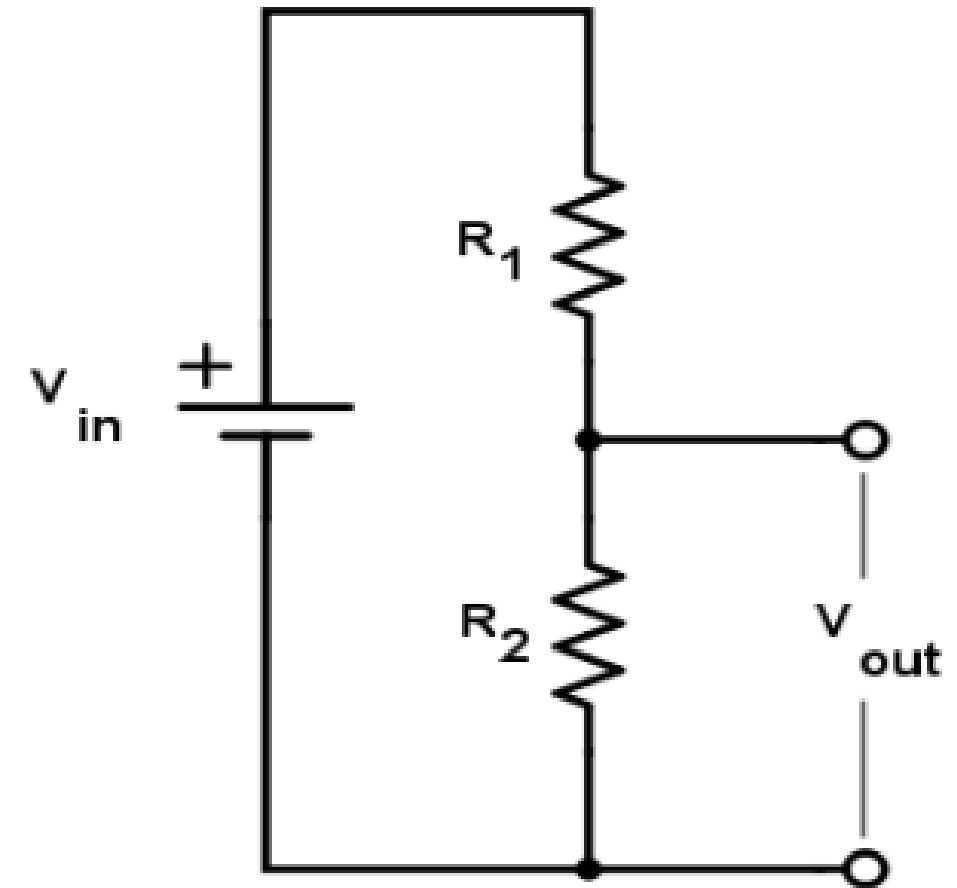
A simple voltage divider:

The flex sensor functions as a variable resistor, we may obtain readings from it by employing a basic voltage divider.



Output Relation:

$$V_{out} = V_{IN} \left(\frac{R}{R + R_{flex}} \right)$$



As the degree of bending increases, the resistance of the flex sensor (R_{flex}) also increases, resulting in a drop in the output voltage.

The equation indicates that the correlation between R_{flex} and V_{out} is non-linear. Therefore, it is necessary for us to create a signal conditioning circuit that is appropriate for our needs.

