INTERNSHIP REPORT

DEVELOPMENT AND ANALYSIS OF OPTICAL SENSORS

27th July 2021

Submitted by:

Arihant Tiwari, 19050

Summer Intern 2021

Submitted To:

Dr. Mitradip Bhattacharjee

EECS Department, IISER Bhopal

Introduction

As a part of the summer internship program 2021 at the Indian Institute of Science Education and Research, Bhopal, I did an eight-week-long internship (25 May 2021 to 27th July 2021) on the topic “Development and Analysis of Optical Sensors” under the supervision of Dr.Mitradip Bhattacharjee, Assistant Professor, Department of Electrical Engineering and Computer Sciences (EECS) at IISER Bhopal.

The Internship started with two tasks: the development of an Infrared light-generating and detecting device capable of acting as a source of infrared radiation, which is then either reflected or transmitted through various materials. The returning or transferred radiation can be detected and used for analysis. This device was prepared using an Arduino and infrared light-emitting diodes and a similar detector. In later stages, I shifted to a pre-synthesized IR sensor module, and the data received by the led-detector set was prone to many disturbances and noises. To overcome this, an IR sensor was used to detect the noise and cancel it.

The second task was to prepare an application for the IR module as mentioned above. As the Arduino sends and receives data through a laptop, which might be bulky and less portable than a mobile phone, an application capable of receiving data from the Arduino and sending signals was needed. I developed a mobile application that could send and receive data from the Arduino, control the LED, and plotting the values detected by the sensor on a graph, giving us insights into the transmitting and reflecting properties of various materials.

The mobile application was developed using MIT app inventor, which sir suggested to me. It sent and received data from the Arduino using an HC-005 Bluetooth module, and the data was shared in the form of bytes.

The second task of the project was to prepare an application capable of detecting colors via a camera. I was successfully able to create an interface module using the Android Studio using the language JAVA. At the same time, the segment responsible for detecting and identifying the color in the particular part of the image was based on the Python Language. I joined the two components mentioned above of codes to create an application that could detect the color of a small circle that it draws around the region the user taps with a finer. This task was later updated to make an application capable of detecting, identifying, and naming the colors in real-time using a camera application. Unfortunately, I could not complete this task in the given period and would love to meet it in the future if I ever get a chance again.

This Internship was one of the most beautiful experiences of my life; I learned many new and exciting things in such a short period. Sir provided me with all the tools and materials needed, which served as a beneficial asset in this project work. Hence I look forward to working again if given the opportunity.

PART 1

INFRARED MODULE MAKING

Infrared Data Collection

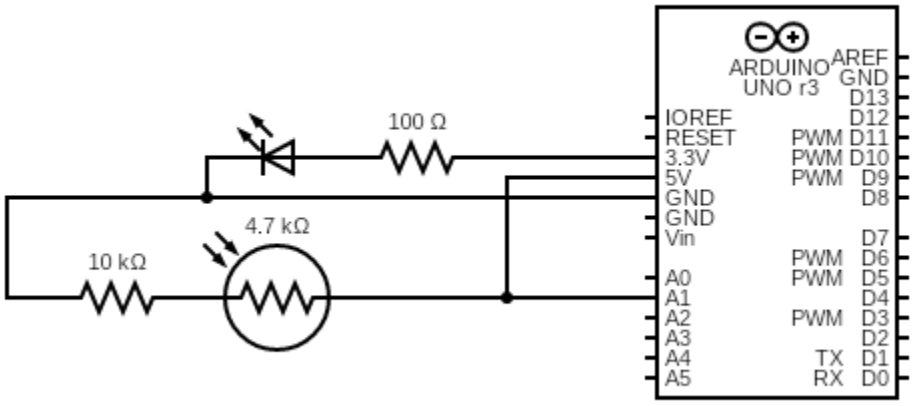
The main objective of this project is to make a device that can collect transmission and reflection data of Infrared Light for various materials and store it in a database.

Equipment Needed

The apparatus required for the conduction of the project are:

1. Arduino UNO R3 Board
2. UNO to USB Connecting Cable
3. IR LEDs
4. 2 Pin IR Detectors
5. 3 Pin IR Sensor Module
6. Jumper Wires (Male to Male)
7. Bread Board
8. Laptop
9. Various materials to test transmission and reflection
10. Resistors (Varios Values)

Circuit



The above is the circuit diagram for the IR Reflection and transmission data collection device.
The Arduino was connected to the laptop by the Arduino to USB cable. The resistors, IR led, and detector was secured on a breadboard, and the final connections between these devices and the Arduino were made using jumper wires.

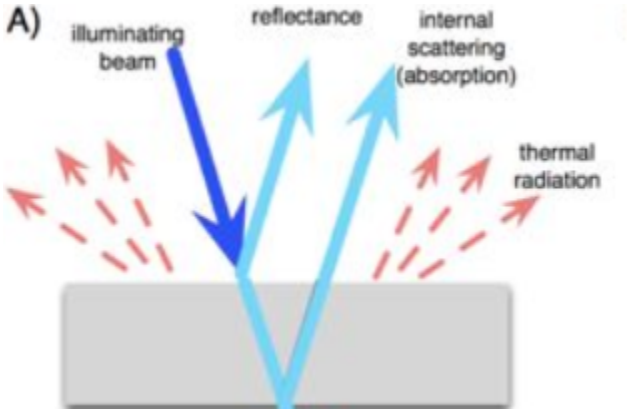
Directions

The following instructions should be followed while constructing the above-given module and conducting the experiment.

- Ensure the parts are fitted perfectly into the breadboard as loose connections might lead to data loss and wrong data collection during the experiment.
- Construct the breadboard circuit and connect the jumper wires to the Arduino to avoid damaging the sensitive device.
- When all the components are connected to the Arduino, connect it to the laptop and upload the Arduino code.
- Ensure the TX and RX pins are not connected to anything while uploading the code to the Arduino, as it uses both those pins to burn the code on the chip.
- Do not touch the 100-ohm resistor during the experiment run as it gets substantially hot.
- Ensure that you do not provide more than 3.3 V to the IR LED to damage the component.
- The two-pin detector has an opposite circuit connection, i.e., its positive terminal is connected to the ground of the Arduino. In contrast, the negative terminal is connected to the positive terminal 5 V pin of Arduino.

Reflective Data Collection

When IR light hits an object, some portion of it is transmitted while the other is reflected. This section aims to collect this reflection data using a two-pin IR detector that detects the IR reflected from a given material, the source of IR being the IR LED.



To collect the reflective data, the IR LED, and the IR Detector should be placed side by side to collect the These devices are unidirectional; putting them close together shall not create any problem.

After placing the emitter and sensor pair side by side and connecting them to the circuit, we secure the Arduino to the laptop and upload the code into it.
We turn on the Serial monitor and the Serial Plotter to start receiving the data from the module.
When no object is placed in front of the system, the IR light from the emitter just goes straight ahead and does not return to the detector. Hence it receives a zero reading. This should be seen in the graph as a simple straight line centered at zero.
As soon as an object is brought in front of this module, IR Light starts to reflect from the thing and is picked up by the detector. Hence we begin to see the rise in the values, along with an increase in the graph.
We bring the object closer and farther away from the module collecting data at the same time.

Hence,

Average or Null Value = 0 (Zero).

This process is repeated with the following materials:

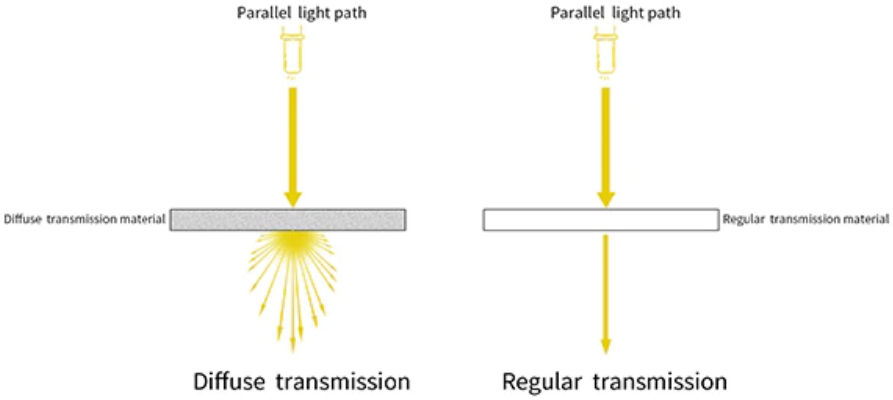
1. Post-it Notes Paper
2. Human Hand
3. Cardboard (Brown Color)
4. Cotton Cloth (White Color)
5. PCB Board (Acrylic Sheet)
6. Mobile Phone (1.2 mm width)
7. Metal Plate (0.9 mm thick)

Although the neutral state of this setup should have been zero because the detector should not receive any infrared radiation from the IR LED, this was not the case. Ideally, I observed that.

1. The IR sensor detected a small amount of radiation no matter where the IR emitter is pointed towards. This suggested that the receiver can pick up the thermal radiation from the objects around that workspace and interpret it as IR light.
2. When the IR emitter was placed just next to the sensor, it displayed a surge in the ideal zero lines. This shows that the emitter and the detector are not unidirectional as they are claimed to be, as some of the IR light leaked through the emitter from the sides and was being picked up by the detector. To overcome this, I placed the thick metallic sheet in between the emitter and the detector. This greatly reduced the leaking and picking up of the IR Radiation.
3. As it was impossible to rule out the picking up of the thermal radiation by the IR sensor, I applied normalization to the data so that the baseline can be averaged out to zero.

Transmission Data Collection

As discussed earlier, when IR light hits an object, some portion of it is transmitted while the other is reflected. This section aims to collect this transmission data using a two-pin IR detector that detects the IR being transmitted through a given material, the source of IR being the IR LED.



For collecting the transmission data, the IR LED and the IR Detector should be facing each other. Since both these devices are unidirectional it means the emitter shoots IR light in a narrow beam and hence the detector should be placed coaxially to it. Ensure that we keep a minimum distance of five to eight centimeters between the emitter and the receiver so as to accommodate the material objects we need to put between these to collect the data. So after setting up and connecting them to the circuit, we connect the Arduino to the laptop and upload the code into it.
We turn on the Serial monitor and the Serial Plotter to start receiving the data from the module.
When no object is placed in between the system the IR light from the emitter just goes straight ahead and into the detector. Hence it receives a high reading as all of the IR being emitted by the IR LED is directed into the sensor without any intervention. This should be seen in the graph as a simple straight line centered at a high value probably 5 Volts, but this depends on the IR sensor we use as all of them have their unique values.

