**NOISE POLLUTION MONITORING PHASE\_5**

**PHASE\_5 Project documentation and submission**

A Brief Note on Sound :

Before understanding Noise, we need to first know a little bit about Sound. After all, Noise is nothing but unwanted Sound. The ‘Sound’ we hear is the result of pressure variation in the air or any medium.

When a source induces vibrations in the air, it is actually producing an alternating band of dense and sparse particles of air. The movement of air particles will result in a fluctuation of atmospheric pressure.

Our ear detects these pressure fluctuations happening above and below the atmospheric pressure and creates the sensation of hearing.

Sound is a form of energy produced by longitudinal mechanical waves in solids, liquids, or gases. We need a source or vibrating object to transmit sound waves. These sound waves travel through a medium. Finally, we need a receiver, an ear in our case, to absorb the energy.

What is Noise?

As we already mentioned before, any unwanted sound is Noise. Here, the term ‘unwanted’ means that it has adverse health effects on human and animal hearing.

We can also define Noise as a sound that interferes with speech and hearing. In terms of public health concerns, noise is a sound that has enough intensity to cause hearing damage

The meaning of noise can be subjective. One person may enjoy listening to heavy metal music at one volume. But the same music at the same volume may be noise to another person.

There are many sources of Noise. Household works and chores, transportation, and construction are some noises everyone encounters frequently. If you live near or work in an industrial area, then there are several sources of noise there. Machines, motors, tools, etc. all create noise.

Effects of Noise On Human Health :

Noise Pollution is the latest category of environmental pollutants (the other being air and water). Several institutions and organizations have formally recognized noise as a threat to the health and well-being of humans. Hearing loss is the first and most important effect of noise.

Apart from physiological health, noise also affects the psychological behavior of humans. Continuous exposure to severe levels of noise can cause hypertension, stress, irregular sleep patterns, etc.

On Environment :

Noise also has a harmful effect on animal life. Overexposure to noise can lead to temporary or permanent hearing loss in many animals. Noise can also cause stress and disturbs the balance of predator – prey detection.

An impact of noise on animals is an increased risk of untimely death. You might have seen the news about the death of whales due to exposure to military sonar.

How Do We Measure Noise?

Before looking at the Noise Level Decibels Chart, we need to first understand how we measure Sound or Noise.

We know that a vibrating source alternately rises and drops the pressure of air particles with respect to atmospheric pressure. This variation in the pressure of the medium (air) above and below the atmospheric pressure is known as Sound Pressure.

The SI units of pressure are pascals (Pa) or Newton per meter square (N/m2). The human ear can detect sound pressures in the range of 20µPa all the way over 200Pa.

Two important points to note here. The range of sound pressure that can be produced is huge from 0.00002Pa to 1000Pa. The second point is the response of the human ear to an increase in sound pressure is not linear.

Hence, we measure sound using the decibel scale. Sound Pressure Level or SPL is the sound or noise measurement expressed as a logarithmic ratio of sound pressure to a reference sound pressure. This logarithmic ratio is the dimensionless unit of Power, the decibel (dB).

SPL = 20 log (p / pref) decibels (dB).

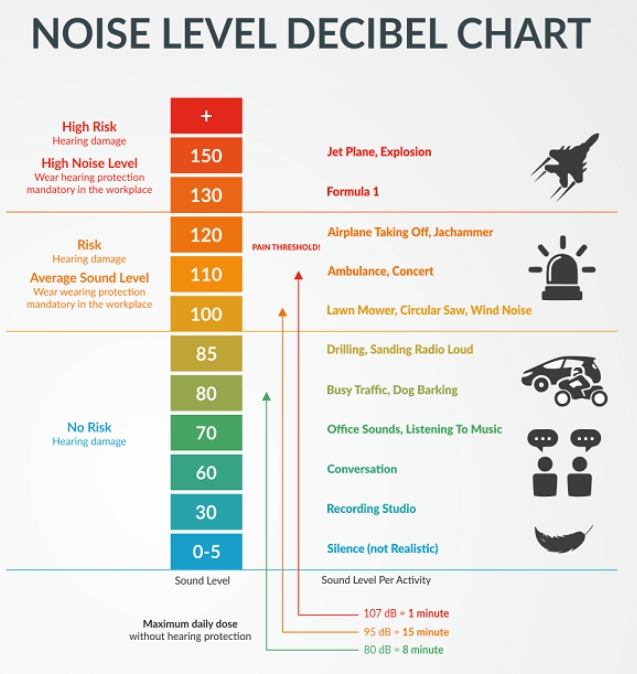
Here, ‘p’ is the root mean square value of the sound pressure in Pa (or N/m2). The reference sound pressure is 0.00002Pa or 2 × 10-5 N/m2.

A common way to represent sound pressure is dBA. This is a weighted Sound Pressure Level adjusted to the human sensitivity of the human ear.

