Smart Home Model Based on Internet of Things (IoT) Framework

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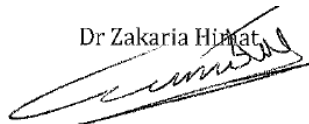
Title: Smart Home model Based on Internet of Things (IoT) Framework

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ACADEMIC HONESTY PLEDGE

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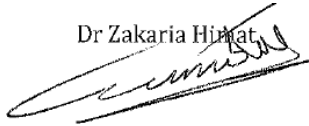| Name	Date	Signature
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Abstract

When we speak about a smart home model, we speak about various aspects in our homes that are integrated in a modern way to create efficiency and sustainability for the users who are within this home. Such homes have several devices that are connected in a way to create convenience for the user and to interact with several aspects of their home through local or remote access.

In this project we aim to make this project multi-featured compared to several other models that focused only on controlling loads through a user interface. We intend to make this available for the user to remote lighting and air conditioning through a user interface that is designed with the addition of several monitoring elements such as temperature, movement and gas detection. We intend to make it as complete as possible and this project has the potential to develop much more to the scale that we have currently set for it.

Keywords: Smart Home Model, efficiency, Security, appliances, remote control, Arduino, WIFI, microcontroller, automation, sensors, programming.

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List of Abbreviations

LED   Light Emitting Diode

PIR   Passive Infrared

WIFI   Wireless Fidelity

MCU   Microcontroller Unit

IOT   Internet of Things

PWM   Pulse Width Modulation

IDE   Integrated development environment

WLAN   Wireless Local Area Network

GSM   Global System for Mobile Communications

LCD   Liquid Crystal Display

NO   Normally Open

NC   Normally Closed

VCC   Voltage Common Collector

GND   Ground

SMS   Short Message Service

WEP   Wired Equivalent Privacy

WPA   WIFI protected access

GPIO   General Purpose Input/output

IOREF   Input/output Reference

COM   Common

IP   Internet Protocol

AC   Alternate Current

DC   Direct Current

SCL   Serial Clock Line

SDA   Serial Data Line

SPI   Serial Peripheral Interface

AI   Artificial Intelligence

HDFS   Hadoop Distributed File System

HTTP   Hyper Text Transfer Protocol

IEEE   Institute of Electrical and Electronics

1. Introduction

Evolution is an indispensable phenomenon that everything must undergo with the progressing of time [1]–[3] This fact has been proven throughout the advancement of mankind where technology revolutionized every aspect of our lives [4]. Hence, it only natural that the wheel of evolution begins rolling towards the main pillar of everyday lifestyle which is the traditional home where we spend most of our time [5], [6]. One can argue that the development of smart homes was bound to happen sooner or later, for which homes play an essential role in transforming and up scaling the society's living standards [7], [8].

The level of advancement in the technologies present in our homes have consistently stagnated and fell behind its counter parts outside the home environment, as they have yet to acquire the prospects of automation and sustainability which contradicts with the direction that the industry has been following for a long time to increase efficiency and ease of use [1], [9] . As a result, its apparent that there is a vast room for development in the smart home section and various ideas and technologies that can be implemented to fill this void [10]–[13].

The brilliance of smart homes lays in its ability to integrate an enormous number of appliances and devices into its framework of operation or simply it can be called 'Scalable'. Thereby, widening its range of abilities and tasks that it can perform [14]. For example, the devices used in the kitchen, living room or at the gate, all can be handled in a programmed sequence of instructions. Hence, transforming them into truly smart devices. In all actuality, devices obtain the term smart when they become able to connect to the internet, hence, gaining the ability to be monitored and controlled remotely from anywhere anytime which opens up the doors for several opportunities and concepts that raise the potential of any system [15]–[17].

Smart homes do not only revolve about luxury and comfort, it presents safety and security aspects that alters our perception and view towards what homes could truly offer us. The ability to monitor and control the house remotely is the quintessence of smart home systems and it is what grant them the prospects of convenience, safety and security. The working procedure and principles of a smart home model can be visualized as a collection of frameworks, each one serving a single purpose.

These frameworks will compose of the set of instructions designed to operate a group of devices in a certain sequence to achieve a suitable outcome. In turn, these collective outcomes determine the benefits of the system.

This report will discuss the design of the smart home system and the benefits it provides. Furthermore, it will describe in detail the flowcharts and the frameworks that composes the system, as this aspect is an important characteristic that defines our project for which the system revels in its scalability and aptitude for further development.

2. Literature Review

First and foremost, it's important for us to review the previous research done on this topic and others implementation of the smart home system in order to benefit from their experience and to pick up from where they have left off to continue the progression and development of this concept.
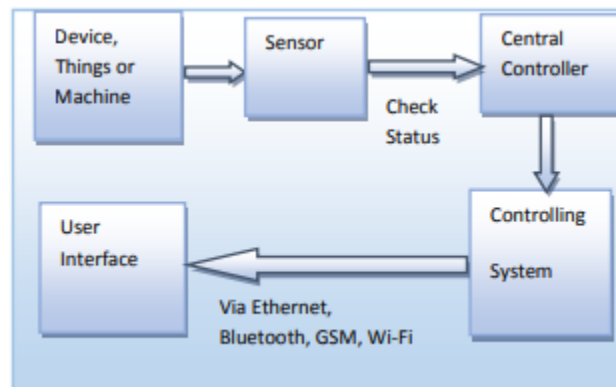
Figure 2-1:General concept of a smart home model

2.1. Wi-Fi based home automation system

This particular home automated system depends on the connection of the internet to operate as its name suggests quite frankly [18]. Using a Wi-Fi connection, the system will be able to connect to the internet and through web server that will act as the middle man between the user and the system itself. Thereby, allowing the user to control the functions of the system remotely and monitors the status of the system periodically through the consistent transmission of data back and forth. In most scenarios, usually an app is developed to act as an interface between the user and the web server as this will make the system easy to use and more feasible. The app will display the readings from the sensors that will be refreshed on certain intervals as well as display the current status of the system and provide controls to operate its functions.

However, the nature of this system requires a constant connection to the internet from both sides at all times. In addition, typically these systems are made to be simple without complex instructions which reduces their capabilities compared to other full-fledged systems.
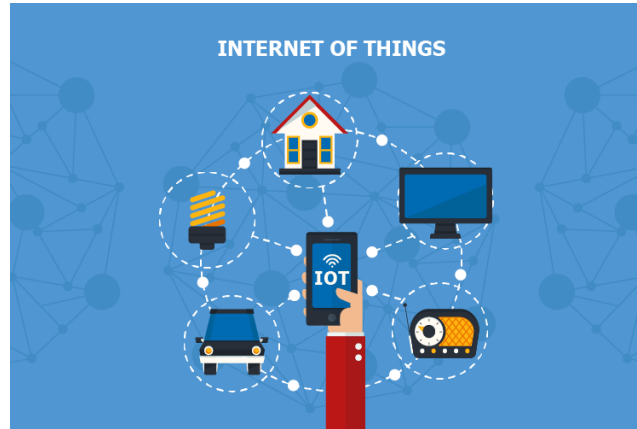
Figure 2-2: Concept of internet of things

2.2. Raspberry PI system

A wildly know application of smart systems is through the utilization of the Raspberry PI platform which is based on the android operating software [19]. In these types of frameworks they needs an interface card to be created and set up to guarantee straight communication between the client who is in absolute controls using the remote capability of the system, the web server that is created , the raspberry pi microcontroller which is comparable to the arduino and obviously the home devices which are the main focal point. The application that was developed acts as the interface between the client and the system shall be then installed on the android cellphone that will issue commands and set of instruction to the home system itself. An interface card has been set up and created to refresh the signals sent by the sensors and later transferred to the microcontroller.

Figure 2-3: Raspberry PI Microcontroller

2.3. Cloud centered smart system

The widespread of cloud-based technologies invited experts to use its prowess in the smart home systems [20]. A cloud-based system means that all the data is stored on a server in a far location but accessible using the internet from anywhere. This method is used as a getaway for the metadata to keep them safe on cloud while the job of the system will be to collect those data from the sensors and appliances and transmitting them consistently. The data will be stored on HDFS (Hadoop Distributed file system). Thus, allowing the user to have the ability to monitor remotly at all times. The microcontroller use to collect the data and recieving them back and forth will be the raspberry pi as it excels in its eficiency and ease of use. Furthurmore, the ecnomomic benefits are quite high as it is available for a very low price [21].
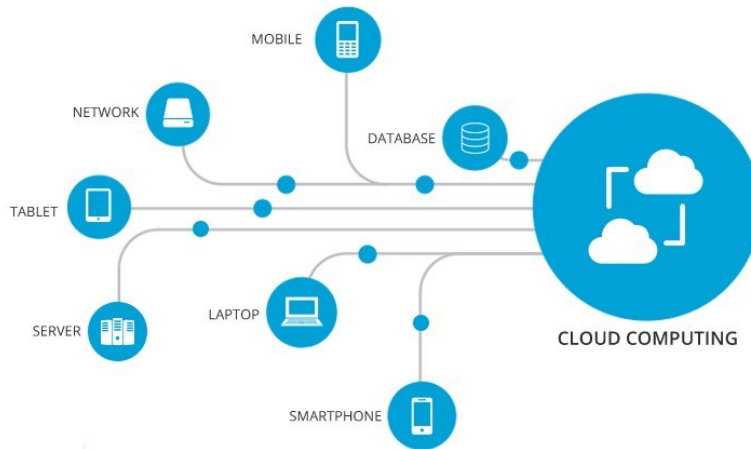
Figure 2-4: Cloud based systems

2.4. ZigBee and Arduino smart systems

A smart home system based on the ZigBee platform was a new technology proposed by Shih-Pang Tseng et al [22]. Similar to its predecessors, the idea revolves around a microcontroller that collects the data from the sensors and actuators placed all around the house using the wireless network created by the ZigBee itself. Hence, creating a closely connected framework where data can be transmitted and received. The system has also introduced numerous ideas such as a smart socket model that can remotely connected by utilizing the network created via the ZigBee. The data thereafter is conveyed to the host PC where all of these data can be monitored and controlled. Meanwhile, the ZigBee correspondingly will create a web server which the user can access through his phone via the internet to control the system remotely.
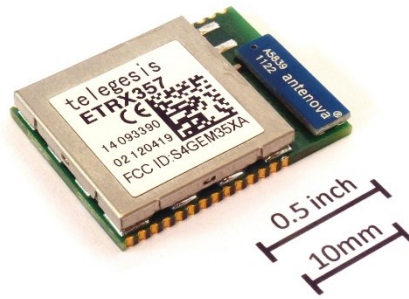
Figure 2-5: Zigbee Network Chip

In the case of the Arduino platform although the concept may sound largely similar to what might be found in previous systems, the Arduino excels in its vast versatility and wide range of applications. Consequentially, it is the perfect candidate to use in a smart home system because the aspect of versatility and scalability is what sought after in this field in order to encompass the large variety of functions that a smart home need. The Arduino enjoys the ability to be controlled through both wired and wireless connections with a wide range of methods of communication in both the two aspects. Additionally, the Arduino houses the web server via the HTTP protocol that is used to build web-based application. [23]

After covering a multitude of previous implementations of home smart systems, we gain a rough understanding on the scope of this topic. Enabling us to visualize the general framework shared by all of these systems which is considered the backbone of smart systems or as one might refer to it as the main building blocks. Only by taking a look at these systems that we can list all their benefits and disadvantages. Thereby, empowering us with the necessary tools to create an even more complete and functional smart system which will be discussed in the upcoming sections of this report.

2.5. Project Gap

As we are following up on the previous systems, we need to create a gap and fill the voids present in those systems. For which research on a certain topic cannot advance forward and progress without using past studies as construction blocks that we build on top and continue on wards. In this project, we determined the weak points present in preceding smart home systems and outlined their structure and framework of operation to place our entire focus on those vulnerabilities and create a more complete system without these negative issues.

Accordingly, we have determined two main scopes that we would like to tackle in our project since previous systems were quite lacking in these two prospects. The first scope that we would place emphasis on is the aspect of security. It's understandable that the most important feature of our houses is that it provides us with security and sense of belonging. Therefore, a considerable amount of people places the security of their homes as the number one priority when they're searching for a smart home system. Old and current systems don't usually focus much on the aspect of security, at least in the case of smart home systems. Henceforth, we developed numerous precautions to increase the level of security. We have divided the security measures into two sections, monitoring and guarding.