Hence,

Average or Null Value (in my case) = 5 Volts

As soon as an object is brought in between the emitter and receiver, IR Light starts to experience resistance from the object placed in between as it now has to transmit through it and then reach the detector, hence we start to see the decrease in the values, along with a downfall in the graph.
This is a stationary set up hence we experience just a drop in the graph as soon as the object is introduced in the middle.
If the object is introduced just for a short period of time, we see a narrow valley in the graph. The objects used in this setup are:

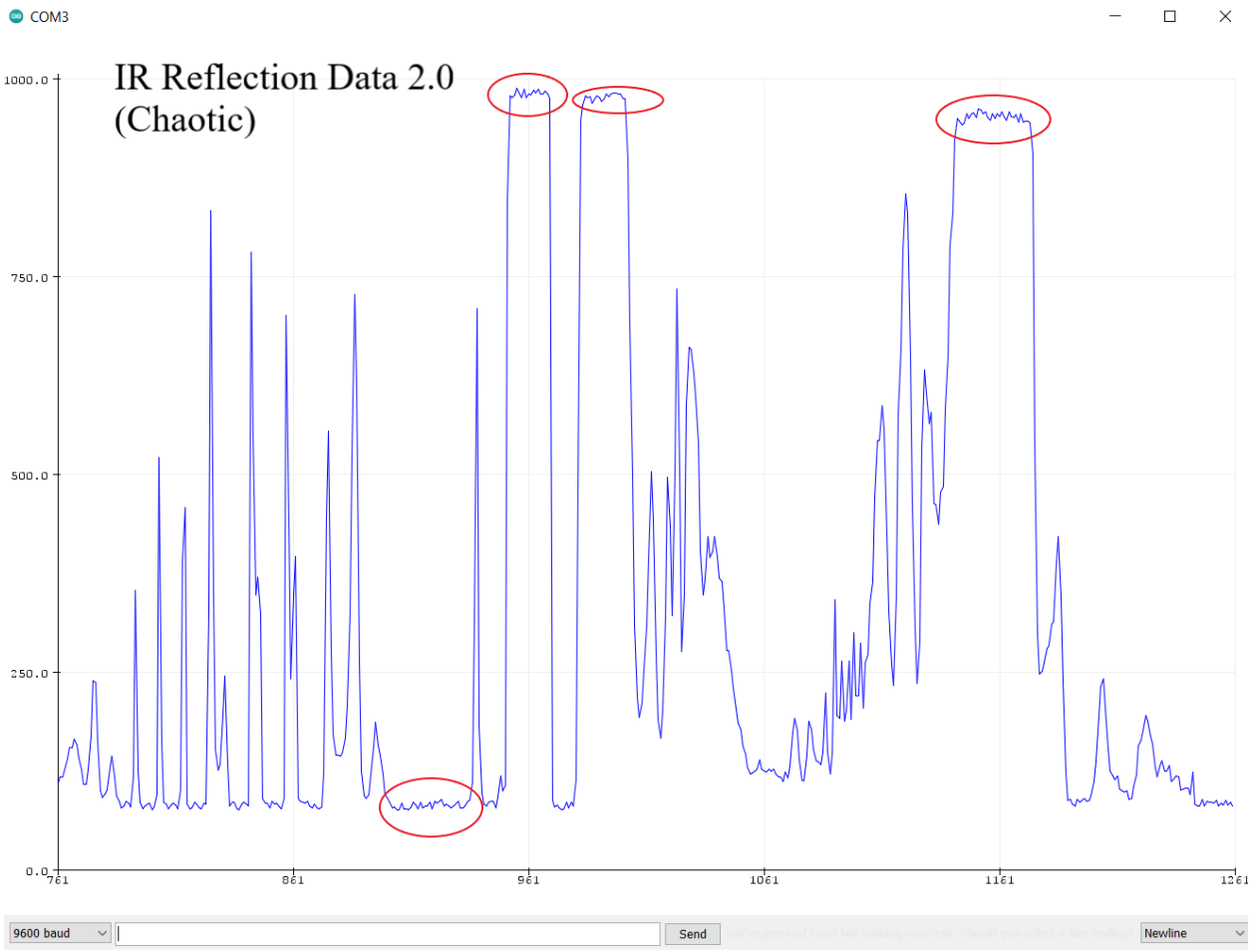
1. Post-it Notes Paper
2. Human Hand
3. Cardboard (Brown Color)
4. Cotton Cloth (White Color)
5. PCB Board (Acrylic Sheet)
6. Mobile Phone (1.2 cm width)
7. Metal Plate (0.9 cm thick)

Although the neutral state of this setup should have been fixed at the highest value because the detector should receive all the infrared radiation from the IR LED, this was not the case ideally, I observed that

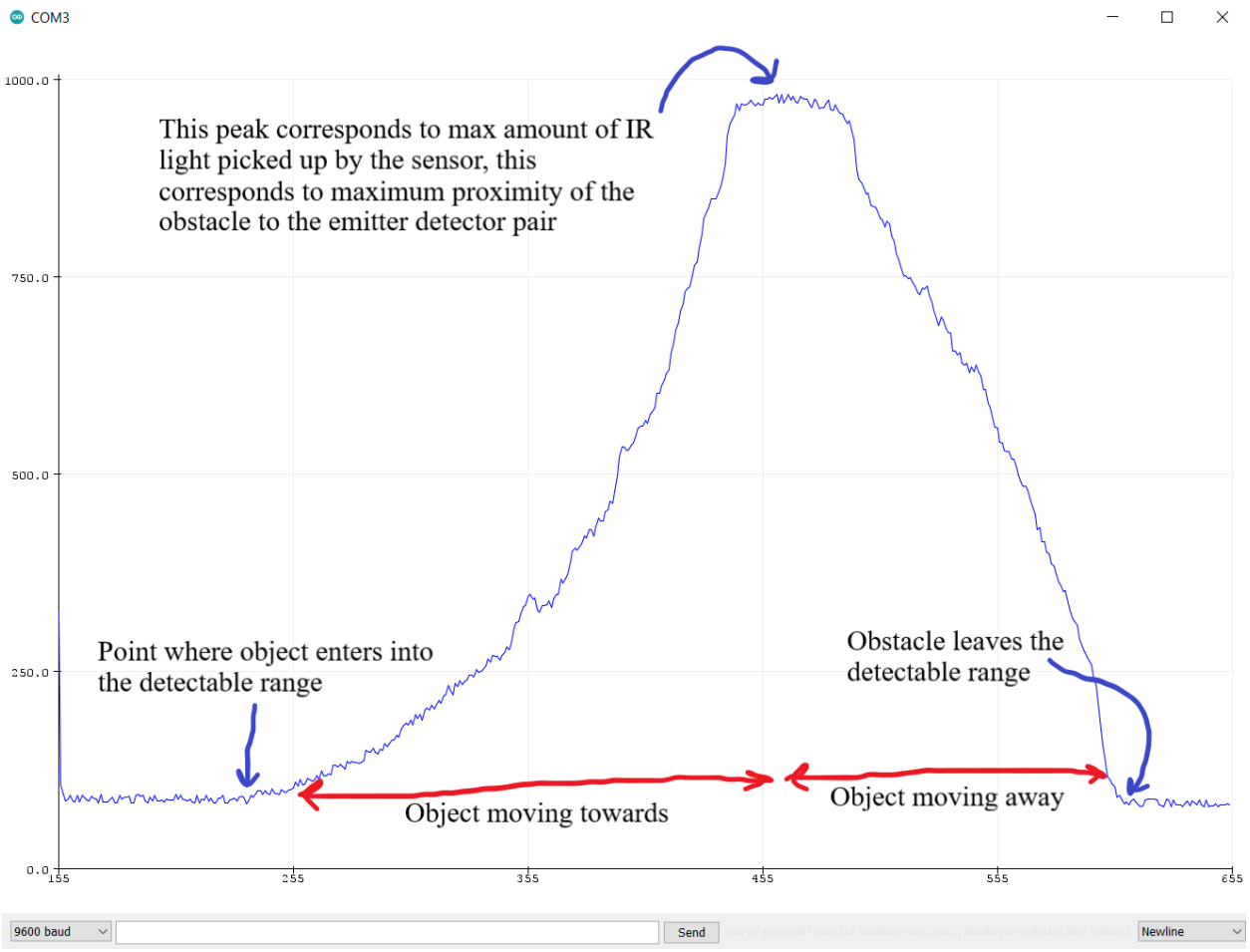
1. The IR sensor was detecting a small amount of radiation no matter where the IR emitter is pointed towards, this suggested that the receiver is able to pick up the thermal radiation from the objects around that workspace and interpret it as IR light.
2. IR sensor which should have been fixed at the highest possible state also deviated from the top value by small amounts. In order to explain this, I used an LDR to determine the intensity of the IR emitted by the LED and found it to be fluctuating. This explains the fluctuations in the data received despite the fact that the IR sensor was coaxial with the IR emitter.

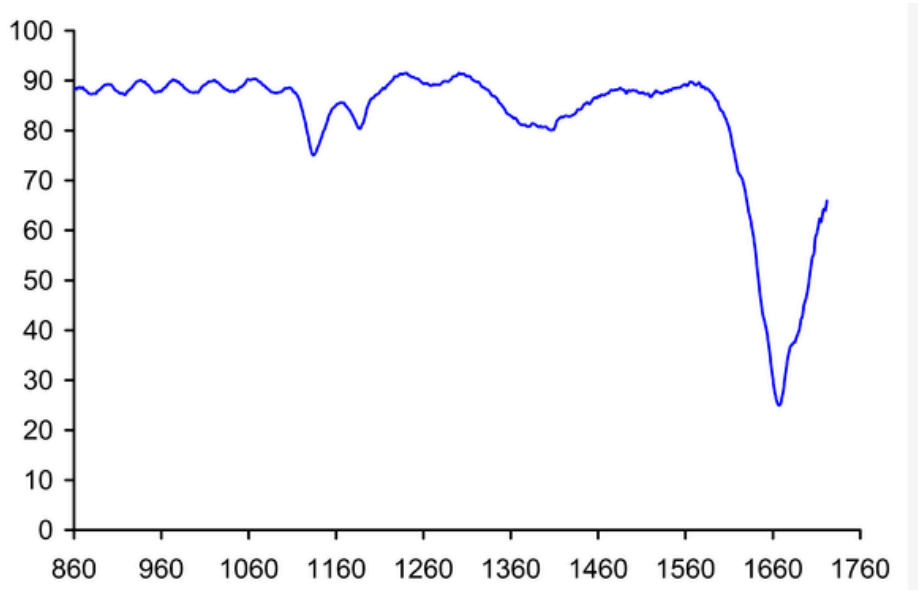
Observation Data

The observation data for the reflection and transmission are collectively given below.



