A Mini Project with Seminar On

Air Quality and Hazardous Gas Detection using IoT for Household & Industrial Areas

Submitted in partial fulfilment of the requirements for the award of the

BACHELOR OF TECHNOLOGY

IN

Department of Computer Science and Business System

BY

Gopaldas Steven	**20241A3223**
Teddu Lokesh	**20241A3256**

Under the Esteemed guidance of

Ms. V. Vishnu Priya

Assistant Professor

Department of Computer Science and Business System

GOKARAJU RANGARAJU INSTITUTE OF ENGINEERING AND TECHNOLOGY

(Approved by AICTE, Autonomous under JNTUH, Hyderabad)

Bachupally, Kukatpally, Hyderabad-500090

2022

GOKARAJU RANGARAJU INSTITUTE OF ENGINEERING & TECHNOLOGY

(Autonomous)

Hyderabad - 500090

CERTIFICATE

This is to certify that the mini project entitled "**Air Quality and Hazardous Gas Detection using IoT for Household & Industrial Areas**" is submitted by **G. Steven (20241A3223) and T. Lokesh (20241A3256)** in partial fulfillment of the award of degree in BACHELOR OF TECHNOLOGY in Computer Science and Business System during Academic year 2022-2023.

'

Internal Guide	Head of the Department
Ms. V. Vishnu Priya	**Dr. G. Karuna**

External Examiner

ACKNOWLEDGEMENTS

There are many people who helped us directly and indirectly to complete our project successfully. We would like to take this opportunity to thank one and all. First, we would like to express our deep gratitude towards our internal guide **Ms. V. Vishnu Priya,** Department of Artificial Intelligence and Machine Learning Engineering, for her support in the completion of our dissertation. We wish to express our sincere thanks to **Dr. G. Karuna,** Head of the Department**,** and to our principal **Dr. J. PRAVEEN,** for providing the facilities to complete the dissertation. We would like to thank all our faculty and friends for their help and constructive criticism during the project period. Finally, we are very much indebted to our parents for their moral support and encouragement to achieve goals.

G. Steven (20241A3223)

T. Lokesh (20241A3256)

DECLARATION

We hereby declare that the mini project titled **"Air Quality and Hazardous Gas Detection using IoT for Household & Industrial Areas"** is the work done during the period from **8th August 2022 to 9th December 2022** and is submitted in the partial fulfillment of the requirements for the award of degree of Bachelor of Technology in Computer Science and Business System from Gokaraju Rangaraju Institute of Engineering and Technology (Autonomous under Jawaharlal Nehru Technology University, Hyderabad). The results embodied in this project have not been submitted to any other University or Institution for the award of any degree or diploma.

G. Steven (20241A3223)

T. Lokesh (20241A3256)

ABSTRACT

The detection and monitoring of hazardous gases is essential for ensuring the safety of individuals in various settings, such as industrial environments and residential areas. gas detectors detect gases like LPG, NH3, alcohol, NOx, Benzene, CO2, Alcohol, Propane, Hydrogen, Methane, Carbon Monoxide, and smoke in the area around them. In this study, we present a system for real-time detection and monitoring of hazardous gases using MQ135 and MQ2 sensors. The system consists of a monitor that is placed in a fixed location and a mobile device that can be carried by the user. The MQ135 sensor is used to detect gases such as ammonia, while the MQ2 sensor is used to detect gases such as carbon monoxide and hydrocarbons. Each of these gases is known through the Parts per Million (PPM) values and can be determined which gas it is. The system utilises a microcontroller to process the sensor data and display the gas concentrations on a user interface. The mobile device also has the capability to alert the user and send notifications through an accompanying app if the gas concentrations exceed a predetermined threshold. The system is reliable, accurate, and easy to use, making it an ideal solution for detecting and mitigating the risks associated with hazardous gases in various settings. The system was tested in various environments and was able to accurately detect and monitor the presence of hazardous gases and it is a reliable and convenient solution for detecting and monitoring hazardous gases in real-time.

LIST OF FIGURES

TABLE OF CONTEXT

LIST OF TABLES

List of Abbreviations:

1. **IoT -** Internet of Things
2. **ARPANET -** Advanced Research Projects Agency Network
3. **IEEE -** Institute of Electrical and Electronics Engineers
4. **CX -** Customer experience
5. **MCU** - Microcontroller Unit
6. **SPI -** Serial Peripheral Interface
7. **USB -** Universal Serial Bus
8. **API -** Application Program Interface
9. **Wi-Fi -** Wireless Fidelity
10. **GND -** Ground
11. **mW -** milliWatt
12. **°C** - celsius
13. **µA -** micro Ampere
14. **Mm -** millimeter
15. **LED -** Light Emitting Diodes
16. **IR -** Infrared Rays
17. **Hz -** Hertz
18. **kHz -** kiloHertz
19. **VDC -** Volts of Direct Current
20. **MEMS -** Micro-electromechanical systems
21. **NFPA** - National Fire Protection Association

CHAPTER 1

Introduction To Internet of Things

1.1 Introduction

The term "Internet of Things" or IoT describes a system of interconnected objects or entities that includes sensors and intelligence and is connected to a network used to describe a system of interconnected objects or entities that includes sensors and intelligence and is connected to a network order to implement automated software. Computer scientist Kevin Ashton first used the phrase "Internet of Things" in 1999. He developed the concept of utilizing RFID chips on objects to follow them along the supply chain while he was employed with Procter and Gamble.

Figure 1. Internet of Things (courtesy: Source [1])

In order to catch the attention of executives, he utilized the phrase "Internet," which was a popular topic of discussion at the time. IoT has emerged as one of the most key inventions in the entire globe, therefore his strategy of leveraging the phrase appears to have been successful. Figure 1 is a typical representation of how IoT connects all the devices and they are used in a wide range of applications and can save time and money, ranging from security systems to the broader agriculture sector.

1.2 History

The concept of combining sensors and expertise to automate a process has been discussed since the 1980s, even if the word "IoT" didn't exist until the early 2000s. At the time, some students at Carnegie Mellon University were engaged in modernizing a Coca-Cola vending machine so that it could monitor the stock inside the machine and the temperature of the soda cans without human intervention. Despite the innovative notion, they could only make limited advancements because they were only able to make limited advancements because of the heavy hardware and low computer power available at the time.

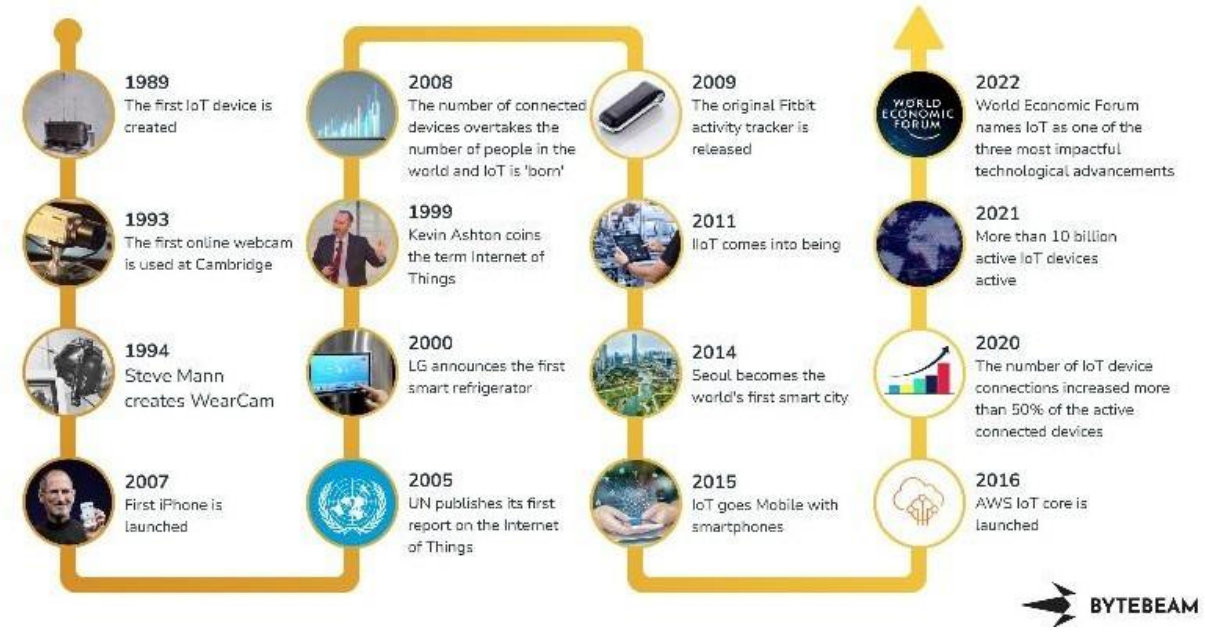

Figure 2. History of IoT (courtesy: Source [2])

But as the decade progressed, more and more IoT-related devices started to appear on store shelves as consumers started to become interested in it. The first "smart" refrigerator was introduced by LG in 2000, and Apple unveiled the first iPhone in 2007. IoT has dominated the IT industry in less than 50 years, with more IoT devices on the planet in 2008 than people. As Google did when it introduced its Nest smart device in 2011, many firms have entered the Internet of Things sector. Google began developing autonomous vehicles in 2009 as well, but Tesla won the race when it introduced its autopilot vehicles in December 2015.

1.3 Working Principle

IoT, which connects numerous objects to the Internet at once, is doing the same thing that the World Wide Web (Internet) did to connect us and transform how we work and communicate. is to strengthen this connection. the promotion of human-machine interaction The person who came up with this idea also discovered that the IoT ecosystem might be used for commercial purposes in industries including healthcare, retail, automotive, industrial, and home automation.

The working of any devices used in ecosystems can be done by using some smart devices like processor, sensor and computer hardware. These devices can collect the data from our environment and provide it to the related edge or device. The devices can communicate with each other and also transfer the data from one to another. It is dependent on nature, On tools or software that helps in retrieving data or by simplifying the method of using that component.

In the following are the major working factors of :

Sensors: IoT is not known without the component named sensor. Sensors help in collecting live data from the external environment, simply senses or detects the actions of the objects in the environment.

AI: After collecting the data enhances concepts or algorithms of Artificial Intelligence to detect when similar objects come by. Suppose when you have an enhanced refrigerator which detects when milk is being placed, etc.

Connectivity: Connectivity in is an essential factor which helps in connecting or networking components with the platform of , It can be a server or cloud. Devices require quick messaging between cloud and the devices in order to maintain efficiency, secure and Bi-directional contact.

Data Processing Analysis: After collecting the data and transferring it to the cloud, Software helps process the data.

Big Analog Data: Analog Data represents the natural and physical world and is everywhere the world and it will also be part of everything like ex: light, sound ,temperature, voltage,radio signals,moisture,vibration,velocity,wind,motion,acceleration,particulates,magnetism,current, pressure etc. It is the oldest, fastest and biggest data.These analog data deals with differently than the Digital data.

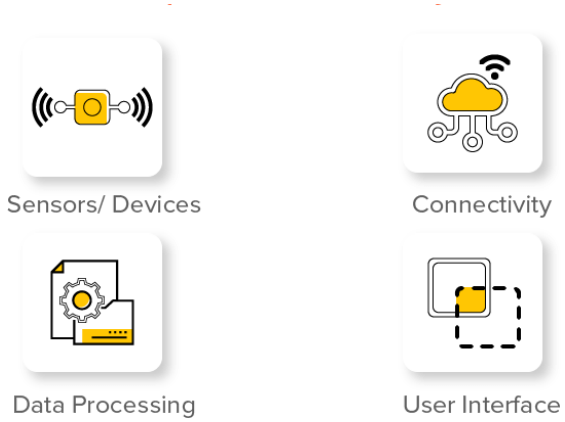

Figure 3. IoT Ecosystem Components (courtesy: Source [3])

Perpetual Activity: The iot is always connected to these 'perpetual activity' to products and users and mostly in three ways we can get benefits from these perpetual activity.

Monitor: It provides continuous monitoring which provides ongoing and real-time knowledge of the condition and usage of a product in marketing.

Maintain: By the impact of these continuous monitoring we can push upgrades, fixes, patches, and management as needed.

Motivate: Constant ongoing and connection to consumers or workers gives organizations a way to motivate others to take some action ,purchase a product.

Deployment

1. Connectivity

When integrating devices, applications, and cloud platforms, it is the main worry. A connected device with valuable information is very valuable. However, when IoT sensors are needed to taking the necessary data and information, weak connectivity becomes a problem.

2. Cross-Platform Capabilities

IoT applications must be created with the consideration of upcoming technology advancements. A balance between hardware and software components is necessary for its development. IoT application developers face a difficulty in ensuring that hardware and platform drivers deliver the optimal performance despite rising device rates and its fixes.

3. Data Collection and Processing

Data will be crucial to the growth of the Internet of Things. The processing or usability of the stored data is more crucial in this case. Development teams should carefully prepare how data is gathered, maintained, or handled within the environment, in addition to security and privacy.

1.4 Distinct Applications of IoT

Organizations can benefit from the Internet of Things in numerous ways. Some benefits apply to all industries, while others are industry-specific. The following are among the common advantages of IoT for businesses:

- Monitor the entire business process.
- Improve employee productivity.
- Generate more sales
- Consolidation and adaptation of business models.
- Make better business decisions
- Improving the customer experience (CX).
- Save time and money.

Real life Applications

There are numerous potential applications for the internet of things when it is combined with other potent technologies like collaboration tools and CPaas (Digital Age Network Solutions). At CarnegieMelon University, the first Internet of Things device was created in the early 1980s. It devised a plan to install a Coca-Cola vending machine on its campus. In today's technology-driven world, working with IoT offers countless opportunities. Many industries, including social media, health, transportation, and medicine, are implementing IoT applications. Depending on the needs of the sector, IoT solutions have different advantages and requirements. Healthcare, Business analytics, transportation, and smart homes and cities are a few examples of domains. IoT offers a wide range of crucial applications in sectors like

1. Healthcare & Medical area

IoT applications are primarily used in the healthcare industry to collect statistical data that can be used to further automate and manage medical procedures. IoT market share climbed from $298 billion in 2014 to $700 billion in 2017, claims a recent report. IoT technology are integrated into wearable and implantable medical equipment to monitor and better patient situations. Investors and the general public will get a variety of advantages from his IoT developments in medicine and healthcare. Millions of people will daily gain from more effective health monitoring systems, which will result in a reduction in the overall cost of life-sustaining care. Methods to lower Childhood obesity was put out during the 2018 IoT Annual Meeting. A robot that uses sensors implanted on a child's chest to gather medical data was created with the aid of AI. Additionally, online surveys regarding individuals diets, levels of physical activity, and other environmental factors were distributed. One illustration of his cutting-edge IoT capabilities in healthcare is this.

2. Wearable Technologies (Technology for the Body)

The most popular term for wearable technology is "wearables." People can track and analyze their personal information by wearing wearables, which are physical technologies. Everything in the modern world is a smart device. Wearable technology has probably benefited the healthcare sector. Patients who use smart devices can monitor their vital signs such as blood pressure and body temperature. Examples can be of Fashion garments, gaming and health fitness wearables.

3. IoT for automation

The Internet of Vehicles (IoV) has recently been growing quickly. The full potential of the Vehicle Internet is being pursued by numerous researchers and groups, who are investing a lot of time and money in this endeavor. The idea of a connected car is rapidly approaching reality. IoT will revolutionize the game and close the present gap between the software and car industries. Creating a network of moving vehicles and objects like traffic signals in order to establish communication between them is the basic idea underlying the linked car concept. A traffic management system that eventually replaces the current traffic light system can be created with the use of vehicle to vehicle and vehicle to network technology.

4. Water Supply

Smart Water employs this technology to keep an eye on and gauge water quality, save water supplies, and help cities run more smoothly. Water meters that are online are connected externally via a sensor, which aids in data collection and analysis. This approach enables us to comprehend consumer behavior as well as supply service flaws. Examples for this can be

- Water quality
- Fisheries
- River and reservoir levels
- Detection of chemicals in water.

5. Smart Home automation and Smart Cities

Improved and better living conditions are provided through smart city IoT applications. IoT will be crucial to managing cities and populations as technology and population both advance. For reasons of cost-effectiveness and sustainability, many services, including energy-saving lights, weather systems, and street lights, will be incorporated into IoT solutions. Recently, home automation has expanded quickly. Customers have benefited from services like voice control, smart air quality changes, AI interactions, and IoT- enabled smart locks in buildings, as well as lighting management for their houses. The security benefits of smart home technology are what draw most people to it. For instance, inside lights can be monitored with a basic IoT device while you're gone, this feature will detect burglars. This application allows you to set up a webcam for home monitoring. The key benefit is that you can do it remotely.

6. Manufacturing

Manufacturing is another key IoT winner. IoT helps the manufacturing sector plan, manage, and analyze processes more effectively. IoT helps manufacturers better see and comprehend their operations. Thanks to RFID and GPS technologies, manufacturers can easily track their items from the starting point to the ultimate destination. IoT helps the manufacturing sector generates more money.

Examples can be Productive maintenance, Supply chain management and movement of goods.

7. Smart Grid

Installation of a smart grid Utility firms are utilizing IoT to distribute energy more effectively. Energy meters, transmission lines, production facilities, and distribution terminals all have the proper sensors installed. The smart grid is the name of this IoT system. Smart Grids make use of the Internet of Things in a variety of ways. At any point during power transmission, they produce a power failure alert. Anomalies in The lines are found using sensors. They keep statistics on peak usage and power consumption. They gather information on consumption at the regional, corporate, and individual levels. When a node is lost during transmission, they can identify it. They are able to locate inefficiencies precisely. Users on a daily basis can assess their energy usage and reduce their carbon footprint.

8. IoT in Education

The education industry is one of the most adaptable and successful when it comes to using IoT devices. Students have reliable access to everything they need to learn, including communication channels and comprehension, thanks to IoT devices. They also give educators the ability to follow students' academic development in real time. Smart boards, Distance learning and Close monitoring can be examples as applications of IoT.

1.5 Advantages of IoT

- Access your information anytime, anywhere, on any device.
- Improved communication between connected electronic devices.
- Sending data packets over connected networks saves time and money.
- Automate tasks to help organizations improve quality of service and reduce the need for human
- Intervention.

Figure 4. Advantages IoT produce (courtesy: Source [4])

1.6 Challenges in Building IoT- based Systems

- As the number of connected devices increases and more information is exchanged in prolong between them, the potential for hackers to steal sensitive information also increases.
- An organization may have to deal with a huge number of (possibly millions) IoT devices, and it is difficult to collect and manage data from all these devices.
- Any device connected to the can be damaged if the system fails.
- The lack of an international standard for IoT compatibility makes it difficult for devices from different manufacturers to communicate with each other.