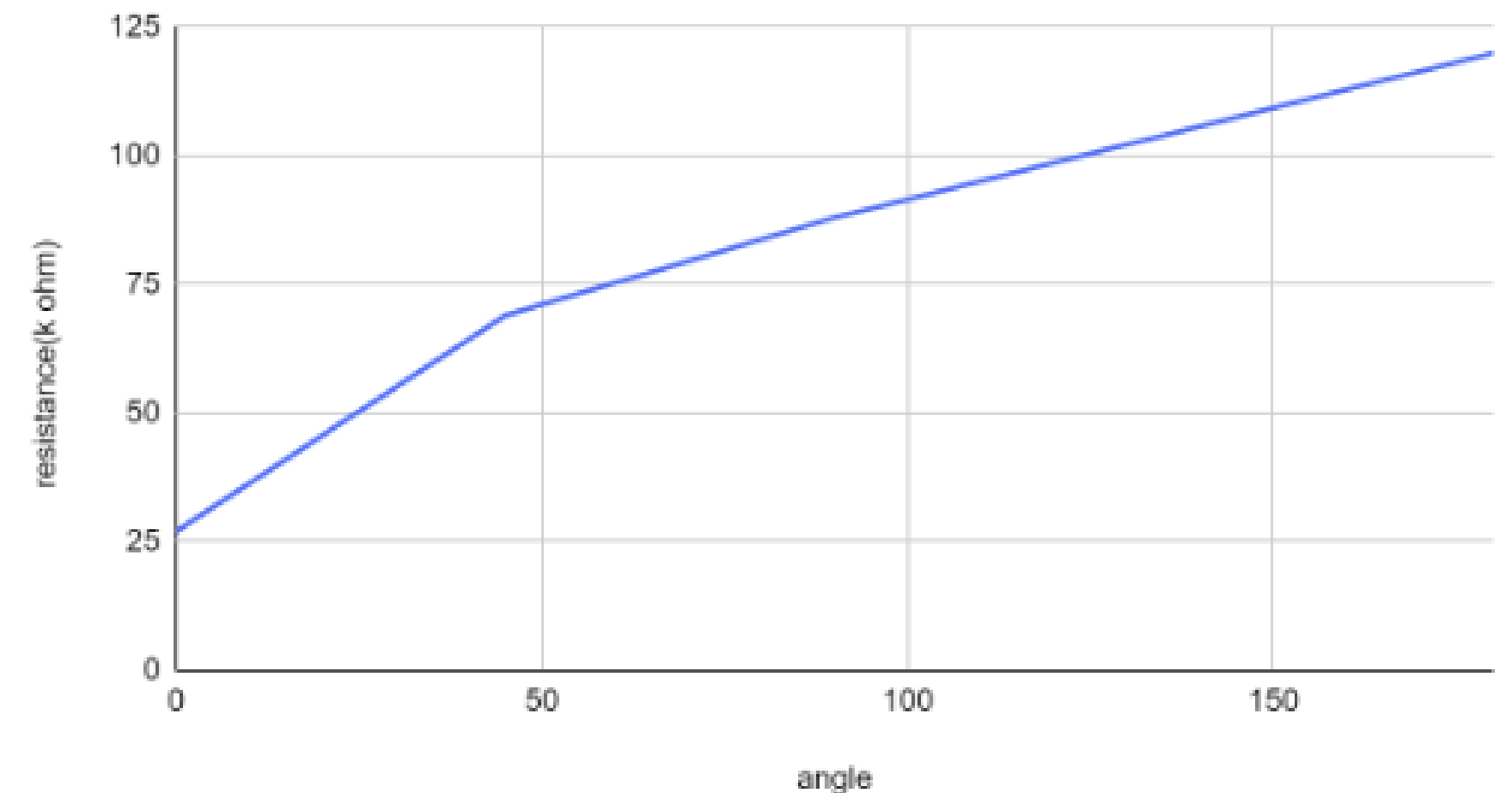
Calibration of the sensor

Procedure:

- Interfacing the sensor with the voltage divider circuit, which is connected to the Arduino micro controller.
- Flex the sensor within a range of 0 to 90 degrees and record the corresponding output voltage.
- Determine the resistance of the flex sensor based on the relationship between voltage and resistance.