The noise (being talked about in the challenges part. Whenever the reciever should ideally receive constant data, it tends to pick up some noise, hence I do not get a pure straight line. (This has to be rectified)


COM3
1000.0
750.0
500.0
250.0
0.0
155
255
355
455
555
655
This peak corresponds to max amount of IR light picked up by the sensor, this corresponds to maximum proximity of the obstacle to the emitter detector pair
Point where object enters into the detectable range
Obstacle leaves the detectable range
Object moving towards
Object moving away
9600 baud
Send
Newline


100
90
80
70
60
50
40
30
20
10
0
860
960
1060
1160
1260
1360
1460
1560
1660
1760

Post-it Notes

Post-It notes Paper			
Transmission		Reflection	
Null	Voltage	Null	Voltage
4.89736	4.83871	1.39296	2.81525
4.94135	4.86315	1.3392	2.82014
4.89247	4.87292	1.34897	2.87879
4.90225	4.86804	1.39785	2.83969
4.90225	4.86315	1.38807	2.85435
4.9218	4.86804	1.34409	2.89834
4.90225	4.82893	1.39296	2.90323
4.88759	4.86315	1.37341	2.85435
4.95112	4.80938	1.39296	2.86901
4.88759	4.85337	1.35386	2.91789
4.89247	4.86315	1.36852	2.90323
4.91202	4.82405	1.39296	2.88856
4.91202	4.85826	1.3392	2.86901
4.93646	4.85826	1.36364	2.85924
4.91691	4.81916	1.3392	2.8739
4.90714	4.82893	1.3783	2.84946
4.93157	4.86315	1.38807	2.82014
4.89736	4.86804	1.37341	2.82502
4.89247	4.81427	1.3392	2.82502
4.90225	4.84848	1.36364	2.88368
4.94135	4.83382	1.35386	2.82502
Average			
4.917138013	**4.859360199**	**1.369591722**	**2.823761788**
Percent Transmission	**98.82**	**Percent Reflection**	**40.99**
Ratio of Transmission to Reflection			**0.414794576**

Human Hand

Hand			
Transmission		Reflection	
Null	Voltage	Null	Voltage
4.95112	1.15347	1.39296	3.33333
4.89247	1.14858	1.36852	3.37243
4.94624	1.13392	1.34897	3.32356
4.88759	1.13881	1.34409	3.32356
4.89736	1.11437	1.35875	3.33822
4.94624	1.1437	1.37341	3.35777
4.91691	1.09482	1.37341	3.35288
4.92669	1.09482	1.40274	3.33333
4.91202	1.10948	1.40274	3.36266
4.92669	1.13881	1.40274	3.348
4.93646	1.13881	1.38319	3.32845
4.8827	1.15347	1.36852	3.35288
4.88759	1.09971	1.39785	3.34311
4.93646	1.13392	1.38319	3.31867
4.9218	1.15347	1.40274	3.33333
4.88759	1.15836	1.40274	3.31378
4.90225	1.17791	1.34897	3.32356
4.95112	1.23656	1.38319	3.39198
4.93646	1.26588	1.36852	3.35777
4.93646	1.261	1.3783	3.33822
4.94624	1.28055	1.35875	3.34311
4.89247	1.22678	1.34897	3.3871
4.9218	1.25611	1.36852	3.37243
4.88759	1.22678	1.35875	3.3871
Average			
4.917688609	1.421284172	1.374512517	3.362432053
Percent Transmission	28.9	Percent Reflection	56.11
The ratio of Transmission to Reflection			1.941522491

Cardboard

Cardboard			
Transmission		Reflection	
Null	Voltage	Null	Voltage
4.88759	0.10264	1.34409	4.7654
4.90225	0.1173	1.37341	4.79961
4.94624	0.09286	1.3392	4.7654
4.94135	0.10264	1.40274	4.74096
4.94624	0.1173	1.34409	4.74585
4.88759	0.08798	1.38319	4.79961
4.92669	0.10264	1.36852	4.78495
4.94624	0.10264	1.34409	4.79472
4.89247	0.08798	1.3783	4.74096
4.94624	0.10264	1.34409	4.74096
4.93157	0.12219	1.38319	4.75562
4.88759	0.09775	1.39296	4.75562
4.94624	0.12219	1.34897	4.78495
4.88759	0.09286	1.39296	4.75073
4.89247	0.11241	1.37341	4.78983
4.89247	0.1173	1.3392	4.74096
4.91202	0.09775	1.34409	4.73607
4.89247	0.12219	1.39296	4.79961
4.88759	0.10753	1.36364	4.74096
4.93646	0.11241	1.3783	4.79961
4.88759	0.08798	1.38319	4.75073
4.94624	0.08798	1.34409	4.75073
4.8827	0.08798	1.34409	4.78495
4.89736	0.08798	1.39785	4.76051
Average			
4.919113377	0.1054544371	1.370952185	4.76782351
Percent Transmission	2.14	Percent Reflection	95.74
Ratio of Transmission to Reflection			44.73831776

Cotton Cloth

Cotton Cloth			
Transmission		Reflection	
Null	Voltage	Null	Voltage
4.95112	4.84848	1.34409	4.01271
4.88759	4.83382	1.34897	4.00782
4.95112	4.81427	1.34897	4.00293
4.88759	4.80938	1.35386	4.02248
4.93646	4.81427	1.36852	3.97849
4.91202	4.86315	1.36364	4.0176
4.93646	4.84848	1.34409	3.99316
4.89247	4.87292	1.35875	3.96383
4.95601	4.87292	1.39296	4.00782
4.89247	4.86315	1.3392	3.97361
4.95112	4.8436	1.3783	3.96872
4.89736	4.87292	1.36852	3.99804
4.95601	4.82405	1.36364	4.02248
4.89736	4.80938	1.35875	3.96872
4.88759	4.86315	1.39785	3.98827
4.93646	4.8436	1.39296	3.99804
4.94624	4.85337	1.34409	3.94917
4.92669	4.82893	1.36852	3.93451
4.91202	4.80938	1.35386	3.92962
4.90714	4.86804	1.34897	3.91984
4.95112	4.85826	1.39296	3.91984
4.88759	4.80938	1.35386	3.95894
4.89247	4.84848	1.38319	3.96383
4.89247	4.84848	1.34897	3.91496
Average			
4.920341656	4.83799702	1.368847682	3.958102318
Percent Transmission	98.33	Percent Reflection	72.91
The ratio of Transmission to Reflection			0.7414827621

PCB (Acrylic)

PCB (Another Arduino)			
Transmission		Reflection	
Null	Voltage	Null	Voltage
4.95112	0.42033	1.39296	4.77028
4.88759	0.38612	1.34409	4.7654
4.95112	0.41544	1.39785	4.77028
4.88759	0.42033	1.36852	4.78983
4.93646	0.41544	1.39785	4.79472
4.91202	0.39589	1.34409	4.7654
4.93646	0.38612	1.39785	4.82893
4.89247	0.43011	1.38807	4.7654
4.95601	0.42033	1.36852	4.78495
4.89247	0.37634	1.38319	4.79961
4.95112	0.40078	1.39785	4.77517
4.89736	0.41544	1.38807	4.77028
4.95601	0.42033	1.38319	4.7654
4.89736	0.43011	1.36852	4.82405
4.88759	0.42522	1.39785	4.77028
4.93646	0.38612	1.36852	4.77517
4.94624	0.43011	1.38319	4.82405
4.90225	0.43011	1.34409	4.7654
4.93646	0.38612	1.37341	4.79961
4.90225	0.96774	1.35386	4.80938
4.95112	1.87683	1.34897	4.75073
4.88759	0.45455	1.37341	4.77517
4.89247	0.435	1.40274	4.75562
4.89247	0.40078	1.34409	4.7654
Average			
4.920341656	0.4116896689	1.372084437	4.790675232
Percent Transmission	8.37	Percent Reflection	96.35
The ratio of Transmission to Reflection			11.51135006

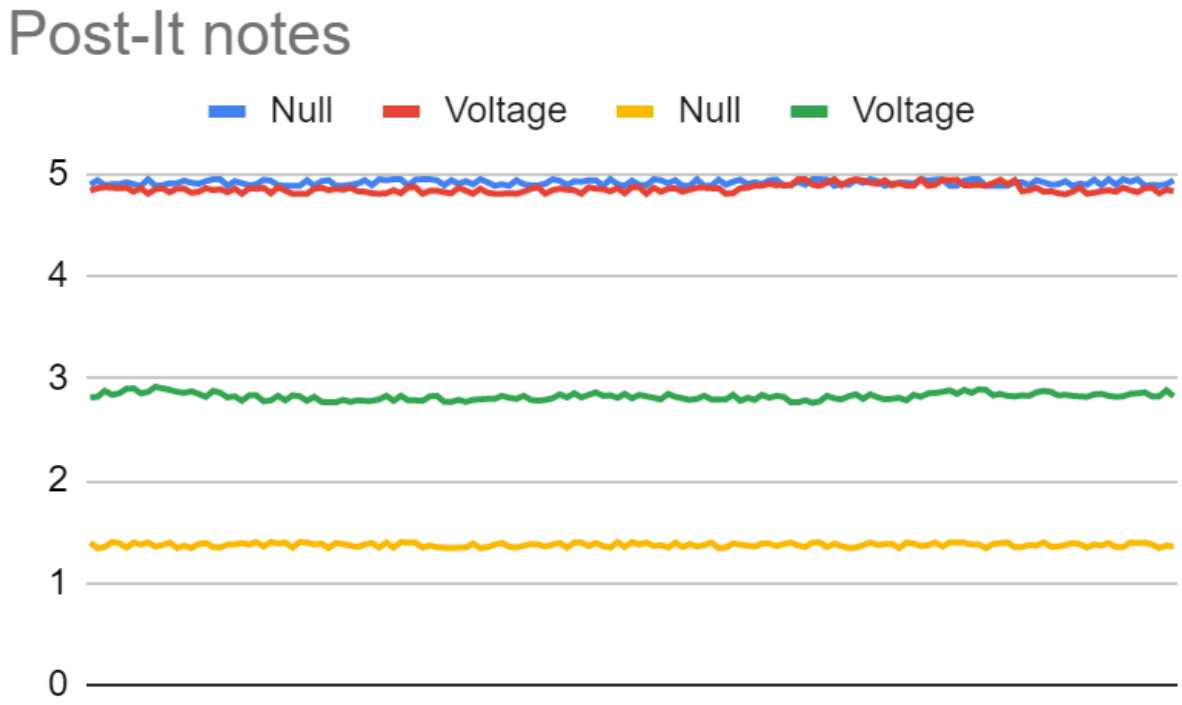
Mobile Phone (1.6 cm)