Firstly, the monitoring will consist of a security camera that will be responsible for surveillance to update the user of the situation surrounding the house at all times and show him the feedback if someone was trying to sneak in. Secondly, the guarding and protection aspect will consist of a keypad locking mechanism that will ensure that only the people living in the house will be able to gain access by using the password for the door lock. However, if someone enters the wrong password, a buzzer will alert the residence of the house lest there is a break-in attempt.

As stated by Dr. Paul Patras (University of Edinburgh), "Smart home systems and the numerous advantages they offer are demonstrating their popularity with clients. It is a significant thing that these systems are created in view of security, and that guidelines should keep pace with advancements in innovation and its applications". Which in turn approve of our contribution to make homes safer and more secure. [24]

The second gap that we will tackle in our outtake on implementing a smart home system is regrading safety and wellbeing. A concerning problem that have been a headache for years are gas leakage accidents, which caused devastating losses for many families and endangered the lives of many individuals especially children who are always the victims of such cases.

Nowadays, there are no smart home systems that focus on solving this problem, they usually tend to push this responsibility to the old firefighting system, but even then, it cannot measure if there is any gas leakage and can only spot if there is any fire. Which is very dangerous as high levels of carbon dioxide can cause suffocation that may affect people in their sleep without warning. Therefore, we have devised a system that will be responsible for monitoring the levels of carbon dioxide in the house and if it reaches above certain level, it will start the sequence programmed in the system to initiate the safety protocols.

It will begin by sending a SMS message to the programmed phone numbers to alert them of the high levels of carbon dioxide in the room. Likewise, the system will send an alert to the authorities informing them of the situation.

3. The Blueprint

In this section of the report, we will be speaking of all the design aspects that are projects consists of and all the technical descriptions for all of our components that we are using in this project. We will be speaking of the block diagram that visualizes how are smart home model will be constructed and the purpose of our design, all the components will be explained and the reason we have opted to go for these components in comparison to other components that can do the same tasks, the IEEE standards that we are going to follow in several parts of our project , the flowchart mechanism that will be describing in the internal flow of operation of our microcontrollers that are considered the hub of each part of our project , the circuit diagrams that we have designed and the codes that will be used to run and operate our microcontrollers.

3.1. Block Diagram
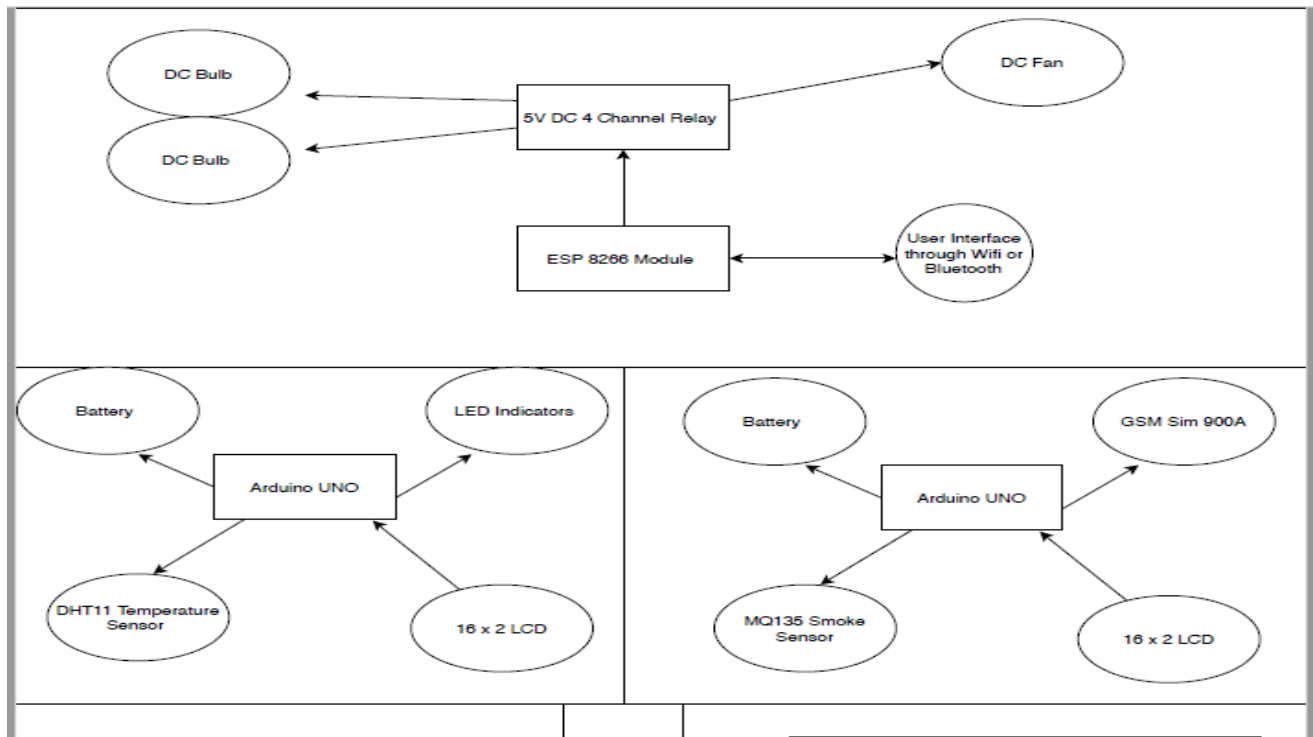
Figure 6: Inner Components of the Smart home Model

So, we have two parts of this smart home model, and inner part that is inside the house and an outer part that is outside the house. We will be speaking first of the inner section of the smart home that we are going to build.

Of course, most smart home models focused on only a single aspect within the home and that is the control of loads and appliances such as bulbs, fans etc. Such loads would give an indication that you can control your home through certain networking algorithms such as WIFI or Bluetooth through a certain user interface that is designed to meet the demands of the user using it. But what most previous projects lacked was the aspect of monitoring and safety that we are planning to implement through our smart home.

As it is visible, we have the upper section of the home which will be controlled through an Espressif microcontroller and these microcontrollers have the advantage of built in WIFI and Bluetooth modules, the ESP8266 comes very handy in IOT applications which deal with humans not interacting directly with appliances rather deal with an interface or an application. This part will be explained in further detail in the design section below when we speak of every component.

Coming to the monitoring aspects of the homes we have constructed a temperature monitoring system as well as a gas leakage detection system. It is visible from the block diagram that we have opted to go for the Arduino Uno which considered to be the most standard and robust type of microcontrollers. The reason we have opted to go for it as the aspects of temperature and gas detection are going to be used locally within the home and we would not need any sort of connectivity for it but all we will need is a screen to view the respective data that is to be known by the user. One of the gaps that we would like to fill is the aspect of safety and most homes can experience gas leakage so we have gone for a gas detection system that will measure the level of gases present and if it exceeds a certain level an SMS will be sent to the numbers of the owners within the home and the reason we have opted for SMS it's because this is the most fastest way of alerting instead of going for an email.

You might be wondering why use multiple microcontrollers when you can use a single micro controller? Multiple microcontrollers give us the ability to be as expansive as possible in each part of the project as we are limited with a number of pins that are present in each microcontroller. Also, if we rely on a single microcontroller to run multiple aspects of the project and if it fails at one point, all our systems would fail so using multiple microcontrollers gives us the ability to have the home still running on all the other aspects in the case of the failure of one.
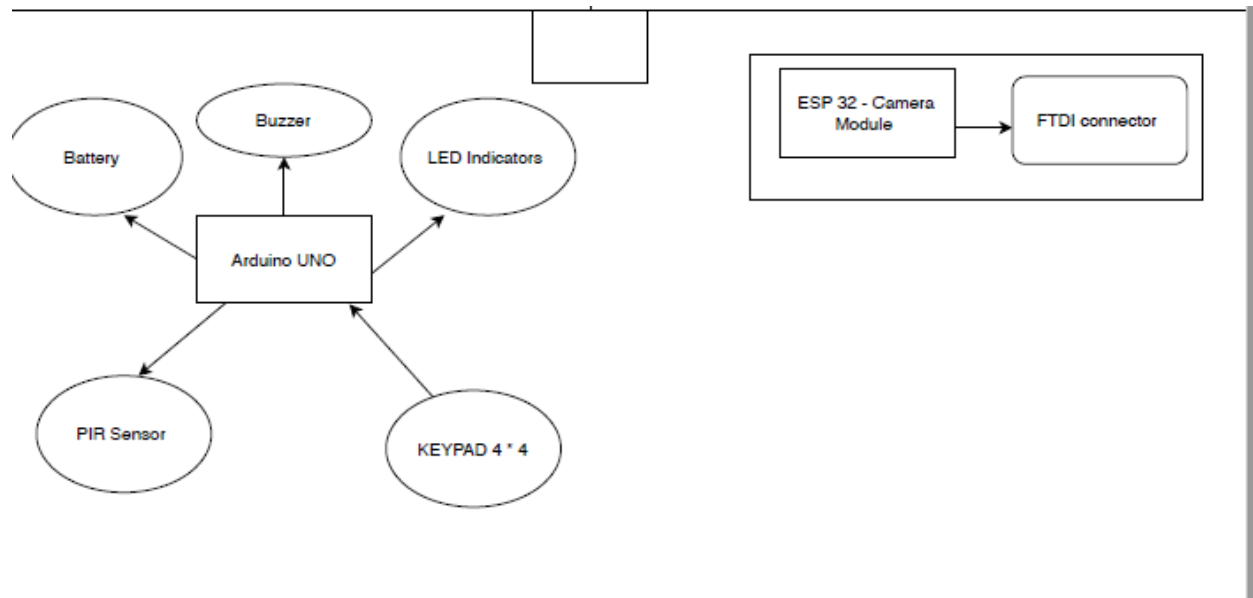
Figure 7: Outer Part of the Smart home Model

Now that we have spoken of the inner block diagram which represents what is going to be present inside the smart home model that we are going to build, it is time to discuss the block diagram of the outer part.

The outer part of our Smart home model will be focusing on the second element that is present in the gap that we want to fulfill, and it is the security aspect. Security is another aspect that has been neglected in most models and it is useless to have a smart home model without any sorts of security measures that is taken to protect your house to a certain extent.

So, we have visualized the security into two aspects:

- Motion detection with password
- Camera Monitoring for continuous inspection

For the motion detection part, we are going for a PIR sensor that will be detecting the heat and radiation that is present inside a moving body in that way the sensor activates, and the user is opted to insert a password through a keypad that is already programmed within the code that is uploaded on the Arduino through the sketch. In the case of the password that is detected is invalid, a buzzer is triggered, and LEDs will light up indicating there is intruder or unrecognized personnel.

The second part that is the camera monitoring that we will be using through an ESP 32 – camera module. This is a very low-cost chip that is designed by Espressif as well for such purposes and it has the ability on functioning WIFI and Bluetooth which gives us the ability to track and inspect the camera from anywhere around the world as long as you are connected to the internet.

These aspects of security are considered important as most smart home systems are considered to be vulnerable to hacking and without the proper safety procedures that can even be expanded in the future within this project it puts the home at stake to be easily infiltrated.

This section only consisted of the description of the block diagram and how the project is visualized without speaking of the technical aspects yet of are components and how each component functions. We will be speaking in full detail about each component individually before going to the flow charts, the IEEE standards that we will follow, the circuit diagrams that we have made and finally the codes that will be built on the IDE and uploaded onto our microcontrollers.

3.2. Theory of Microcontrollers

As we are using two types of microcontrollers that are the Arduino Uno and the ESP8266 dual core alongside the ESP 32 camera module, it is important to first understand the concept behind microcontrollers and how important of a peripheral it is to our project.

A microcontroller is considered to be an integrated circuit that is used in multiple applications and appliances that are present that have microcontrollers built in it. This chip consists of a running processor that is similar to the CPU present in our computers, a memory stack that stores all the data in which the microcontroller is running on and input/output ports that are used to give input data in terms of analog or digital and give output in terms of analog or digital. [25]

Microcontrollers are considered to be embedded systems that can be found in various systems such as automobiles, robotics, medical devices, home appliances and among other devices. They are miniature computers that control small features of a larger product which in our case we have every component controlled by its own microcontroller.

 Any microcontroller has a set of elements that make it function:

- A processing unit: This is considered to be the heart that operates the device and it involves all the operations and commands that are programmed to do the given tasks.
- Memory: it stores all the data that is within the processor and all the instructors that take place whether it is program memory or data memory.
- I/O pins: these are the pins that take data from input and output devices and process it within the microcontroller itself.