The Internet of Things (IoT) has rapidly become a big part of people's lives, communications and businesses. Across the globe, Internet-enabled devices are transforming our global entitlement into a larger, empowered realm.IoT faces many kinds of challenges, and the following can be the Security Challenges in IoT

1.Increased with more devices

Ransomware uses encryption to effectively lock users out of various devices and platforms, but uses users' valuable data and information. Example – A Hacker can hijack your computer's camera and take pictures. Malware Access Points allow hackers to demand a ransom to unlock your device and return your data.

2. Brute force and default password risk

Weak credentials and credentials make almost all IoT devices vulnerable to password hacking and brute force. An organization that uses factory-default credentials on devices puts both its business and his assets, and its customers and their valuable information, at risk of being vulnerable to brute force attacks.

3. Inadequate Testing and Updates

As IoT devices become more prevalent,IoT manufacturers strive to manufacture and ship the devices as quickly as possible, but offer too little security. there is no. Most of these devices and IoT products have not received sufficient testing and updates and are vulnerable to hacking and other security issues.

4. Lack of encryption

Encryption is a great way to prevent hackers from accessing your data, but it is also one of the major IoT security challenges.These drives are similar to the storage and processing capabilities found in traditional computers. As a result, there is an increasing number of attacks where hackers can easily manipulate algorithms designed to protect them.

1.7 Drawbacks

1. Increased Cost and Time to Market

Embedded systems have a minor cost constraint. When designing IoT devices, a better approach needs to be taken to address cost modeling and optimal costing of digital electronic components. Designers also need to solve design time issues and boot embedded devices at the right time.

System Security

Systems should be designed and implemented to be robust, reliable, and secure with cryptographic algorithms and security procedures.Covers different approaches to securing all components of an embedded system, from prototype to deployment

2. Battery Life

The issue of integrating a compact chip with a low density and low power consumption into a battery is a packaging limitation. If you keep up with the mobile industry, you've surely noticed that screen size seems to have no upper bound. For instance, "phablets," which resemble tablets in size, are becoming more popular. A huge display is practical, but its benefits don't always lie in the fact that the larger battery has allowed for a larger screen. Even while computers are becoming more compact, their battery life is unchanged. The issue of integrating a compact chip with a low density and low power consumption into a battery is a packaging limitation.

If you keep up with the mobile industry, you've surely noticed that screen size seems to have no upper bound. For instance, "phablets," which resemble tablets in size, are becoming more popular. A huge display is practical, but its benefits don't always lie in the fact that the larger battery has allowed for a larger screen. Even while computers are becoming more compact, their battery life is unchanged.

Failures of IoT in Real-life

- **Dyn Attack**

1. An IoT botnet was used to execute the worst DDoS assault against service provider Dyn ever back in October 2016. As a result, several websites were offline, including CNN, Netflix, Reddit, Twitter, and the Guardian.
2. This Internet of Things botnet was made possible by the software Mirai. After becoming infected with Mirai, computers continuously scour the internet for susceptible IoT devices before infecting them with malware by logging in using well-known default usernames and passwords. Digital cameras and DVR players, for instance, were among these devices.

- **Webcam Hack**

1. Furthermore, TechNewsWorld claims that TRENDnet "marketed its SecurView cameras for numerous applications ranging from home security to baby monitoring and claimed they were secure, the FTC stated. Keeping with the baby theme, TRENDnet said the cameras were safe. They had flawed software, though, so anyone with access to a camera's IP address could view it and occasionally even listen.
2. Additionally, the FTC claimed that TRENDnet's mobile applications for the cameras saved customers' login details in plain, readable language on their mobile devices from at least April 2010 [until roughly January 2012] and sent user login credentials in clear, readable text over the Internet.
3. It is standard security procedure to safeguard IP addresses from hackers and to encrypt or at the very least password-protect login credentials, therefore TRENDnet's inability to do so was unexpected.

- **Hackable Cardiac Device**

1. The FDA acknowledged that St. Jude Medical's implanted cardiac devices contain flaws that might give a hacker access to a device, according to a 2017 CNN report. The FDA warned that once inside, they may drain the battery or deliver improper pacing or shocks.
2. The tools, which include pacemakers and defibrillators, are used to track and manage a patient's heart health and avoid heart attacks.
3. The transmitter that reads the device's data and wirelessly communicates it with doctors included a vulnerability, the story added. The FDA said that by gaining access to a device's transmitter, hackers may control it.

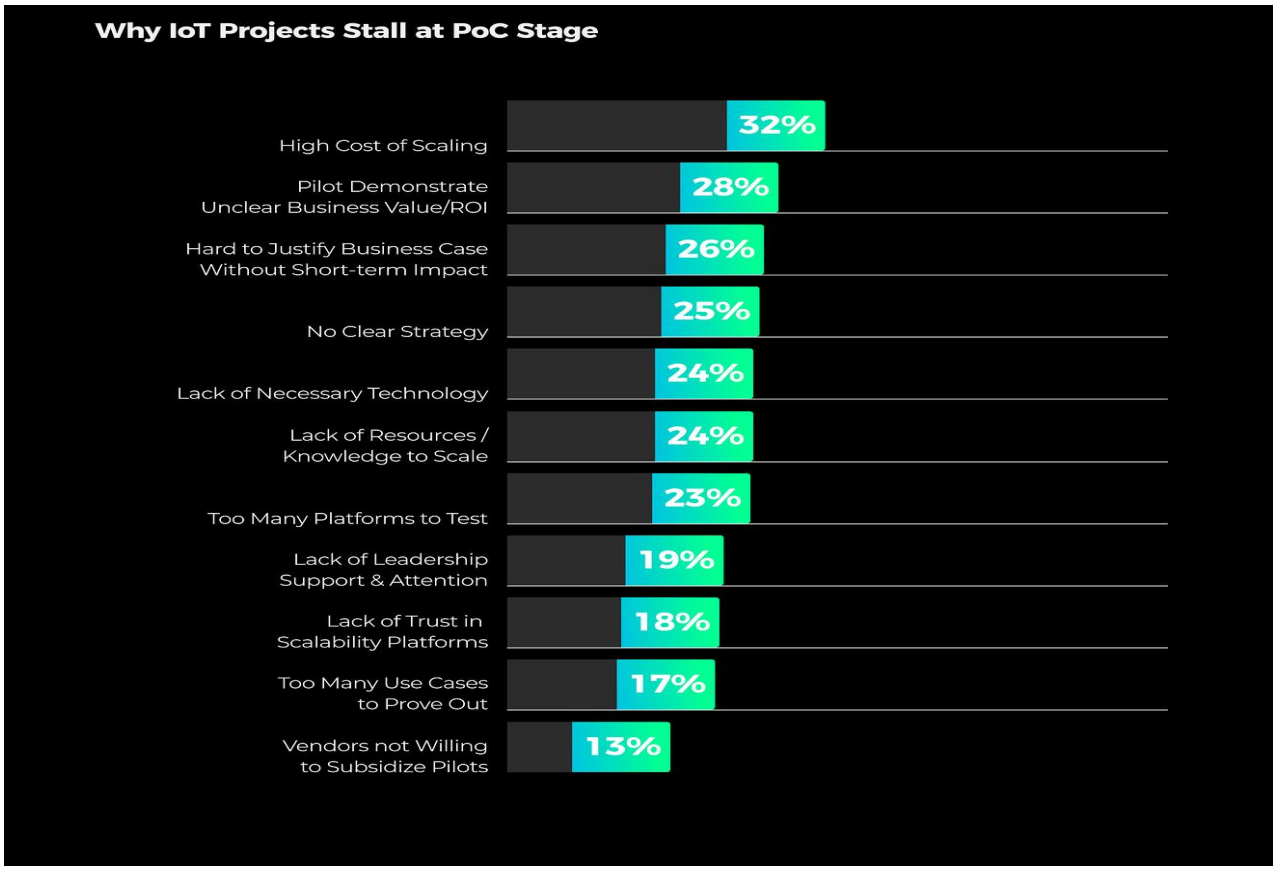

Figure 5. Failures of IoT in various stages (courtesy: Source [5])

The Figure explains why IoT projects fail in real life through percentage.

Chapter 2

Literature Survey

2.1 Existing Approach

Sourav Debnath, Samin Ahmed, Suprio Das, Abdullah-Al Nahid, Anupam Kumar Bairagi has worked on detection of Gases, proposed project title is “IoT based Low-Cost Gas Leakage, Fire, and Temperature Detection System with Call Facilities” [1] which was published in November 2020. Their main objective was on building a low-cost system that detects and alerts the user about the leakage.

The following are some of the objectives of their project proposal

Goals

- To develop a model that is Low-cost gas detection system sensors
- Alert users through phone call and also graphical alert on web server
- To apply machine learning to know accuracy of the sensors stakeholders

Components used

- Esp32, flame, MQ2, gsm sensor, dht11 and buzzer

Block Diagram

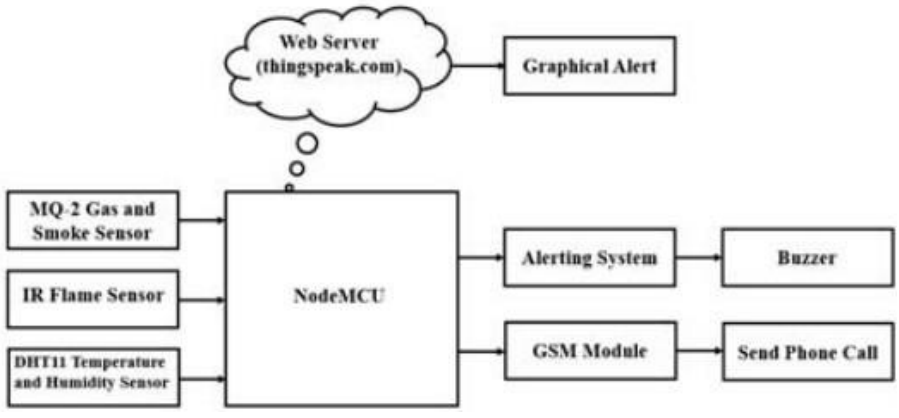

Figure 6. Block Diagram of Existing approach [1](Courtesy: Source [6])

Gagan Parmar; Sagar Lakhani; Manju K. Chattopadhyay has worked on detecting quality of the air, proposed project title is “An IoT based low cost air pollution monitoring system” [2] which was published in October 2017. Their main objective was on building a low-maintenance and low-cost system that produces continuous values of gas concentration.

The following are some of the objectives of their project proposal

Goals

- To measure concentrations of gasses such as CO, CO2, SO2 and NO2 using semiconductor sensors
- Realization of data is gathered by sensors it is displayed on Raspberry pi 3 based Web Server
- To provide low cost infrastructure to enable the data collection and dissemination to all stakeholders

Components used

- Raspberry pi 3, Nucleo F401REtx, ESP8266, MQ135 and MQ7.

Block Diagram

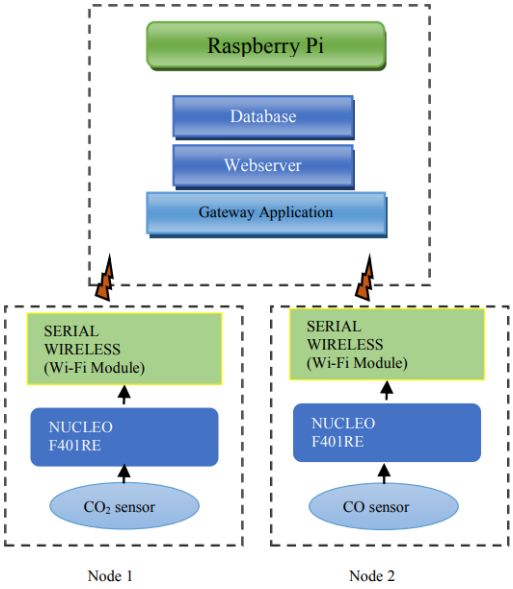

Figure 7. Block Diagram of Existing approach [2] (Courtesy: Source [7])

Anand Jayakumar A1, Praviss Yesyand T K2, Venkstesh Prashanth K K3, Ramkumar K4 Chattopadhyay has worked on developing air pollution monitoring system, proposed project title is “IoT Based Air Pollution Monitoring System" [3] which was published in March 2021. Their main objective was to build a system in which users can monitor the pollution level from anywhere using their computer or mobile device.

The following are some of the objectives of their project proposal

Goals

- To build a system using MQ2 and MQ7 sensor for monitoring Air Quality
- Also to show the air quality in PPM on the LCD and also as on webpage

Components used

- Raspberry Pi, MQ2 and MQ7.

Block Diagram

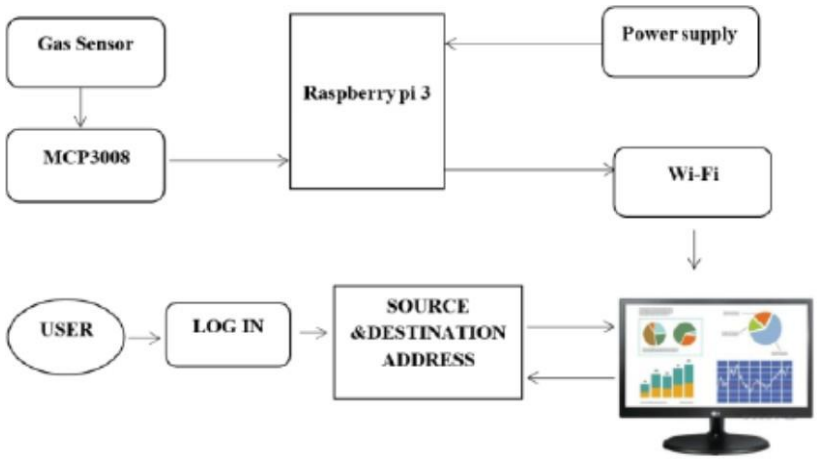

Figure 8. Block Diagram of Existing approach [3] (Courtesy: Source [8])

2.2 Description of various Sensors and Components

ESP32

Esp32 is a feature-loaded MCU with integrated Wi-Fi and Bluetooth connectivity for a wide-range of applications. In the present era This component is mostly used in IoT projects and its related applications. Generally IoT devices built using ESP32 include; smart energy devices, smart security devices, and smart industrial devices. For our mini-project in the domain of IoT, we use ESP32. Because of its wide range of options and is compatible with many sensors. It stands out from other sensors as it provides advanced features such as

Hybrid Wi-Fi & Bluetooth Chip

ESP32 has a dual compatibility which means it can act as a slave to the host MCU or can also function as a standalone device, because of this the communication stack overhead on the main application processor can be reduced significantly. ESP32 interacts with other systems via I2C / UART or SPI / SDIO interfaces to provide Bluetooth and Wi-Fi functionality.

High Level of Integrity

The ESP32 is the best choice for many IoT related projects as it is integrated with many HandsOn technologies and features. It requires a very low Printed Circuit Board (PCB) as it is integrated with many features such as an in-built antenna, low noise receive amplifier, switches, RF balun, filters, power amplifier, and power management modules and so on which makes ESP32 priceless. The below figure 7 is the Node MCU model.

Figure 9. Esp32 Node MCU (courtesy: Source [9])

Ultra-Low Power Consumption

For instance we take a watch, smart watch(for example), it's frustrating to have a microcontroller which drains a lot of power and battery, Engineered for mobile devices, wearable electronics and IoT applications.ESP32 consumes ultra-low power with a combination of several kinds of exclusive software. ESP32 also includes a wide range of features, such as fine-grained clock gating, various power modes and dynamic power scaling.

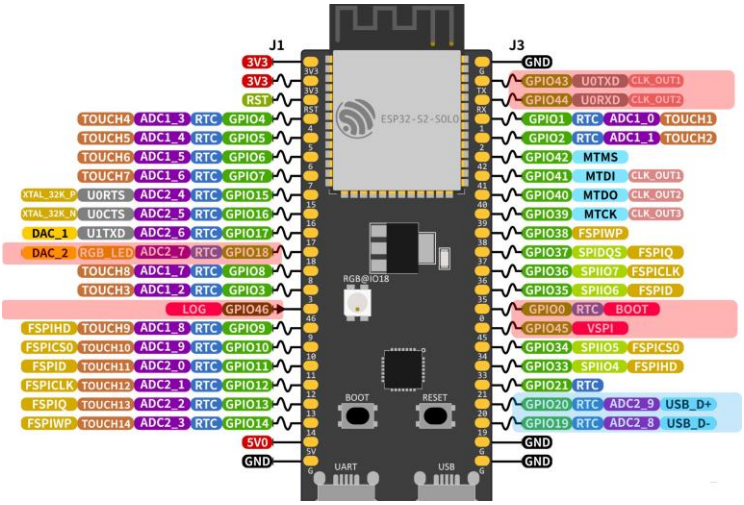

Figure 10. Esp32 Pins (courtesy: Source [10])

ESP 32 has the following features

- Wi-Fi (2.4 GHz band)
- Bluetooth
- Dual high performance Xtensa® 32-bit LX6 CPU cores
- Ultra Low Power co-processor
- Multiple peripherals

Software that is required to use the Node MCU

- Toolchain to compile code
- To develop a complete application we use the build tools CMake and Ninja.
- The ESP-IDF package, which primarily consists of toolchain management scripts and the ESP32 API (software libraries and source code)

MAX30102 (Pulse Oximeter & Heart-Rate Sensor)

Function :- This sensor is used to measure the heart beat as well as the blood oxygen level.

The MAX30102 sensor is used to measure the pulse(generally referred as heart rate) and also the SPO2 levels(blood oxygen levels) of a person with utmost accuracy.

The MAX30102 contains internal LEDs,low-noise electronics, photodetectors and optical elements with ambient light rejection.The MAX30102 sensor comes in handy for design-in process for mobile and small wearable devices (like smart watches) making the tasks easy and less clumsy.