Observation

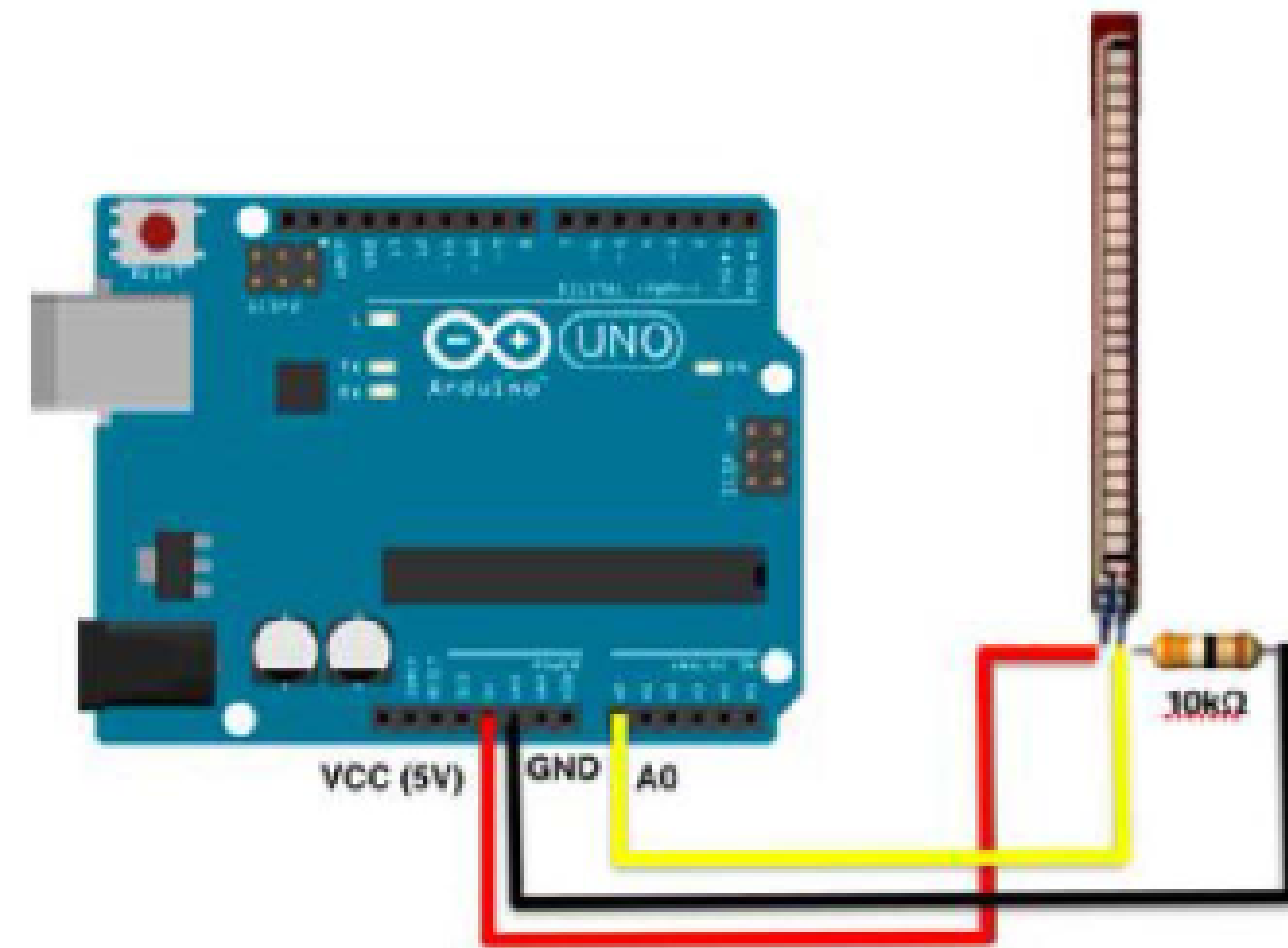
resistance(k ohm) vs. angle



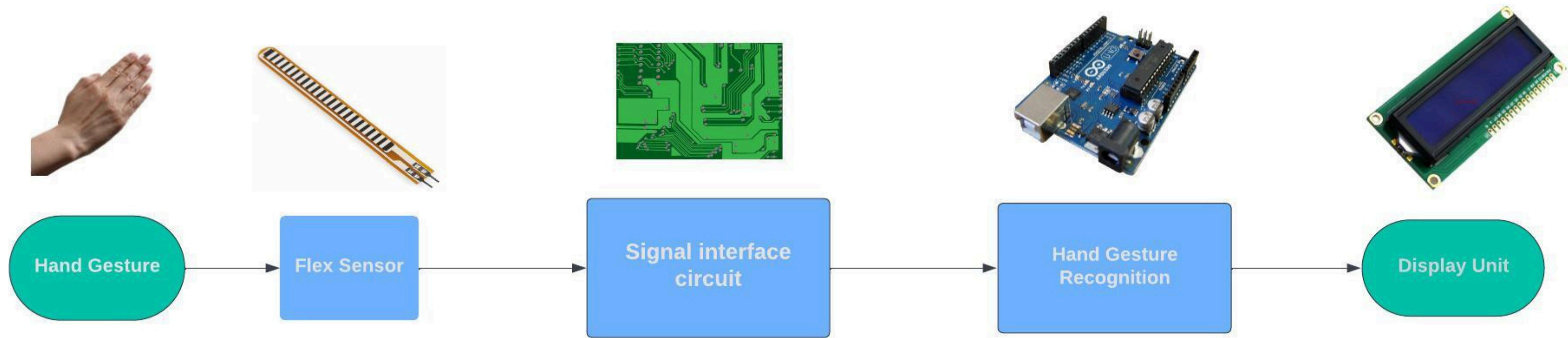
There is a nearly linear relationship between the bend angle and resistance of the sensor within the range of (0,90).