Microcontrollers come in different bit ranges from 4-bit up to 64-bit processors. And we will be seeing this when we speak about the microcontrollers that we are going to use in our project

In the following part of the report, we will be speaking about both the Arduino and Espressif microcontrollers that we are going to use.

Figure 8: Different types of Microcontrollers

3.3. What is Arduino?

Now that we spoke about microcontrollers it is necessary to speak about what Arduino is before going to the microcontrollers that we will be using in our project.

So, the main question that arises in our minds is what the Arduino environment is and what is Arduino in general?

This global platform that has been now a huge open source that is available to everyone and it has the ability to link devices such as sensors and many other peripherals with the software language that is developed by C++.

Arduinos can be used in various applications and multiple project ideas resort to use the Arduino environment as the main aspect in their project due to how sophisticated it is and its ease of use and programming as well compared with other interfaces. People from different scientific backgrounds can go for the Arduino to implement what they would like to implement based on their area of interest. [26]

This open-source platform allows people to publish their works and several beginners can access these fundamentals and these sources to learn and enrich their skill by learning new ideas of how to program and how to connect various peripherals to each other and not only beginners but also

experts could work on existing ideas by referring to published works that could assist them in their endeavors.

There are boards that are made by the Arduino company itself and there are other boards that are also supported by the same Arduino development environment that uses the same programming language. These boards are considered to act as the main source of communication between the inputs received and the outputs delivered to the respective recipient. The board can be used from activating an LED, to sending information to an LCD screen or activating a motor or running multiple items in your house as we are doing. This is achieved of course through the transmission of instructions from one end to another end by the use of the programming language that is done through the integrated development environment. We will be speaking later in the report about all the programs that we have designed for each microcontroller with complete detail and explanation

There are multiple advantages to why we use the Arduino environment compared with other microcontroller platforms such as:

- Programming simplicity and flexibility for the user to program regardless of their ability to program.
- Can function on multiple operating systems and not limited to a single operating system making it of great convenience to the user.
- It is relatively cheaper compared to other development boards.
- Open-source platform which makes it expandable and the libraries can be updated every day and this will be of advantage as devices get updated every day and so is the software that gets updated.

3.3.1. Arduino Uno R3

Now that we have spoken about Arduino in general its time to speak about the Arduino based microcontroller that we will be using which is the Arduino Uno R3. It is based on the microcontroller designed by Atmel called "ATmega328". [27]

The Uno pinout consists of the following:

- 14 Digital pins for digital output
- 6 Analog inputs
- A power jack
- A USB connection
- ICSP header

The pinout offers so much versatility to provide several options such as activation of devices or reading analog data from various types of sensors like how we are using it in our own project.

The following figure will show the Arduino Uno Pinout and we will explain them later in details
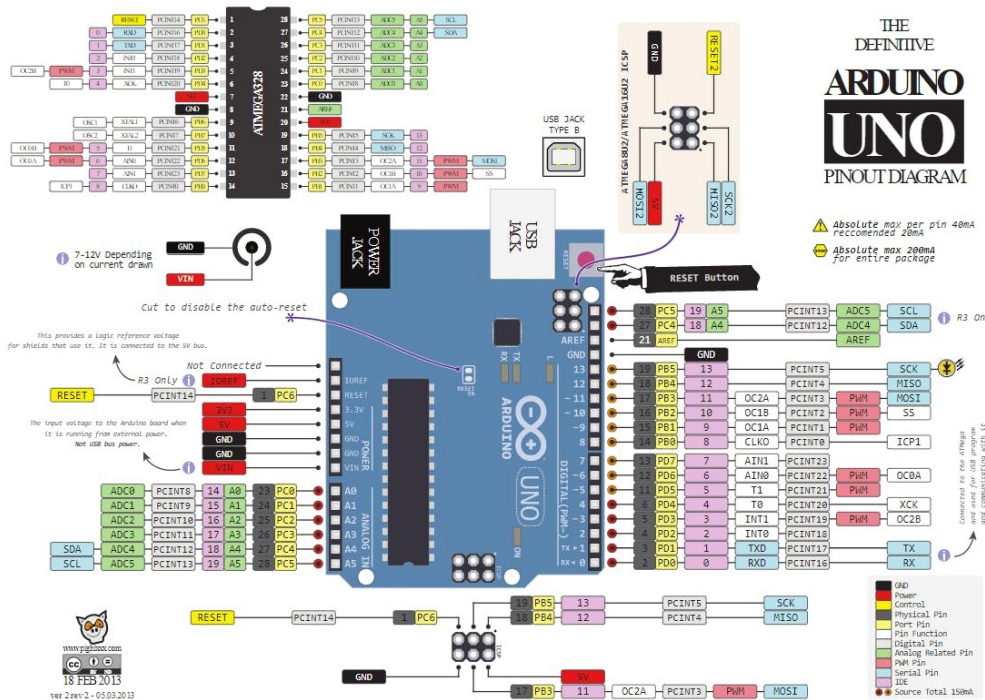
Figure 9: Arduino Uno R3 Pinout

The Arduino Uno can be powered in 3 ways that will be mentioned below:

- USB cable: in this source of power the cable is connected to the computer and a voltage of 5V and 500mA of current are provided to the board.
- VIN pin: This pin uses an external power source as the source that powers the development board. The voltage should be within the 7-12 volts as per the manufacturer states.
- Barrel Jack: This is a DC power jack which can be connected to a battery or a wall adapter and it is recommended to give 7-12 volts. Even though it can handle from 5-20 volts but due to the voltage regulators within the board could overheat with time and get damaged above 12V and below 7 might not be sufficient enough to run the board or to have enough power to supply. [28]
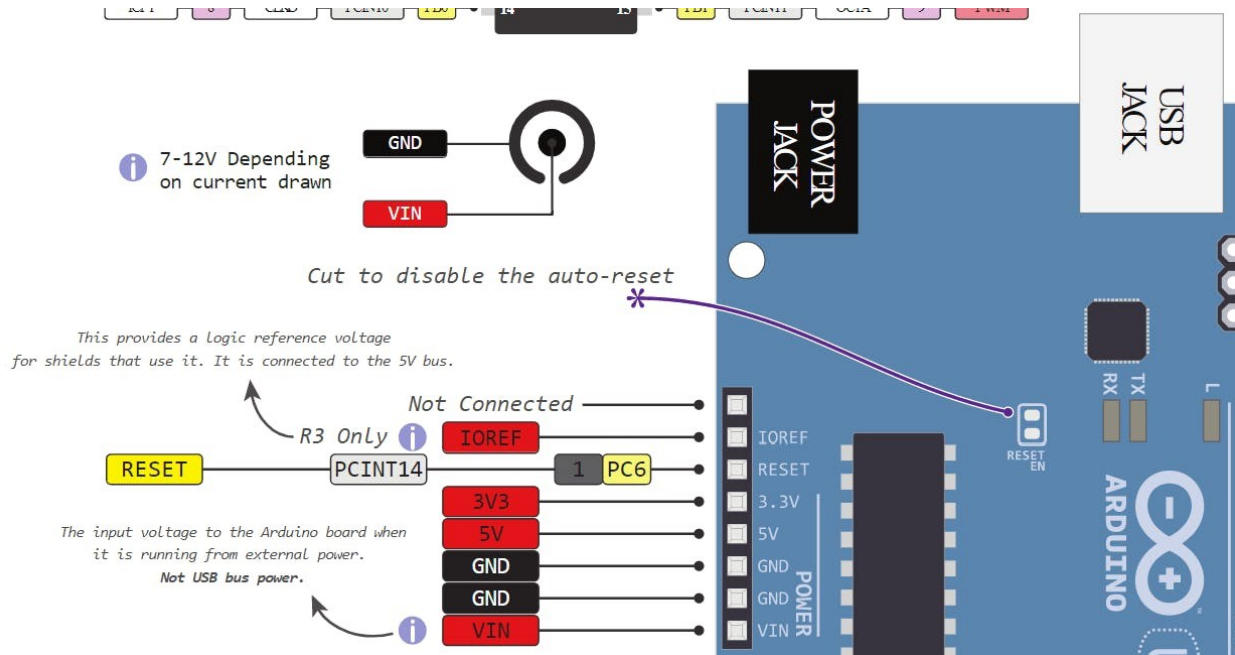
Figure 10: Power supply Pinout

There are other pins available in the UNO board that are also essential for powering such as:

- 5V and 3.3V pins: These pins provide external regulated voltage to certain components that require certain specified voltage.

- GND: There 5 GND pins that are all interconnected with each other. In any electrical circuit, the circuit needs to be closed and the GND pins provides this.

- RESET: this resets the Arduino back to normal.

- IOREF: This pin provides the reference for the voltage at which the microcontroller is operating.

3.3.1.2.   Analog Inputs Pinout

Inside the Arduino Uno we have 6 Analog pins that take advantage of the ADC feature. These pins take analog inputs, but they can also function as digital I/O.
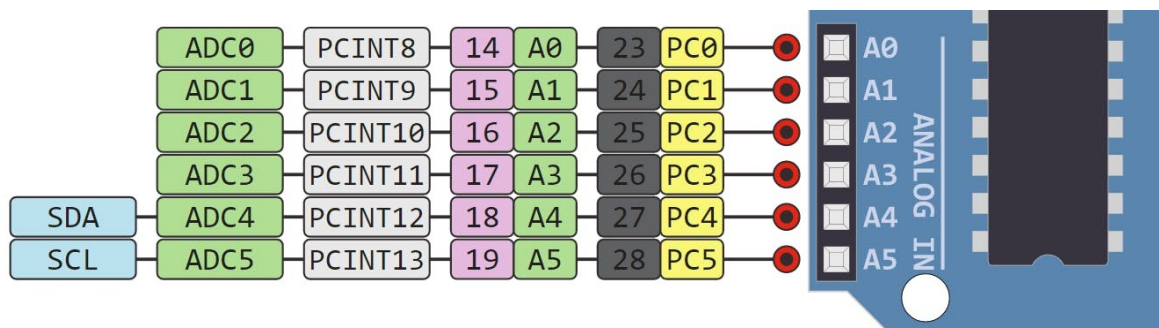
Figure 11: Analog pins

The analog to digital converter is an electronic circuit that has the ability to convert analog signals to digital signals. The processor can't take in directly analog signals so it has to convert them into digital in order for it to process and use it through its operation.

So, these pins can read analog voltages and convert them into bits for the microprocessor to understand and process.

3.3.1.3.   Digital Pins Pinout

There are 14 pins that are available at the Arduino that serve as digital inputs and output pins.

Pin 13 is connected directly with the in-built LED that is present within the Arduino board.

Pins 3,5,6,9,10,11 all have the ability of PWM which will be explained later on in this section.
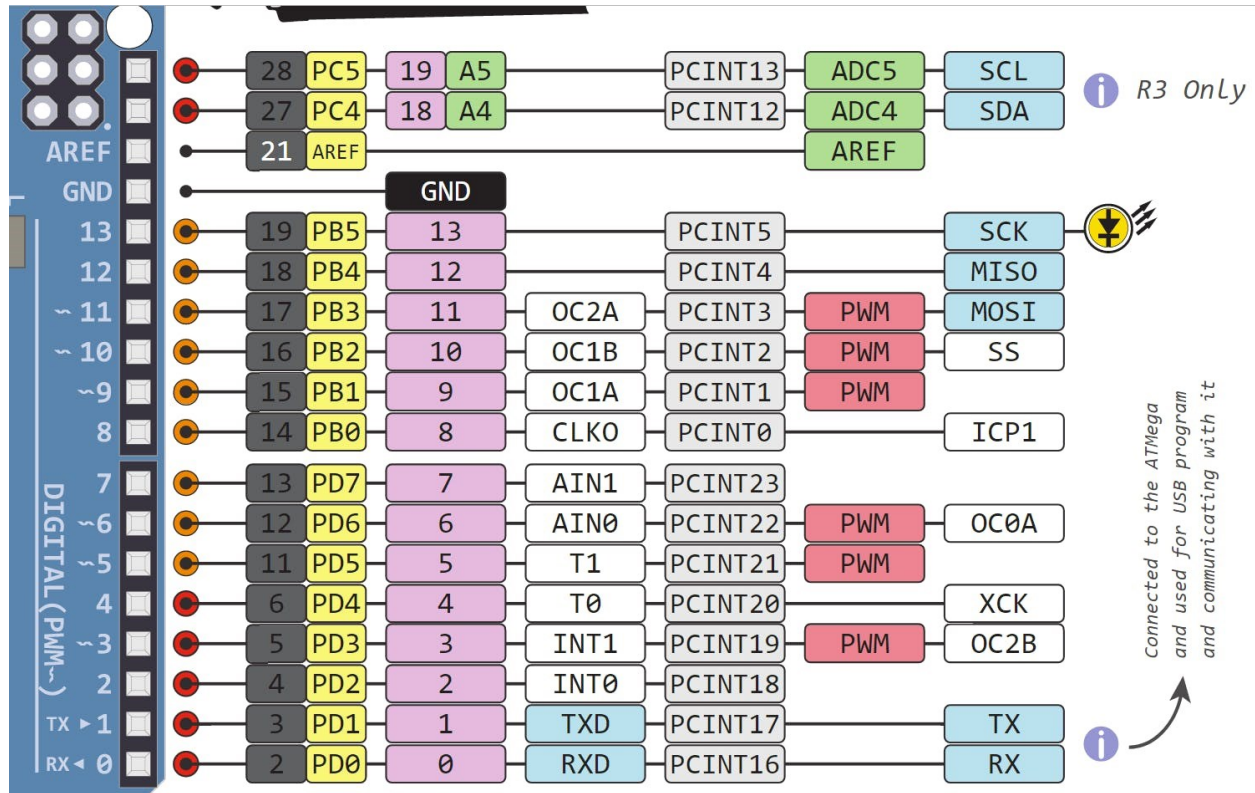
Figure 12: Digital Pins Pinout

Digital data is the data that is represented by either a binary value of 0 or 1. These pins can be configured depending on the user to function as inputs or outputs. So, they either have two states whether they are functioning or whether they are off. When they are at the ON state, they will be at a HIGH voltage state of 5V and when they are at the LOW state, they will be at a 0V state. [29]

So, the digital pins can vary in terms of voltage from 0-5V as per what is supplied.