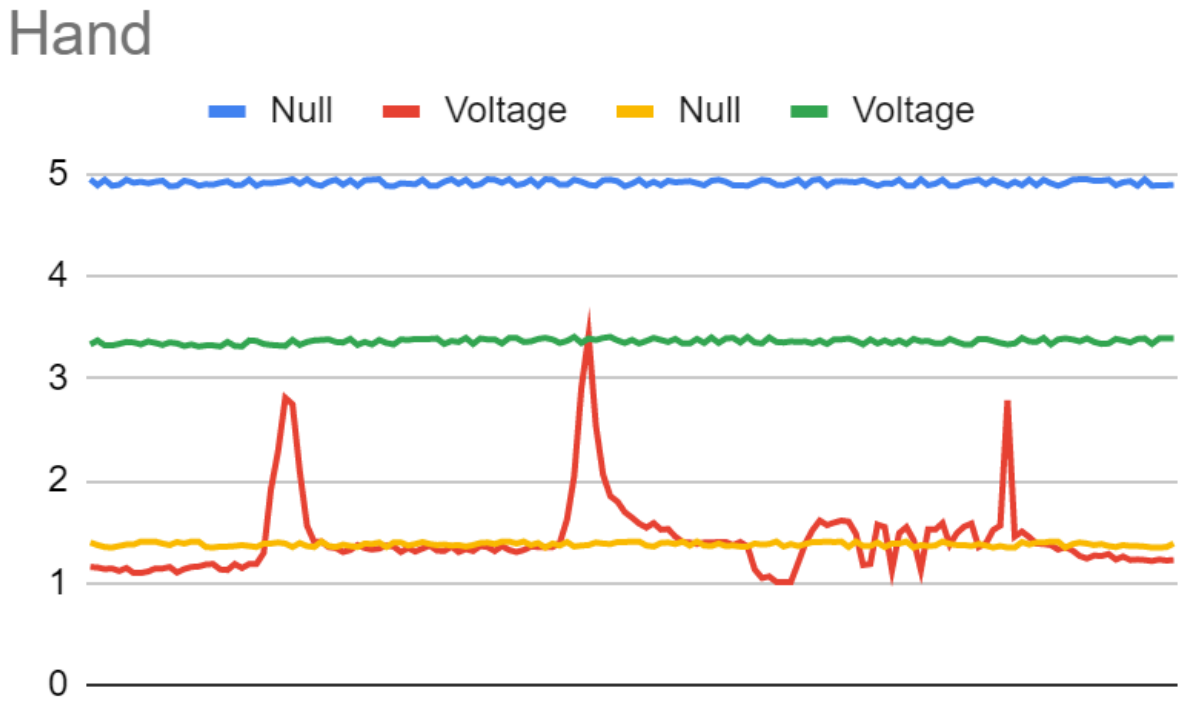
Mobile Phone			
Transmission		Reflection	
Null	Voltage	Null	Voltage
4.94624	0.00978	1.39296	4.85826
4.90225	0.02933	1.3392	4.89736
4.88759	0.01466	1.39296	4.89247
4.95112	0.01466	1.39296	4.8827
4.91202	0.01466	1.34409	4.83871
4.90714	0.02933	1.39296	4.86804
4.95112	0.02933	1.3392	4.83382
4.95112	0.01955	1.3392	4.83871
4.94624	0.02933	1.38807	4.8827
4.90714	0.02444	1.3392	4.83871
4.90225	0.00978	1.3783	4.88759
4.9218	0.01955	1.34897	4.87781
4.90225	0.02444	1.34409	4.87292
4.95601	0.00978	1.35875	4.88759
4.90225	0.00978	1.35386	4.87292
4.88759	0.01466	1.39296	4.88759
4.95601	0.02933	1.36364	4.8436
4.95112	0.01955	1.35875	4.83871
4.94624	0.02444	1.35875	4.86315
4.89247	0.01955	1.39785	4.83871
4.89247	0.02444	1.35386	4.87292
4.91691	0.01955	1.37341	4.86315
4.95112	0.02933	1.35386	4.89736
4.95112	0.01955	1.36852	4.88759
Average			
4.920698411	0.02168887417	1.366679007	4.865121987
Percent Transmission	0.44	Percent Reflection	98.44
The ratio of Transmission to Reflection			223.7272727

Metallic Plate (0.9 cm)

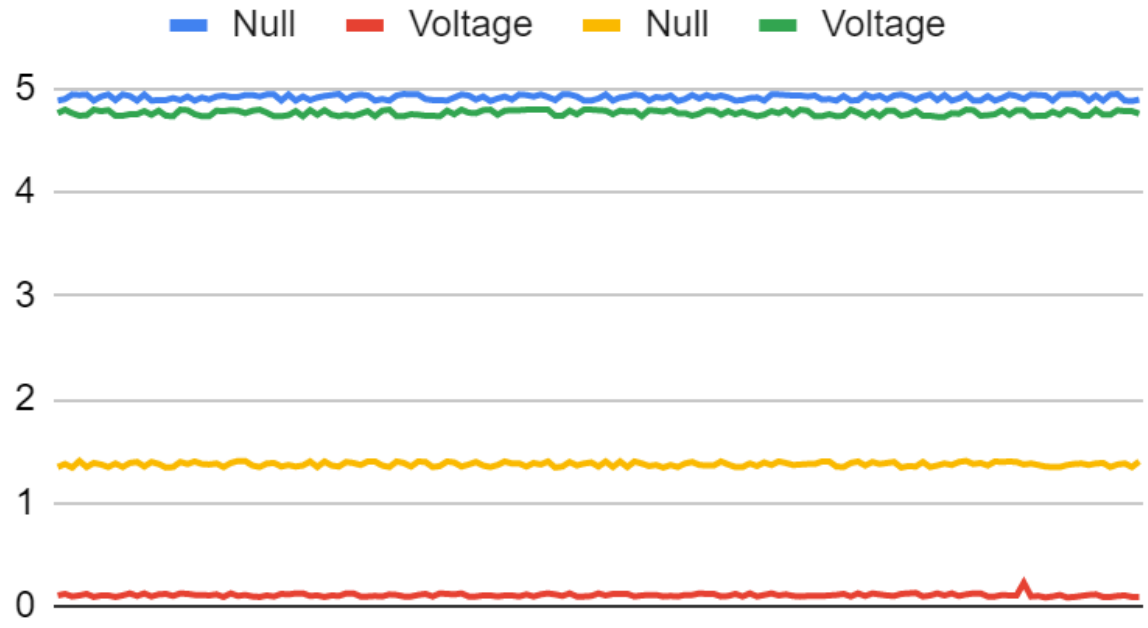
Metal Plate			
Transmission		Reflection	
Null	Voltage	Null	Voltage
4.94624	0.05865	1.39785	4.85826
4.95112	0.04399	1.39785	4.85337
4.92669	0.05865	1.3783	4.83871
4.95112	0.05376	1.36852	4.8827
4.94135	0.05376	1.39785	4.88759
4.89247	0.06354	1.3392	4.88759
4.93157	0.05376	1.36852	4.81916
4.94135	0.04888	1.37341	4.8827
4.93646	0.06354	1.3392	4.82893
4.88759	0.05865	1.39785	4.82893
4.91691	0.05865	1.39296	4.8827
4.90714	0.06354	1.39296	4.83382
4.93157	0.04888	1.37341	4.8827
4.93646	0.06354	1.38807	4.81916
4.93646	0.04888	1.3392	4.8436
4.90714	0.05376	1.35386	4.8436
4.94135	0.0391	1.39296	4.82405
4.8827	0.05865	1.36852	4.82893
4.94624	0.04399	1.36364	4.84848
4.94135	0.04888	1.34897	4.87292
4.93157	0.0391	1.3392	4.83382
4.89736	0.0391	1.38319	4.82405
4.95112	0.05376	1.34897	4.82893
4.93646	0.06354	1.38807	4.81916
4.93646	0.05376	1.39785	4.8436
Average			
4.923449404	0.05515609272	1.368005828	4.852984503
Percent Transmission	1.12	Percent Reflection	98.02
The ratio of Transmission to Reflection			87.51785714