For measuring the degree of bending to detecting hand gestures.

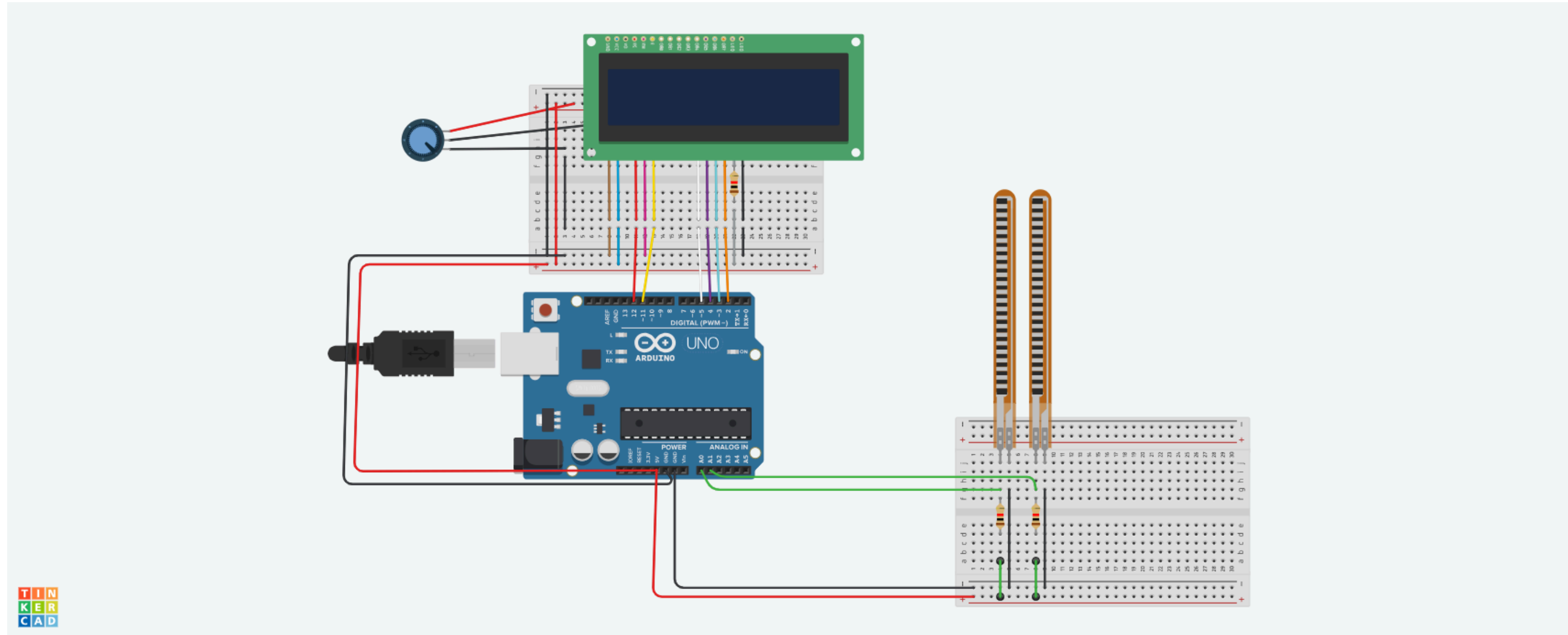
Flux sensors are affixed to the fingers and measurements are obtained when the fingers are flexed.