3.3.1.3.1.   What is Pulse Width Modulation?

So, when we speak about Pulse Width Modulation, it is a modulation method that is used to encode a message into a pulsing signal. It is consisting of two essential aspects:

- Frequency
- Duty Cycle

The frequency of the pulse width modulated signal will dictate the time period to complete a single cycle and how it will quickly fluctuate from high to low. The duty cycle then is able to determine how long it would stay high at the total period and this is represented through a percentage. [30]

The pins always produce a frequency of 500Hz, while the duty cycle can vary depending on the parameters that are set.
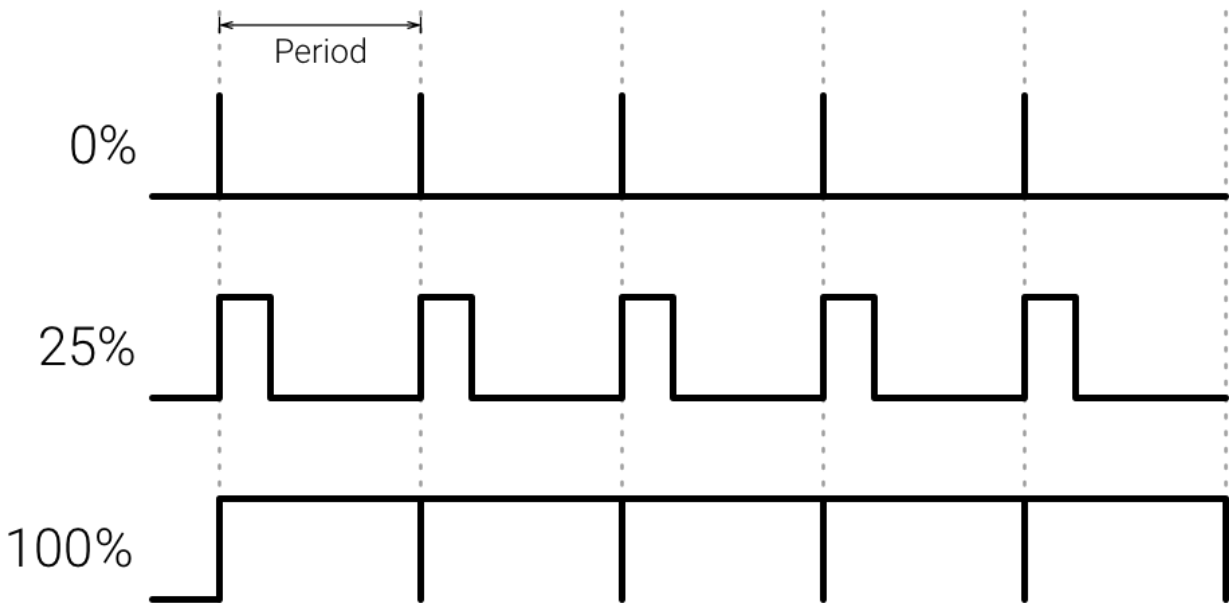
Figure 13: Duty Cycle Illustration

These signals can be used for various applications such as LED dimming, DC motor speed control and several other applications.

3.3.2. Espressif Micro controllers

Espressif is a company that focuses on creating and developing solutions that are based on the Internet of things phenomena through the use of the WIFI and Bluetooth protocols. [31]

They have gone on to create the microcontroller that we will be using and speaking of in the following section and that is the ESP32 series of chips, modules, and development boards.

By taking advantage of the ability of short and long ranged communication, it is considered to versatile in terms of its uses and it makes it very cost effective due to the variety of tasks that can be done using it.

Espressif have been keen to offer very robust ways of Internet of things without worrying about excess energy to be used or security issues and it is one of the main reasons we are relying on such microcontrollers to use in our web-based applications in our smart home model.

It is notable to mention that this is an open-source technology, which means that developers from all around the world can interconnect devices through the smart phenomena which is something that is required in most projects today.

The ESP chips have offered solutions for developing interconnected appliances to control through a highly secured medium and fast wireless connectivity in comparison with the normal Arduino Uno.

With these types of chips, a huge number of components can be saved as it is all connected within the board itself without any extra components such as resistors, capacitors or inductors etc.

3.3.2.1.   ESP 32- Wroom – 32

The Esp32- WROOM-32 is one of the powerful Microcontroller units that have built in WIFI and Bluetooth protocols. The purpose of them is to target various applications from low power tasks such as small sensors to demanding tasks that require high amount of power. [32]
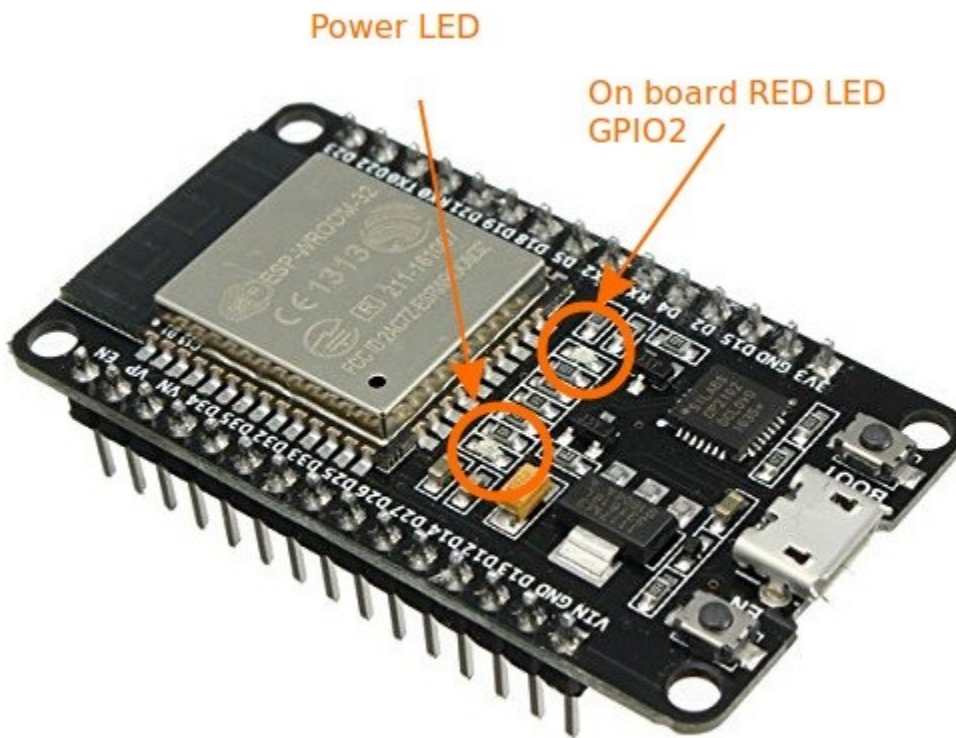
Figure 14: ESP32 Module

The Chip that is embedded within the ESP32 is a "D0WDQ6" chip and this chip makes it very scalable and adaptive to multiple environments. It has two cores that are controlled on an individual level and the clock frequency is between 80MHz to 240MHz.

With Bluetooth and WIFI, the module can target multiple applications that require direct connection through the internet for long ranged connectivity and Bluetooth for low energy applications that require local control.

3.3.2.1.1.   ESP32 WROOM32 Pinout
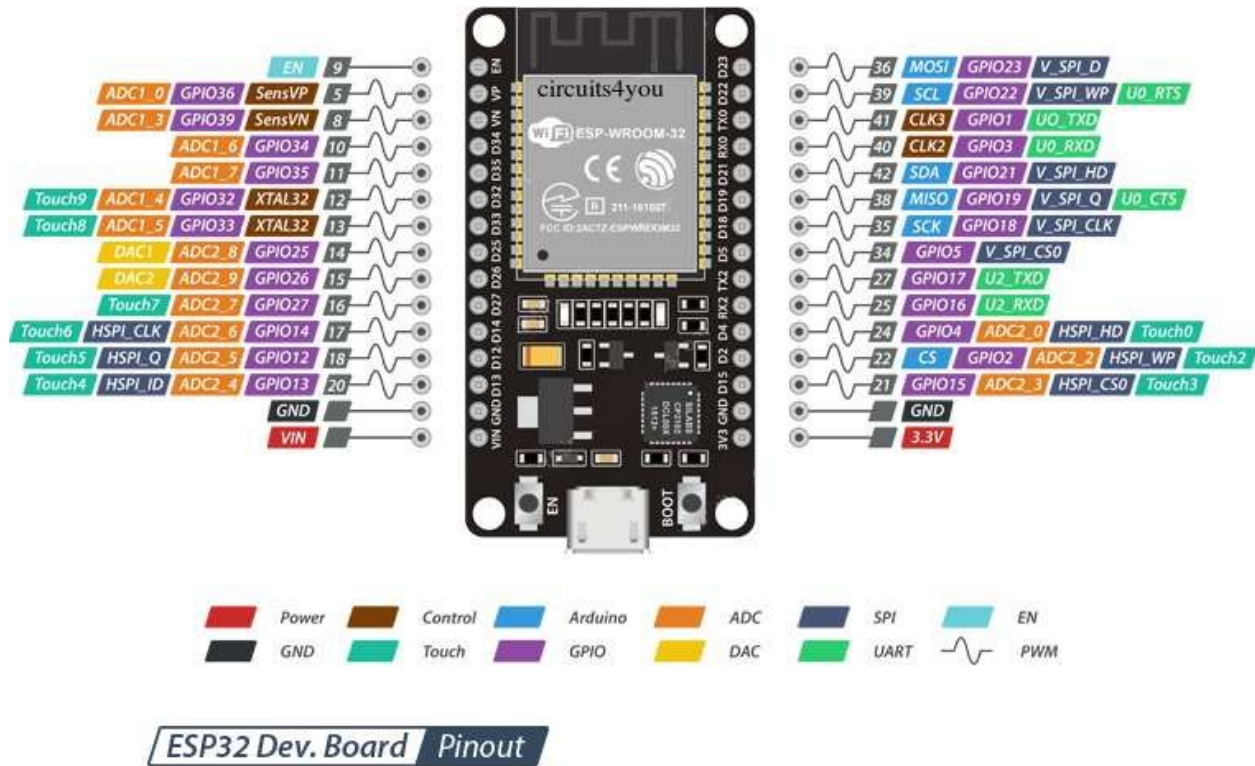
Figure 15: ESP32 Pinout

ESP32 has certain Peripherals that are included that we will be specifying here below:

- It has 2 I2S interfaces (Inter-IC sound) and it is a serial bus that is specifically designed to function audio devices. [33]
- 16 Pulse width modulated output channels
- 2 I2C interfaces and this is a serial protocol for low-speed devices which was invented by Philips and now is used in all integrated circuits. [34]
- 2 Digital to Analog converters.
- 18 Analog to digital converter channels
- 10 Capacitive sensing GPIOs (General- purpose input/output)
- 3 Serial Peripheral interfaces [35]
- 3 Universal Asynchronous Receiver/Transmitter interfaces

The ESP 32 has 16 channels that are configured to give you a pulse width modulated signal with various number of properties. All the pins that are output pins can be used for the purpose of pulse width modulation.