Uses of MAX30102 sensor

- Smart phones
- Wearable devices
- Fitness gadgets
- Tables

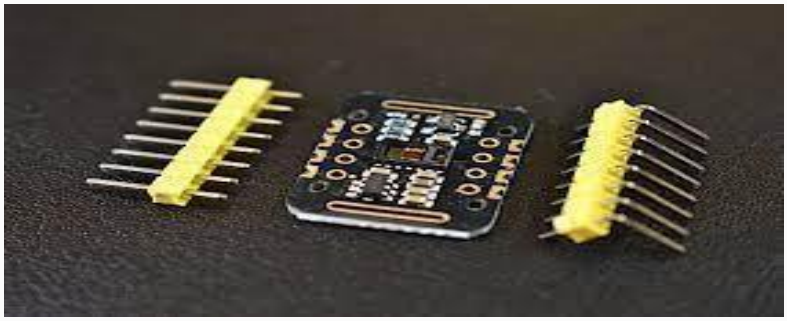

Figure 11. MAX30102 sensor (courtesy: Source [11])

The Advantages of MAX30102

- With simple technology such as the LED Refractive Solution we can monitor heart rate as well as the blood oxygen level**.**
- Works under extreme temperature conditions such as as low as -40°C and even as hot as +85°C.
- The MAX30102 provides fast data outputs.
- MAX30102 operates on low power
  - For power savings, programmable sample rate and LED current
  - Heart rate is measured at very low power consumption (< 1mW)
  - Very low consumption of Shutdown Current (0.7µA)

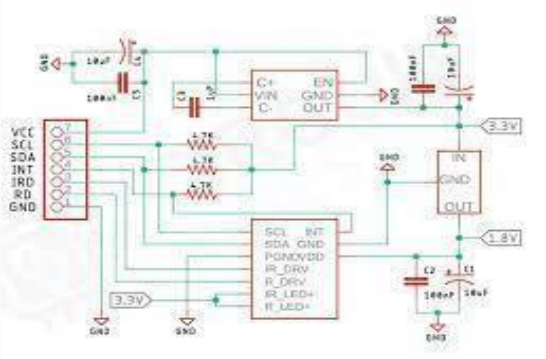

Figure 12. MAX30102 System Diagram (courtesy: Source [12])

MAX30102 Arduino Library

The communication between Arduino and MAX30102 is handled using a library from Sparkfun. The high-speed reading of the IR and red reflectance data will be handled by the Sparkfun library.

- The Arduino IDE contains
  - Open Sketch, choose Include Library, and then click Manage Libraries.
  - In the search box, enter "max30".
  - On your PC, save the "Sparkfun MAX3010x Pulse and Proximity Sensor Library" file.

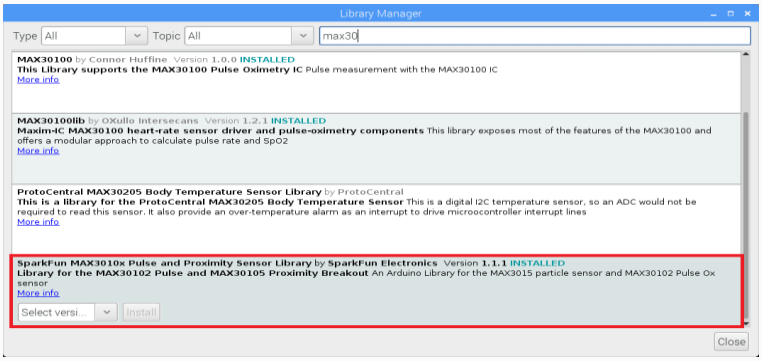

Figure 13. MAX30102 Library (courtesy: Source [13])

Ultrasonic Sensor

Description

The sensor's name suggests that it has something to do with ultrasonic waves, which is what it does. Yes, the ultrasonic sensor is a sensor that measures the separation between two objects using ultrasonic waves. The common optical sensor, which has a transmitter and receiver to send and receive waves accordingly, is in contrast to the ultrasonic sensor. The Ultrasonic Sensor, in contrast, is made up of a single component that may function as both a wave emitter and receiver. In order to maximize space and improve sensor compatibility, this form of circuit design has been specifically created to eliminate all kinds of extraneous components.

Working

Distance Calculation Since the Ultrasonic sensor's goal is to determine distance using signals that are emitted by the sensor and then received back, it must make sure that the sensor maximizes compatibility while also delivering incredibly accurate results. In order to do so, the Distance formula is applied:

Distance D = 1/2xTxC is a formula.

Where:

D -> the distance to be determined.

T -> The amount of time between sending and receiving waves.

C -> Sonic Wave Speed

Applications

- Chemical plants to ascertain the precise measurement of the liquid level.
- Robot sensing
- Automobile assembly
- Beam detection.
- Drink filling machines that stop the corresponding liquid output when the bottle reaches a specific level.
- Car washing.
- The use of speed guns to measure vehicle speeds.

Ultrasonic sensor benefits

- The ultrasonic sensor can easily find deeper objects from a distance since it produces very high frequencies.
- Effortlessly integrates with a microcontroller.

Figure 14. Ultrasonic Sensor HCSRO4 (courtesy: Source [14])

Disadvantages

- To operate the sensor properly, engineers and technicians with extensive knowledge are required.
- Ultrasonic sensors must be water resistant or they would be quickly damaged.
- Controls the microcontroller interface, which calls for extremely skilled and experienced programmers.

Performance:

- Range: Under controlled conditions, 0.1% - 0.2% accuracy
- Accuracy: 1% - 3% accuracy.
- Power Consumption: 20mA
- Output Type: Analog
- Pin-arrangement: 4-Pin
- Wave format: Acoustic Weave
- Frequency Modulation: 20Hz - 120kHz
- Response time: 50 ms - 200 ms
- Sensor Range: 40 cm - 300 cm
- Transmission Angle: 5°
- Voltage Range: 20 VDC - 30 VDC

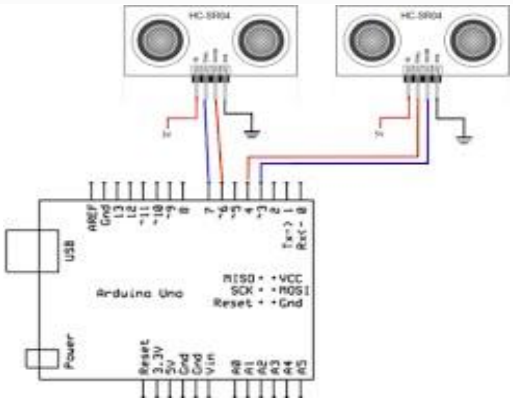

Figure 15. HCSRO4 Sensor Diagram (courtesy: Source [15])

INMP441

The INMP441 is a widely used sensor in various IOT Projects and its numerous applications. The following are some of its features that make it an important part of the project :

- High-Performance
- Low Power
- Digital-Output
- Omnidirectional MEMS microphone with a bottom port

Figure 16. INMP441 Sensor (courtesy: Source [16])

The complete INMP441 solution consists of :

- A MEMS sensor
  - Micro Electro-Mechanical System, or MEMS, a chip technology where between a pair of capacitive plates the sensors are composed in the form of a suspended mass.

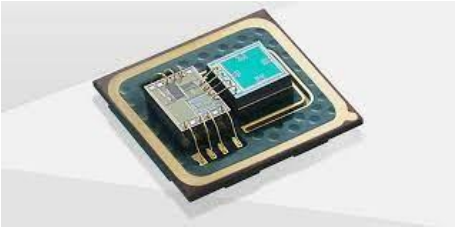

Figure 17. INMP441 Sensor (courtesy: Source [17])

- When tilted, a difference in electrical potential is created by this suspended mass. The measured difference is the calculated change of capacitance.

- Signal Conditioning
  - The exquisite re-construction of the signal that prepares it for the next stage of processing.

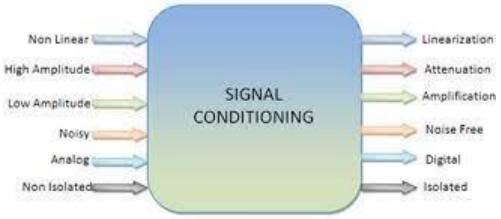

Figure 18. INMP441 Sensor Diagram (courtesy: Source [18])

- Most of its applications involve the structural or environmental measurement, such as vibration and temperature measured by the sensors.
- An analog-to-digital converter translates following
  - analog signals,
  - real world signals like
  - current
  - light intensity
  - voltage
  - distance
  - pressure
  - temperature

Passive Infrared Sensor (PIR)

Description

A PIR sensor essentially functions as a motion detection sensor. By looking at the name, it is clear that the sensor projects infrared rays onto a target item in order to detect motion. The spectrum of infrared rays is broad, and they are also renowned for being simple to employ.

Figure 19. PIR Sensor (courtesy: Source [19])

Working of Passive Infrared Sensor

Any change in heat (infrared) radiation is found using a passive infrared sensor. It works by gathering thermal energy from the surroundings, which is then stored and processed for use in the future. Although this application is often thought of as a system that uses heat detection as its primary capability, the system is also capable of detecting any movement and any temperature that is slightly higher than the ambient temperature. As a result, even cooler things can be seen if they are traveling somewhat more quickly. Since these sensors are typically passive, they can last for over 15 years.

Components of a PIR Sensor

- Lens
- Circuit Board

Performance

- Range: 5m - 12m
- Category: Pyro Electric
- Pin-Arrangement: 3-Pin
- Power Consumption: 5V
- Setting time: 10 sec- 60 sec

Areas of Application

- Outdoor Lighting systems
- Garden Lightings
- Automated Lighting in homes
- Public Lifts & Elevators
- Basement lighting
- Solar Lighting
- Other Automated Lighting-related applications.

Advantages

- PIR Sensors don't require an external implementation or connection, making it more simple to move these sensors from one place to another.
- Since PIR sensors use infrared rays to function, they can detect an object that is warmer than the target temperature even if it is hidden by another object.

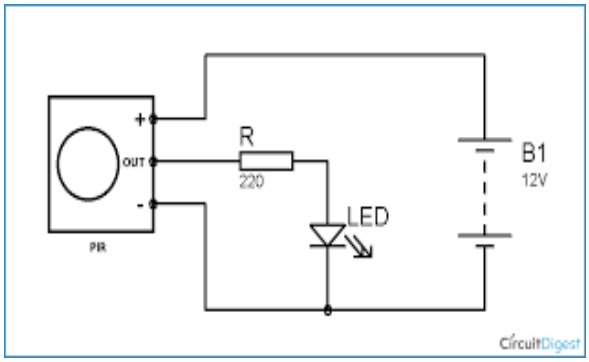

Figure 20. PIR Sensor Circuit Diagram (courtesy: Source [20])

Soil Moisture Sensor

Description

An inexpensive electronic device called a soil moisture sensor is commonly used to measure the moisture content of a specific soil sample. The amount of water in the soil is measured by this sensor. To continue with the components that make up the majority of the soil moisture sensor:

- Sensing Probe: This device checks if current is flowing through the soil and determines the resistance characteristics that correlate to the amount of soil moisture.
- Sensor Module: The Sensor module gathers information from sensor probes and processes it to produce the desired output form (eg. Digital or Analogue).

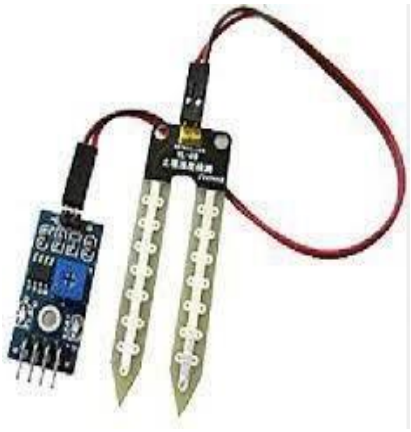

Figure 21. Soil Moisture Sensor (courtesy: Source [21])

PIN Arrangement

- VCC: +5V Supply
- Digital Output: 0 or 1
- Analogue Output: 0 to 1023
- GND: Ground

Areas of application

- Agriculture
- Landscape irrigation
- Simple sensors for gardeners.
- Research

Performance

- Soil temperature: -40 to +80 °C
- Maximal Fluctuation: ±0.5 °C(temperature) and ±5%(moisture)
- Rating: IP66
- Output: 4~20mA
- Accuracy measure: ±2%

Advantages

- Saves Water, Increases yields, and increases the quality of the crop.
- Easier measurement.
- Produces accurate results.
- Low-cost
- Immediate output of results.

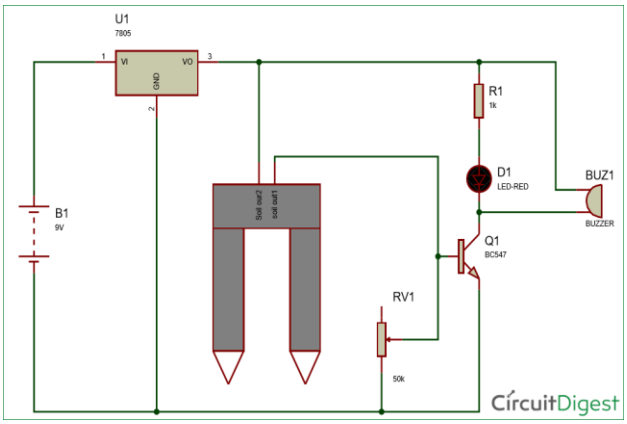

Figure 22. Soil moisture Sensor Circuit Diagram (courtesy: Source [22])

Disadvantages

- Requires skilled personnel for data processing and information gathering.
- Because the output depends on a number of parameters, an in-depth analysis of the inputs and other dependent variables are required.
- There is a considerable likelihood of inaccurate value prediction due to the bigger particles in the provided soil sample.
- Needs each type of soil being utilized to be individually calibrated.

Infrared Sensor (IR)

Description

IR detectors are tiny microchips that include a photocell tuned to hear infrared light. Every TV and DVD player has one of these in the front to listen for the IR signal from the clicker.

They are essentially always used for remote control detection. A matching IR LED is located within the remote control, and it generates IR pulses to instruct the TV to switch on, turn off, or change channels. It requires a bit more effort to evaluate a setup because IR light cannot be seen by the human eye.

PIN Arrangement

- Pin 1 is the output so we wire this to a visible LED and resistor and resistor to it.
- Pin 2 is ground.
- Pin 3 is VCC, connected to 3-5V.

Since the LED is red and easier for us to see than IR, the detector will pull the output low when it detects an IR signal.

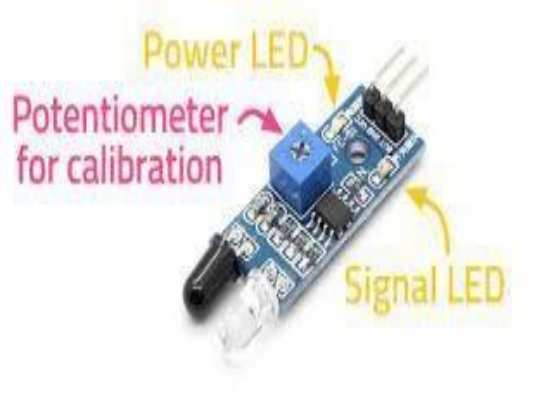

Figure 23. Infrared Sensor (courtesy: Source [23])

Advantages

- Moving objects are read via IR sensors. On moving objects, contact-based temperature sensors perform poorly. For detecting the temperatures of tyres, brakes, and related equipment, infrared temperature sensors are the best option.
- IR sensors are not brittle. Without touch, there is no friction. Infrared sensors have longer operational lifetimes since they don't incur wear and tear.
- IR sensors can offer extra information. By aiming an IR sensor at various locations on the item being read, it can measure an object with more precision than touch devices.
- By monitoring changes in temperature within the area of vision, IR sensors may be utilised to find motion.

Disadvantages

- Hard objects (such as barriers and doors), smoke, dust, haze, brightness, and other factors all affect infrared wavelengths. Therefore, it cannot pass through doors or partitions.
- High-energy infrared rays can damage eyes.
- It can only operate one device at a time in the screen and control application.
- Additionally, controlling objects outside of Line of Sight is challenging (Line of Sight).
- To convey, the transmitter and collector must see one other.
- It is supported by a more constrained reach, and as a result, its execution degrades across greater distances.
- Compared to cable transmission, it maintains a lower information rate.

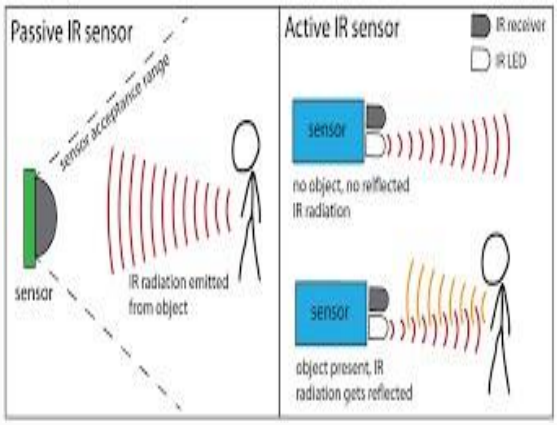

Figure 24. Infrared circuit Diagram (courtesy: Source [24])

Types of IR Sensors

There are two different kinds of IR sensors available active and passive

1. Active infrared Sensor
    - Infrared source and infrared detector are the two components of an active infrared sensor. The LED and infrared laser diodes are examples of infrared sources. Photodiodes and phototransistors are two types of infrared detectors. An item reflects the infrared radiation from the infrared source, which then falls on the infrared detector.

2. Passive Infrared Sensor
    - Infrared detectors are essentially what passive infrared sensors are. Infrared sources and detectors are not used by passive infrared sensors. They come in two varieties: thermal and quantum. Infrared radiation is used as the heat source in thermal infrared sensors. The most popular types of thermal infrared detectors are thermocouples, pyroelectric detectors, and bolometers.

Areas of application

- Climatology
- Meteorology
- Photobiomodulation
- Flame Monitors
- Gas detectors
- Water analysis
- Moisture Analyzers
- Anesthesiology testing
- Petroleum exploration
- Rail safety
- Gas Analyzers
- IR Imaging Devices
- Infrared Tracking
- Radiation Thermometers
- Night Vision Devices

Magnetic Switch

The opening of doors and windows is detected using straightforward magnetic switches. The magnet and a magnetically sensitive switch are the two essential components of a magnetic switch (usually a reed switch enclosed within a glass envelope). Switches can be either generally closed or normally open (close on alarm) (open on alarm). Some can be found in Form-C contacts (your choice of normally open or normally closed, both in one switch).

For any requirement, there are numerous different magnetic switch form factors. There are switches available for surface mounting as well as for hiding inside the door and its frame.
Higher detection performance is offered by infrared quantum type sensors. It is quicker than infrared detectors of the thermal kind. Wavelength affects how photosensitive quantum type detectors are. Better switches may be buried, whereas more affordable switches are typically surface mounted and housed in a plastic box. Switches are designed for special uses like hiding within hollow metal or wood doors. These cannot be used in place of one another.

Figure 25. Magnetic Switch (courtesy: Source [25])

Switches with Balanced Bias
Simple magnetic switches have the drawback that a burglar might be able to place a magnet next to the switch while the door is open, tricking the system into not detecting that the door or window has been opened.