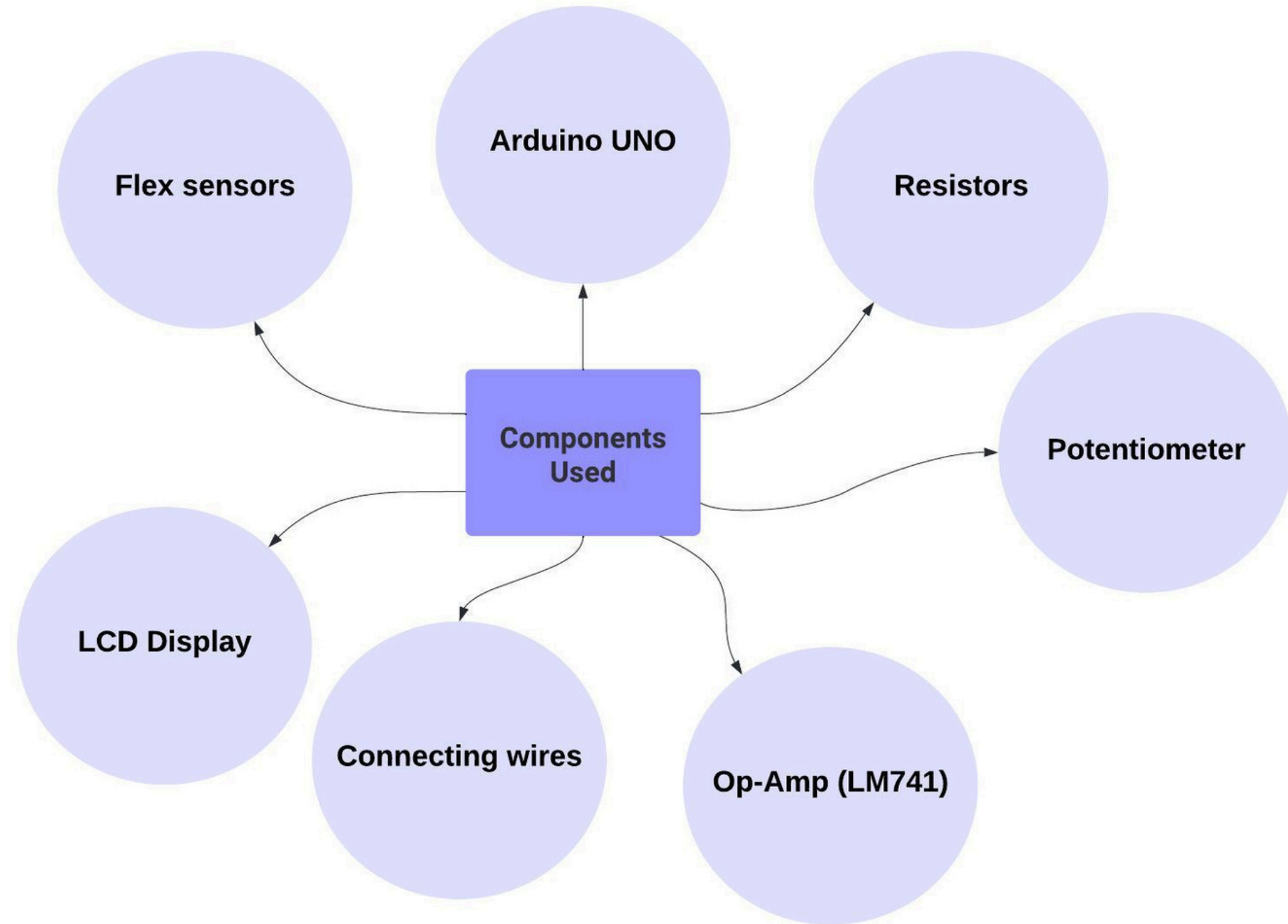
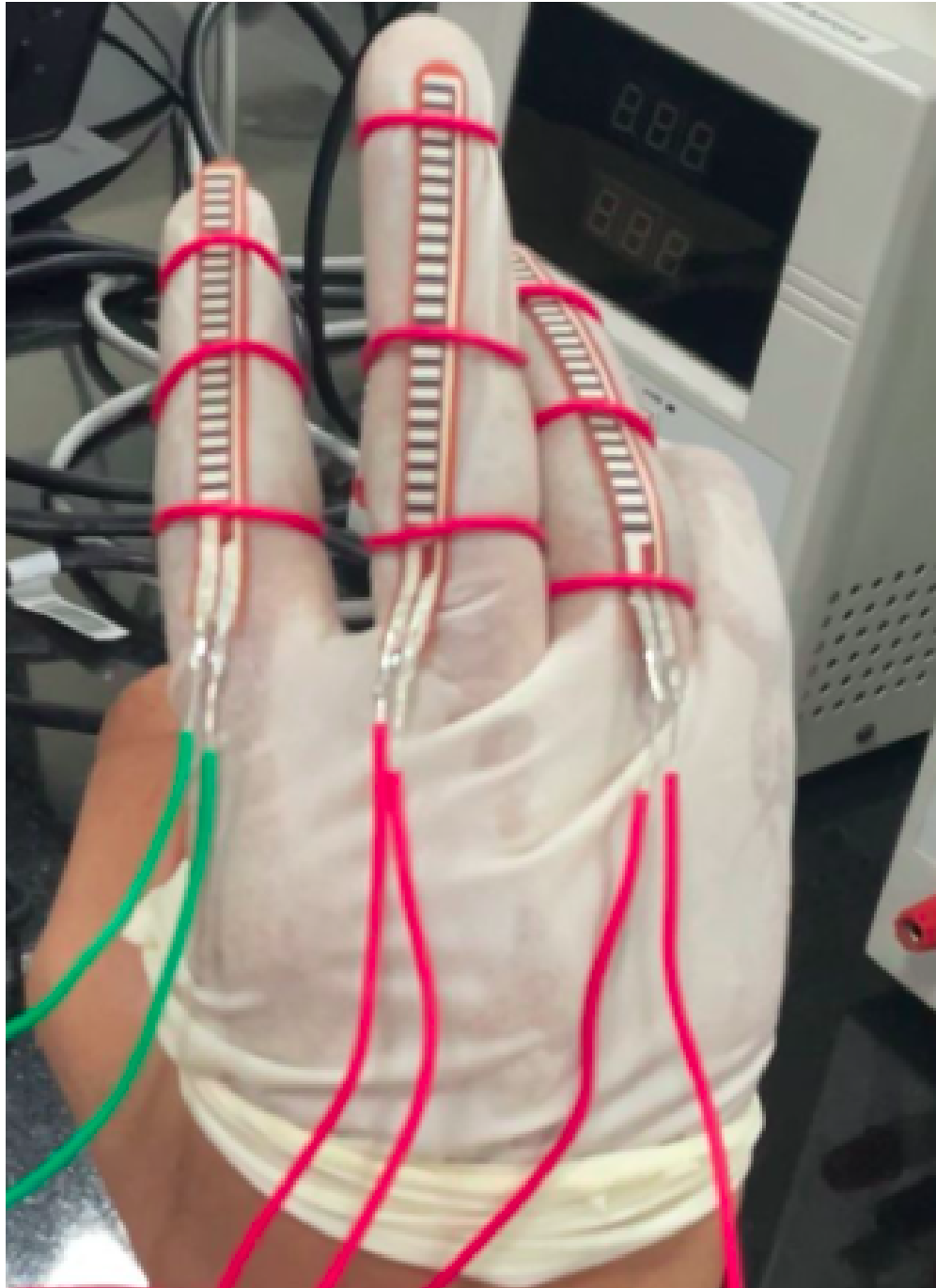
Block Diagram of the system