Pulse width modulated signals are generated through certain parameters that should be declared within the code which are:

- The pin in which the signal is generated
- The percentage of Duty Cycle
- The Frequency of the signal that is generated
- The channel of the pulse width modulation\

It is worth mentioning that this robust chip will be very robust in the application of IOT that we will be using in the upper part of the home as controlling appliances through either WIFI or Bluetooth ensures user flexibility and ease of use without the struggle of having to open something manually as well as the ability to track the appliances that are open making it very cost efficient and power efficient as well.

3.3.2.2.   ESP 32 Camera Module

The ESP 32 camera module is considered to be a very innovative chip due to its miniature size and the small camera module which it has which is a small system that can operate independently without the use of all the pins present within the board.

Figure 16: ESP 32 Camera module

This microcontroller can be used for multiple applications such as wireless monitoring, wireless identification, positioning systems and several other applications to the internet of things. It is

considered to be such an effective module for such applications that require the internet to be involved within it. [36]

It has notable features that should be pointed out even for its small size it considered to be such a powerful microcontroller chip, some of the features are as follows:

- It is considered to be the smallest chip with integrated WIFI and Bluetooth capability which is considered to be humongous.
- It is a 32-bit CPU which runs on low power of 5V.
- It has the ability to Upload images through the WIFI and viewed from anywhere.
- The photos can be stored through a micro-SD card that can be inserted within the chip.
- It supports two types of cameras OV2640 and OV7670 types.

These are a few of the features that are included in this small sized yet effective chip which will be considered to be very useful for our smart home model. As security is one of the measures that we have taken for project, we would like to completely utilize the use of the ESP 32-camera to constantly monitor the home entrance through the web server that it creates, and this is another application in which Internet of things is put in full effect and user security is achieved.

3.3.2.3. IOT Automation and User Interface

So now that we have spoken about the microcontroller that have built in connectivity modules it is time to speak about the IOT and the difference between WIFI and Bluetooth. So, the Idea behind IOT is to have communication between devices without an actual connection which is touchable or physical and this is what we intend to do with the appliance control. But the question how to choose between both communication protocols? [37]
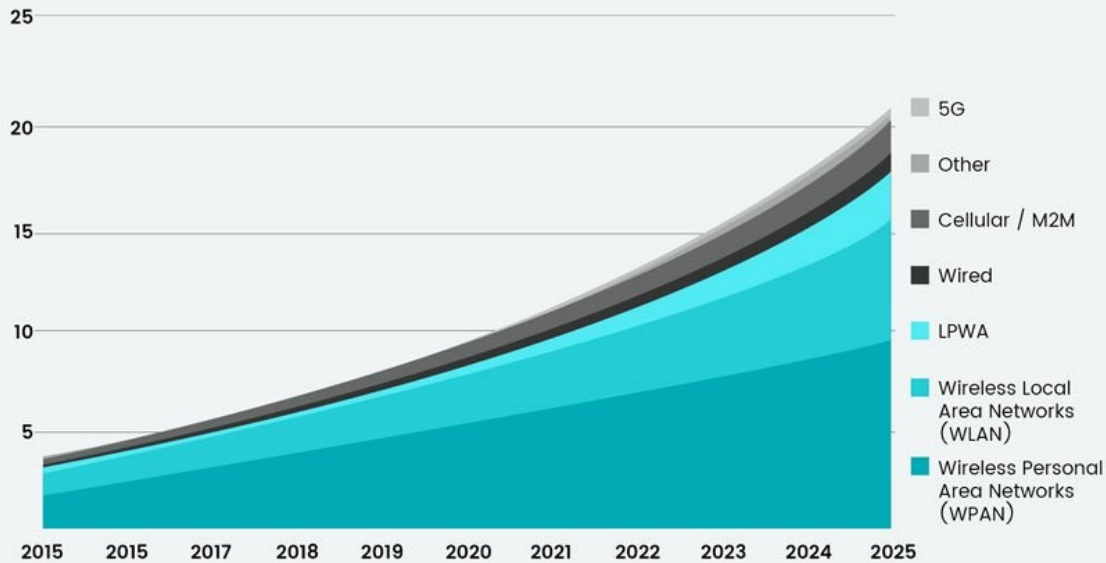
Figure 17: IOT connected devices around the world

Bluetooth Technology

Bluetooth is known for its physical proximity and in can manage only a number of devices connected to it without the need of any sort of password or security but only a local connection is required.

It uses Ultra high frequency radio waves that reach between 2.400 to 2.485 GHz, this technology is seen in multiple technologies such as headphones, speakers etc.

Not any device can connect to the Bluetooth with the compatibility that it will have in order to connect. There two versions of Bluetooth protocols that are used generally by IOT applications the classic protocol and the low energy protocol, the latter is used for low power consumption applications.

Bluetooth has its advantages such as due to its limited area that it covers there is no possible attacks from remote connections. Also, in terms of energy it consumes less energy so for low power applications Bluetooth can be used.

WIFI technology

WIFI which considered to be a modern phenomenon that is available in most smart devices that come with the built-in capability.

WIFI needs to be inbuilt in the microcontroller if you want to use this technology. It operates on WIFI credentials which could be a risk for malicious attackers to intrude your system. Stationary devices are mostly where WIFI is used.

Comparison between WIFI and Bluetooth for IOT devices:

1. WIFI has the advantage of faster speed when transferring data where at the least we experience 54 Megabytes transfer rate compared to Bluetooth which has only 3 Megabytes transfer rate which is a substantial difference.
2. Security is the first question that arises and the privacy of the data that is being transferred. Bluetooth is assumed to be the most secure protocol due to the proximity limit. But WIFI can also be secure for data transmission by adding a layer of security that is present in security protocols such as WPA or WEP.
3. WIFI and Bluetooth can also detect your location and provide accurate information to where you are located.
4. Range of coverage also differs between WIFI and Bluetooth and generally WIFI covers more range but also several factors such as frequency, antenna types and environmental routers located outdoor have an effect.
5. WIFI requires more power for it to function properly compared to the Bluetooth which is designed for less power applications.

There is no clear deciding choice when going for an option between Bluetooth and WIFI as it all depends on the IOT application that is being designed and the purpose that it will be used for and whether the data transferred is huge or not. Considering this is a smart house we intend to make it

feasible for the user to operate from a large distance remotely through the use of the WIFI technology.

User Interface:

To successfully interact with the two applications that we are implementing the IOT technology in it we need an application or a user interface which the user can see and monitor everything that he would like to control. For the ESP 32 camera module, it creates its own application by default through the camera web server feature with all the modifications that you can do to the camera such as face recognition or photo contrast etc.

The second application which is the appliance control through the IOT which will be through the switching through the Relay that it connected it. We will be able to use existing software such as Blynk which is a software or an application that is perfect for IOT applications and here we can link the ESP WROOM-32 with the app and the user would have control over his own network and his appliances to switch them on and off and this will be clear when we come to the results and discussion section.

3.3.3. Arduino Programming language i.e. Sketch

Now that we have understood the hardware point of view of the microcontrollers that we will be using in our project, it is important to put the same emphasis on the software point of view i.e. the programming language. Arduino has its own development environment called Arduino IDE which is an editor that enables the user to write their own code in a very sophisticated way that makes it very easy for the user to use. The programming languages that are used are C and C++ and they are used for all microcontrollers whether it is Arduino or Espressif. [38]

The Arduino language is made up of three different categories or divisions and they are:

- Functions
- Structure
- Values

Now we will state certain functions that are used in most programs that are designed through the IDE and what is the task of each one:

1. analogRead(): This piece of code is used to read the value that is present within the analog pin that is being operated. [39]
2. DigitalRead(): This code is used to read the state of which the digital pin is at, whether it is at high or low. [40]
3. AnalogWrite(): It is used to give an analog value to any pin for any sort of application such as motor starting or LED lighting. [41]
4. digitalWrite(): It associates or gives a certain state to the digital pin. [42]
5. delay(): it provides delay for a certain amount of time. [43]
6. pinMode(): this determines how the pin would be operating, whether as an input or output. [44]

3.4.   Monitoring Sensors

As we have mentioned in the section which we have described about our block diagram, are project will be focusing on a variety of monitoring aspects rather than just appliance control. So therefore, we will be using 3 types of sensors in our project which we have chosen as they offer the most reliable options for the user. The three sensors that we are going to use are:

- DHT11 (Temperature sensor)
- MQ135 (Air quality sensor)
- HC-SR501 (PIR Motion Sensor)

We will be speaking about every sensor in details and how it has a role in our project and what are the specification of each sensor.

3.4.1. DHT11 Sensor

This is a sensor that is used for temperature and humidity measuring purposes. It comes with an NTC that measures the temperature and an inbuilt microcontroller to output the values to serial data. [45]

The sensor is considered to be of easy use due to its calibration that comes from the manufacturer. The sensor is limited between 0 degrees Celsius to 50 degrees Celsius and a humidity range from 20 to 90 percent with an error of 1 degree or 1%. It is considered to be the ideal choice when going for temperature measurement applications. We intend to make the user track his temperature through an LCD screen and LED indicators that will make it convenient to know the current temperature of the home.
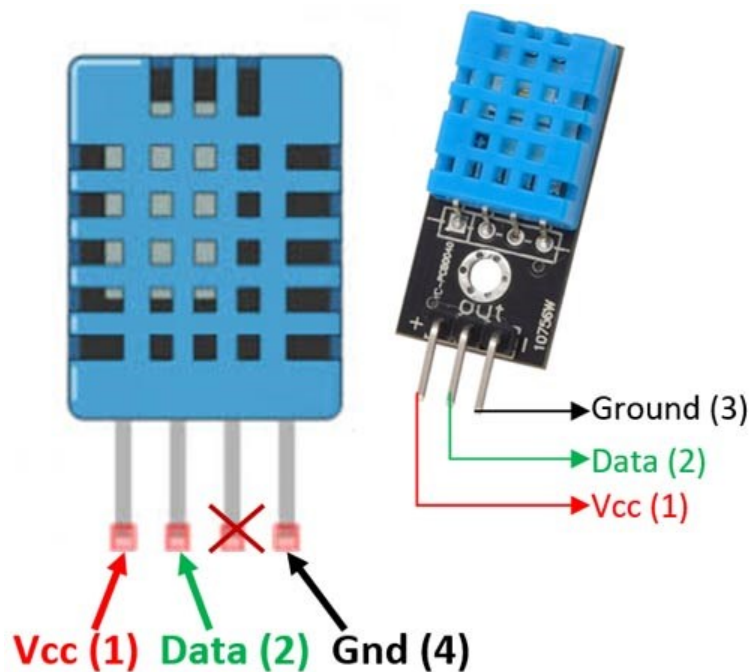
Figure 18: DHT11 Pinout

It has can withstand voltage of 3.5V up to 5.5V with an operating current of 0.3mA. It has the advantage of its small size to be suitable in any environment and its accuracy is considered to be a standout advantage for us choosing this sensor.

3.4.2. MQ135 sensor
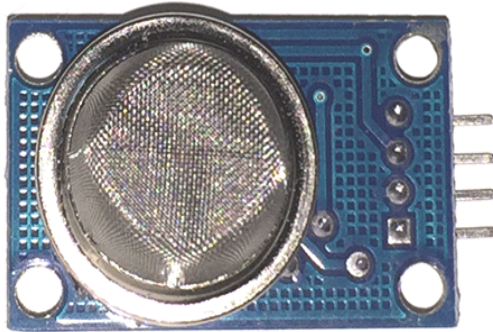
Figure 19: MQ135 sensor

This is a type of sensor that is in used in most equipment that require air quality control and it is suitable for measuring a wide range of hazardous gases such as alcohol, benzene, CO2, smoke and several other hazardous gases that are considered to have an effect on the air. [46]

In our application, we will be using this to detect any sorts of leakage gas that can affect the quality of the air within the home. If any sort of gas is detected to be of abnormal level it is translated into a signal to warn the user through an SMS alert. The Sensor will be constantly measuring the Gas level within the area and it is viewed through an LCD screen as well.