The following table shows the relationship between Sound Pressure Level in dB and Sound Pressure in Pa.

|  |  |  |
| --- | --- | --- |
| **Sound Pressure Level (SPL)**  dBA | **Sound pressure**  Pa |  |
| 140 | 200 | Idle jet engine |
| 120 | 20 | Discomfort in hearing |
| 110 | 6.3 | Motorcycle at 20 feet |
| 100 | 2 | The sound caused by a pneumatic drill |
| 90 | 0.63 | Subway traffic |
| 80 | 0.2 | When someone is shouting |
| 74 | 0.1 | Passing vehicle |
| 60 | 0.02 | If you are having a quite conversation |
| 50 | 0.00063 | Normal household |
| 40 | 0.0002 | Library |
| 30 | 0.00063 | Wishpering |
| 20 | 0.0002 | Leaves rustling |
| 0 | 0.00002 | Threshold of hearing (reference sound pressure) |

**Noise Level Decibels Chart:**



Overexposure to noise above 70dB for an extended period can cause severe damage to human ears and may even lead to permanent hearing loss.

Use proper hearing protection when you are working with power tools or if you have a construction job.

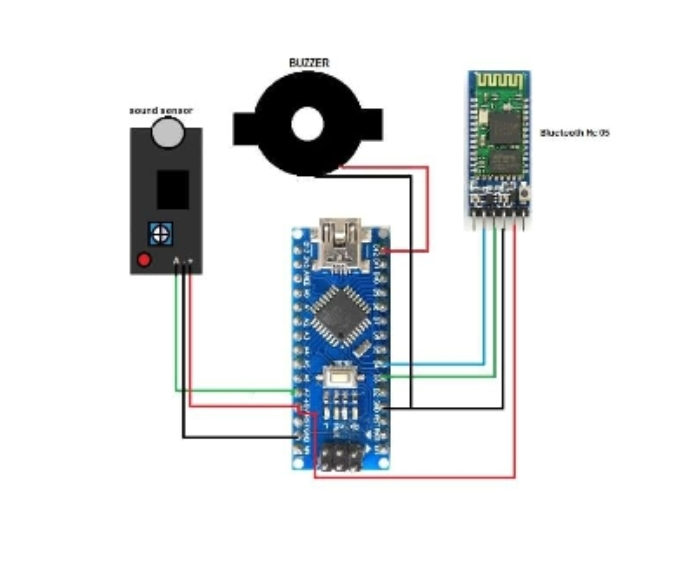
We call any ‘unwanted’ sound as Noise. There are several sources of noise such as automobiles, construction works, tools, and industries. Noise Pollution is becoming a serious concern due to the increase in vehicles, heavy industries, power tools, etc. By having a proper idea of the levels of noise that is safe for human ears, then we can take proper precaution.

Noise pollution is a pervasive environmental issue with wide-ranging consequences for individuals, communities, and ecosystems. Noise pollution monitoring plays a crucial role in assessing the impact of noise pollution and developing effective strategies for its mitigation. As students interested in this field, exploring noise pollution monitoring techniques, their applications, and potential solutions can contribute to a cleaner, quieter, and healthier environment for all.

Noise level measurement procedure are processes which record sound level or acoustic energy level in the specified area. Sound or Noise level meter measures noise in Unit decibel (dB).

Components Required

* Vibration motor/ Buzzer
* Bluetooth HC 05
* Sound sensor module
* Wires
* Arduino Nano



Power the Arduino and connect the Bluetooth with your app. After successful connection, you can test it by making loud noises. When your sound level crosses the threshold value, the Noise Detector device will buzz to notify about it and at the same time the app will start recording the sound and it will go on recording until the noise level comes down below the threshold level.

System uses air sensors to sense presence of harmful gases/compounds in the air and constantly transmit this data to microcontroller. Also system keeps measuring sound level and reports it to the online server over IOT. The sensors interact with microcontroller which processes this data and transmits it over internet. This allows authorities to monitor air pollution in different areas and take action against it. Also authorities can keep a watch on the noise pollution near schools, hospitals and no honking areas, and if system detects air quality and noise issues it alerts authorities so they can take measures to control the issue.

IOT :

The Internet of Things (IoT) is a system of interrelated Computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction. IoT has evolved from the convergence of wireless technologies, micro-electro mechanical systems (MEMS), micro services and the internet. The convergence has helped tear down the silo walls between operational technology (OT) and information technology (IT), allowing unstructured machine - generated data to be analyzed for insights that will drive improvements.

**ESP32 Wi-Fi Module:**

An ESP32 wifi module is a microcontroller board that can connect to the internet and perform various tasks. It can be used in a noise pollution monitor to send the sound data to a cloud platform or an app, where it can be stored, analyzed, and visualized. For example, you can use the ESP32 wifi module with a sound sensor and an LCD display to measure the sound level in decibels (dB) and show it on the screen. You can also use the Blynk app to monitor the sound level remotely from your smartphone. Alternatively, you can use the ESP32 wifi module with an array of sound sensors to locate the sources of noise pollution and alert the authorities or take corrective actions.

Some of the advantages of using the ESP32 wifi module in a noise pollution monitor are:

- It is a low-cost and easy-to-use device that can be programmed with Arduino IDE

- It has built-in wifi and bluetooth capabilities that enable wireless communication and data transfer

- It has multiple analog and digital pins that can interface with various sensors and devices

- It has a high-performance dual-core processor that can handle complex calculations and operations

**Ultrasonic sensor:**

Ultrasonic sensors can also be used to monitor noise pollution in the environment. Noise pollution is the excessive and harmful sound that affects the health and well-being of humans and animals. Some of the sources of noise pollution are traffic, industries, construction, aircraft, and loud music.