Circuit diagram



Components Used



Implementation

The experiment utilizes three flex sensors, one affixed to the index finger and the other two fingers.

Since we have three sensors, we used only four signs:

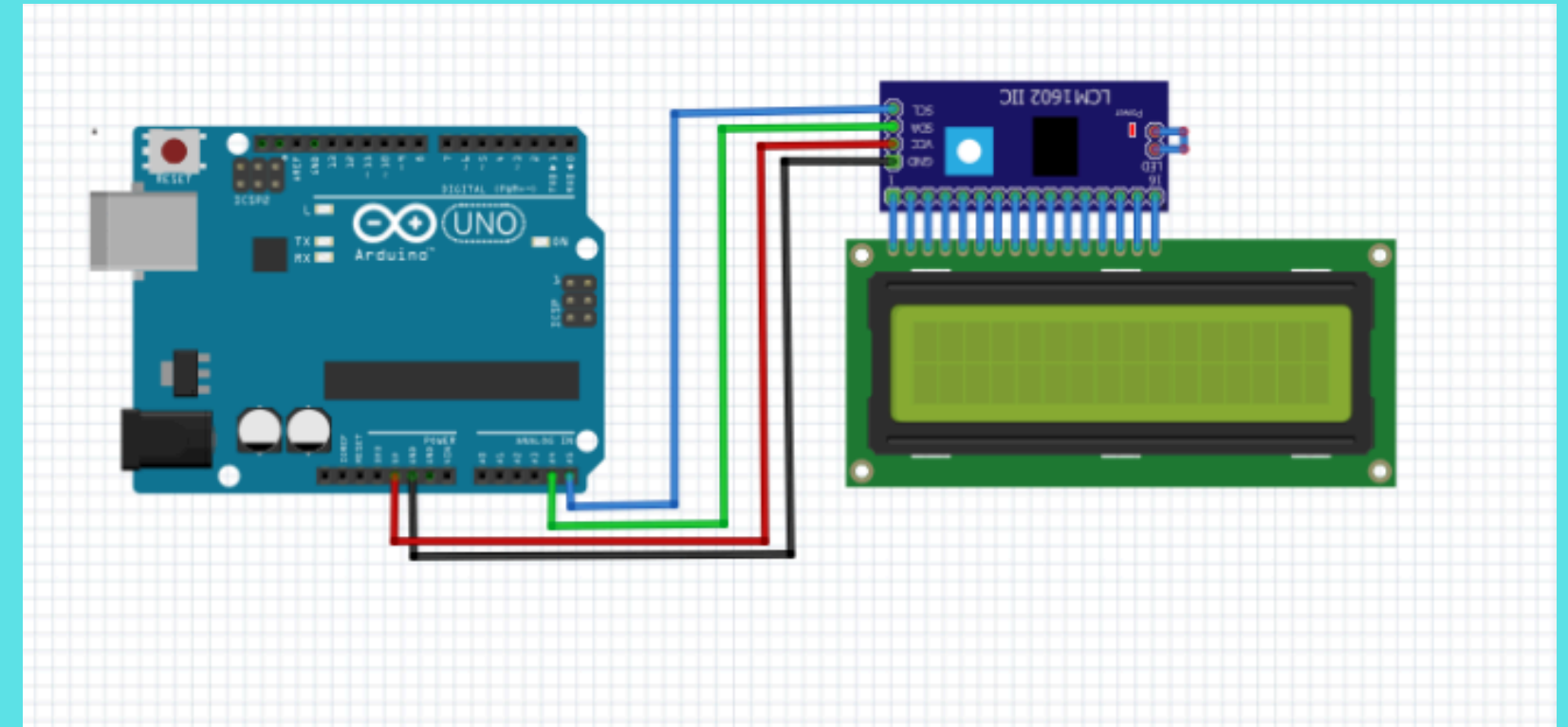
1. Each finger flat on the ground—"Three"
2. Curled inside ring finger and flat other two - "Two"
3. Curled inside ring finger, middle finger, flat index finger - "One"
4. All three fingers curled inside—"Zero"