Pin No.	Pin Name
1	Vcc(+5V)
2	Ground
3	Digital Out
4	Analog out
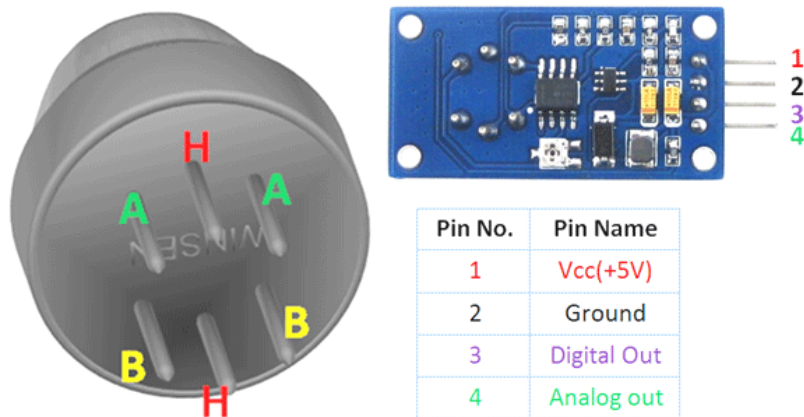
Figure 20: MQ-135 Pinout

The description of the pinout is as follows:

- VCC: For 5V operating supply
- Ground: for grounding the system
- Digital Out: To obtain a digital output
- Analog out: 0-5V outputs based on the gas intensity.

The MQ-135 has several advantages that has made us choose it such as:

- High Sensitivity and response level are high.
- It can last for long and it is stable.
- It can detect on large scales.

This application is considered to be useful to ensure the user safety within the home as most of these gases are considered to be health hazardous and to ensure the gas is pure, we will be implementing this.

3.4.3. HC-SR501 Sensor

PIR sensors are such sensors that use infrared radiation that is radiated from any moving body that is represented in the form of heat. In our application, the sensor is used to activate a security system that can only be disabled through the right password that can be entered through the keypad.

PIR sensors detects the levels of the IR that is emitted by body and most bodies that are above 0 Kelvin are prone to emit IR i.e. all bodies. [47]

The PIR sensor consists of two parts that are considered to be the core of this peripheral:

- A pyroelectric sensor
- Fresnel lens which focuses the signals to the above sensor.
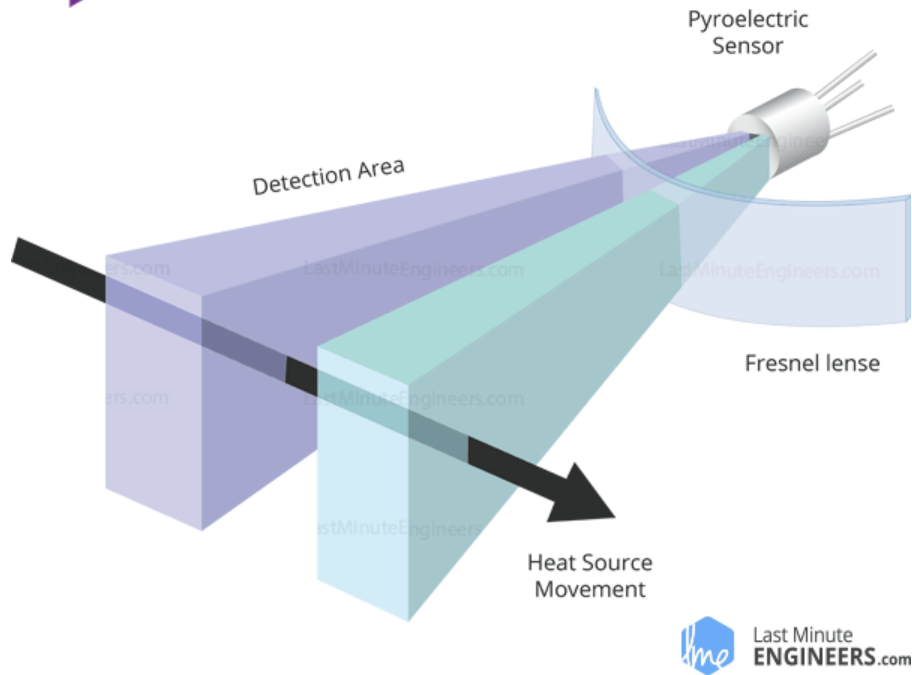
Figure 21: PIR concept

The pyroelectric sensor consists of two slots that allow the radiation to go through it. Behind each slot, there are electrode that produce positive and negative outputs respectively. Where we are looking for the change in IR levels.

When there is no movement detected by the sensor, the slots have the same amount of IR radiation giving an output of zero.

But when a body is detected it and it leaves it will generate a positive and negative cycle that results in the indication of a body detected.
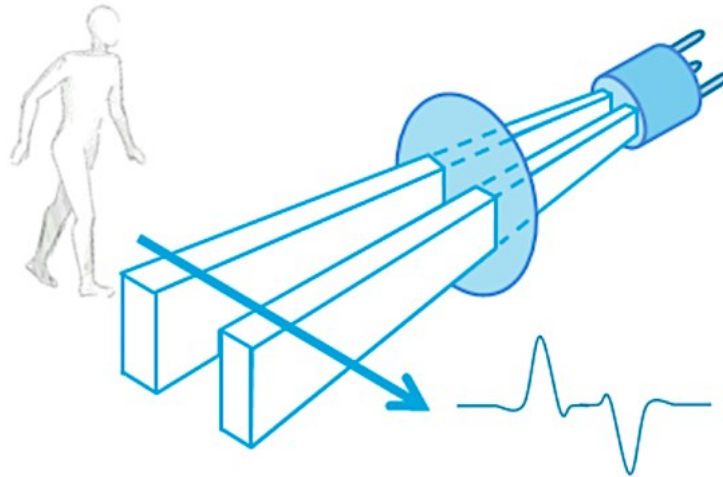
Figure 22: Signal Indication of Moving body

The HC-SR501 is considered to be the ideal choice when going for motion detection. They are easily used for such applications. They consume low power and are rugged and of solid shape.

They operate from 4.5 to 12V but ideally 5V is used.
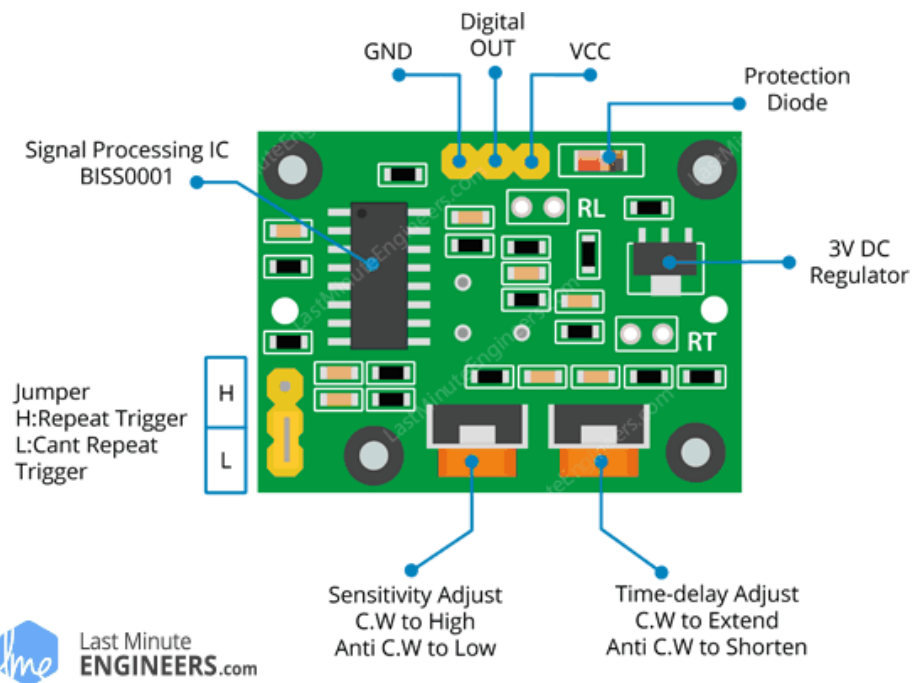
Figure 23: PIR sensor pinout

There are 3 pins that are available to interface with the outside world:

- VCC: to supply the 5V power to the sensor.

- Output: 3.3V logical output that indicates low and high depending on the motion detection.

- GND: to connect the sensor to the ground point.

3.5.   Global system for mobile communication

GSM is considered to be widely present in all of our mobile phones at it is a digital network that interconnects mobile communication to send data through compression from one mean to the other. [48]

We will be implementing this technology in our gas leakage system as a means to connect the user's mobile phones to the system to get alerted in the case of variation of gas levels. Therefore, with this technology we will be able to implement this feature in the safety aspect of gas detection.

To achieve this, we will be using a SIM900A module that is a module that can be used to implement IOT applications related to such scenarios where you need communication with a mobile network. It is considered to be very powerful, and it will be very useful for this application.
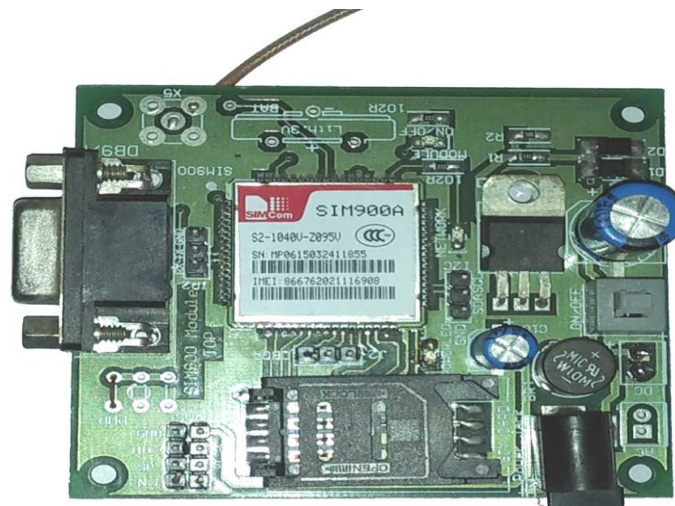
Figure 24: SIM900A GSM Module

The SIM900A GSM module consist of 68 terminals and it is shown in the below figure.
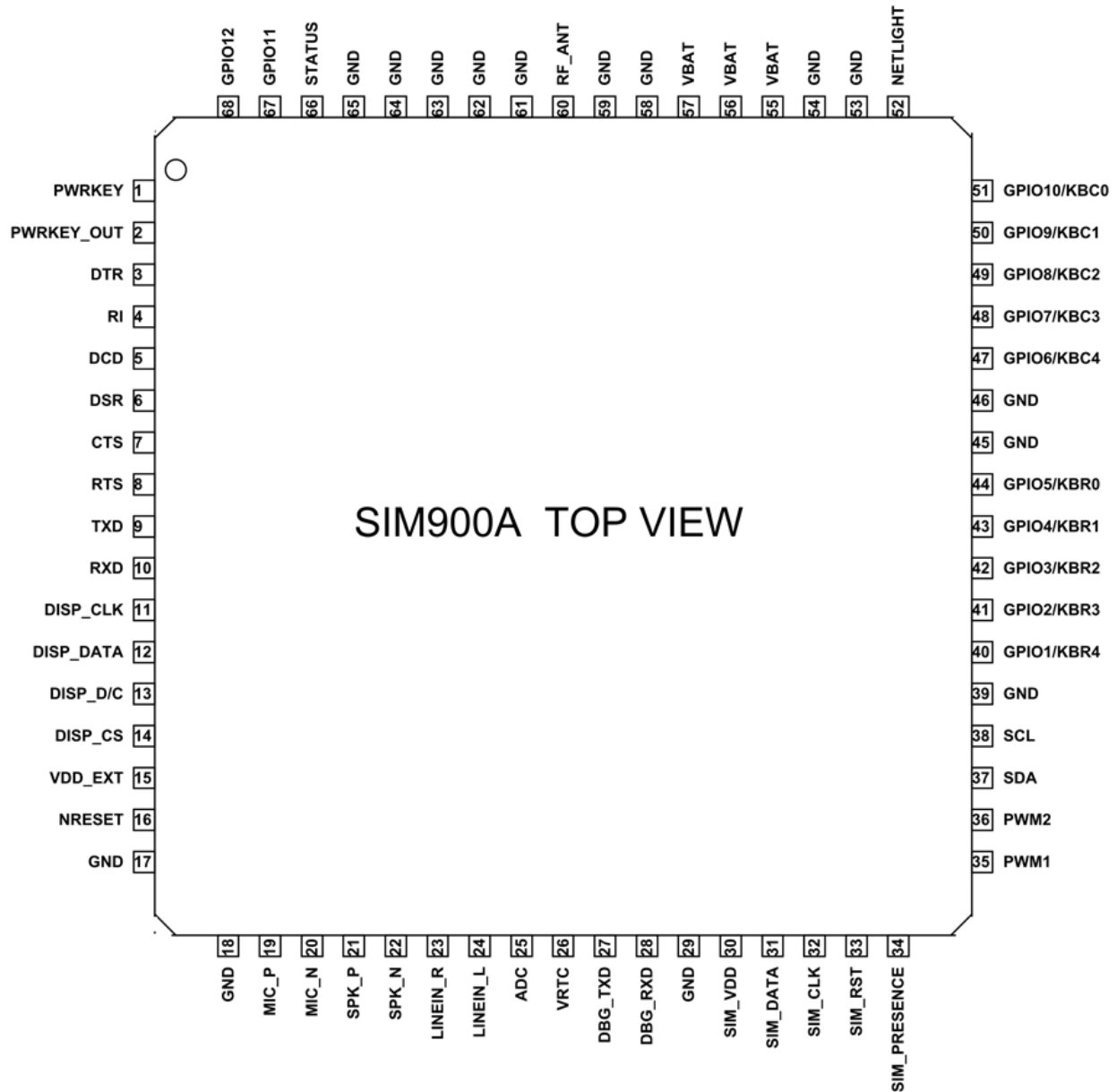
Figure 25: Module Pinout