One way to use ultrasonic sensors for noise pollution monitoring is to measure the sound pressure level (SPL) in decibels (dB) at different locations and compare them with the permissible limits. The SPL is a logarithmic measure of the ratio of the sound intensity to a reference level. The reference level is usually the threshold of human hearing, which is about 20 micropascals (µPa) or 0 dB.

To measure the SPL, an ultrasonic sensor can be attached to a microcontroller and a display device. The sensor emits ultrasonic sound waves and receives the reflected waves from the surrounding objects. The sensor converts the sound waves into electrical signals, which are then processed by the microcontroller to calculate the SPL. The SPL can be displayed on an LCD screen or sent to a cloud server for further analysis.

Another way to use ultrasonic sensors for noise pollution monitoring is to detect and locate the sources of noise pollution. For example, an array of ultrasonic sensors can be installed along a road or a building to identify the vehicles or machines that produce excessive noise. The sensors can measure the time difference of arrival (TDOA) of the sound waves from the noise source and use triangulation methods to estimate its position and direction. This information can be used to alert the authorities or take corrective actions.

ultrasonic sensors have some advantages over other types of sensors for noise pollution monitoring, such as:

- They are less affected by ambient noise and weather conditions than microphone-based sensors

- They can cover a large area and detect distant noise sources than acoustic sensors

- They are relatively low-cost and easy to install

**Microphone:**

A microphone is a device that converts sound waves into electrical signals. It can be used to measure the sound pressure level (SPL) in decibels (dB), which is a common parameter for noise pollution monitoring. A microphone can also capture the frequency and duration of sound, which are important factors for analyzing the impact of noise on human and environmental health.

Some of the uses of microphone in noise pollution monitoring are:

- Occupational noise exposure assessment: Microphones can be attached to workers or placed in work environments to measure the noise dose and peak levels that they are exposed to. This can help prevent hearing loss and other health problems caused by excessive noise.

- Environmental noise mapping: Microphones can be installed in strategic locations across a city or a region to measure the noise levels from various sources, such as traffic, industries, construction, etc. This can help identify the areas with high noise pollution and plan appropriate mitigation measures.

- Noise source identification and localization: Microphones can be used in conjunction with other sensors and algorithms to detect and locate the sources of noise pollution, such as vehicles, machines, or events. This can help enforce noise regulations and take corrective actions.

**Programing:**

In the code, given below we are using MicroPython to read analog input from a pin using the machine.ADC module and printing the readings to the console.

the code is written in MicroPython, a version of Python designed for microcontroller and embedded systems programming.

Why we use MicroPython?

MicroPython is a version of Python that runs on microcontrollers, which are small and low-cost devices that can interact with the physical world and the internet. MicroPython is used in IoT (Internet of Things) projects because it has some advantages, such as:

- It is easy to learn and use, especially for beginners who are familiar with Python

- It allows rapid prototyping and testing of IoT applications

- It supports many features of Python, such as data structures, modules, exceptions, and generators

- It can interface with various sensors, actuators, displays, and communication protocols

**Code:**

import machine

import time

import urequests

import ujson

import network

import math

wifi\_ssid ='Sheki'

wifi\_password = 'jesuslovesyou'

wifi = network.WLAN(network.STA\_IF)

wifi.active(True)

wifi.connect(wifi\_ssid, wifi\_password)

# Wait for Wi-Fi connection

while not wifi.isconnected():

pass

ultrasonic\_trig = machine.Pin(15, machine.Pin.OUT)

ultrasonic\_echo = machine.Pin(4, machine.Pin.IN)

microphone = machine.ADC(2)

calibration\_constant = 2.0

noise\_threshold = 50

firebase\_url = 'https://noise-pollution-monitor-default-rtdb.firebaseio.com/'

firebase\_secret ='https://noise-1fcc1-default-rtdb.firebaseio.com/'

def measure\_distance():

ultrasonic\_trig.value(1)

time.sleep\_us(10)

ultrasonic\_trig.value(0)

pulse\_time = machine.time\_pulse\_us(ultrasonic\_echo, 1, 30000)

distance\_cm = (pulse\_time / 2) / 29.1

return distance\_cm

def measure\_noise\_level():

noise\_level = microphone.read()

noise\_level\_db = 20 \* math.log10(noise\_level / calibration\_constant)

return noise\_level, noise\_level\_db

def send\_data\_to\_firebase(distance, noise\_level\_db):

data = {

"Distance": distance,

"NoiseLevelDB": noise\_level\_db

}

url = f'{firebase\_url}/sensor\_data.json?auth={firebase\_secret}'

try:

response = urequests.patch(url, json=data)

if response.status\_code == 200:

print("Data sent to Firebase")

else:

print(f"Failed to send data to Firebase. Status code: {response.status\_code}")

except Exception as e:

print(f"Error sending data to Firebase: {str(e)}")

try:

while True:

distance = measure\_distance()

noise\_level, noise\_level\_db = measure\_noise\_level()

print("Distance: {} cm, Noise Level: {:.2f} dB".format(distance, noise\_level\_db))

if noise\_level\_db > noise\_threshold:

print("Warning: Noise pollution exceeds threshold!")