Graphical Representation

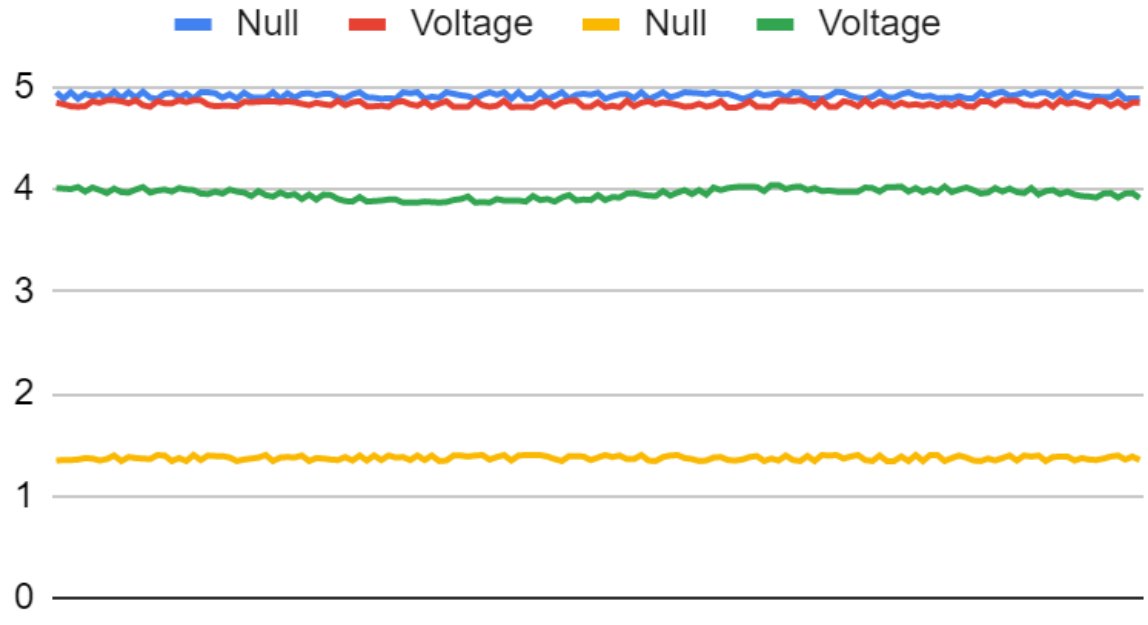




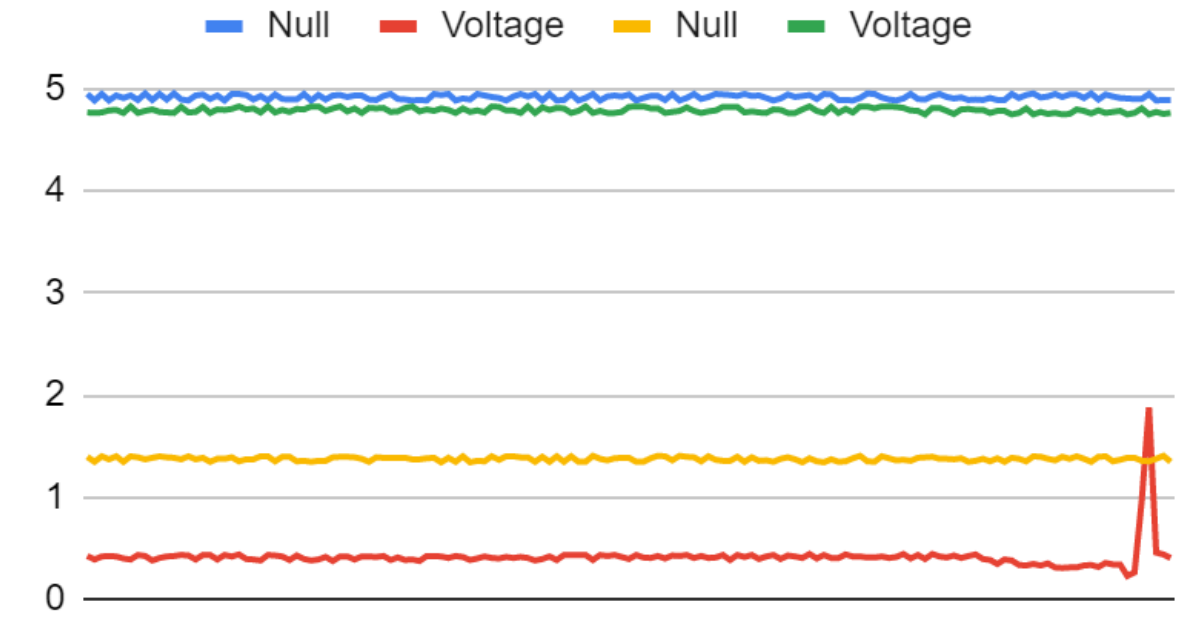
Cardboard



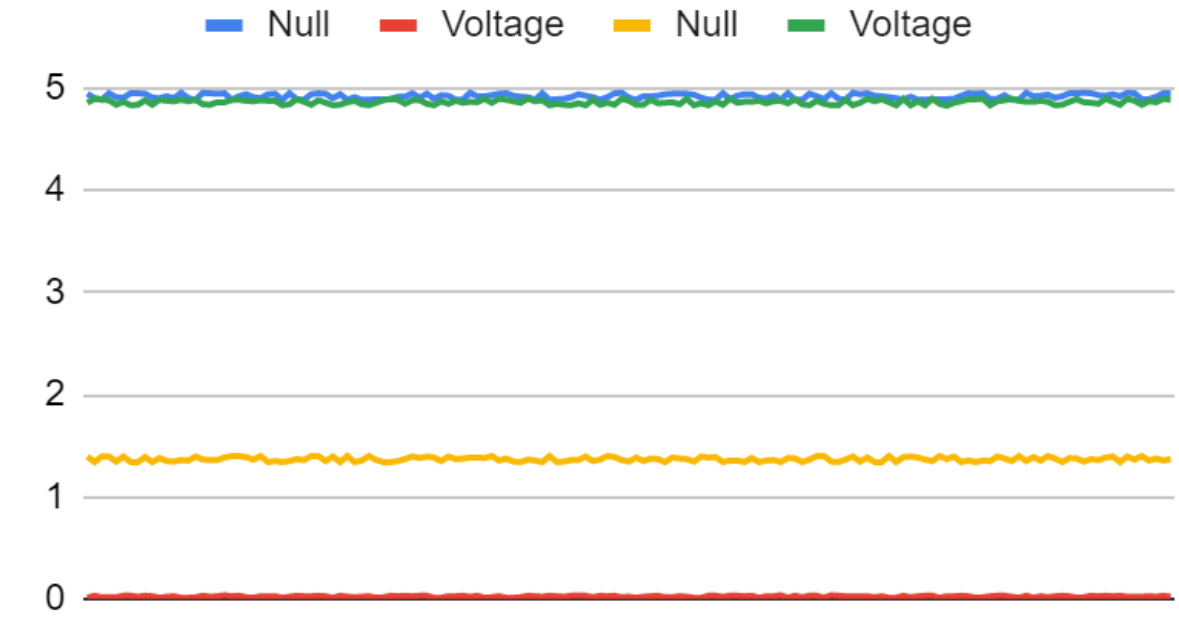
Cotton Cloth

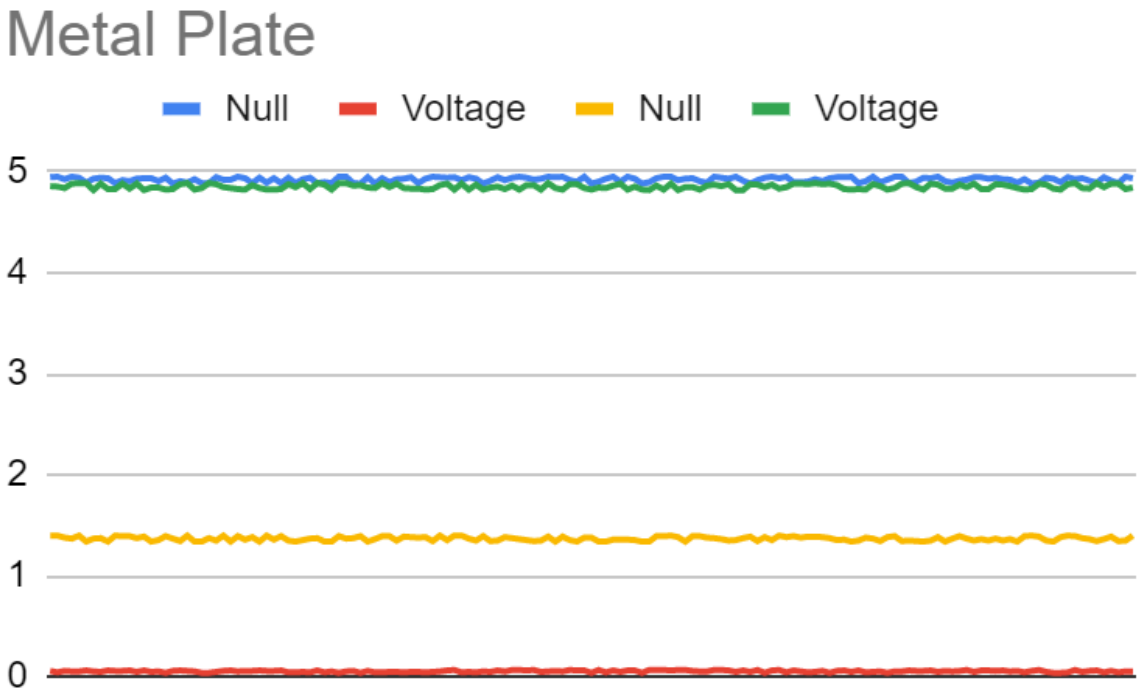


PCB (Another Arduino)

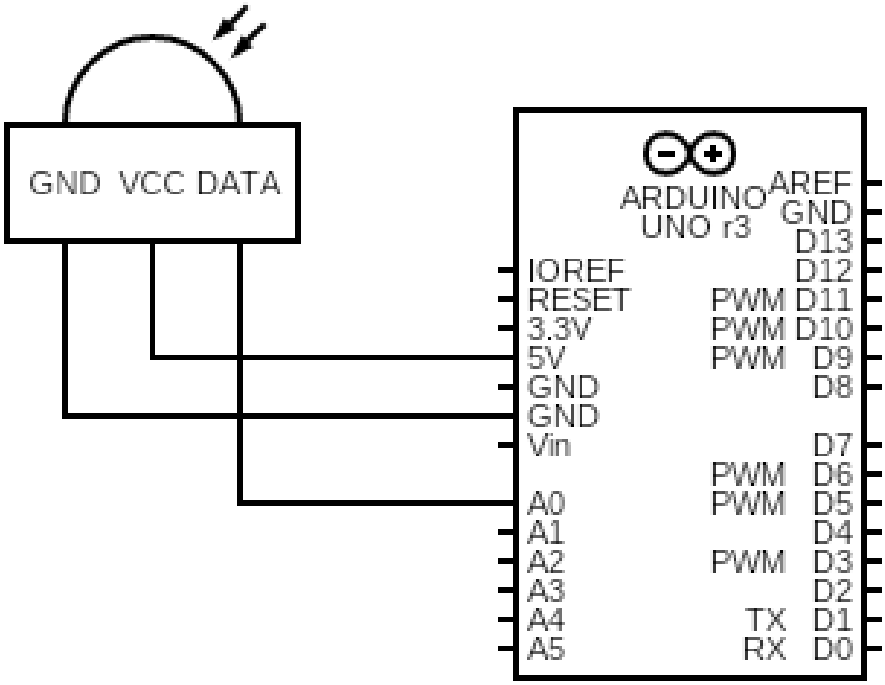


Mobile Phone





To overcome the above visible noisiness, I used an IR Sensor module and the circuit for the same is given below:



Results

The results from all the above discussions are finalized in a table, with the transmission percentage, reflection percentage, and the ratio of both of these.