Magnetic switches with a balanced bias are intended for high-security applications. Any disruption in the magnetic field, such as opening a door or window, will result in a change in the state of the magnetic switch since it is suspended in its case between two magnets that are oppositely polarized (one horizontal and the other vertical). The switch will sound an alert if a magnet is placed close to it in an attempt to trick it.

PIN Arrangement

- 1st wire- any I/O
- 2nd wire-GND

Advantages

- Capabilities for simple and dependable sensing and actuation
- Low component weight reduces the risk of overloading delicate electronics
- inexpensive unit pricing
- Low total cost of ownership with high performance
- Generally simple customization
- reliability and effectiveness throughout a long service life
- There is no need for power to operate.
- Low-profile designs for simple integration in locations with limited space

Disadvantages

- For it to function, a separate magnet is needed. Additionally, it is ineffective when the magnet is placed more than a few millimeters from the switch component.
- When coupled with a controller or logic chip, it must be reported.
- Reed switches are not capable of being shrunk like other surface mount chips.
- Glass envelopes are prone to damage.
- Arcing might happen in between encounters.
- It may unintentionally get triggered by other magnetic fields.
- Only ferrous objects can be utilized to detect anything that gets in the way of the magnet or switch.

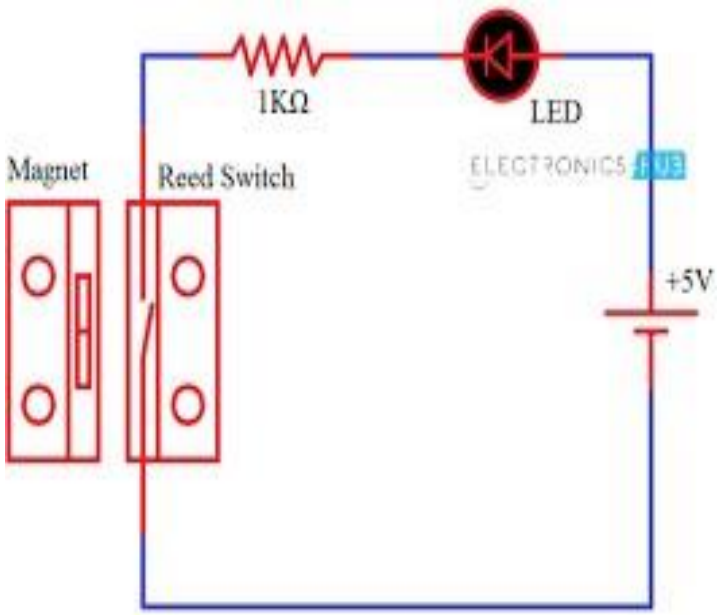

Figure 26. Magnetic Switch Architecture (courtesy: Source [26])

APDS-9960

Description

The Broadcom APDS-9960 is an 8-pin device that combines a digitized RGB, ambient light, proximity, and gesture sensor. Red, green, blue, and clear (RGBC), as well as vicinity and gesture detection via an IR LED, as well as vicinity and gesture detection via an IR LED, are all provided by the device's I2C-compliant interface. The RGB and ambient light sensing capability measures light intensity through various attenuation materials, such as darkened glass, and varying lighting circumstances. Additionally, precise ambient light and linked color temperature detection are made possible by the inbuilt UV-IR blocking filter.

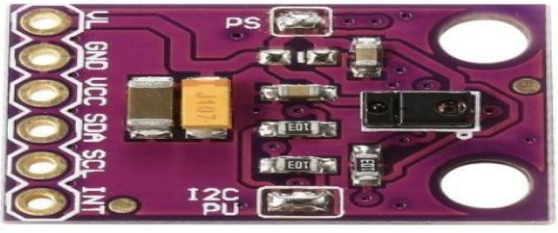

Figure 27. APDS-9960 (courtesy: Source [27])

PIN Arrangement

- Pin-1, SDA. This pin is used for I2C communication.
- Pin-2, INT. This pin is active low during interrupt events.
- Pin 3, LDR. For proximity LEDs, this pin serves as an LED driver input. It links the LED drivers to a steady power supply.
- Pin 4, LEDK. This pin is linked to the LDR pin when utilizing the internal LED driver circuit.
- Pin 5, LEDA. This pin is connected to VLEDA on PCB.
- Pin 6, GND, is a ground pin.
- Pin 7, SCL. To give a clock signal for I2C serial data, utilize this pin.
- Pin 8, VDD. The supply voltage ranges from 2.4V to 3.6V.

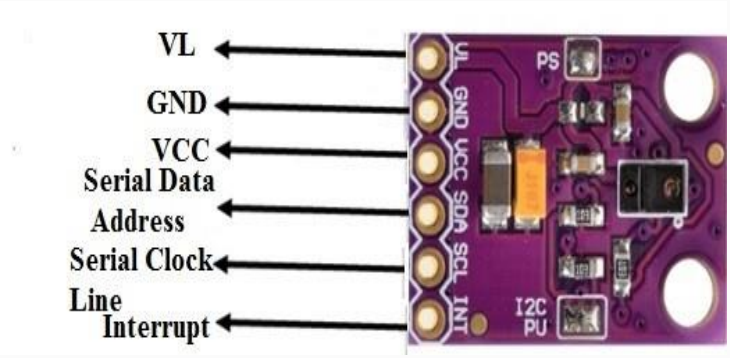

Figure 28. APDS-9960 Pin Diagram (courtesy: Source [28])

Applications

- Numerous functions of the APDS-9960 include proximity sensing, RGB color sensing, gesture detection, and ambient light sensing.
- This gadget is used to replace mechanical switches.
- The APDS-9960's RGB sensor is used to calculate color temperature.
- The proximity detecting engine of the APDS-9960 gadget is used to adjust the brightness of TVs, cellphones, etc.
- The device's many sensor engines are also used by gesture robots.
- in medical technology.
- LCD monitors.
- RGB monitors and APDS-9960 are used for RGB rating.

BMP280

Description

Absolute barometric pressure sensors, like the BMP280, are very practical for mobile applications. It may be used in battery-powered devices like watches, GPS modules, and cell phones because of its tiny size and low power consumption. Based on Bosch's tried-and-true piezo-resistive pressure sensor technology, the BMP280 has a high degree of precision and linearity, long-term stability, and strong EMC resilience. Highest flexibility is guaranteed by a variety of device operation choices. The device is tuned for filter performance, resolution, and power consumption.

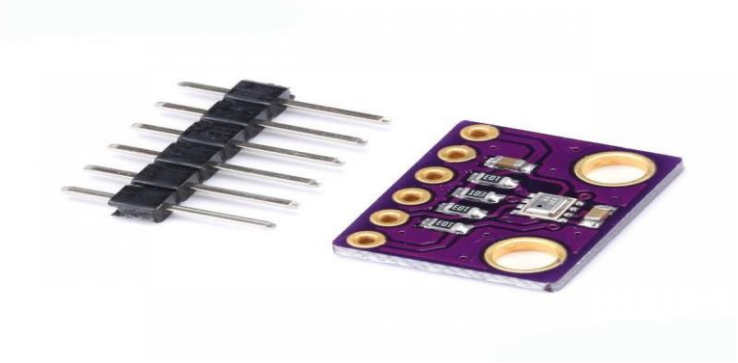

Figure 29. BMP280 Sensor (courtesy: Source [29])

PIN Arrangement

- **PIN 1** VCC- Power source of 3.3VDC
- **PIN 2** GND-Ground
- **PIN 3** SCL-Serial Clock
- **PIN 4** SDA-Serial Data
- **PIN 5** CSB-Output to chip
- **PIN 6** SDO-Serial Data Out

Applications

- Upgrading GPS navigation (e.g. time-to-first-fix improvement, dead-reckoning, slope detection)
- Mobile phones, tablet computers, and GPS devices
- Navigation within (floor detection, elevator detection)
- Applications for outdoor navigation, recreation, and sports
- Home weather stations and weather forecasts

- Airborne toys
- Application in healthcare (e.g. spirometry)
- Indicator of vertical velocity (such as danger or sink speed)
- Watches

Figure 30. BMP280 Pin Diagram (courtesy: Source [30])

Advantages

- It needs 3.3V of power to function.
- There are no level shifters or integrated voltage regulators in it.
- The BMP280 sensor, an improved version of the BMP085 or BMP180 or BMP183 sensor, is used by the board.
- It accurately measures barometric pressure and temperature to within 1 hPa and 1.0°C, respectively.
- The module's maximum current is 1.12mA.
- The range of pressure is 300 to 1100 hPa, or +9000 to -500 meters above sea level.
- The module is 11.5 mm by 15 mm.

Disadvantages

- Very low frequency response.
- Require filtering if a DC output is desired.

BMP 280 measures

- Temperature
- Humidity
- Pressure
- Altitude

MPU 6050

Description

- Micro Electro-Mechanical System (MEMS) MPU6050 has a three-axis gyroscope and an accelerometer. It aids in the measurement of motion-related characteristics such as velocity, direction, acceleration, and displacement.
- Digital Motion Processor (DMP), a component of MPU6050, has the ability to resolve difficult calculations.
- A hardware 16-bit analogue to digital converter is part of the MPU6050. This feature allows it to simultaneously capture three-dimensional motion.
- This module can be used with a well-known microcontroller like Arduino because of its widely available and well-known characteristics. MPU6050 will be a fantastic option for you if you're seeking for a sensor to regulate the movements of your drone, self-balancing robot, remote control cars, or something similar.
- The I2C module is utilized by this module to interface with Arduino.
- The MPU6050 is less expensive and has the advantage of being simple to combine with an accelerometer and gyro.

Figure 31. MPU-650 Sensor (courtesy: Source [31])

PIN Arrangements

- **PIN 1** VCC-POWER
- **PIN 2** GND-Ground
- **PIN 3** SCL-Serial Clock
- **PIN 4** SDA-Serial Data
- **PIN 5** XDA-Auxiliary Serial Data
- **PIN 6** XCL-Auxiliary Serial Clock
- **PIN 7** ADO-IC2 address select
- **PIN 8** INT- Interrupt

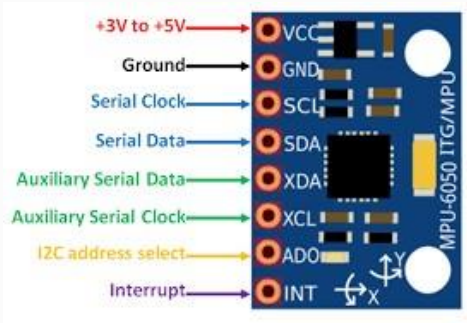

Figure 32. Pin Diagram of MPU-650 Sensor (courtesy: Source [32])

Application

- The MPU6050 is the first integrated six motion tracking system.
- It utilizes the I2C protocol for communication.
- It includes a built-in 16 BIT ADC with exceptional precision.
- 3 to 5 volts are required for it to operate.
- It is made up of a digital motion processor, which offers powerful processing.
- It is a built-in feature of the temperature sensor.
- With IIC devices like magnetometers, it may be utilized as an interface.
- Its pins have a 0.1 inch pitch.
- The range of its acceleration is +/-2g, +/-4g, +/-8g, and +/-16g.
- It measures 21.2mm (0.84") in length, 16.4mm (0.65") in width, and 3.3mm (0.13") in height, not including the pins.
- It weighs 2.1 grams.
- Its 4x4x0.9 mm QFN package is the smallest and thinnest available for portable electronics.

Chapter - 3

Proposed Methods

3.1 Problem Statement

The human body is sensitive to a variety of harmful gasses and dangerous chemicals or compounds found in the atmosphere. If the level of such gasses surpasses the human body's tolerance limit, a person may be in danger or perhaps perish if the quantity is sufficiently high relative to sustainability. The quantity of dangerous gases in regions where people live, such as industrial areas, near gas wells, and also houses, must be detected and measured by a gas detection and measurement system in order to deal with this kind of problem. Different harmful and hazardous gasses, like natural gas (CH4) common in household kitchen stoves or Lpg in cylinders, various types of burning fuels, etc. are everywhere around us. Because there are more poisonous gasses present in manufacturing environments, there is a higher chance that one of those gasses will cause an accident. As a result, numerous types of gasses, including CH4 (Methane), CO (Carbon Monoxide), and fuels for burning, are present in these locations as exhaust gasses while manufacturing. So it is essential to have such a monitoring system as to properly safeguard human life.

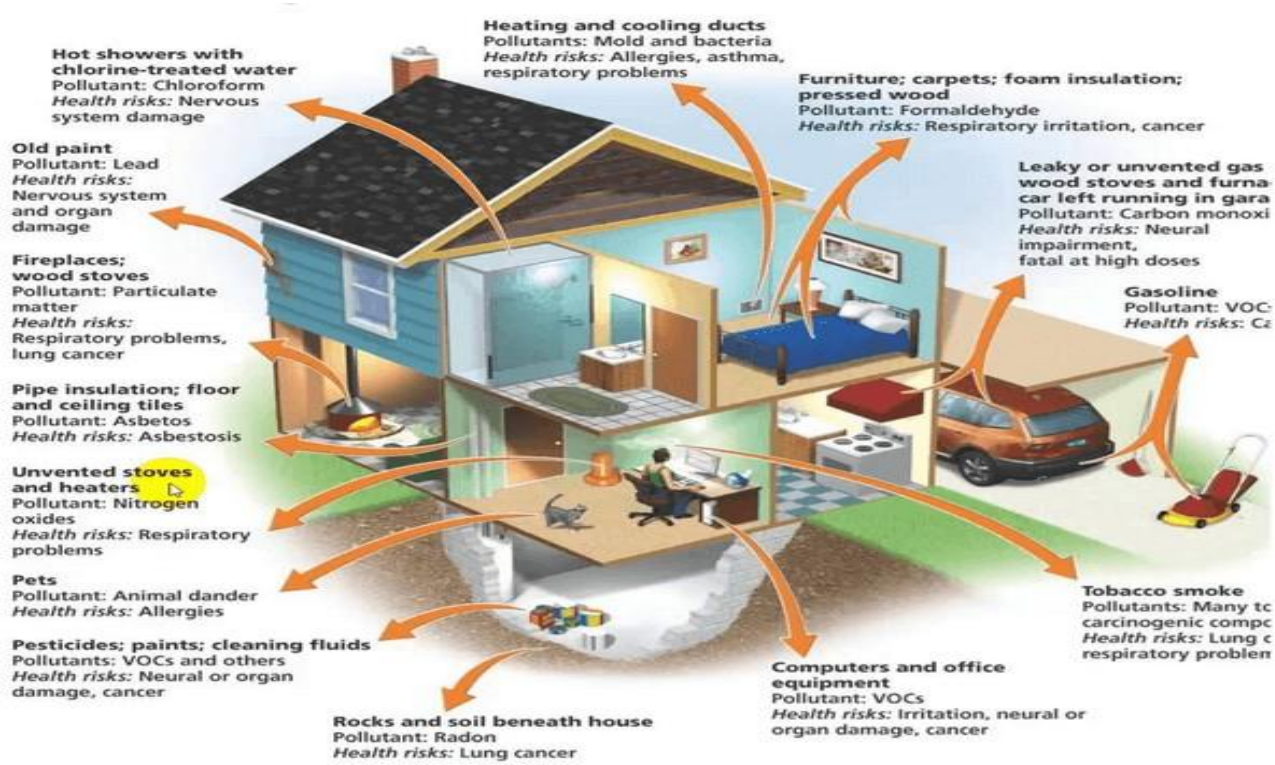

Figure 33. Pollution within the house (courtesy: Source [33])

At the moment, accidents are happening more frequently as a result of the increased usage of gasses and fuels in both domestic and industrial settings. The frequency of gas leakage-related explosion-related accidents is rising alarmingly quickly in Bangladesh. According to a survey conducted by Titas Gas Transmission Company Ltd., Bangladesh, the number of gas leakage-related explosions was estimated to be 3,819 in 2013–2014 and 5,123 in 2014–2015. These disasters were caused by gas cylinders and pipelines. The most hazardous explosions are those caused by gas cylinders. One may argue that storing a gas cylinder inside a house without the necessary security and upkeep is equivalent to keeping a live bomb inside the house and residing with it.

Figure 34. Pollution near Industrial areas (courtesy: Source [34])

Gas leakage from a cylinder's body or valves may happen throughout the entire kitchen, room, or area if it is not properly maintained or monitored. Thus, a tiny spark might start a fire that spreads quickly, like a storm, and result in a huge explosion. As a result, there may even be important lives lost in casualties. The fifth of March 2019 saw a recent event in Gazipur that claimed the life of a worker. Therefore, regular maintenance and monitoring are essential to preventing this kind of tragic tragedy. Because of this, a technical monitoring system must be put in place. Through this monitoring system, anyone may assess an area's toxicity or hazard and take the appropriate action. Particularly wireless surveillance is more efficient because users may see around without coming close. A poisonous and harmful gasses monitoring system is therefore absolutely important.

Objective

Wireless Detection and Monitoring of Gases present in the environment is considered as the main objective of this project. To do so, We consider using Blynk Application that displays the PPM values of the gasses present around. The data is taken from the MQ2 and MQ135 sensor, with the help of ESP32 a Node MCU that transmits data through WIFI. When the readings are displayed, through the application made using Blynk source we will be adding a file that displays the gasses according to its PPM values. List of Toxics and combustible materials are displayed in the application file itself. Usage of two gas measurement sensors is essential because of its unique feature of detecting gasses. Both the sensors measure different gasses as its core features are different. With this people can get the awareness of the pollution present around and take the health measurements accordingly and by the knowledge of knowing about pollution can create reduction of polluting materials.