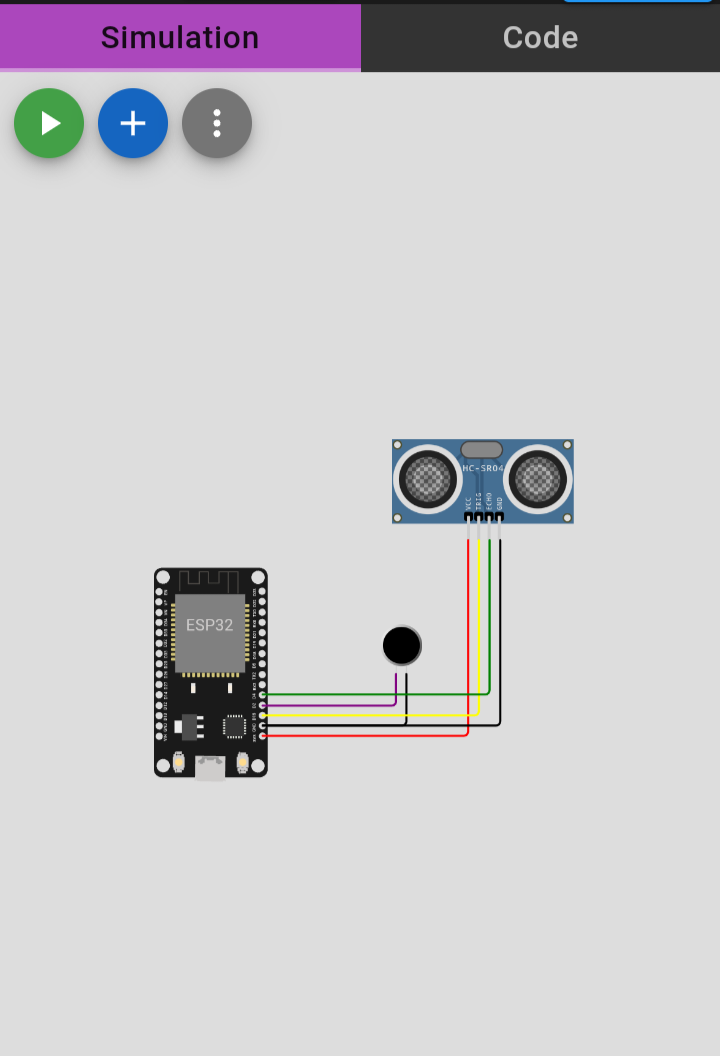
send\_data\_to\_firebase(distance, noise\_level\_db)

time.sleep(1)

except KeyboardInterrupt:

print("Monitoring stopped")

**Connect components:**



**Explanation for the code above:**

The code above is a Python code to monitor noise pollution using an ultrasonic sensor and a microphone. It also sends the measured data to Firebase Realtime Database.

First few lines import the necessary libraries, such as `machine`, `time`, `urequests`, `ujson`, `network`, and `math`.

The following lines define the Wi-Fi credentials and connect to the Wi-Fi network.

Later the lines define the pins for the ultrasonic sensor and the microphone.

After that lines define the calibration constant and the noise threshold.

Then this function measures the distance using the ultrasonic sensor. It triggers the sensor and measures the pulse width of the echo signal. The distance is then calculated using the following formula:

```

distance\_cm = (pulse\_time / 2) / 29.1

```

Later the function measures the noise level using the microphone. It reads the analog value from the microphone and converts it to a decibel value using the following formula:

```

noise\_level\_db = 20 \* math.log10(noise\_level / calibration\_constant)

```

Then the function sends the measured data to Firebase Realtime Database. It uses the `urequests` library to make a PATCH request to the Firebase URL with the distance and noise level data.

After that comes the main loop of the program. It continuously measures the distance and noise level, and sends the data to Firebase. If the noise level exceeds the threshold, it prints a warning message.

To use this code, you will need to:

\* Install the necessary Python libraries.