The GSM module is considered to have several features that can make it standout from other GSM modules that are present such as:

- Interfaces for Keypad and display
- Sim card insertion to use for connection
- Operates at 5V maximum
- Has a power saving mode that consumes 1.5mA at sleep
- Can take Audio input and speaker input

The GSM module can be programmed with certain libraries through the integrated development environment to exchange data between both mediums. With the proper coding you will let the GSM to act as a cellular network that will send messages through the SIM card number that you have equipped in it and you would be able to transmit the data to the other end. [49]
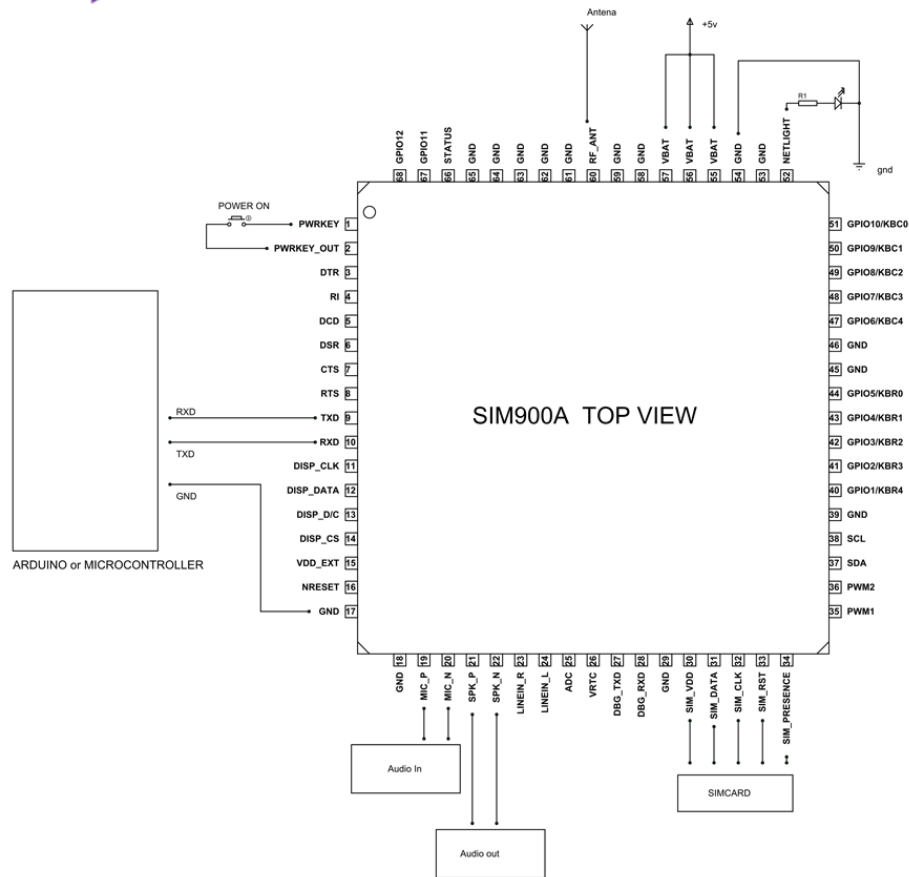
Figure 26: Module connection

3.6.   Other Peripherals

Now that we have spoken about the major components that act as vital in our project, there are several other secondary components that we will be speaking about in brief to show their role and how they function in our project.

3.6.1. LCD SCREEN

The most common types of LCD modules are the 16*2 modules as they are very popular due to them being cost-effective and very friendly when it comes to programming them. In applications such as Temperature and gas level monitoring we will be providing convenience for the user to see the desired information he wants to see.

The reason behind them being named 16*2 is due to their size as they have 16 columns and 2 rows, there are several other dimensions for LCDs but these are the most widely seen and used. [50]
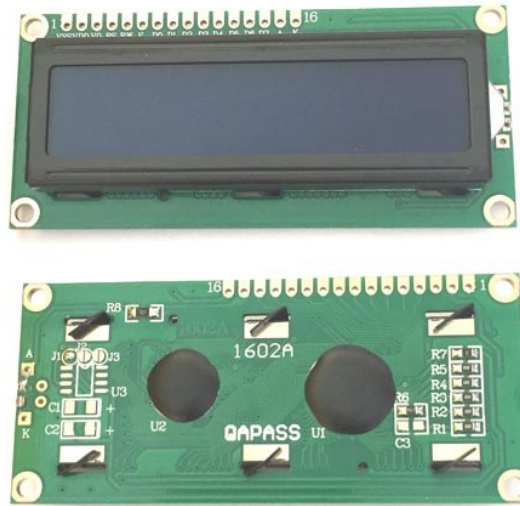
Figure 27: LCD module

Figure 28: LCD module pinout

There are several features that are associated with this LCD module such as:

- It can provide alphanumeric data
- It operates at 5.5V
- 2 rows which each row printing a total of 16 characters.

3.6.2.   4*4 Keypad

The keypad that we have used is a 4*4 keypad which makes it have 4 rows and 4 columns. For systems which require human interaction such as the security system for the motion detection. It is considered to be the most ideal keypad for any sorts of human interaction.

Figure 29: Keypad Module

There are certain specifications that made us choose this keypad for our security interface:

- It has long life lasting
- Its ultra-thin making it fit in any model
- Each button operates at 24V maximum voltage
- Maximum current that goes through each button is 30mA
- Easy interface to deal with
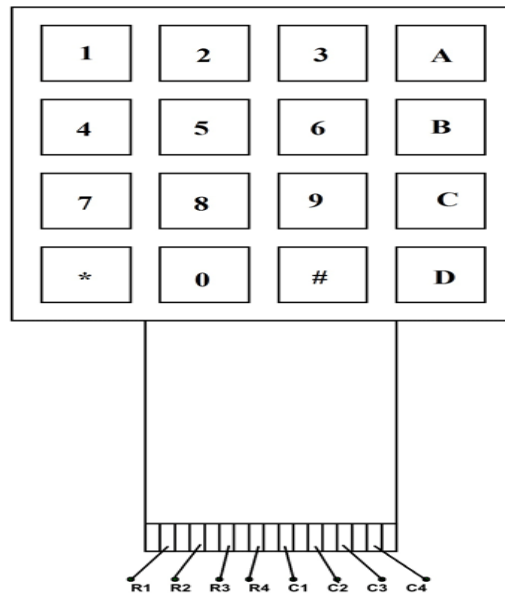
Figure 30: Pinout for Keypad

It can be used for various applications such as security, vending systems, industry or any device that requires an input. [51]

3.6.3. Buzzer

The buzzer is used for only one purpose and it is to produce a sound that is triggered based on a certain command. It will sound power when it is connected to a certain source of power.

We will be using this buzzer as a component in the security system as an indication that the system has been breached due to incorrect passwords have been entered.
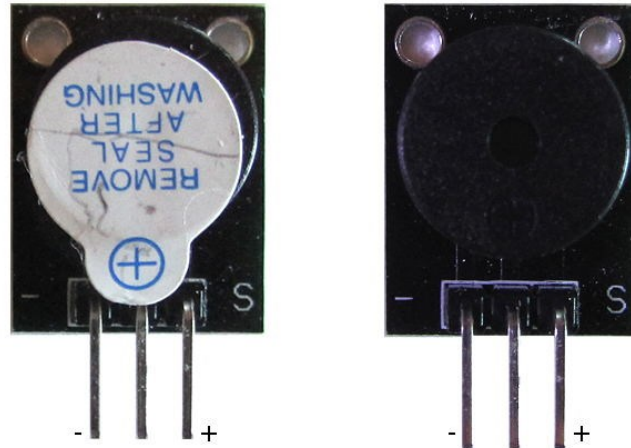
Figure 31: 3 pin buzzer

The Arduino can control the buzzer to switch it on and off. In most alarm circuits it is a very useful component that can serve the purpose of indication. [52]

3.6.4. Resistors and types of Resistors used

As we know resistors is a fundamental component in electricity that acts to limit the current through a certain active component or reduce the voltage across the component. In components such as LEDs where they consume very small current to operate, to avoid any of them burning out we will use resistors to limit the current. [53]

Resistors are made of two types:

- Fixed Value resistors
- Variable Value resistors

4 Band Resistor

www.CircuitsToday.com

Figure 32: Typical 4 Band Resistor

We are dealing with 0.25W and 0.3W resistors as the components don't draw out high amounts of current as the voltage is quite low. Therefore, it is very important to choose your power rating when going for resistor values.
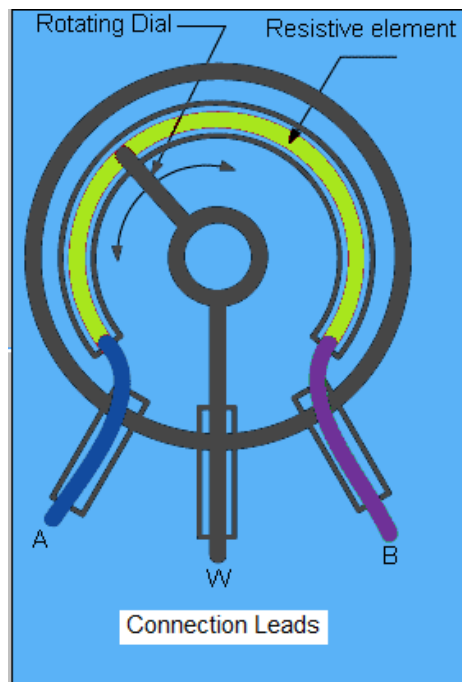
Figure 33: Variable Resistors

Variable resistance is used in certain circuits that require the presence of resistance but adjustment to be done. We will be using this resistor to adjust the brightness of the LCD screens as LCD screens don't come with automated brightness but it needs to adjusted manually.

3.6.5. LEDs

LEDs also known as light emitting diodes are considered to be very versatile components in any electronic circuit. These tiny bulbs can fit anywhere and be used for multiple applications. In our project we use them as indicators for temperature and for security which is very advantageous and offers the user to understand what is going on. They are considered to have multiple advantages to the ordinary bulbs such as less electricity consumption, longer life span and they don't burn out. [54]

An LED could produce more lumens per watt more than a regular bulb. A 60W bulb would generate lumens of a range 750-900, but at 6-8W you could receive the same number of lumens. The LED bulb could last for 25000 hours, but the normal 60W bulbs would last for 1200 hours.

They are very cost effective, and they are now being integrated all around the world in various situations and applications. They might be expensive at first but on the long term its costs will be very less due to the amount of energy that it consumes is considered to be very low.

Figure 34: Light Emitting Diode

3.6.6. 5V Relays

Any relay has a main function and it is to function as a switch for whatever load is connected to it. For the appliances control that will be doing which is going to be controlled through the ESP WROOM-32, we will be using a 5V 4-channel relay which gives us the ability to connect up to 4 different appliances.