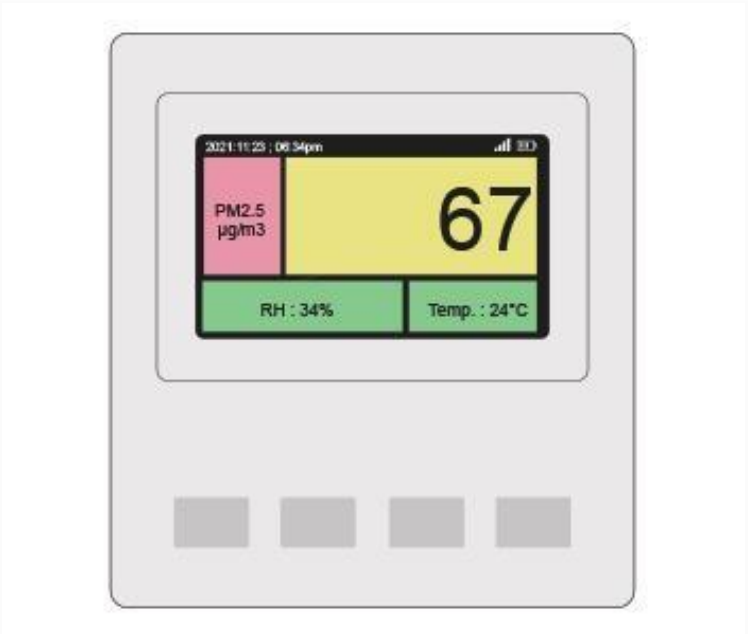

Figure 35. Gasses Monitoring System (courtesy: Source [35])

Risk Elements - Toxic gasses (Its sources, effects and types)

- **Nitrogen**

  It is the gas that is most common in the atmosphere. And over 75% of the air that we inhale is made up of nitrogen. Therefore, among all damaging, risky, and toxic gasses, N2 ranks as the most harmful. It is widely distributed in the atmosphere because it is the gas which we inhale most frequently. There are gasses called nitrogen dioxide and nitric oxide in a lot of industrial and home situations. the primary factors of air pollution as a result.

  The production of explosions and rocket fuel needs nitrogen dioxide, while the most common source of nitric oxides include industrial and vehicle emission, combustion of fossil fuels, agricultural activities, etc. The current permitted threshold for nitrogen dioxide and nitric oxide for an 8-hour work shift is 25 ppm (Parts Per Million) and 5 ppm, respectively. Nitrogen dioxide and Nitric oxide have fatal values of 100 ppm and 20, respectively.

  Respiratory system, eyes and skin irritation are common exposure effects. Once exposed for longer periods of time, they can also cause death in large concentrations.

- **Hydrogen Sulfide (H_2S)**

  H_2S, sometimes referred to as sewage gas, is a colorless gas that is extremely dangerous and highly combustible. It smells distinctly like "rotten eggs" even in tiny amounts.

  H_2S is used in a variety of industrial operations, including mining, the manufacture of paper and pulp rayon, oil and gas processing, and more. As opposed to that, it naturally happens in locations like sewers, eruptions, compost pits, and natural gas wells. Other causes of hydrogen sulfide include the use of natural gas, the production of electricity, the gasification of coal, refineries, petrochemical plants, wastewater treatment facilities, and the production of semiconductors. H_2S can develop in small spaces like telephone tunnels, manholes, and sewage systems due to its density more than the atmosphere.

For an 8-hour work shift is 20 ppm (Parts Per Million) to nearly 50 ppm but does not exceed above it.

And there are many other gasses like Carbon monoxide, Ozone as smog, Benzene which are dangerous to humans with respect to their organs like lungs, heart. Few of the gasses are listed in this below table.

Toxic gasses	Ranking
Carbon Monoxide	3
Sulfur Dioxide	3
Arsine	4
Hydrogen Cyanide, Hydrogen Fluoride, Hydrogen Sulfide	4
Ozone	4
Chlorine	3
Florine	4

Ammonia	3
Nitrogen Dioxide, Nitric Oxide	3
Hydrogen Chloride, Hydrogen Bromide	3
Vinyl Chloride	2
Ethylene Oxide	3

Top Ranked Hazardous Gasses by NFPA (courtesy: Source table [1])

Harmful effects from the Gasses

These toxins contribute to a respiratory system that is not functioning properly, either singly or in combination. The disease raises the risk of pneumonia and other respiratory tract infections including bronchitis. The unwell folks ultimately generate much less and perform noticeably poorly. Therefore, appropriate ventilation is necessary to provide individuals with a clean atmosphere for inhalation and a high-productivity setting.

Strong oxidants, which are highly reactive chemicals, can instantly react with the airway epithelial lining and cause conditions like necrosis. Less reactive gasses, on the other hand, can trigger capillaries endothelial necrosis by diffusing past the epithelium without obviously causing harm.

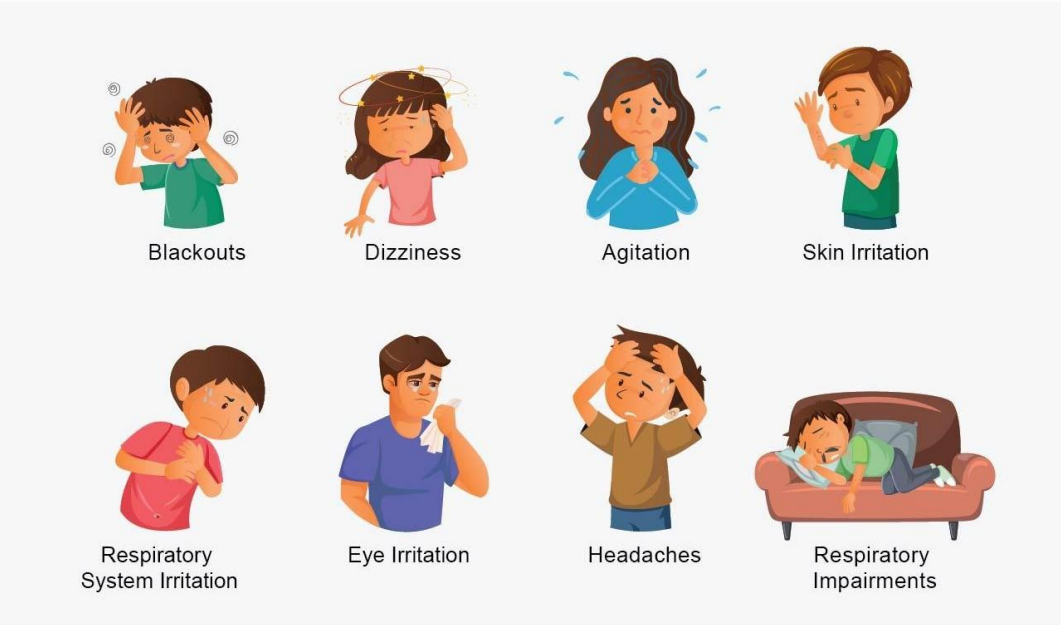

Figure 36. Harms from Hazardous Gasses (courtesy: Source [36])

The main unintentional gasses that contribute to smoke inhalation casualties are carbon monoxide (CO) and hydrogen cyanide (HCN). CO interferes with cell respiration in tissues at the cellular level. Additionally, CO can attach to proteins in skeletal and cardiac muscle, which can have extremely toxic effects.

Severe toxic gas exposures can cause death or severe, irreparable lung diseases, among other body part damages. Although the lungs have some ability to recover, not all injuries can be fixed.

Experiments show that they have an effect on a range of organs and systems. Dioxins have a long half-life once they are ingested into the body because of their chemical tenacity and ability to be taken by fatty tissues, which causes them to be retained in the body. In the body, they have an estimated lifespan of 7 to 11 years.

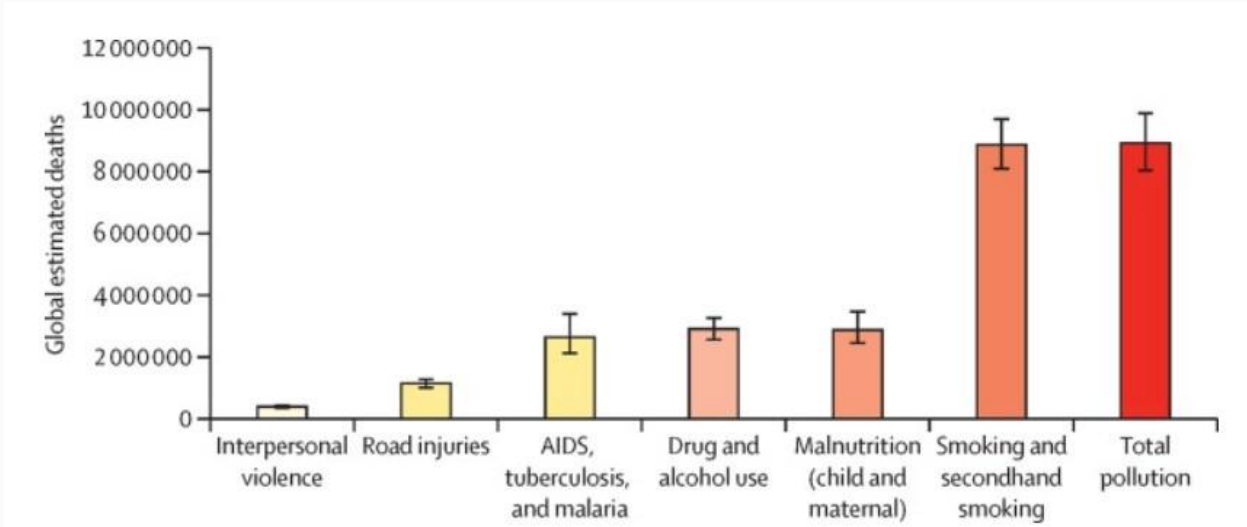

Figure 37. Bar chart Displaying Deaths due to pollution (courtesy: Source [37])

According to the above Figure, Data from the Institute for Health Metrics and Evaluation and Global Burden of Diseases, Risk Factors and Injuries Study 2019. Error bars are 95% CI. Indicates the Global estimated deaths due to the pollution from the gasses.

The GBD 2019 data demonstrate that there are gender differences in how pollution affects disease and disability. Compared to women, the Male gender are highly probable to pass away from exposure to occupational, ambient and lead pollutants. Children and women are more likely than men to pass away from water pollution exposure. pollution.
The impacts of polluted air on mortality and morbidity are compared with those of other factors associated on morbidity and mortality, demonstrating that pollution remains one of the main causes of disease and early death around the world.

The negative impacts of pollution on wellness continue to outweigh those of conflict, violent extremism, infectious diseases, HIV, tuberculosis, prescription painkillers, and liquor, and the number of pollution-related deaths is comparable to that of smoking (figure 33)

3.2 An Insight on Architecture Diagram

3.2.1 Architecture Diagram

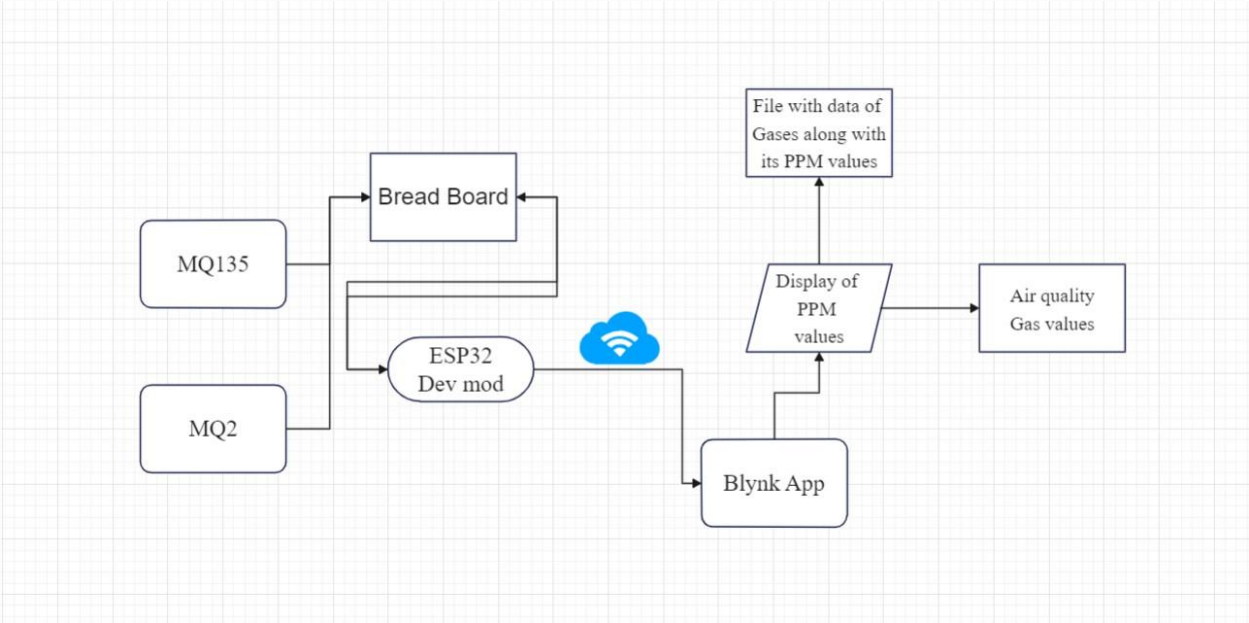

Figure 38. Architecture Diagram

Flow of the project

Step - 1: Connection of the sensors, Esp32 dev kit to the Breadboard and execution of code that connects to the mobile application.

Step - 2: Reading of the Gasses, that is their ppm values are displayed and are monitored.

Step - 3: PPM and the gasses data file is referred to in the mobile application itself and learn the gasses present around.

Note: The Detecting system is measured continuously, so as to train the sensor to give accurate measurements with the data that it inculcates.

The MQ135 and MQ2 sensors are connected to the breadboard along with the Node MCU i.,e ESP32 and the data is transferred through this wifi module to the Blynk Mobile application. The values are then compared to the data file containing the list of gasses.

MODULES

1. **Module I** - Reading values from the sensor and Transferring it to the (Blynk) mobile application.
2. **Module II** - Notify or Prompt the User.

3.2.2 CONNECTIVITY DIAGRAM

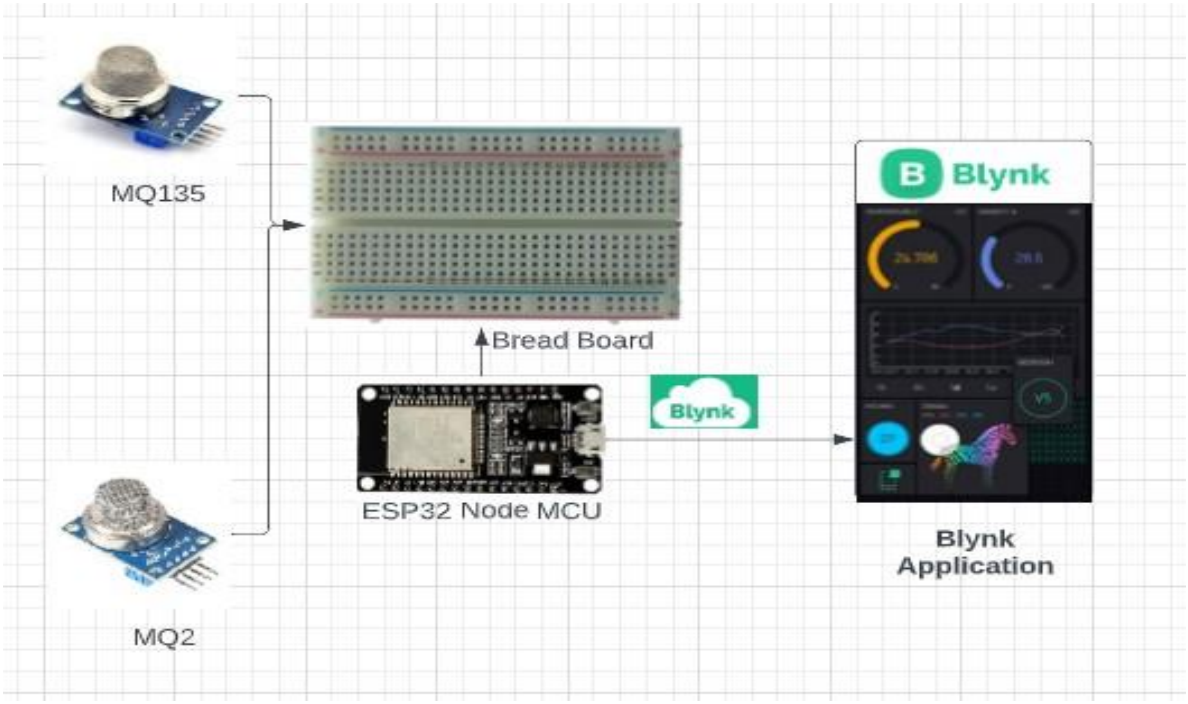

Figure 39. Connectivity Diagram

3.2.3 Software and Hardware Requirements

Software - Arduino IDE & Blynk IoT

- **Arduino IDE:** In addition to a text editor for writing code, a message area, a text terminal, a toolbar with buttons for frequently used operations, and a number of menus, the Arduino Integrated Development Environment, sometimes known as the Arduino Software (IDE), is also available. In order to upload programmes and communicate with them, it connects to the Arduino hardware.

Writing sketch:Sketches are computer programmes created using the Arduino Software (IDE). These drawings are created in a text editor and saved as files with the.ino extension. The editor offers functions for text replacement and text searching. When saving and exporting, the message section provides feedback and shows errors. The console shows text generated by the Arduino Software (IDE), including error messages in their entirety and other data. The configured board and serial port are visible in the window's bottom right corner. You may create, save, and save drawings, validate and upload programmes, view the serial monitor, and more using the toolbar buttons.

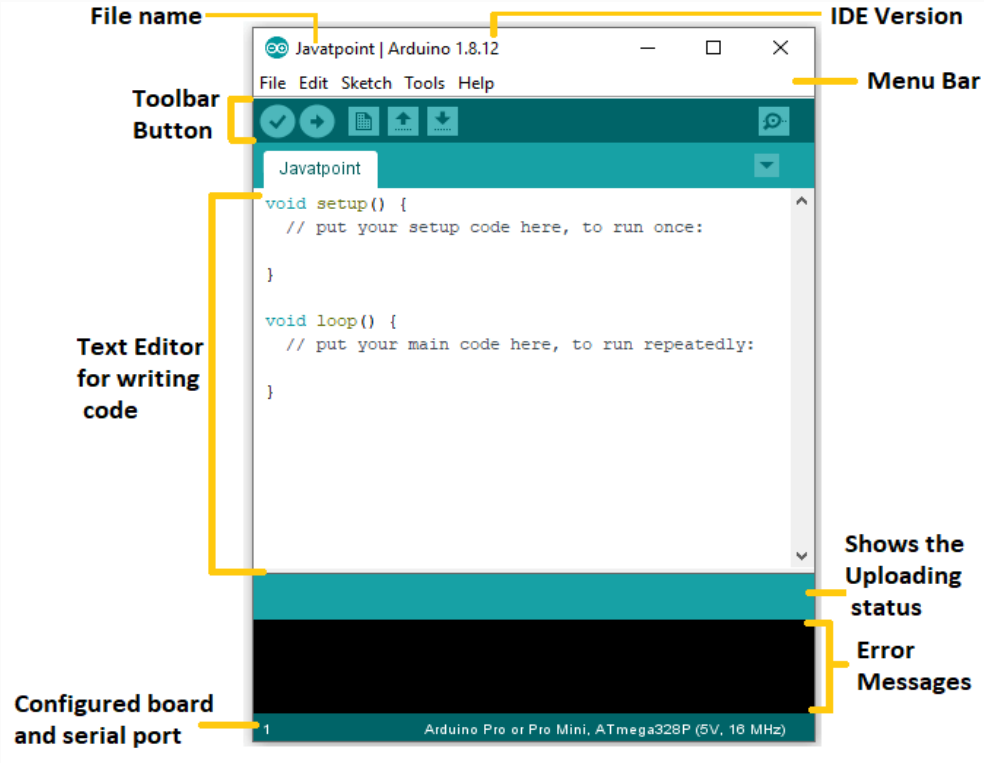

Figure 40. Gas Monitoring System (courtesy: Source [38])

- **Blynk IoT:** Blynk is an Internet-of-Things framework for both Android and IOS smartphones that allows users to remotely operate devices like Arduino, Raspberry Pi, and Node MCU. Using this application, you can compile and provide the right address on the various widgets to construct a User Interface.