Material	Percent Transmission	Percent Reflection	Ratio
Paper	98.82	40.99	0.414794576
Human Hand	28.9	56.11	1.941522491
Cardboard	2.14	95.74	44.73831776
Cotton Cloth	98.33	72.91	0.7414827621
PCB	8.37	96.35	11.51135006
Mobile Phone	0.44	98.44	223.7272727
Metal Plate	1.12	98.02	87.51785714

Hence we observe the pattern that
Reflectivity: Mobile > Metal Plate > PCB > Cardboard > Cotton Cloth > Human Hand > Paper
Transmissivity: Paper > Cotton Cloth > Human Hand > PCB > Cardboard > Metal Plate > Mobile

Conclusion and Discussion

We constructed a circuit consisting of an Infrared LED and an IR detector to make an IR Module. This device is capable of emitting Infrared Radiation in a unidirectional fashion. The IR detector is also unidirectional in nature which means that both the sensor and the emitter detect and emit radiation in one particular direction that is normal to the PN Junction in them.
This feature allowed us to construct a compact circuit with the emitter and the detector side by side. We connected this assembly to an Arduino and used its Analog Input pin to receive the detector data.
We collected data for two instances, which is

1. **Reflection**: For the collection of reflection data, we set the receiver and the transmitter in such a way that the only method for the detector to pick up some infrared radiation is only when it gets reflected from a surface.
   We observed that when the object is farther away we receive a small input at the detector which keeps on increasing as we approach the module. This happens because when the objects get closer and closer, more of the IR radiation gets reflected back into the detector. Hence the peak of the graph increases with the reflective surface approaching.

We also observed that the average value without any reflecting object in front of the module should be zero but it is not the case because of the disturbances and the thermal radiation picked up by the sensor and interpreted as infrared radiation from the emitter. This problem was solved when I used a pre-prepared IR sensor module readily available at the market.
We observed that materials such as paper, and cloth reflected the least amount of radiation which means most of it was either absorbed or transmitted through. The metallic plate and the mobile phone showed the maximum amount of reflection.

2. **Transmission:** For a collection of transmission data, we set the receiver and the transmitter in such a way that the emitter and the receiver are coaxial to each other such that all the radiation emitted by the IR LED falls directly on the IR detector giving a high detection value at the analog pin of the Arduino.
   We observed that the cotton cloth and the paper transmitted most of the IR radiation falling on them hence the fall in the intensity of IR radiation on the detector was negligible. Materials such as the mobile phone, metallic plate showed absolutely zero transmission power which means they are opaque to IR radiation. The materials such as the hand and the PCB board, basically a sheet of Acrylic showed the intermediate amount of transmission and reflection, which means that half of the radiation falling on them was reflected back and detected by the sensor in the previous experiment while half of it directly passes through and is detected on the other side in this experiment.

PART 2

APPLICATION MAKING

Introduction

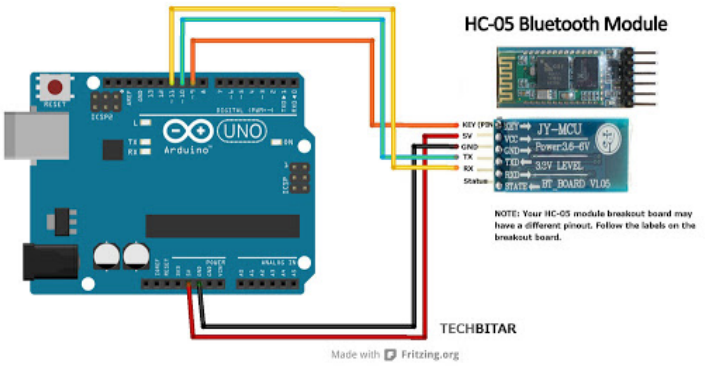
The data from the IR Module that we made in the previous project was taken by an Arduino and can only be visualized by using the Arduino application on a laptop. As the laptop is bulky, the module becomes non-portable. Hence if someone wants to use the module for doing data analysis on the field, it would be a challenging task. To overcome this, I developed an android application that uses Bluetooth communication to control the IR LED and the detector as well as receive the data from the IR sensor and plot it on the mobile interface along with giving us the exact value of the voltage detected by the IR Sensor.
This makes the whole project more portable and easy to use and also allowing the user to control and receive data remotely.