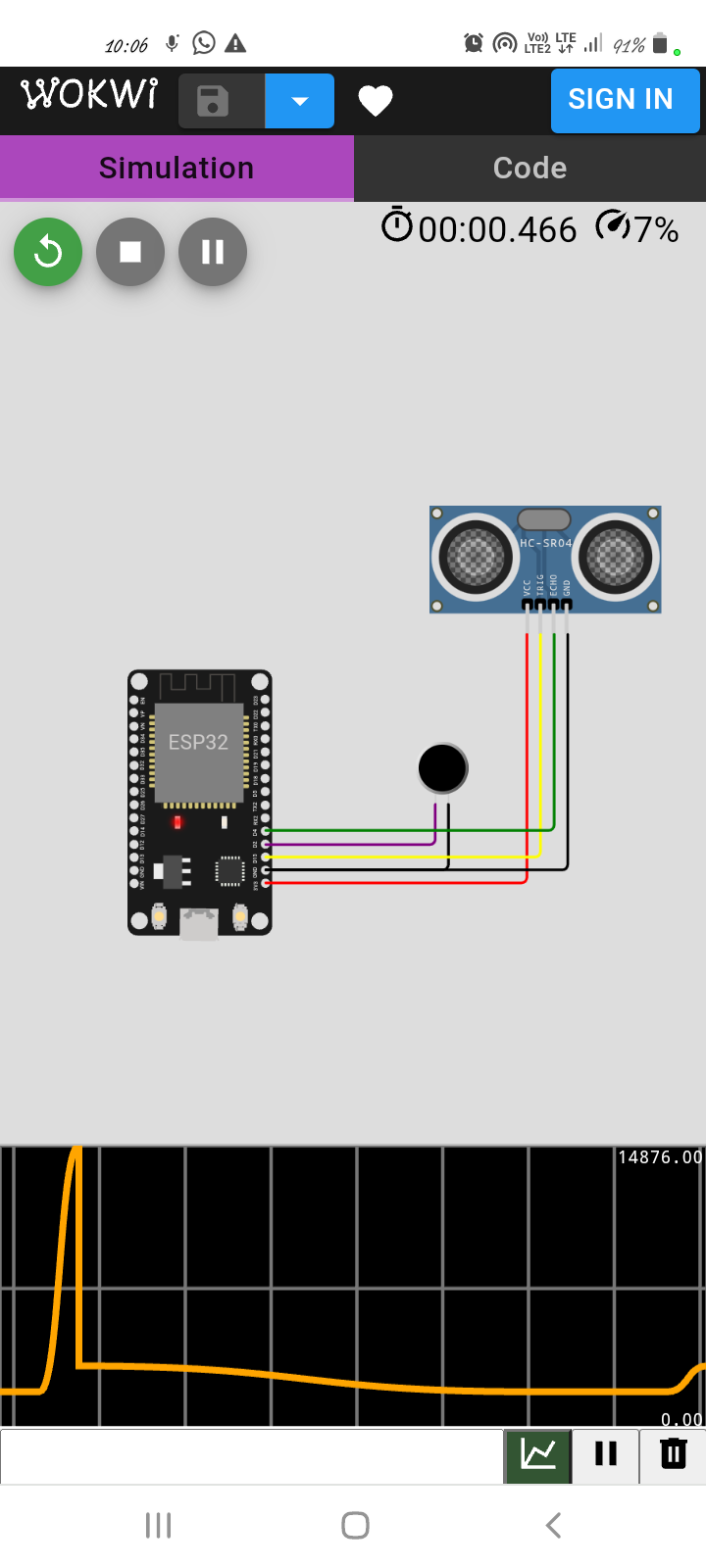
\* Replace the `wifi\_ssid` and `wifi\_password` variables with your own Wi-Fi credentials.

\* Replace the `firebase\_url` and `firebase\_secret` variables with your own Firebase URL and secret.

\* Connect the ultrasonic sensor and the microphone to the appropriate pins on your microcontroller.

After these steps we can run the code and it will start monitoring noise pollution. The measured data will be sent to Firebase Realtime Database, where you can view and analyze it.

**Output:**

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**Output link:**

<https://wokwi.com/projects/379675165725791233>

Till this we have connect the components in wokwi and stimulated the components

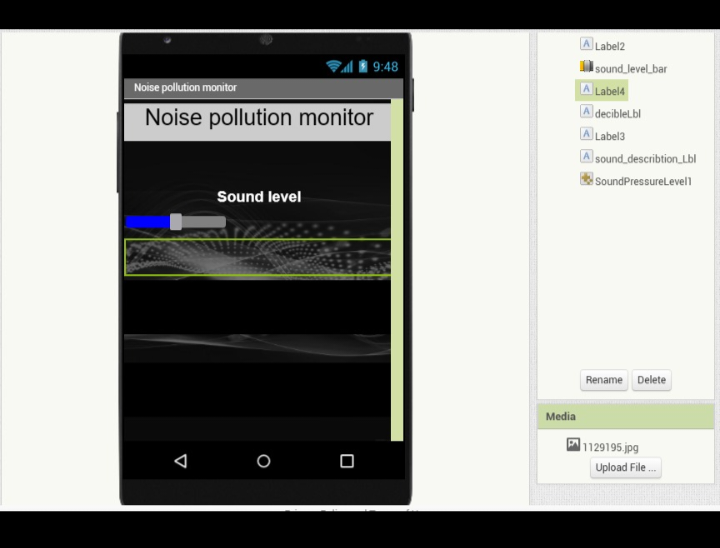
After this we need to build an app, I'm using MIT app inventor here

In phase 4 submission we had submitted 3 app development phases.

From that we choose one and submitted here.