  For use with the IoT, Blynk was created. It can store information, visualize it, display sensor data, remotely operate hardware, and perform many other fascinating things.

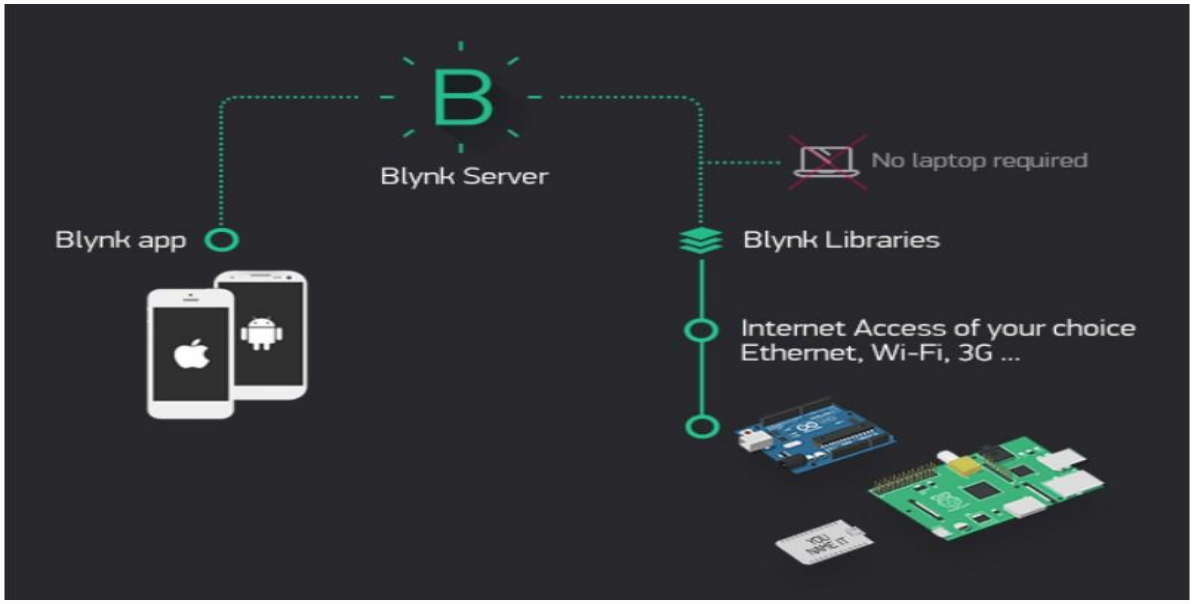

Figure 41. Process Flow through Blynk (courtesy: Source [39])

Three major parts of Blynk IoT

App: Using the many widgets offered, it enables you to develop stunning interfaces for your projects.

Server: It is in charge of managing all communications between the hardware and the smartphone.

You can operate a personal Blynk server locally or utilize the Blynk Cloud. It can even be started on a Raspberry Pi, is open-source, and has no trouble supporting thousands of devices.

Libraries: It provides communication with the server for all widely used hardware platforms and handles all incoming and outgoing commands.

Hardware

- Esp32
- Bread Board
- Jumper wires
- Resistors
- MQ135
- MQ2

ESP32

Esp32 is a feature-loaded MCU with integrated Wi-Fi and Bluetooth connectivity for a wide-range of applications. In the present era This component is mostly used in IoT projects and its related applications. Generally IoT devices built using ESP32 include; smart energy devices, smart security devices, and smart industrial devices.

For our mini-project in the domain of IoT, we use ESP32. Because of its wide range of options and is compatible with many sensors. It stands out from other sensors as it provides advanced features such as described below.

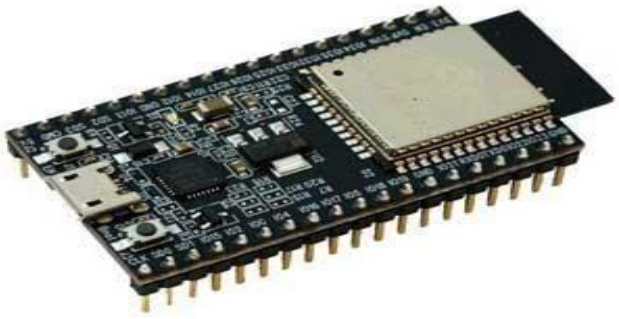

Figure 42. Esp32- Dev module (courtesy: Source [9])

Hybrid Wi-Fi & Bluetooth Chip

ESP32 has a dual compatibility which means it can act as a slave to the host MCU or can also function as a standalone device, because of this the communication stack overhead on the main application processor can be reduced significantly. ESP32 interacts with other systems via I2C / UART or SPI / SDIO interfaces to provide Bluetooth and Wi-Fi functionality.

High Level of Integrity

The ESP32 is the best choice for many IoT related projects as it is integrated with many HandsOn technologies and features. It requires a very low Printed Circuit Board (PCB) as it is integrated with many features such as an in-built antenna, low noise receive amplifier, switches, RF balun, filters, power amplifier, and power management modules and so on which makes ESP32 priceless. The below figure 7 is the Node MCU model.

Ultra-Low Power Consumption

For instance we take a watch, smart watch (for example), it's frustrating to have a microcontroller which drains a lot of power and battery, Engineered for mobile devices, wearable electronics and IoT applications.ESP32 consumes ultra-low power with a combination of several kinds of exclusive software. ESP32 also includes a wide range of features, such as fine-grained clock gating, various power modes and dynamic power scaling.

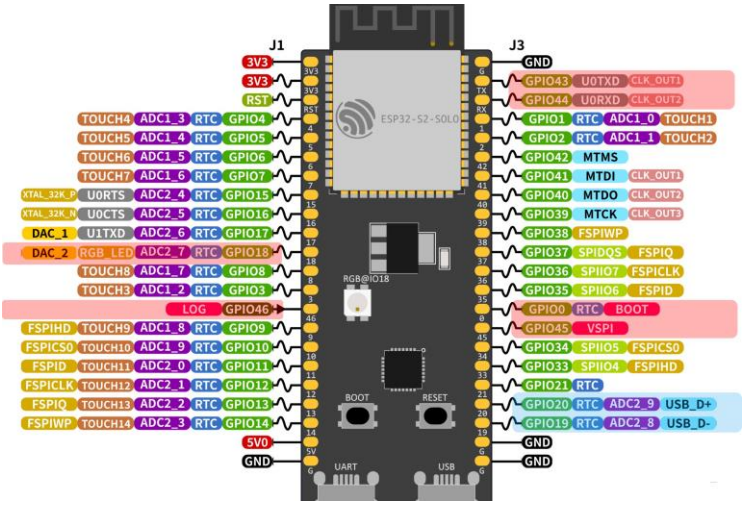

Figure 43. Esp32 Pins Description (courtesy: Source [10])

ESP 32 has the following features

- Wi-Fi (2.4 GHz band)
- Bluetooth
- Dual high performance Xtensa® 32-bit LX6 CPU cores
- Ultra Low Power co-processor
- Multiple peripherals

Bread Board

It is a thin board of plastic which is used to wire together electronic parts, such as microchips, transistors, resistors etc. Breadboards are used to create electronic circuit prototypes that can be used again in the future. They can be utilized to develop unique systems, but they rarely end up as consumer goods.

The spring clip connections on the breadboard are often placed in matrices with some blocks of links already connected. To build the circuit patterns, the components and jumper wires—various wire lengths with connectors at both ends—are inserted into the clips. Additionally, the boards often have metal strips to the position that is utilized for signal buses and common power rails.

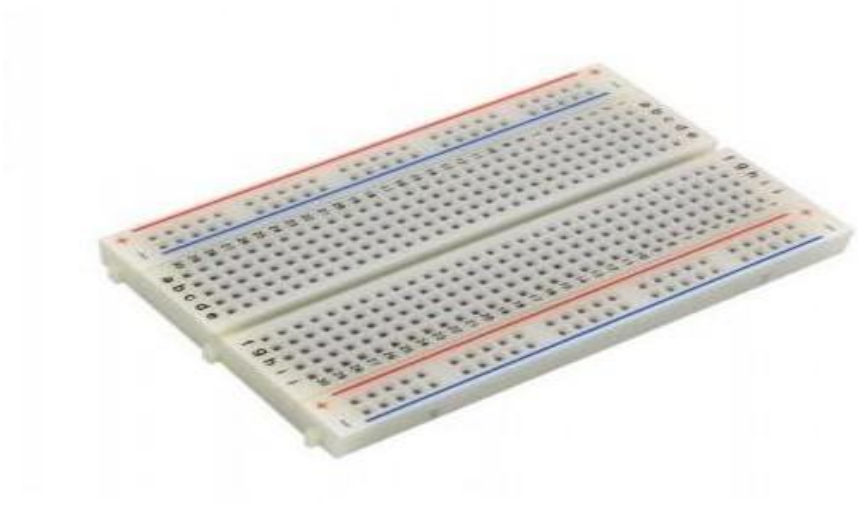

Figure 44. Bread Board (courtesy: Source [40])

Features

- Withstanding voltage is 1000V AC
- Insulation Resistance is DC500 V or 500 M ohms
- Rating is 5 Amps
- ABS plastic through color legend & heat distortion temperature is 183’F
- Tie points are two hundred
- Distribution Strips are two
- Pitch style is 2.54 mm

Advantages

- Temporary prototypes of electronics projects can be made using this.
- Since it has no need of soldering, it is reusable
- These boards are light weight as it is made of plastic
- Easy testing system
- Simple and economical
- Easy to add and remove components
- Has different sizes and shapes
- Arrangement is simple and can be easily understood

Disadvantages

- Cannot be used for high current applications
- To make simple circuits, it require more physical space
- More connections on the board makes confusion while modifying
- Less reliable connections
- Limited signaling

Applications

- A breadboard's primary use is to create straightforward electrical connections between various components so that you may test your circuit before attaching it to the board.
- These boards make it simple to add and remove various components, which immediately brings to mind the term "prototyping."
- This board provides a quick and affordable solution for designers who need to check their simple circuits or modules.

Jumper wires

Simply said, jumper wires are wires with connector pins at either end that can be utilized to connect two places without soldering. Using breadboards and other prototype tools, jumper wires are frequently used to make it simple to change a circuit as required. Fairly easy. Jumper wires are actually among the most elementary things there are.

Figure 45. Jumper Wires (courtesy: Source [41])

Jumper wires are of three distinct types: male to male, female to female and male to female. They are classified into three types based on their end points of connectivity. male to male has pins protruding and can plug into things, but female to female has ends without pins and are used to plug things into it. Whereas female to male has one end with a pin and other end without a pin.

Resistors

Resistors are passive electrical components which resists or limits the flow of current. Resistors are found in almost all the electric circuits and networks. Basically Resistance is measured in Ohms. One ampere passing through a resistor with one voltage across terminals is an Ohm.

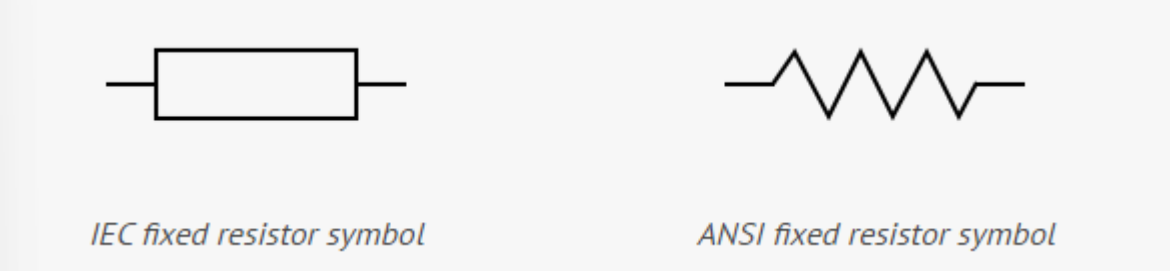

Figure 46. Resistors Notation (courtesy: Source [42])

There are numerous applications for resistors. Some examples are voltage division, heat production, loading and matching circuits, take control, and time constant setup. They have resistance ratings that span over nine orders of magnitude and are marketed for use in various applications. They can be less than a square millimeter for electronics or utilized as electrical brakes to disperse kinetic energy from moving trains.

MQ135 sensor

The MQ-135 Gas Sensor can identify dangerous gasses and smoke, including ammonia (NH3), sulfur (S), benzene (C6H6), and CO2. This sensor, like the others in the MQ series of gas sensors, has a pin for both digital and analogue output. The digital pin turns high when the amount of these gasses in the air exceeds a predetermined threshold. The on-board potentiometer can be used to adjust this threshold value. An analogue voltage that is produced by the analogue output pin can be used to approximately determine the concentration of various gasses in the atmosphere.

The MQ135 air quality sensor module requires about 150mA and runs at 5V. Prior to producing reliable results, it needs to be heated up.

One of the well-known sensing applications from the MQ family that is frequently used in air quality monitoring equipment is the MQ135. It is functional between 2.5V and 5.0V and can produce both digital and analogue signals. The pinouts and significant parts of a MQ135 Module are indicated below.

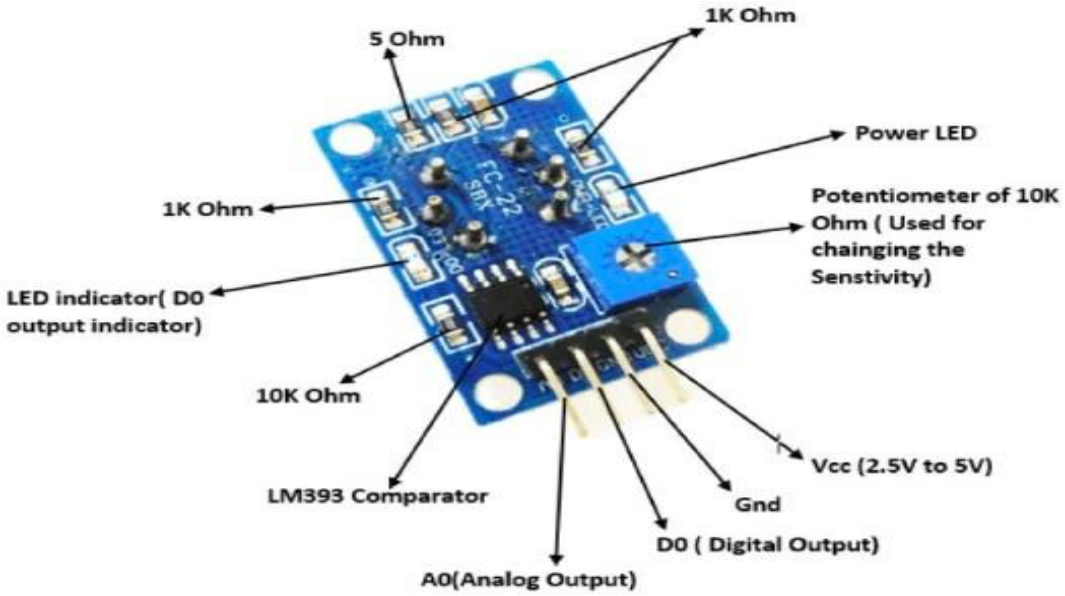

Figure 47. MQ135 Sensor Details (courtesy: Source [43])

Keep in mind which all MQ sensors must be powered on for a pre-heat period before they can begin to function. Typically, this preheat period lasts from a few seconds to a few minutes. The charge LED will blink on when you turn on the module; keep it in this mode until the pre-heat period is finished.

Specifications of MQ135

- Power consumption - 150mA
- Operating Voltage - 2.5 V to 5.0 V
- Detects - NH3, CO2, Benzene, Smoke, Alcohol, Nox\
- Analog Output - 0-5 V at 5 V Vcc
- Digital Output - 0 - 5 V at 5 V Vcc
- Typical operating Voltage - 5 V

Pin configuration - MQ135

Pin 1 - VCC: Positive power supply that power up the sensor which is of 5v

Pin 2 - GND: Reference potential pin, connects sensor module to the ground

Pin 3 - Digital Out (Do): It is a digital output that adjusts threshold value with potentiometer. And it is used to detect and measure gas

Pin 4 - Analog Out (Ao): Generates analog output signal of 0 to 5 V and depends of intensity of gas. Used to measure gasses in PPM

For Air Quality using MQ135

Figure 48. MQ135 Sensor Port Details (courtesy: Source [44])

H - pins: MQ135 has 2 of H-pins, one connects to voltage supply and other is to the ground.

A - pins: Here A-pin is connected to the voltage supply

B - pins: Bothe A and B pins can be interchanged. One pin is to generate output and the other is Connected to the ground.

Specifications and Features

The MQ135 air quality sensor specifications and features are listed below.

- It has a wide detection scope.
- High sensitivity and faster response.
- Long life and stability.
- The operating voltage: +5V.
- Measures and detects NH3, alcohol, NOx, Benzene, CO2, smoke etc.
- Range of analog output voltage: 0V-5V.

- Range of digital output voltage: 0V-5V (TTL logic).
- Duration of preheating: 20 seconds.
- Used as an analog or digital sensor.
- The potentiometer is used to vary the sensitivity of the digital pin.
- Heating Voltage: 5V±0.1.
- Load resistance is adjustable.
- Heater resistance: 33 ohms±5%.
- Heating consumption:<800mW.
- Operating temperature: -10°C to -45°C.
- Storage temperature: -20°C to -70°C.
- Related humidity: <95%Rh.
- Oxygen concentration: 21% (affects the sensitivity).
- Sensing resistance: 30 kilo ohms to 200 kilo ohms.
- Concentration slope rate: ≤0.65.
- Preheat time: over 24 hrs.
- Simple drive circuit.