Apparatus

To make this application we need,

1. Laptop with Internet access
2. Android device to test the application
3. HC-005 Bluetooth module
4. MIT App inventor

Circuit

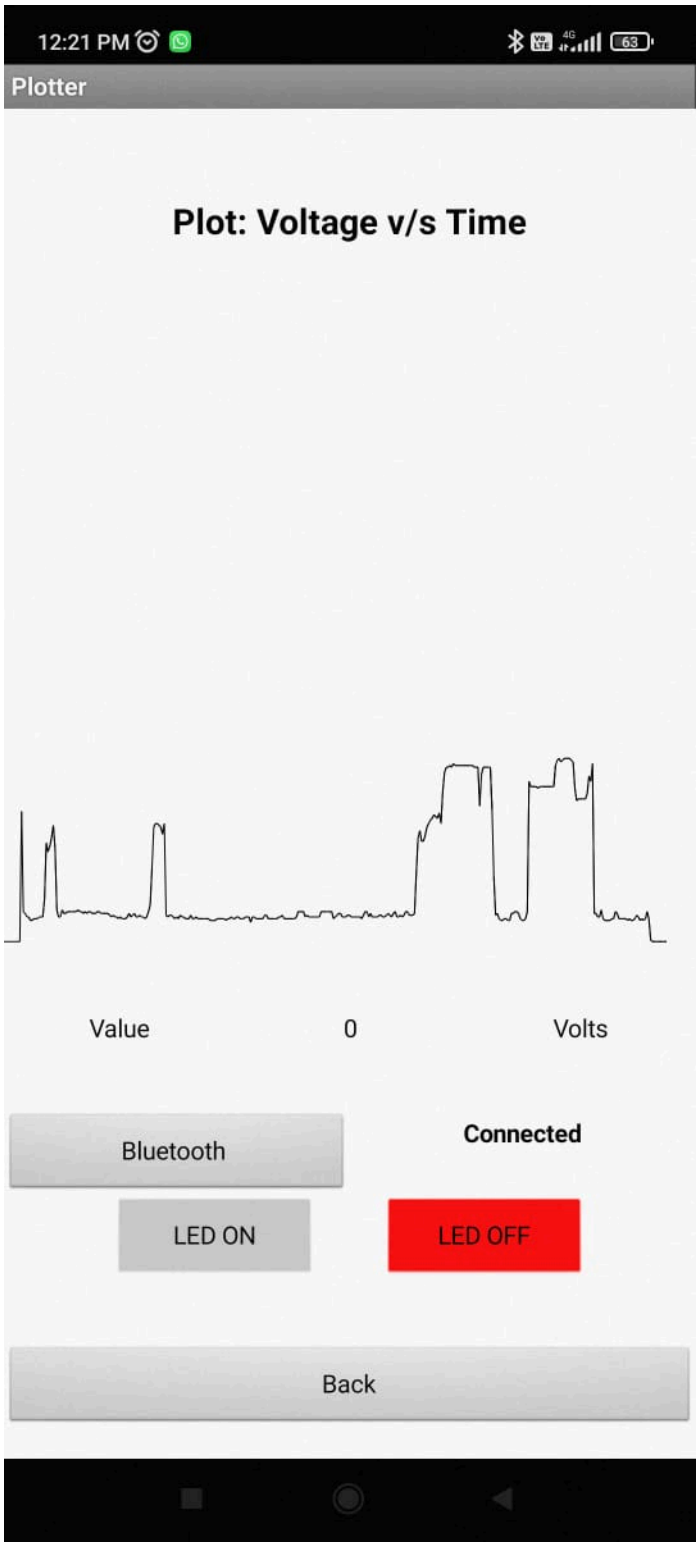


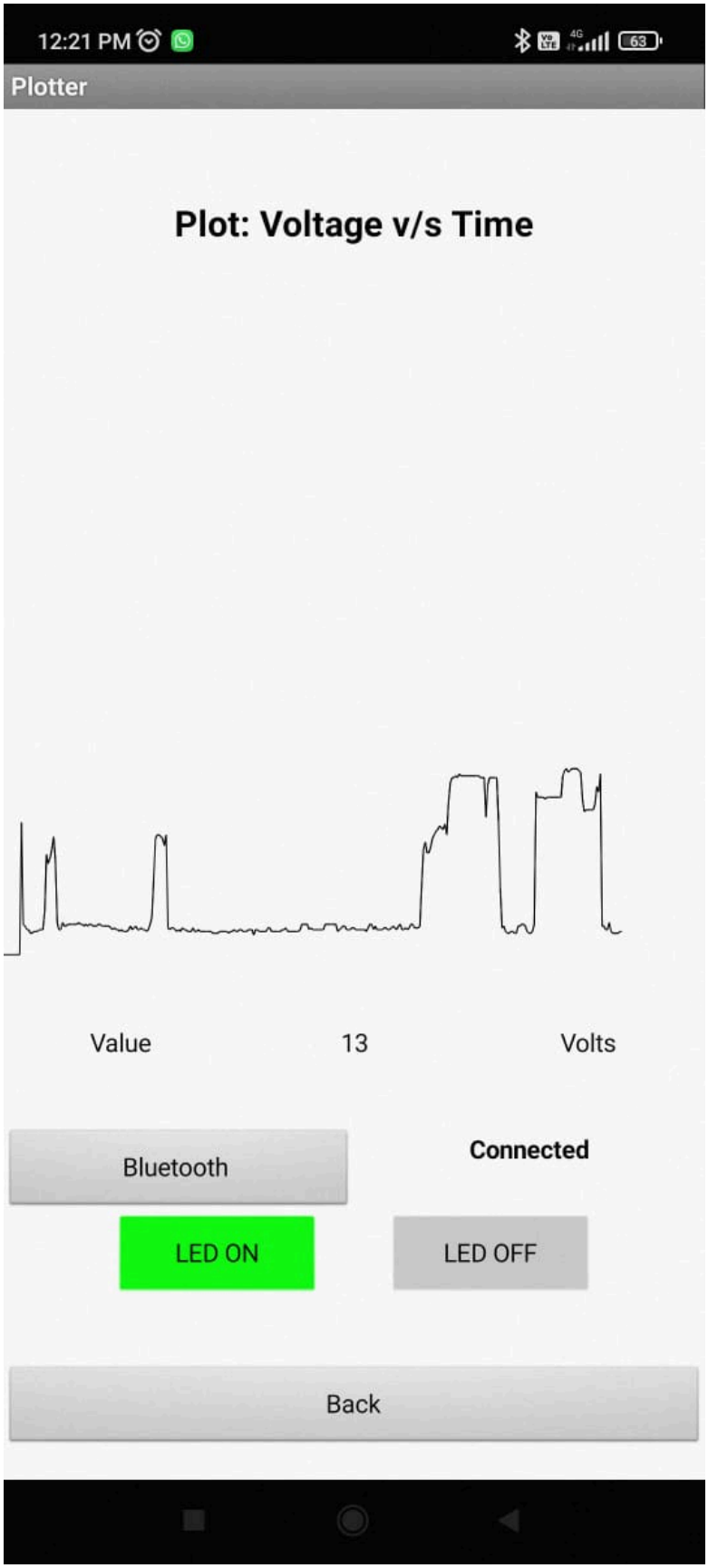
Specifications

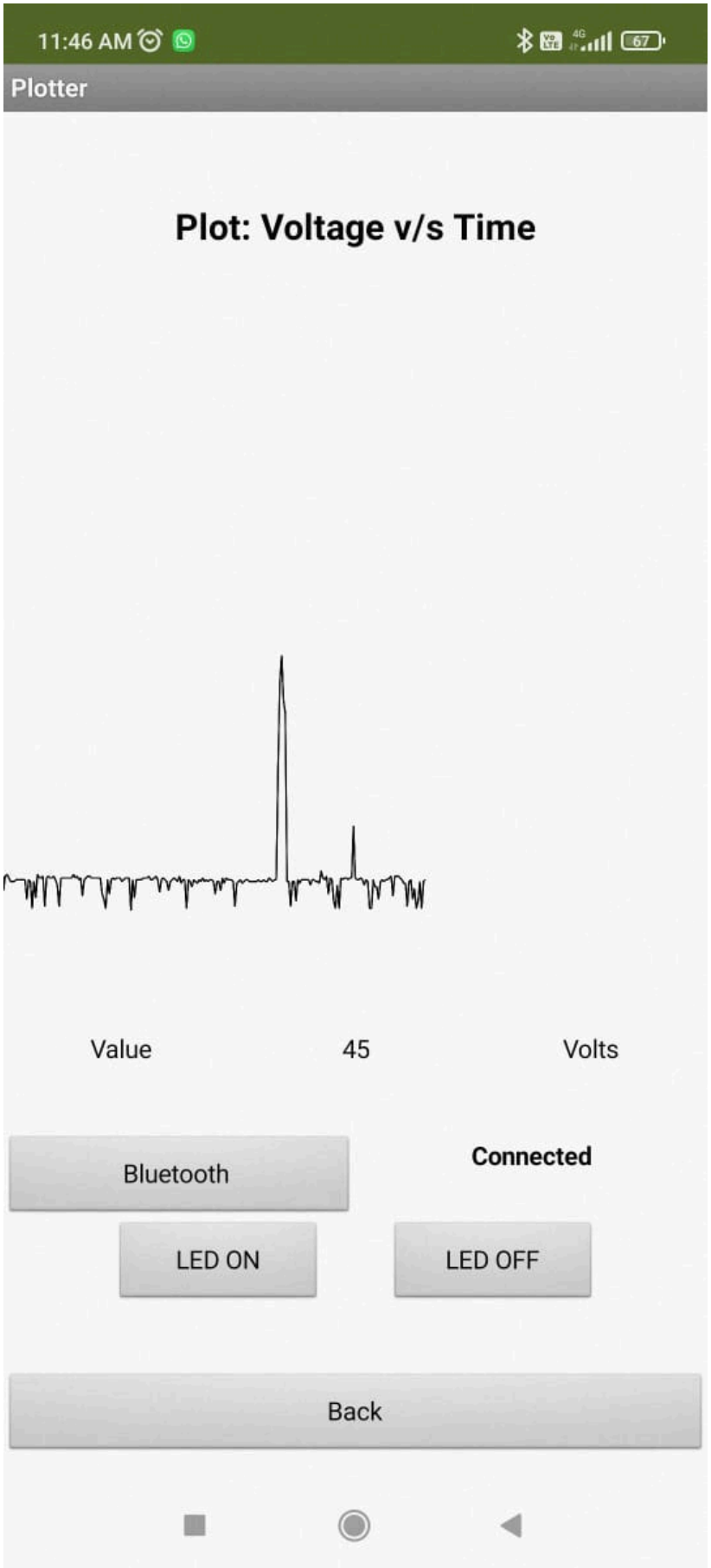
The application contains 4 pages:

1. **Home Page:** This contains the welcome words and the logo of the application. It also has 3 buttons that lead you to the IR Module controller and plotter, reading about IR Reflectivity and reading about IR Transmission respectively.

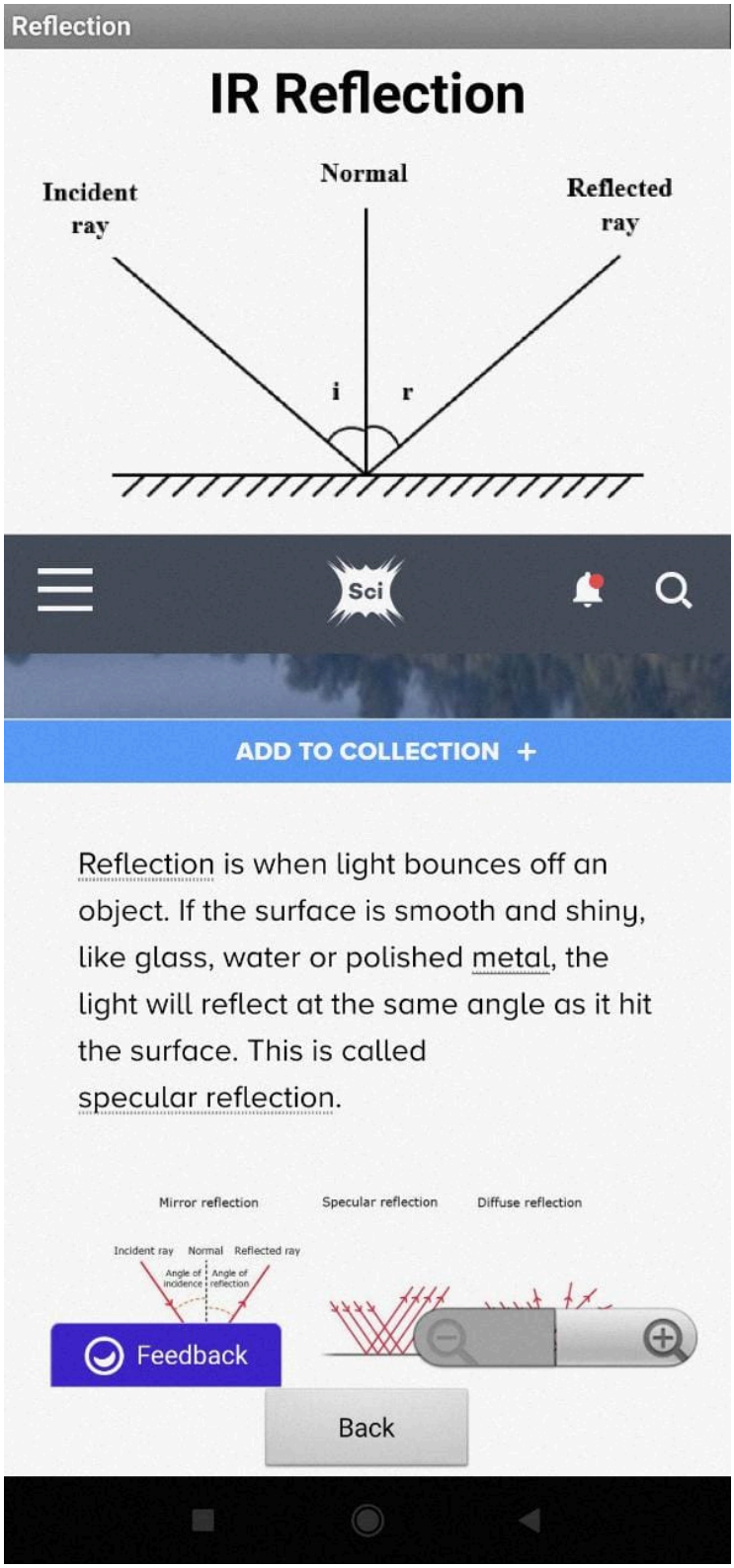
2. **Plotter:** This page contains the user interface, to control the LED light. It also contains the list of all the available Bluetooth devices and the option to connect to the HC-005 module. It also contains the canvas on which the data received from the Arduino is displayed.



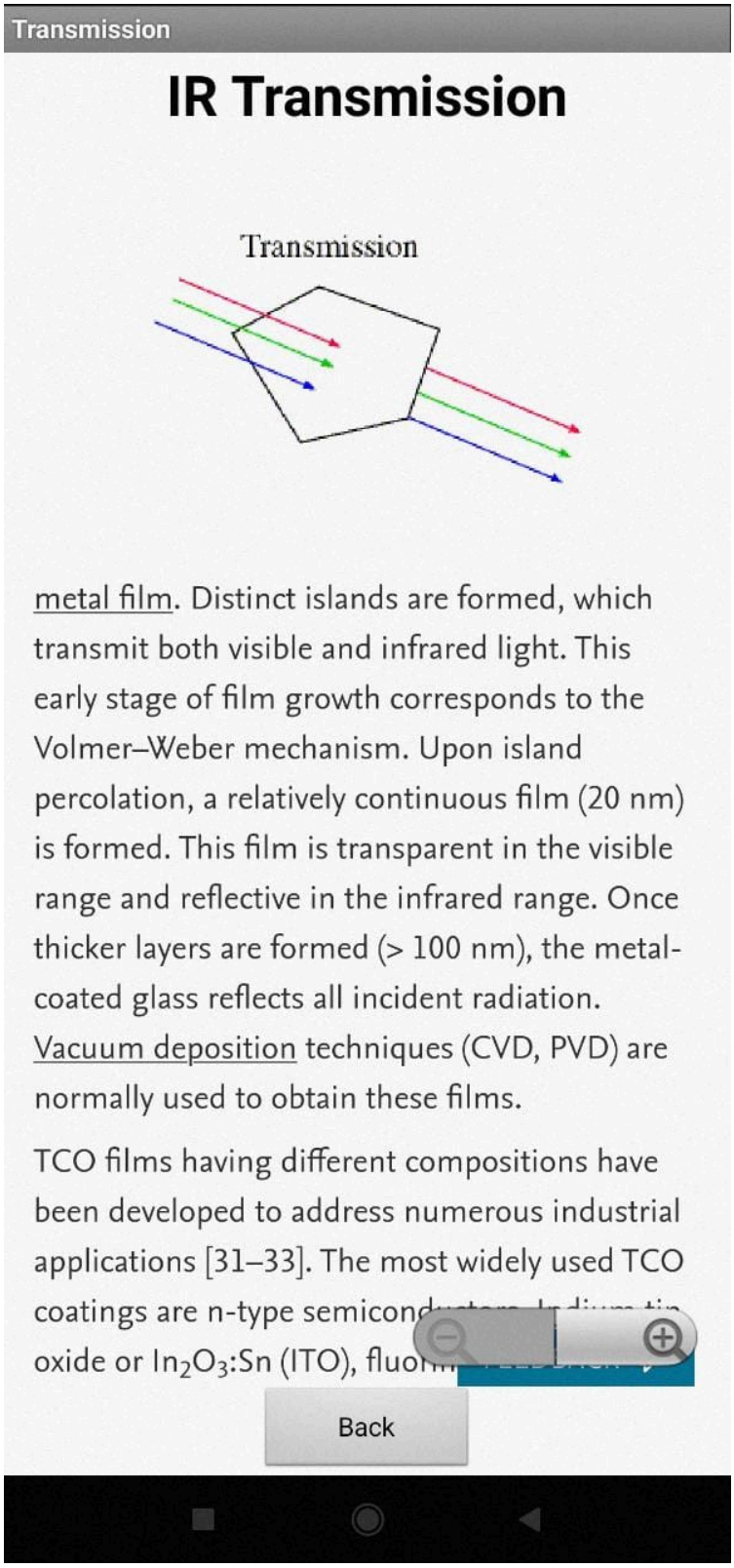

12:21 PM
Plotter
Plot: Voltage v/s Time
Value
13
Volts
Bluetooth
Connected
LED ON
LED OFF
Back


11:46 AM
Plotter
Plot: Voltage v/s Time
Value
45
Volts
Bluetooth
Connected
LED ON
LED OFF
Back

3. **Reflectivity Page:** This page contains the snippet from a webpage that contains information about the reflectivity of IR radiations from various sources and materials.