The resistance of the each flex sensor increases when we curl the respective finger.

Infercaing with Arudino with I2C module

I2C_Address_Finder.ino

```
1  #include <Wire.h>
2  void setup()
3  {
4  Wire.begin();
5  Serial.begin(9600);
6  Serial.println("\nI2C Scanner");
7  }
8  void loop()
9  {
10 byte error, address;
11 int Devices;
12 Serial.println("Scanning...");
13 Devices = 0;
14 for(address = 1; address < 127; address++)
15 {
16
17 Wire.beginTransmission(address);
18 error = Wire.endTransmission();
19 if (error == 0)
20 {
21 Serial.print("I2C device found at address 0x");
22 if (address<16)
23 Serial.print("0");
24 Serial.print(address,HEX);
25 Serial.println(" !");
26 Devices++;
27 }
28 else if (error==4)
29 {
30 Serial.print("Unknown error at address 0x");
31 if (address<16)
32 Serial.print("0");
33 Serial.println(address,HEX);
34 }
35 }
36 if (Devices == 0)
37 Serial.println("No I2C devices found\n");
38 else
39 Serial.println("done\n");
40 delay(5000);
41 }
42
```



This code finds the address of I2C module and configures it to the arduino .After than LCD module is connected to I2C. This reduces the connection complexity of the circuit

Code for determination of angle defection

angle.ino

```
1  #include <Wire.h>
2  #include <LiquidCrystal_I2C.h>
3  LiquidCrystal_I2C lcd(0x27, 16, 2);
4  const int flexPin = A1;
5  // Change these constants according to your project's design
6  const float VCC = 5;
7  // voltage at Arduinio 5V line
8  const float R_DIV = 22000.0; // resistor used to create a voltage divider
9  const float flatResistance = 20000.0; // resistance when flat
10 const float bendResistance = 70000.0; // resistance at maximum bend
11 void setup()
12 {
13   Serial.begin(9600);
14   pinMode(flexPin , INPUT);
15   lcd.init();
16   lcd.begin(16, 2);
17   lcd.backlight();
18   lcd.setCursor(0, 0);
19   lcd.print("  Lets start  ");
20   lcd.setCursor(0, 1);
```

```
21   lcd.print(" Project  ");
22   delay(2000);
23   lcd.clear();
24 }
25 void loop() {
26   // Read the ADC, and calculate voltage and resistance from it
27   int ADCflex = analogRead(flexPin);
28   float Vflex = ADCflex * VCC / 1023.0;
29   float Rflex = R_DIV * (VCC / Vflex - 1.0);
30   Serial.println("Resistance: " + String(Rflex) + " ohms");
31   Serial.println("v_flux: " + String(Vflex) + "v");
32   // Use the calculated resistance to estimate the sensor's bend angle:
33   float angle = 0;
34   if(Rflex<=40000 ){
35     angle = 0;}
36   else if(Rflex>=40000 && Rflex<65000){
37     angle = 90;}
38   else if(Rflex>=65000 ){
39     angle = 180;}
40   //float angle = map(Rflex,
41
42   Serial.println("Bend: " + String(angle) + " degrees");
43   lcd.println(String(angle));
44   delay(2000);
45   lcd.clear();
46 }
47
```