Applications of MQ135 Air Quality Sensor

- Used in the detection of excess or leakage of gasses like nitrogen oxide, ammonia, alcohol, aromatic compounds, smoke, and sulfide.
- Used as air quality monitors.
- Used in air quality equipment for offices and buildings.
- Used as a domestic air pollution detector.
- Used as an industrial air pollution detector.
- Works as a portable air pollution detector.

MQ 2 sensor

A Metal Oxide Semiconductor (MOS) type gas sensor called the MQ2 is used primarily to identify gasses like methane, butane, lpg, smoke, etc. Because gas detection relies on a change in the sensing material's resistance as a result of contact with the gas, it is also known as chemiresistors. You can check out these Gas Sensors if you wish to monitor a different kind of gas.

The MQ2 Gas Sensor Module consumes about 800mW and operates on 5V DC. Between 200 and 10,000 parts per million, it can detect LPG, smoke, alcohol, propane, hydrogen, methane, and carbon monoxide.

The MQ2 gas sensor module requires a 5V supply to operate, at which point the Power LED will begin to glow. Before beginning to read the output, allow it some preheating time. The Output LED will glow at a particular gas concentration while measuring the gas present. The potentiometer can be used to alter it. Alternatively, you can use the Analog Output to observe how your programme responds to various gas concentrations.

Figure 49. MQ2 Sensor (courtesy: Source [45])

Specifications of MQ2

- Preheat time is over 24 hours
- Operating Voltage - 2.5 V to 5.0 V
- Detects - LPG, Smoke, Alcohol, Propane, Hydrogen, Methane and Carbon Monoxide
- Sensing Resistance is 10k ohm to 60k ohms
- Concentration Range 200 to 10000 ppm
- Heater Resistance is 33Ω ± 5%

Pin configuration - MQ2

Pin 1 - VCC: Positive power supply that power up the sensor which is of 5v

Pin 2 - GND: Reference potential pin, connects sensor module to the ground

Pin 3 - Digital Out (Do): shows the presence of flammable vapors. When the gas concentration reaches the threshold level (determined by the potentiometer), D0 becomes HIGH; otherwise, it becomes LOW.

Pin 4 - Analog Out (Ao): Provides a proportional analogue output voltage to gas concentration, meaning that a higher gas concentration will produce a higher voltage and a lower gas concentration will produce a lower voltage.

Applications of MQ2 sensor

These sensors can detect the presence of gasses in the air, including smoke, butane, methane, and LPG, but they cannot distinguish between different gasses. They are unable to identify the gas, thus.

When detecting a single gas, the module form of this sensor can be utilized without a microcontroller interface. This is limited to gas detection. However, if ppm calculations are necessary, the sensor should be utilized alone.

This sensor is also utilized in hospitals to maintain environmental requirements, monitor air quality, and detect gas leaks. These are employed in companies to find dangerous gas leaks.

3.3 Modules and its Description

Module 1 - Collection of Data

- The MQ135 and MQ2 sensors are used to detect the concentration of various gases in the air. The sensors work by measuring the electrical conductivity of the air, which changes in the presence of certain gases.
- The data that is collected from these sensors is typically reported in units of parts per million (PPM), which is a measure of the concentration of a particular gas in the air.
- The data from the MQ135 and MQ2 sensors will be displayed in real time on a mobile application called "Quickstart Device." This means that the readings will be continuously updating as long as the system is turned on and the sensors are functioning properly.
- The "Quickstart Device" mobile application will store the data from the sensors, allowing users to access the readings at any time. This can be useful for monitoring the air quality in a particular location and detecting any changes or trends over time.

Module 2 - Notify/prompt the user

- The data displayed into the mobile app has two LCD screens.
- The first screen displays the data from the MQ135 sensor.
- The second screen displays the data from the MQ2 sensor.
- Now the status of both the screens is constantly changing according to the environment and it is monitored, observed and recorded.
- The user can view the gasses present based on the ppm values in the mobile application itself.
- Blynk application has the data file that has the gasses and its ppm values along with this, it also has the brief description of what ppm values is and how it is calculated.
- The data file contains the health measurements that user can practice so as to be healthy and get well from the inhalation of the hazardous gasses.

Chapter 4

Results And Conclusion

4.1 Description about Dataset

No dataset is used in this project. There is no static use of data in this project. Only the dynamic readings from the sensor are used for the application.

4.2 Experimental Results

Module 1 - Collection of Data

MQ135 and MQ2 sensors are connected to the microcontroller, that is ESP32 and the readings of the gases from surroundings are taken using the sensor. With these two gas sensors, the ppm values of gases and the quality of the air is known. Using arduino IDE, we can see the output in the serial monitor.

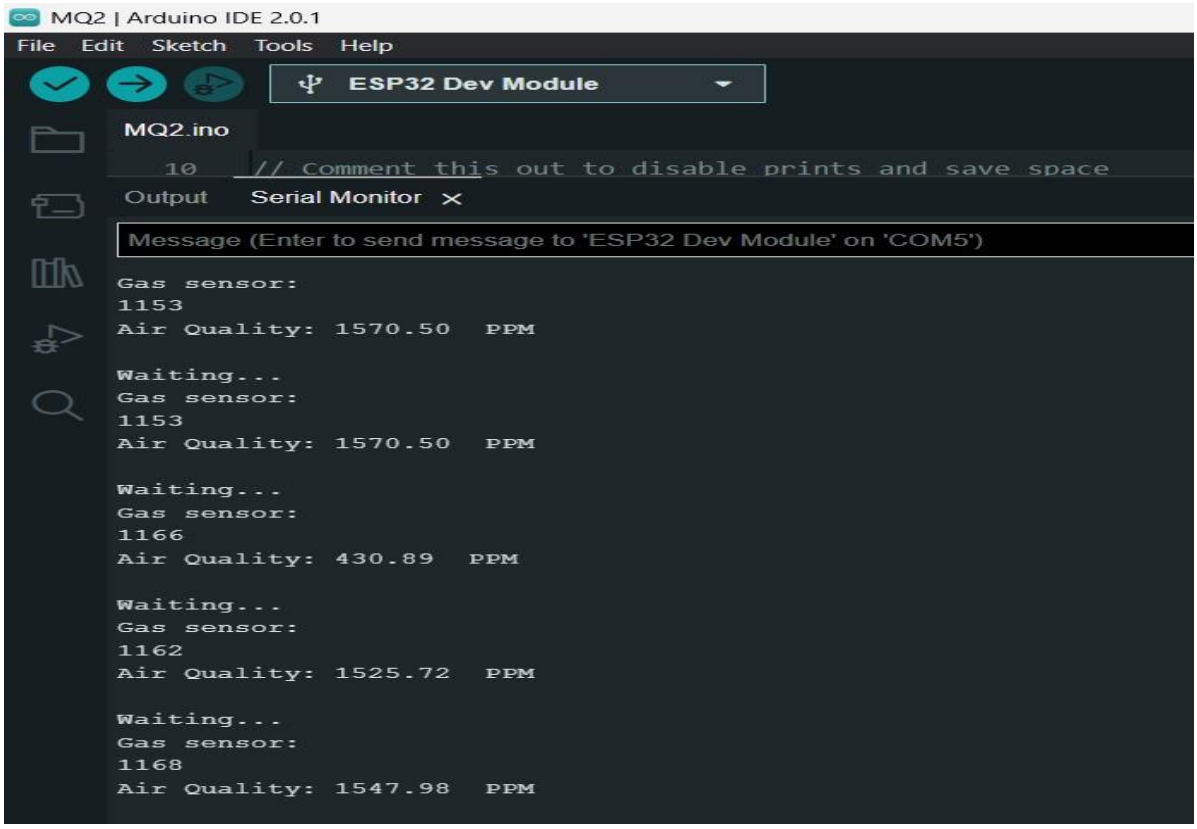

Figure 50. Readings from the sensors in Serial Monitor

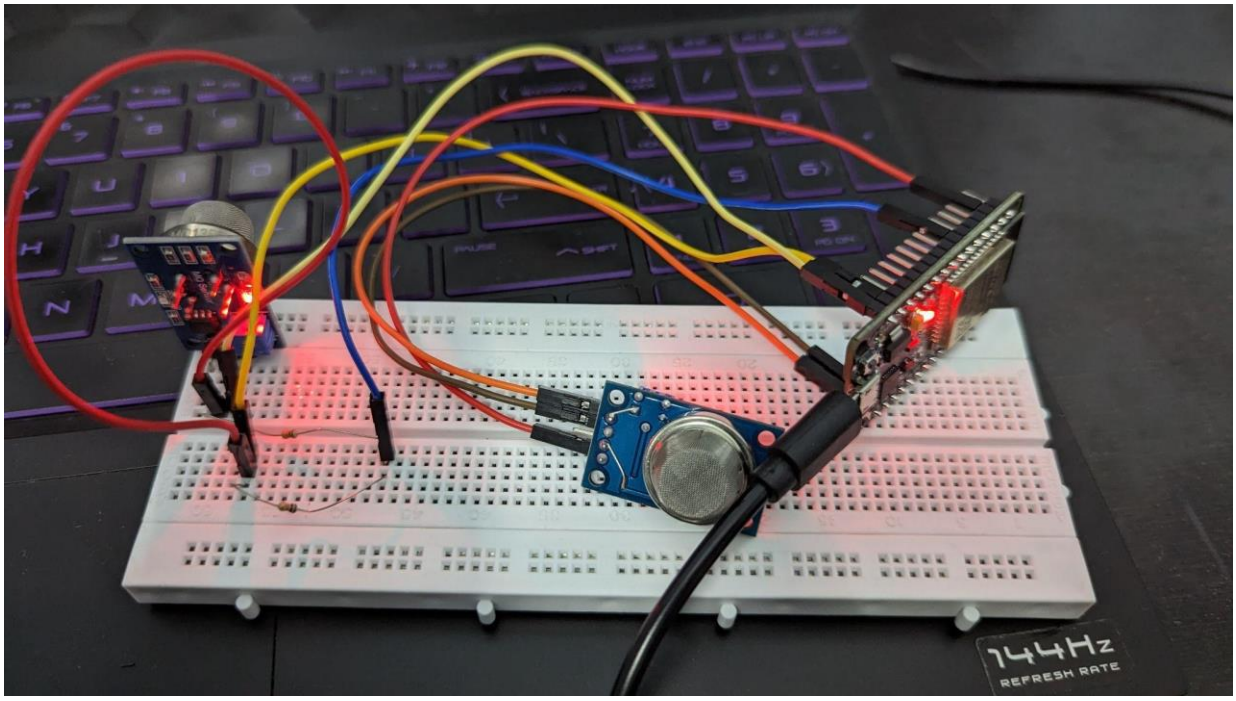

Figure 51. Hardware Setup of the Project

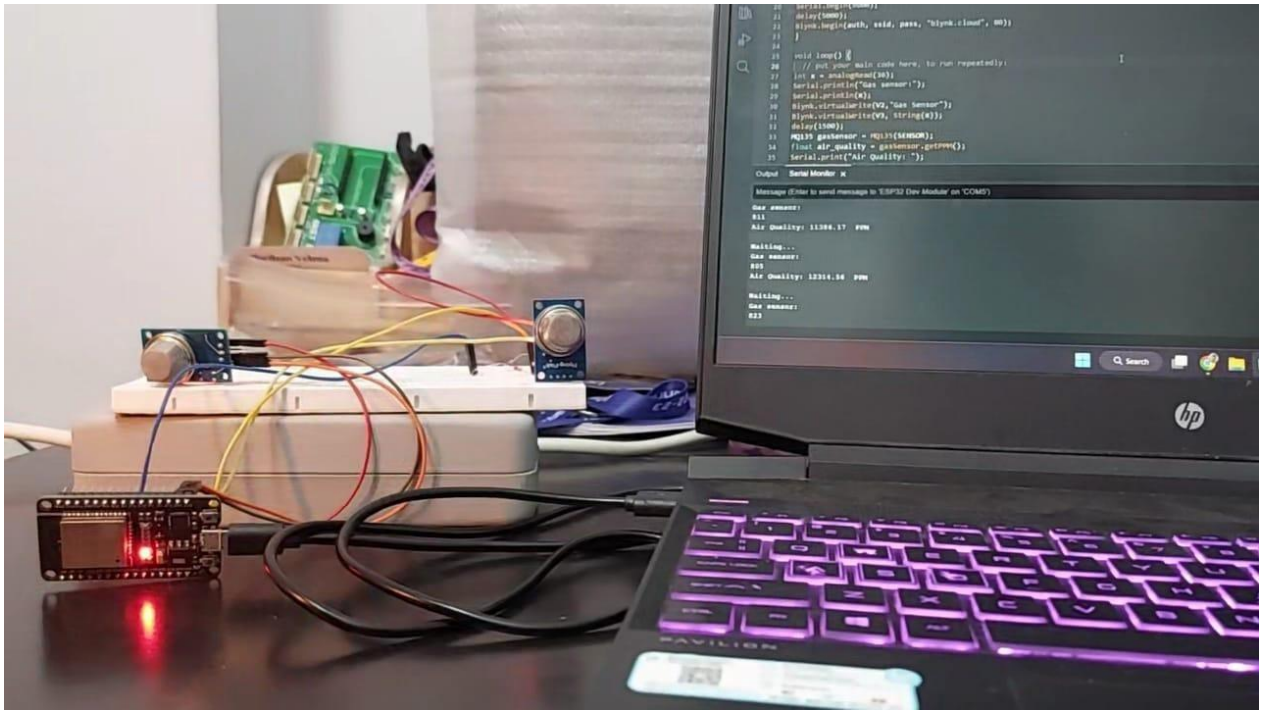

Figure 52. Connecting ESP32 Microcontroller with Arduino IDE

Module 2 - Notify/prompt the user

The data is then displayed in the mobile application, The values from both the sensors are displayed in different screens. One with the ‘Air Quality’ are the values from the MQ135 and the ‘Gas value’ are the values from the MQ2 sensor. There is a button at the bottom ‘click here’, which takes to a data file containing the details of all the gasses along with its ppm values.

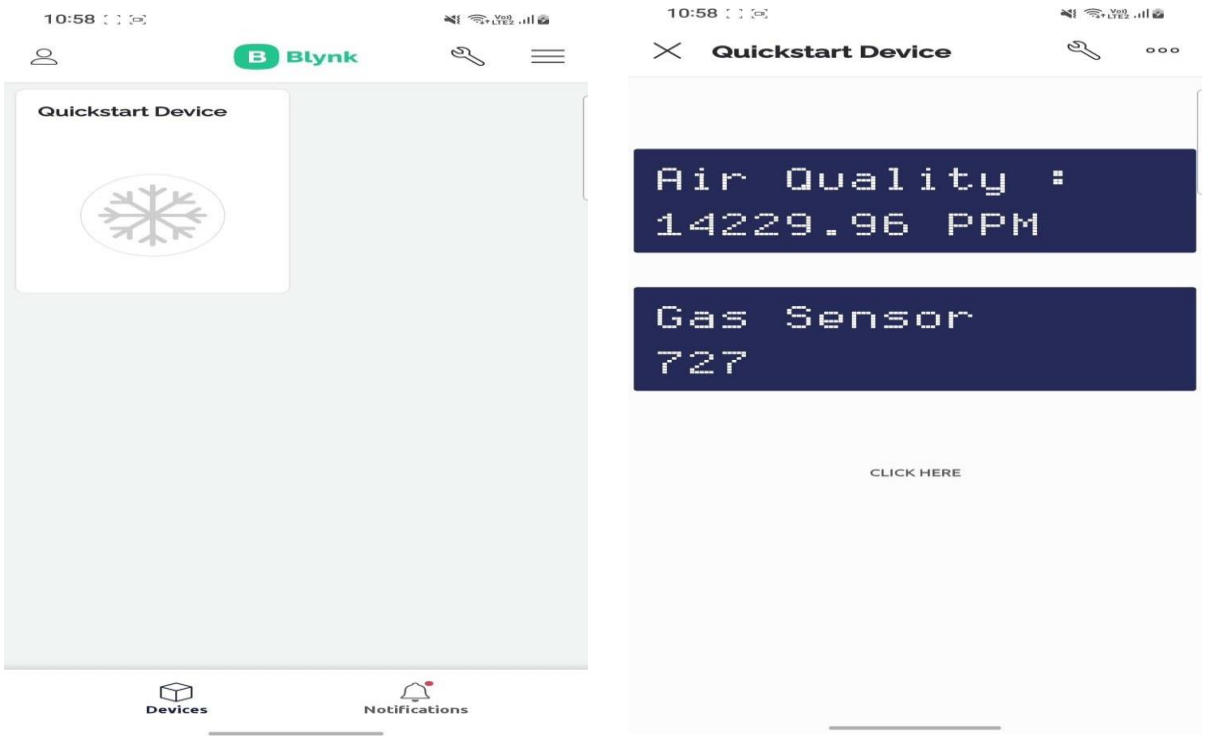

Figure 53. Display of gas value and Air Quality in Blynk Application

The Application gets the readings updating automatically, due to the connection to the Blynk Cloud with the help of ESP32 dev module kit. So the values detected by the sensors will be transferred directly to the application through the MCU and the Blynk network.