Here is the application we created to display our output

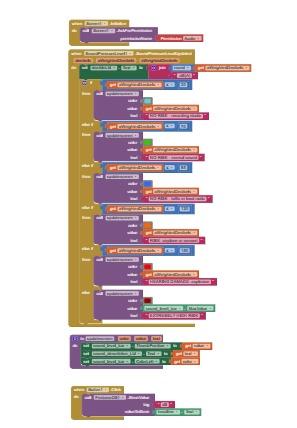
App interface:



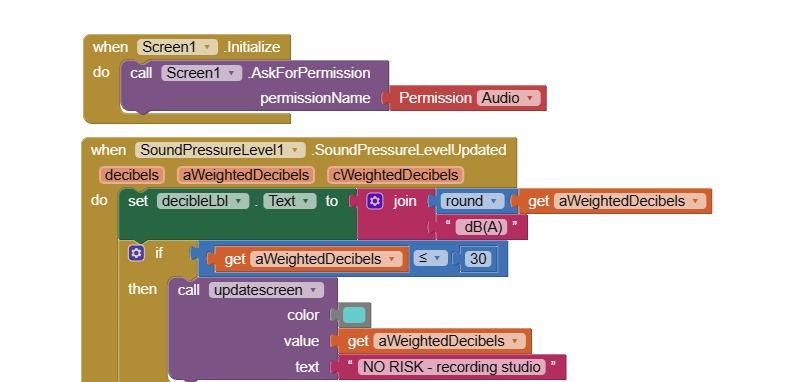
This was the developing stage of the application

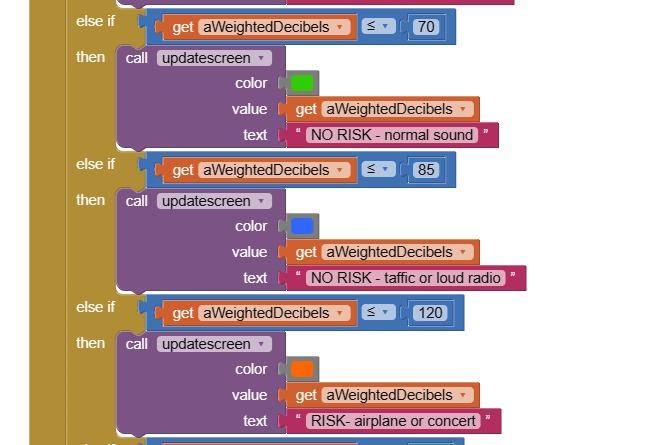
Here we are gonna see the block arrangement of the app

Full view :

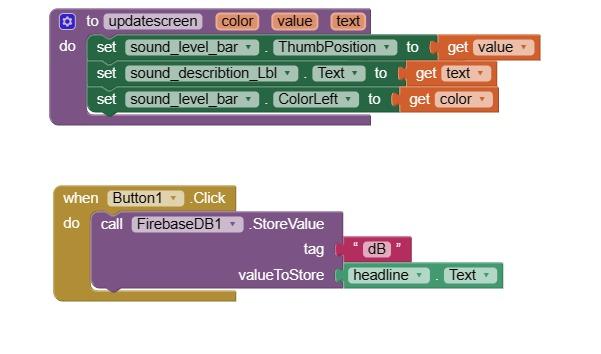


Clear view of blocks :