Code for determination of Hand gesture recognition

```
1  #include <Wire.h>
2  #include <LiquidCrystal_I2C.h>
3  LiquidCrystal_I2C lcd(0x27, 16, 2);
4  int index_finger;
5  int middle_finger;
6  int third_finger;
7  // Change these constants according to your project's design
8  const float VCC = 5;
9  // voltage at Arduino 5V line
10 const float R_DIV1 = 22000.0; // resistor used to create a voltage divider
11 const float R_DIV2 = 33000.0;
12 const float R_DIV3 = 33000.0; // resistor used to create a voltage divider
13 const float flatResistance1 = 20500.0; // resistance when flat
14 const float bendResistance1 = 70400.0; // resistance at 90 deg
15 const float flatResistance2 = 33000.0; // resistance when flat
16 const float bendResistance2 = 100000.0; // resistance at 90 deg
17 const float flatResistance3 = 30500.0; // resistance when flat
18 const float bendResistance3 = 140000.0; // resistance at 90 deg
19 void setup()
20 {
21     Serial.begin(9600);
22     pinMode(A0, INPUT);
23     pinMode(A1, INPUT);
24     pinMode(A2, INPUT);
25     lcd.init();
26     lcd.begin(16, 2);
27     lcd.backlight();
28     lcd.setCursor(0, 0);
29     lcd.print(" Lets start  ");
30     lcd.setCursor(0, 1);
31     lcd.print(" Project ");
32     delay(2000);
33     lcd.clear();
34 }
35 void loop() {
36     int index_finger = analogRead(A0);
37     int middle_finger = analogRead(A1);
38     int third_finger = analogRead(A2);
39     delay(1000);
40 }
```

```
41 float Vflex1 = index_finger * VCC / 1023.0;
42 float Rflex1 = R_DIV1 * (VCC / Vflex1 - 1.0);
43 float Vflex2 = middle_finger * VCC / 1023.0;
44 float Rflex2 = R_DIV2 * (VCC / Vflex2 - 1.0);
45 float Vflex3 = third_finger * VCC / 1023.0;
46 float Rflex3 = R_DIV3 * (VCC / Vflex3 - 1.0);
47 Serial.print("index_finger = ");
48 Serial.println(Rflex1);
49 Serial.print("middle_finger = ");
50 Serial.println(Rflex2);
51 Serial.print("third_finger = ");
52 Serial.println(Rflex3);
53
54 if (Rflex1 < 75000 && Rflex2 < 70000 && Rflex3 < 80000) {
55     lcd.clear();
56     lcd.setCursor(1, 0);
57     lcd.println("three");
58     delay(2000);
59     Serial.println("three");
60 }
61 else if (Rflex1 < 75000 && Rflex2 < 70000 && Rflex3 > 80000) {
62     lcd.clear();
63     lcd.setCursor(1, 0);
64     lcd.print("two");
65     delay(2000);
66     Serial.println("two");
67 }
68 else if (Rflex1 < 75000 && Rflex2 > 70000 && Rflex3 > 80000) {
69     lcd.clear();
70     lcd.setCursor(1, 0);
71     lcd.print("one");
72     delay(2000);
73     Serial.println("one");
74 }
75 else if (Rflex1 > 75000 && Rflex2 > 70000 && Rflex3 > 80000) {
76     lcd.clear();
77     lcd.setCursor(1, 0);
78     lcd.print("zero");
79     delay(2000);
80     Serial.println("zero");
81 }
82 }
```


Observations And Conclusion

- A linear connection between the resistance levels and the bending was discovered.
- The sensor's resistance varies even with very little bending.
- It takes some time for the resistance to return to its flat resistance value once it has been bent. Occasionally, the deformation of the flux sensor (because the sensor was too thin) prevents the resistance from returning to the flat resistance values.
- It was challenging to get the results to be repeatable. This might lead to a measurement inaccuracy for the bending.

Demo link : https://drive.google.com/drive/folders/1-JQFaPncxTtOX0QSTZY8p5VU9Lqu_ICX

THANK YOU