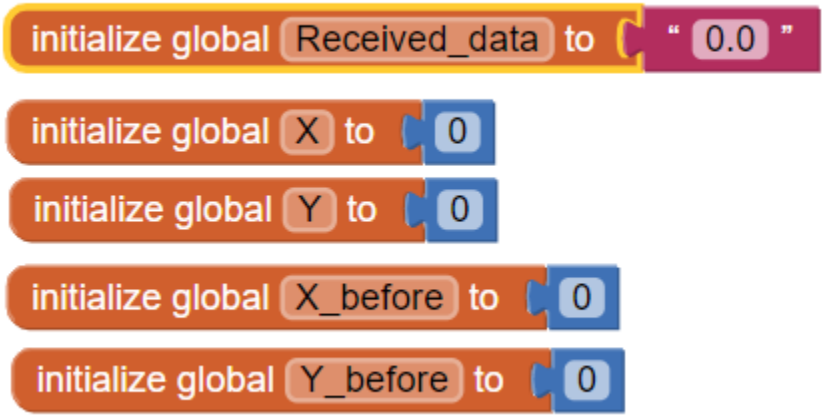
4. **Transmission Page:** This page contains the snippet from a webpage that contains information about the transmissivity of IR radiations from various sources and materials.



Logistics

The following is the description of the Block diagram or the logistics part of the application.

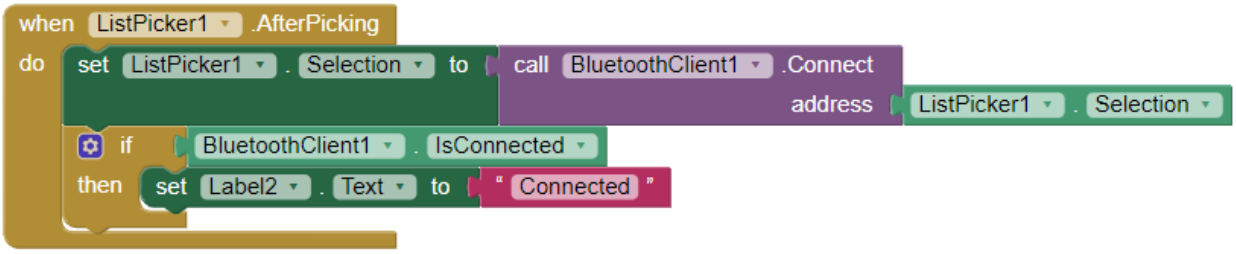
1. **Declaration of Variable**



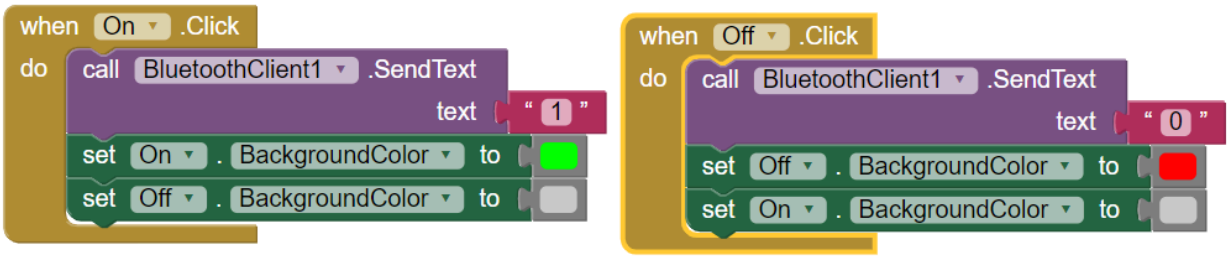
   a. Receive_data: To store the incoming bytes from the Arduino
   b. X: For the dynamic X coordinate of the graph
   c. Y: For the dynamic Y coordinate of the graph
   d. X_before: Dynamic X predecessor
   e. Y_before: Dynamic Y predecessor

2. **Assigning the list of available Bluetooth devices to the ListPicker**

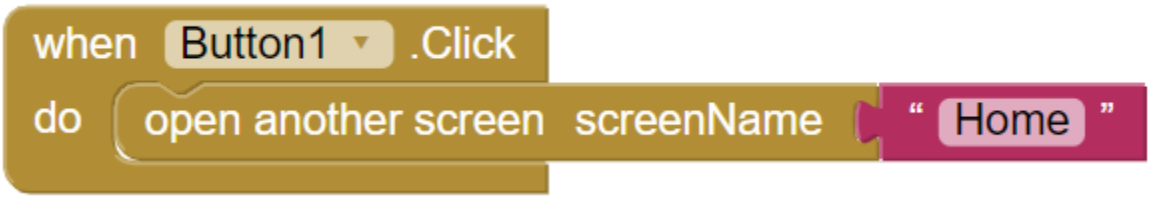
3. **Picking and assigning the selected Bluetooth device to the Bluetooth driver**



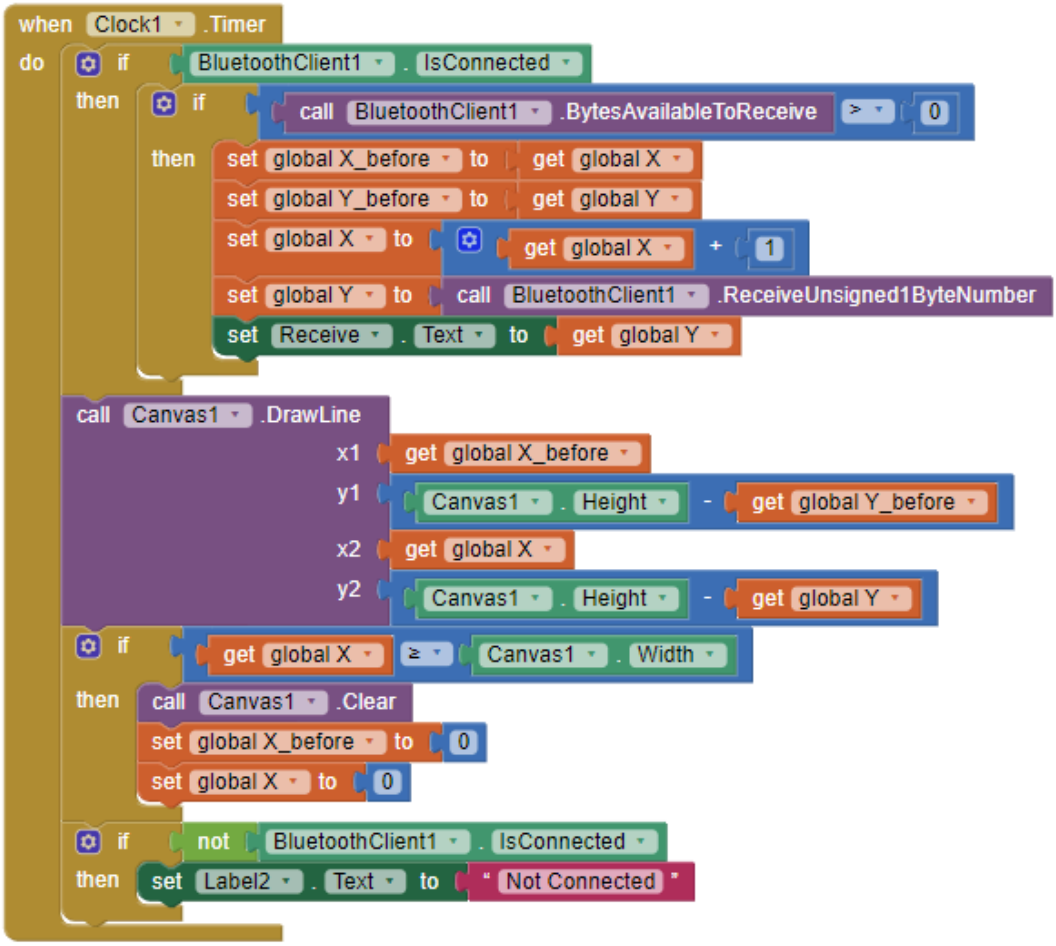
4. **Turning the LED on and OFF via Bluetooth**



5. **Navigating back to home**



6. **Data Receiving and Graph Plotting**



Link to the apk file: [APK]

Results

The application was successfully prepared and proved to be very handy in the project as it was able to do the following tasks easily.

1. Connect to the HC-005 module of the Arduino and facilitate wireless communication.
2. Control the LED and the Sensor via Bluetooth.
3. Receive data from the Arduino and show it on the screen.
4. Show the graphical representation of the data received.
5. Provide information about IR reflection and transmission.

Vote of Thanks

I was very fortunate to be able to work under the guidance of Dr. Mitradip Bhattacharjee, as this internship taught me many new things in the greatest of depths. I was able to create a problem, started to work on it, faced difficulties, learned to overcome it, applied the methods, did research, and refined my methods to finally get the problem solved in the most efficient way possible.
I am highly obliged and thankful to sir to provide me with this opportunity and very motivated to work again on this project and do further research and refinements if I get a chance to.

Thanks and Regards
Arihant Tiwari
19050
Department of Physics
IISER Bhopal