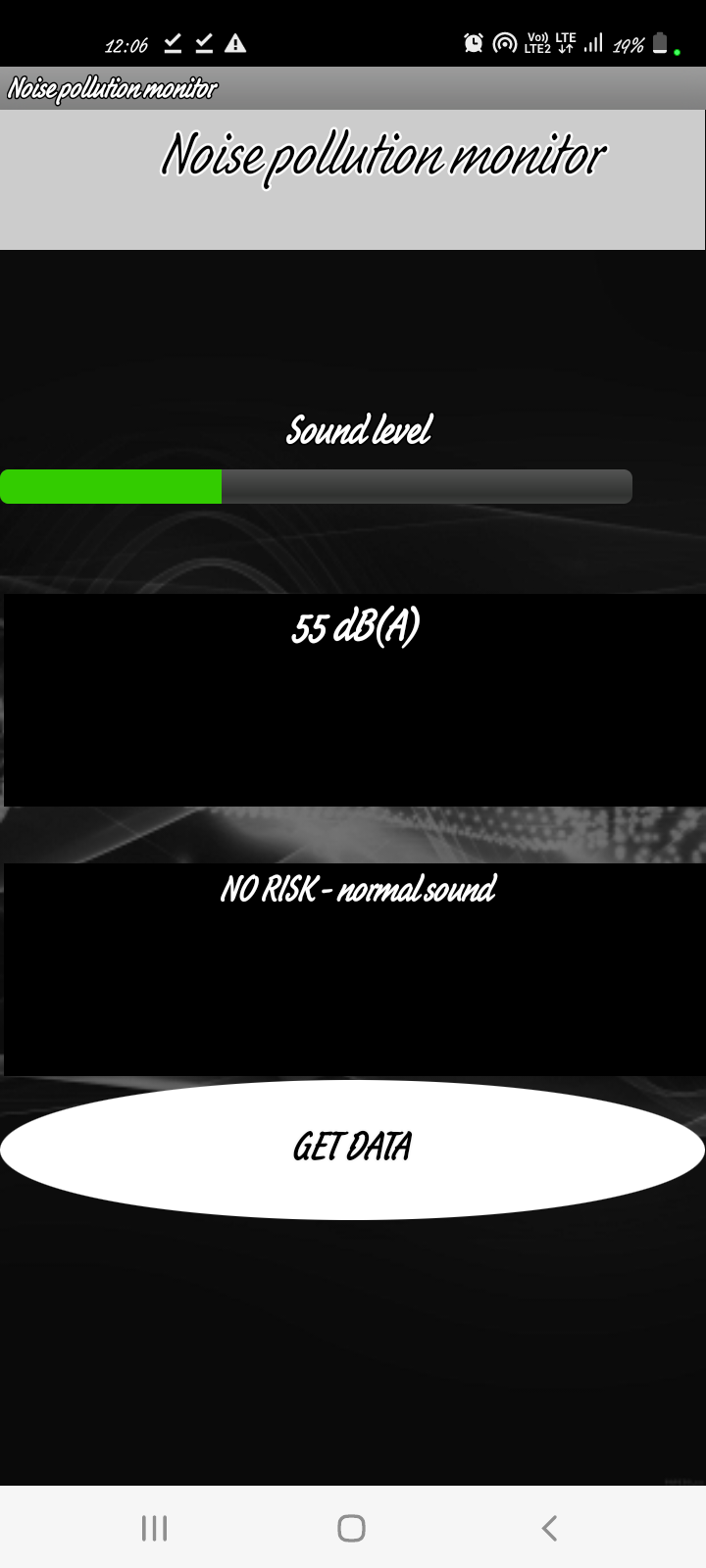


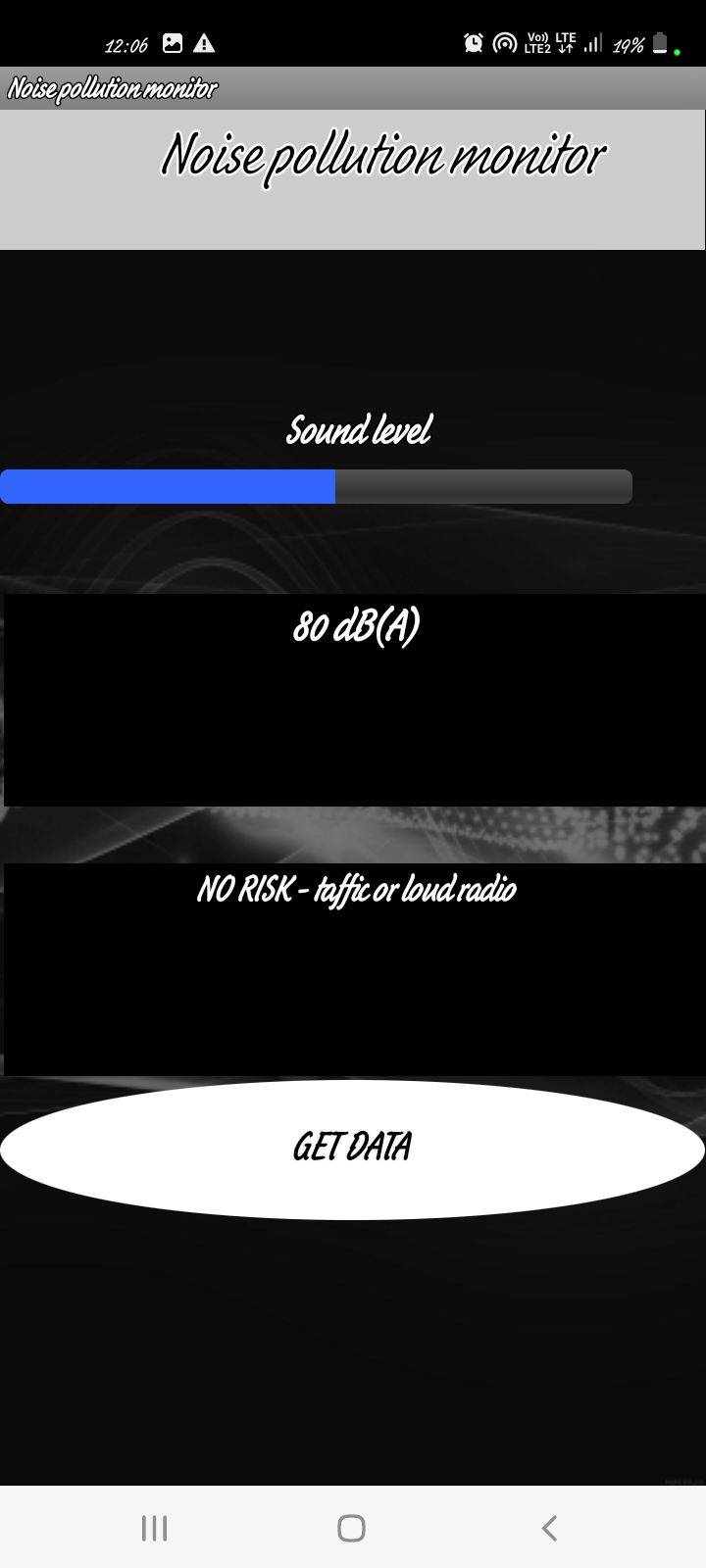


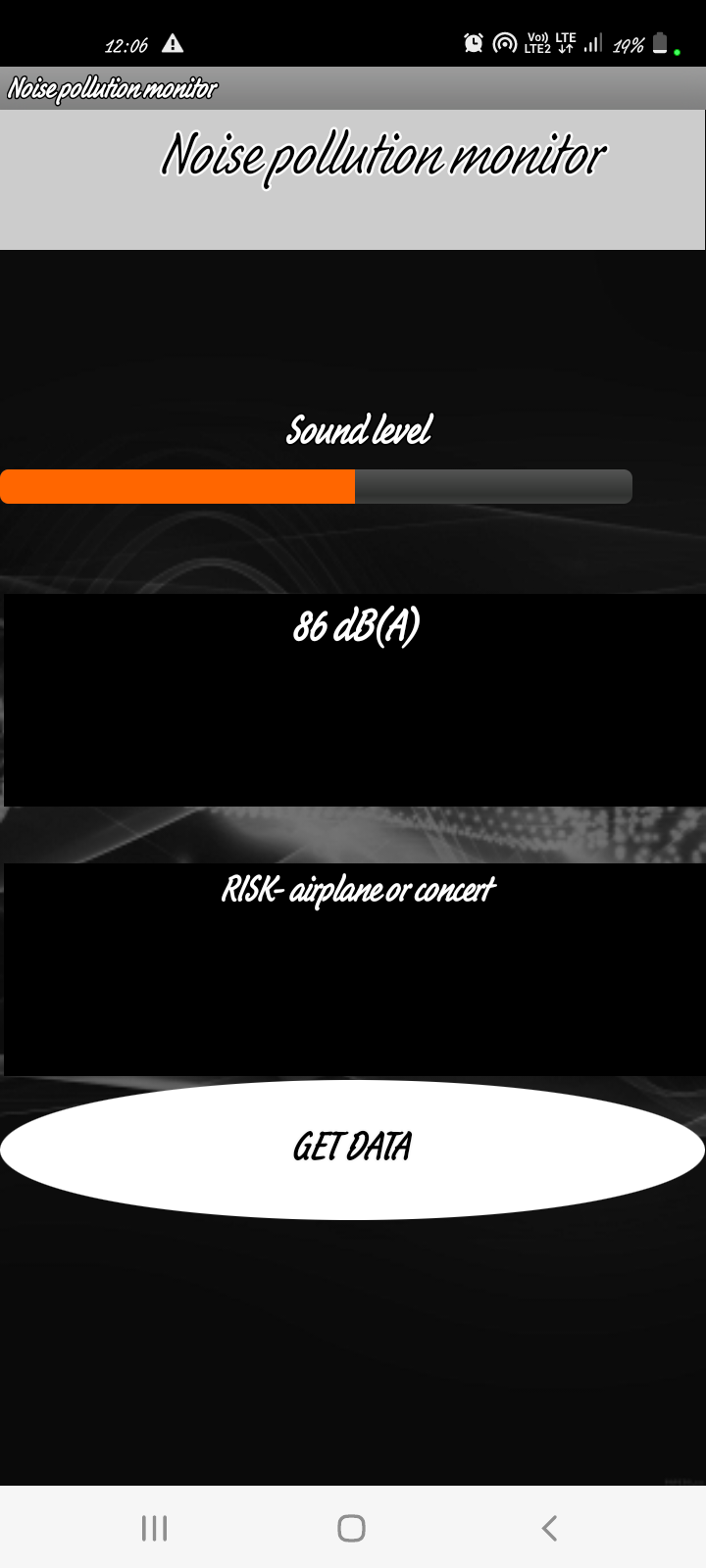




Output from the app:



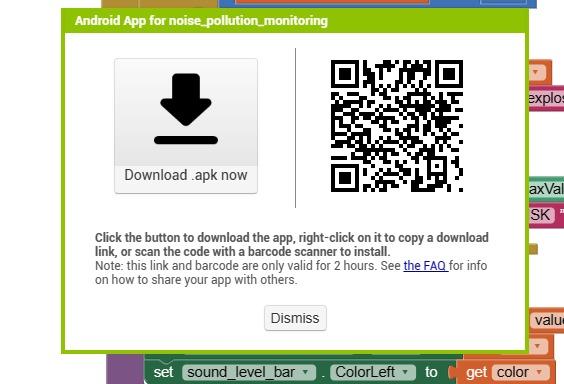




The sound level changes the colors of the lever to indicate the risk in the atmosphere.

This app helps to detect real time noise pollution monitoring and warns people.

QR code to download the app



Noise pollution is the excessive and harmful sound that affects the health and well-being of humans and animals. This project aims to develop a noise pollution monitoring system using ultrasonic sensors, ESP32 wifi modules, and microphones. The system can measure the sound pressure level (SPL) in decibels (dB) at different locations and compare them with the permissible limits. It can also detect and locate the sources of noise pollution using time difference of arrival (TDOA) and triangulation methods. The system can send the sound data to a cloud platform or an app, where it can be stored, analyzed, and visualized. The system can also alert the authorities or take corrective actions based on the noise levels. The system has some advantages over other types of sensors, such as low-cost, easy-to-use, wireless communication, high-performance, and less affected by ambient noise and weather conditions. The system can be used for occupational noise exposure assessment, environmental noise mapping, and noise source identification and localization.

THANK YOU