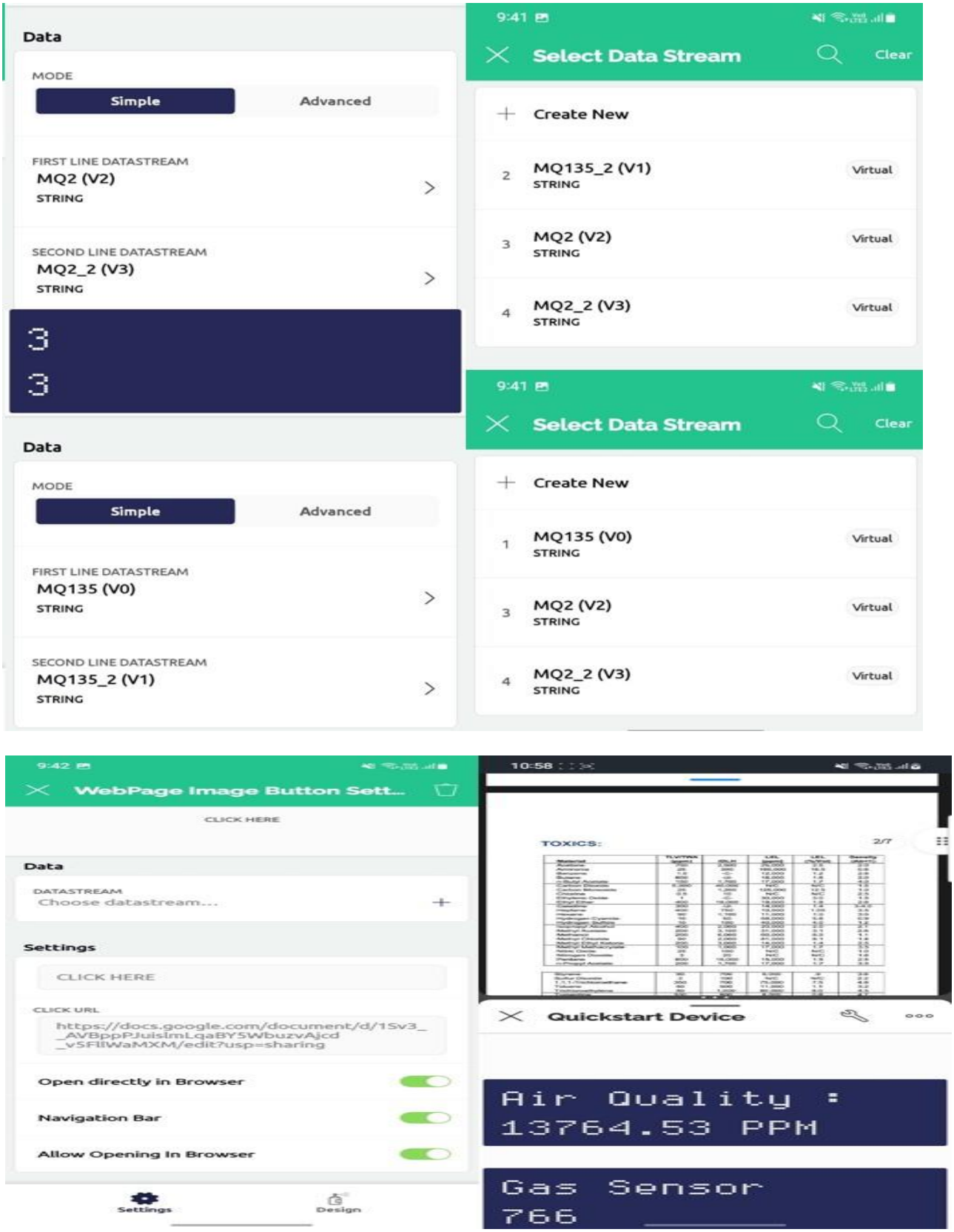

Figure 54. Backend view of the Application

Final Output of the project both in Application and Monitor

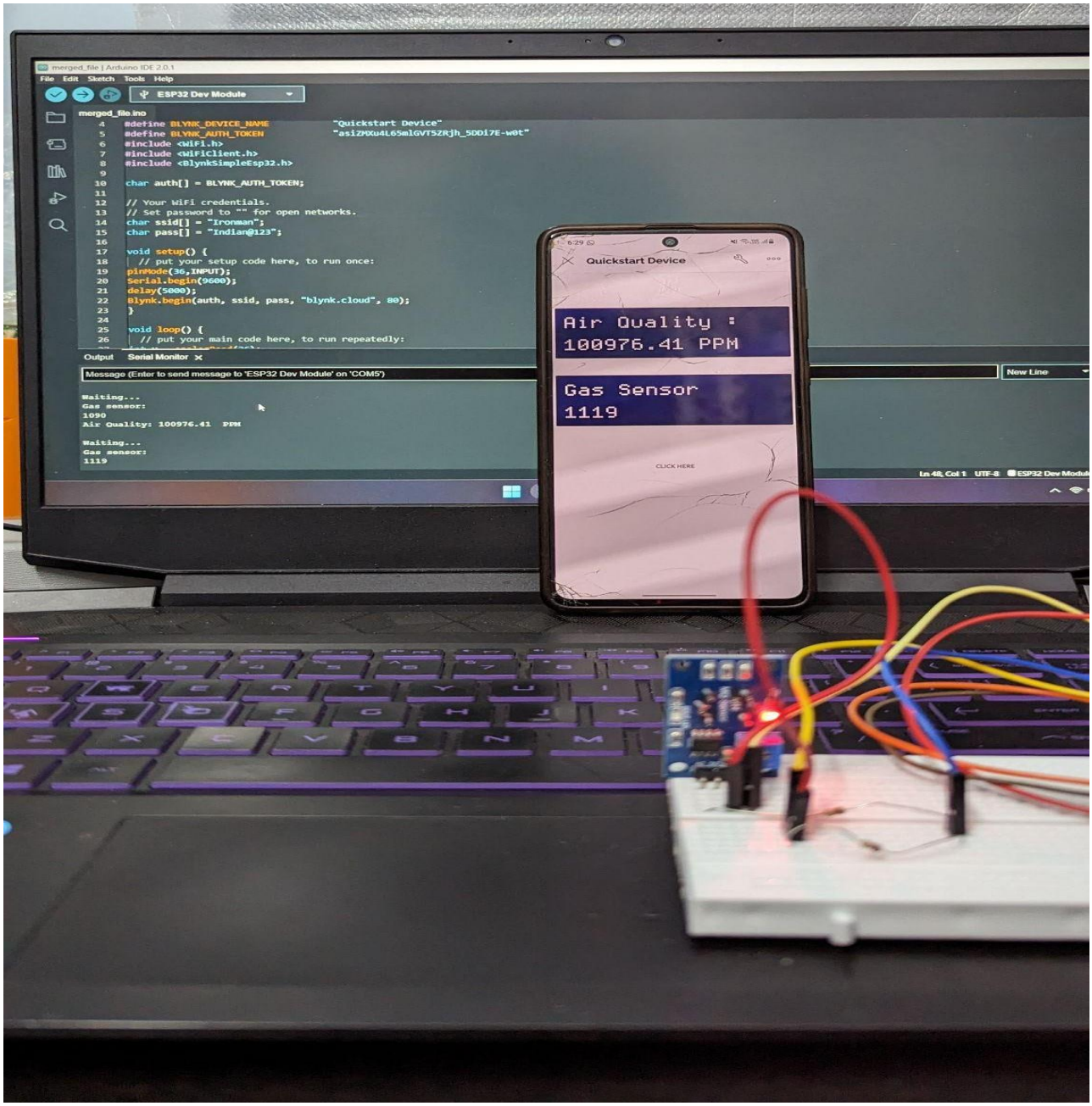

Figure 55. Display of the Project in monitor and Mobile

4.3 Significance of the proposed system and its advantages

The proposed system will notify the user about the air quality around him and also prompt the user about the hazardous gasses based on the ppm values**.** In the similar system of this idea, only one gas sensor is attached with other components which was a complicated process. Whereas this system produces accurate readings with the two sensors and is simple to access or use.

1. With MQ135 we get the Air Quality (in ppm) detects NH3, alcohol, NOx, Benzene, CO2, smoke etc.
2. MQ2 detects Methane, Butane, LPG, smoke etc. (in ppm)
3. When the heart rate or the oxygen level readings become abnormal, the alerting system is enabled.
4. After the system is enabled , an SMS is sent to family members and medical authorities along with the live location of the patient.

Advantages

1. Can check easily and know the gasses around us.
2. Not expensive.
3. Ease in supervision and awareness of the pollution in surroundings.
4. Very less hardware equipment.
5. It is a precautionary system that protects human health.
6. User friendly
7. No man power required.
8. Easy to operate.
9. Can also be used as monitoring system
10. Easily accessible to view the gasses by the ppm values.

Chapter 5
Conclusion and Future Enhancements

5.1 CONCLUSION

It is important to have systems in place to detect and monitor hazardous gases in various settings, as these gases can pose a risk to the health and safety of individuals. The system described in this study utilises MQ135 and MQ2 sensors to detect and monitor gases such as ammonia, carbon monoxide, and hydrocarbons in real-time. The system consists of a fixed monitor and a mobile device that can be carried by the user, and utilises a microcontroller to process the sensor data and display it on a user interface. The mobile device also has the ability to alert the user and send notifications through an accompanying app if the gas concentrations exceed a predetermined threshold. Overall, the system appears to be reliable, accurate, and easy to use, making it an effective solution for detecting and mitigating the risks associated with hazardous gases in various settings. Hazardous gases can pose serious risks to individuals in various settings, including industrial environments and residential areas. It is essential to have systems in place to detect and monitor these gases to ensure the safety of people in these areas. In this study, we present a system for real-time detection and monitoring of hazardous gases using MQ135 and MQ2 sensors.

Overall, the system described in this study provides a reliable and convenient solution for detecting and monitoring hazardous gases in real-time. Its ability to detect a wide range of gases, as well as its accuracy and ease of use, make it an invaluable tool for ensuring the safety of individuals in industrial and residential settings.

5.2 APPROACH ADOPTED

The system consists of a stationary monitor and a mobile device that can be carried by the user. The MQ135 sensor is used to detect gases such as ammonia, while the MQ2 sensor is used to detect gases such as carbon monoxide and hydrocarbons. The system utilises a microcontroller to process the sensor data and display the gas concentrations on a user interface. The mobile device can also send notifications through an accompanying app if the gas concentrations exceed a predetermined threshold.This system is reliable, accurate, and easy to use, making it an ideal solution for detecting and mitigating the risks associated with hazardous gases in various settings. The system was tested in a variety of environments and was found to be effective in accurately detecting and monitoring the presence of hazardous gases.

5.3 FUTURE ENHANCEMENTS

There are many potential enhancements that could be made to a hazardous gas detection and monitoring system in the future. Some potential ideas for enhancements include:

- Faster response times: Faster response times could allow the system to alert people to the presence of a hazardous gas more quickly, potentially reducing the risk of exposure or injury.
- Enhanced durability: Improving the durability of the sensors and other components of the system could allow it to operate more reliably in harsh or challenging environments.
- Enhanced communication capabilities: Allowing the system to communicate with other devices, such as smartphones or smart home systems, could allow for more convenient and efficient monitoring and alerting.
- Automatic shutdown or ventilation control: Integrating the system with ventilation systems or other building systems could allow for automatic shutdown or ventilation control in the event of a hazardous gas leak.
- Expanded range of detectable gases: Expanding the range of gases that the system can detect could allow it to protect against a wider variety of hazards.

CHAPTER 6

APPENDICES

SAMPLE CODE OF PROPOSED SYSTEM

```
#include "MQ135.h"
#define SENSOR 32
#define BLYNK_TEMPLATE_ID           "TMPLRiz3Z0GU"
#define BLYNK_DEVICE_NAME           "Quickstart Device"
#define BLYNK_AUTH_TOKEN            "asiZMXu4L65mlGVT5ZRjh_5DDi7E-w0t"
#include <WiFi.h>
#include <WiFiClient.h>
#include <BlynkSimpleEsp32.h>

char auth[] = BLYNK_AUTH_TOKEN;

// Your WiFi credentials.
// Set password to "" for open networks.
char ssid[] = "WiFi ID";
char pass[] = "WiFi Password";

void setup() {
  // setup code:
pinMode(36,INPUT);
Serial.begin(9600);
delay(5000);
Blynk.begin(auth, ssid, pass, "blynk.cloud", 80);
}
```

```
void loop() {
  // main code
int x = analogRead(36);
Serial.println("Gas sensor:");
Serial.println(x);
Blynk.virtualWrite(V2,"Gas Sensor");
Blynk.virtualWrite(V3, String(x));
delay(1500);
MQ135 gasSensor = MQ135(SENSOR);
float air_quality = gasSensor.getPPM();
Serial.print("Air Quality: ");
Serial.print(air_quality);
Serial.println("   PPM");
Serial.println();
Serial.println("Waiting...");
Blynk.virtualWrite(V0, "Air Quality : ");
Blynk.virtualWrite(V1, String(air_quality) + " PPM");
// func();
// Serial.println("Waiting...");
// delay(5000);

Blynk.run();
}
```

References

- **Picture references**

[1]Internet of Things
https://www.aeologic.com/blog/introduction-to-iot/

[2] History of IoT
https://bytebeam.io/blog/a-brief-history-of-internet-of-things-iot-cl8ipnm83212891kphdhq3845m

[3] IoT ecosystem Components
https://appinventiv.com/blog/what-is-internet-of-things/

[4] Advantages IoT has
https://www.spiceworks.com/tech/iot/articles/top-applications-internet-of-things/

[5] Failures of IoT in Various stages
https://www.softeq.com/blog/75-of-iot-projects-fail-heres-what-you-could-do-to-avoid-this-scenario

[6] Block Diagram of Existing approach 1
https://ieeexplore.ieee.org/document/9333530

[7] Block Diagram of Existing approach 2
https://ieeexplore.ieee.org/document/8378212/authors#authors\

[8] Block Diagram of Existing approach 3
https://www.researchgate.net/publication/350679256_IoT_Based_Air_Pollution_Monitoring_System

[9] Esp32 Node MCU
https//www.amazon.in/SquadPixel-ESP-32-Bluetooth-Development-Board/dp/B071XP56LM

[10] Esp32 Pins
https://medesign.seas.upenn.edu/index.php/Guides/ESP32-pins

[11] Max30102
https //makersportal.com/shop/max30102-heart-rate-and-pulse-oximeter-sensor

[12] Max30102 System Diagram
https//circuitdigest.com/microcontroller-projects/how-max30102-pulse-oximeter-and-heart-rate-sensor-works-and-how-to-interface-with-arduino

[13] Max301012 Library
https//makersportal.com/blog/2019/6/24/arduino-heart-rate-monitor-using-max30102-and-pulse-oximetry
[14] Ultrasonic sensor HCSR04
https//www.google.com/url?sa=i&url=https%3A%2F%2Fwww.indiamart.com%2Fproddetail%2Fhc-sr04-ultrasonic-sensor-module-19727491430.html&psig=AOvVaw0sSebDL_paH7V4IH4LTyqg&ust=1669121970332000&source=images&cd=vfe&ved=0CBAQjRxqFwoTCLC37YKqv_sCFQAAAAAdAAAAABAO
[15] HCSR04 Sensor Diagram
https://www.researchgate.net/figure/Ultrasonic-sensors-and-Arduino-circuit-diagram-Sensors-echo-and-trigger-pin-are_fig3_332916346
[16] INMP441 Sensor
https//www.amazon.in/Techtonics-Omnidirectional-Microphone-Interface-Supports/dp/B08VVTW45S
[17] INMP441 Sensor
https //andersoncontrol.com/shop/signal-conditioning-icl/
[18] INMP441 Sensor Diagram
https //www.wardsauto.com/technology/bosch-sitime-team-next-gen-mems-resonators
[19]PIRSensor,
https://www.amazon.in/Generic-HC-SR501-Sensor-Pyroelectric-Infrared/dp/B00VNWWZM0
[20] PIR Sensor Circuit Diagram,
https://circuitdigest.com/electronic-circuits/pir-sensor-based-motion-detector-sensor-circuit
[21]Soil Moisture Sensor,
https//www.amazon.in/REES52-SOILSENSOR-Moisture-Automatic-Watering/dp/B01HVSCNL2
[22] Soil Mouisture Sensor Circuit Diagram,https
//circuitdigest.com/electronic-circuits/soil-moisture-sensor-circuit-diagram
[23] Infrared Sensor,
https //thestempedia.com/tutorials/what-is-an-ir-sensor/
[24] Circuit Diagram of Infrared Sensor,
https//www.easybom.com/blog/a/infrared-sensor-types-working-principle-and-applications

[25] Magnetic Switch,
https//robu.in/product/mc-38-wired-door-window-sensor-magnetic-switch-home-alarm-system/
[26] Magnetic Proximity Sensor,
https //www.omch.co/magnetic-proximity-sensor/
[27] APDS-9960
https://www.deltakit.net/product/apds-9960-rgb-infrared-gesture-sensor/
[28] APDS-9960 Pin Diagram,
https //www.elprocus.com/apds-9960/
[29] BMP 280 Sensor,
https//www.electronicscomp.com/bmp280-barometric-pressure-altitude-sensor-module-india
[30] BMP 280 Pin diagram,https
//startingelectronics.org/pinout/GY-BMP280-pressure-sensor-module/
[31] MPU 6050 Sensor,Robokits Triple Axis Accelerometer & Gyro Mpu-6050 Breakout Price in India - Buy Robokits Triple Axis Accelerometer & Gyro Mpu-6050 Breakout online at Flipkart.com
[32] Pin Diagram of MPU 6050,
https //components101.com/sensors/mpu6050-module
[33]Pollution within the house
https://www.avasflowers.net/blog/the-12-best-plants-to-clean-the-air-in-your-home/
[34] Gases around Industrial Areas
https://www.aqi.in/blog/toxic-gases-sources-symptoms-after-effects/
[35] Gases Monitoring System
https://www.aqi.in/blog/toxic-gases-sources-symptoms-after-effects/
[36] What harms does gasses bring
https://www.aqi.in/blog/toxic-gases-sources-symptoms-after-effects/
[37] Barchart of Deaths
https://www.thelancet.com/journals/lanplh/article/PIIS2542-5196%2822%2900090-0/fulltext
[38] Arduino IDE https //www.javatpoint.com/arduino-ide
[39] Process Flow through Blynk
https://elearn.ellak.gr/mod/book/view.php?id=2950

[40] Bread Board
https://potentiallabs.com/cart/buy-breadboard-medium-online-hyderabad-india
[41] Jumper Wires
https://blog.sparkfuneducation.com/what-is-jumper-wire
[42] Resistors Notations
https://eepower.com/resistor-guide/resistor-fundamentals/what-is-a-resistor/
[43] MQ135 Sensor
https://quartzcomponents.com/products/mq-135-air-quality-gas-sensor-module
[44] MQ135 Sensor pin details
https://www.elprocus.com/mq135-air-quality-sensor/
[45] MQ2 Sensor
https://quartzcomponents.com/products/mq-2-gas-sensor-module#:~:text=MQ2%20Gas%20sensor%20is%20a,Gas%20comes%20in%20to%20contact.

- **Research Papers Reference**

[1]https://ieeexplore.ieee.org/document/9333530
[2]https://ieeexplore.ieee.org/document/8378212/authors#authors\
[3]https://www.researchgate.net/publication/350679256_IoT_Based_Air_Pollution_Monitoring_System
[4]https://ieeexplore.ieee.org/document/9333530

- **Tables**

[1] https://www.aqi.in/blog/toxic-gases-sources-symptoms-after-effects/ nfpa abb

[1] https://www.watelectronics.com/breadboard-construction-types-working/ [breadboard]
[2] https://www.elprocus.com/mq135-air-quality-sensor/ [mq135]
[3] https://www.elprocus.com/an-introduction-to-mq2-gas-sensor/ [mq2]