These relays can control appliances that draw large current, and we are dealing with a relay that is used for 250V AC or 30V DC at 10A. This interface is controlled directly from the microcontroller through the interface that the user will be using.
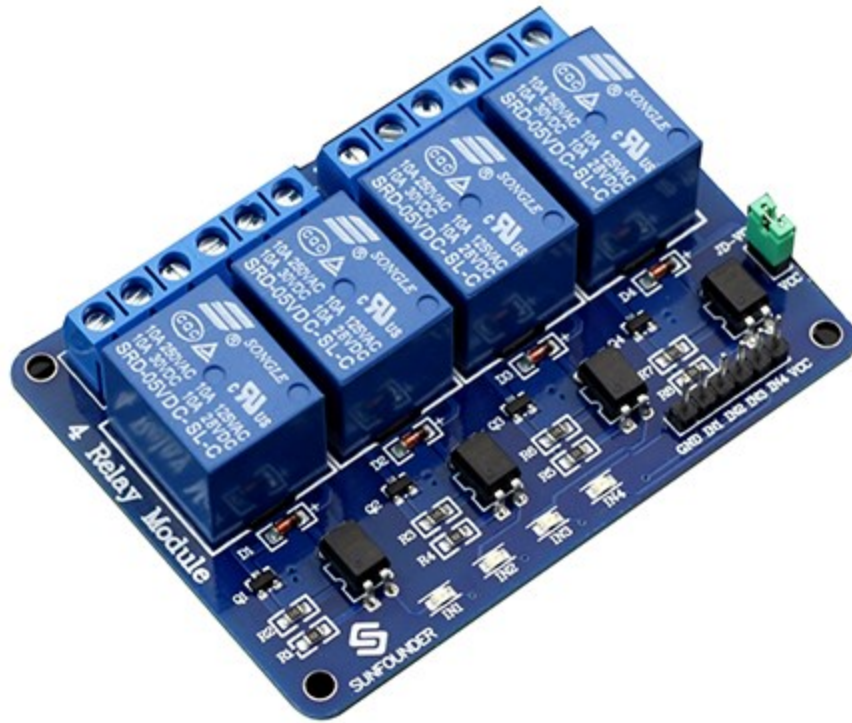
Figure 35: 5V 4 Channel Relay

Working principle

When the signal port is at low level, it will light up and the optocoupler will start to conduct and draw current to it, and this will result to the transistor conducting and the relay coil will get energized and the NO contact is closed. When the signals are at high level the NC relays are closed. So, the signal ports can connect or disconnect the load through this process. [55]
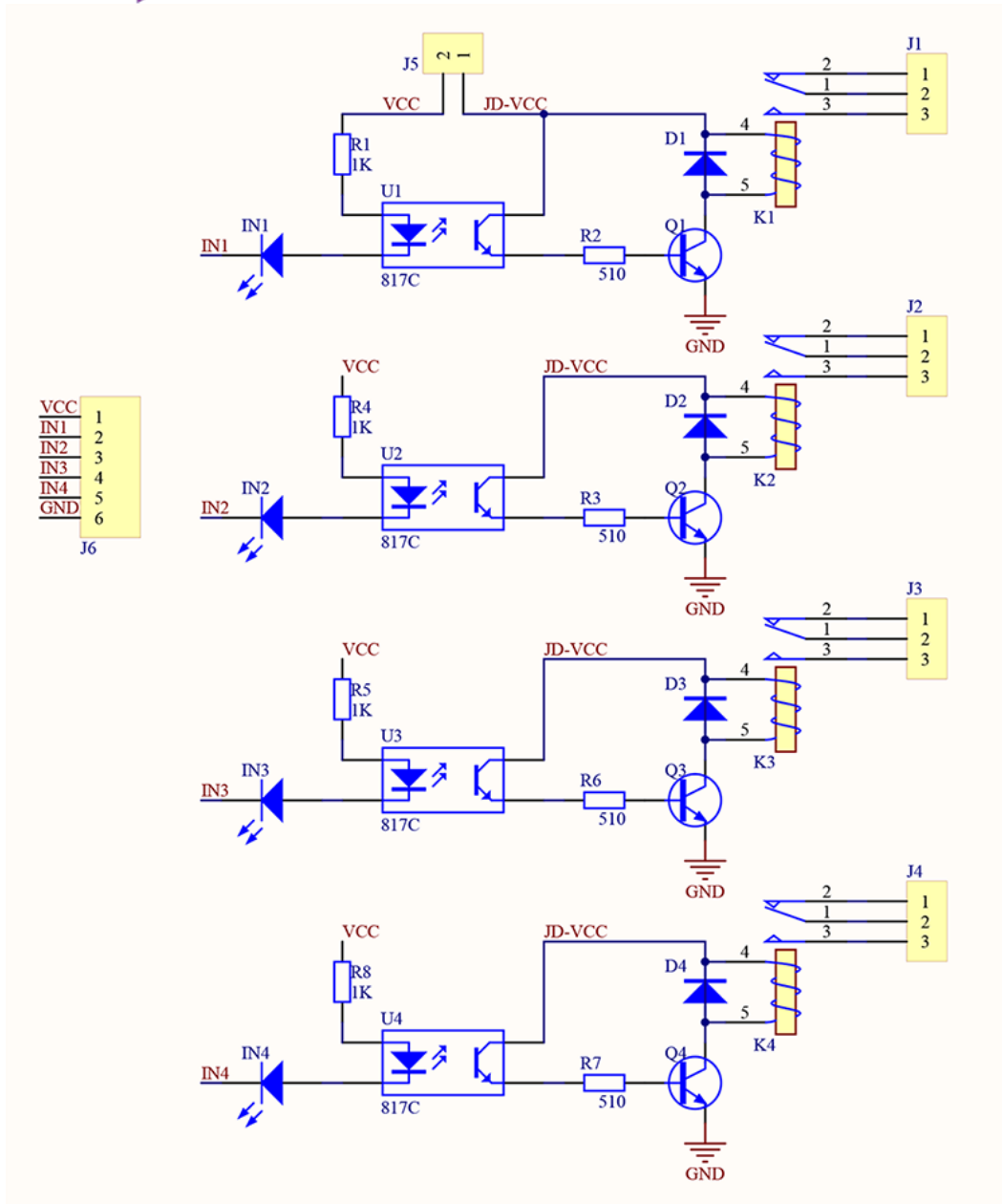
Figure 36: Working principle of Relay

3.6.7. Jumper Wires

Jumper wires are the electrical wires that will be used throughout all the connections that are going to be done within our project. We have male to male connectors, male to female connectors and female to female connectors which will be used for various pins and with the breadboard. [56]
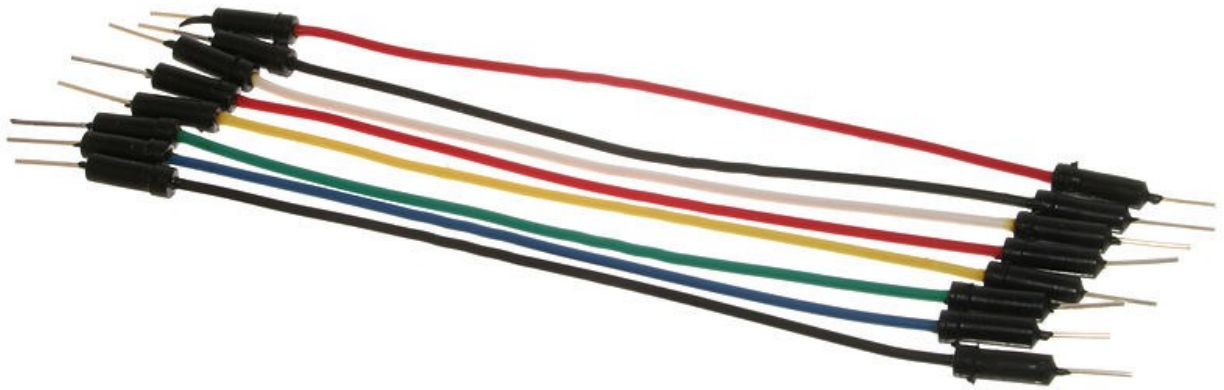
Figure 37: Jumper Wires

3.7. Flow Charts for Program implementation

Now that we have spoken about all the physical components of our project it is time to speak about the logic of each part of the project and based on that logic, we can implement the code and the circuit which will be discussed in the implementation section.

We will be discussing the flowcharts that we have designed for the appliance control, the temperature monitoring, security monitoring and the Gas leakage system.

3.7.1. Appliance Control using WIFI

So for us to implement the logic that we can use to implement the code that is required to run this system through WIFI and for us to identify the PINS that we are going to select which will be connected to the relays we will be designing a flow chart that illustrates the flow of operation and the conditions present of it.
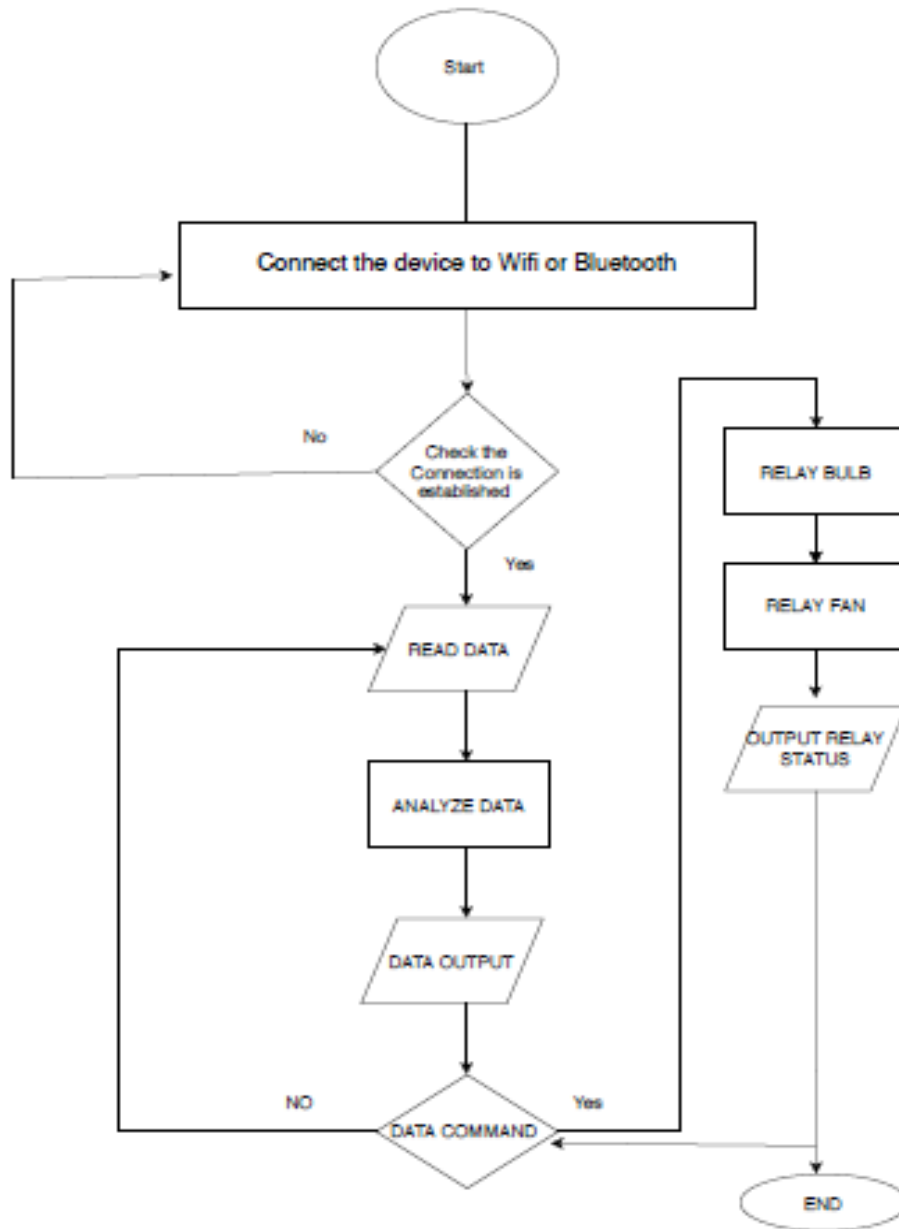
Figure 38: Appliance control flow chart

Through the logic we have implemented we can design a code that establishes a connection for the ESP32 with the WIFI connection and it would generate a certain IP address which enables the user to access the application to control appliances such as bulb or fan.

The program will be designed on the number of pins that we will be selecting and the number of relays that we are using. Based on that the user can give a command through the user interface that is designed.

3.7.2. Gas leakage system

As we have mentioned earlier that we will be implementing a gas detection system that detects hazardous gaseous as a part of safety that can be done within the home. Through a set of conditional operations, we will be able to trigger the alert that would be sent to the GSM module that would enable to alert the user through an SMS message that he has to open his windows to remove the excess gas.
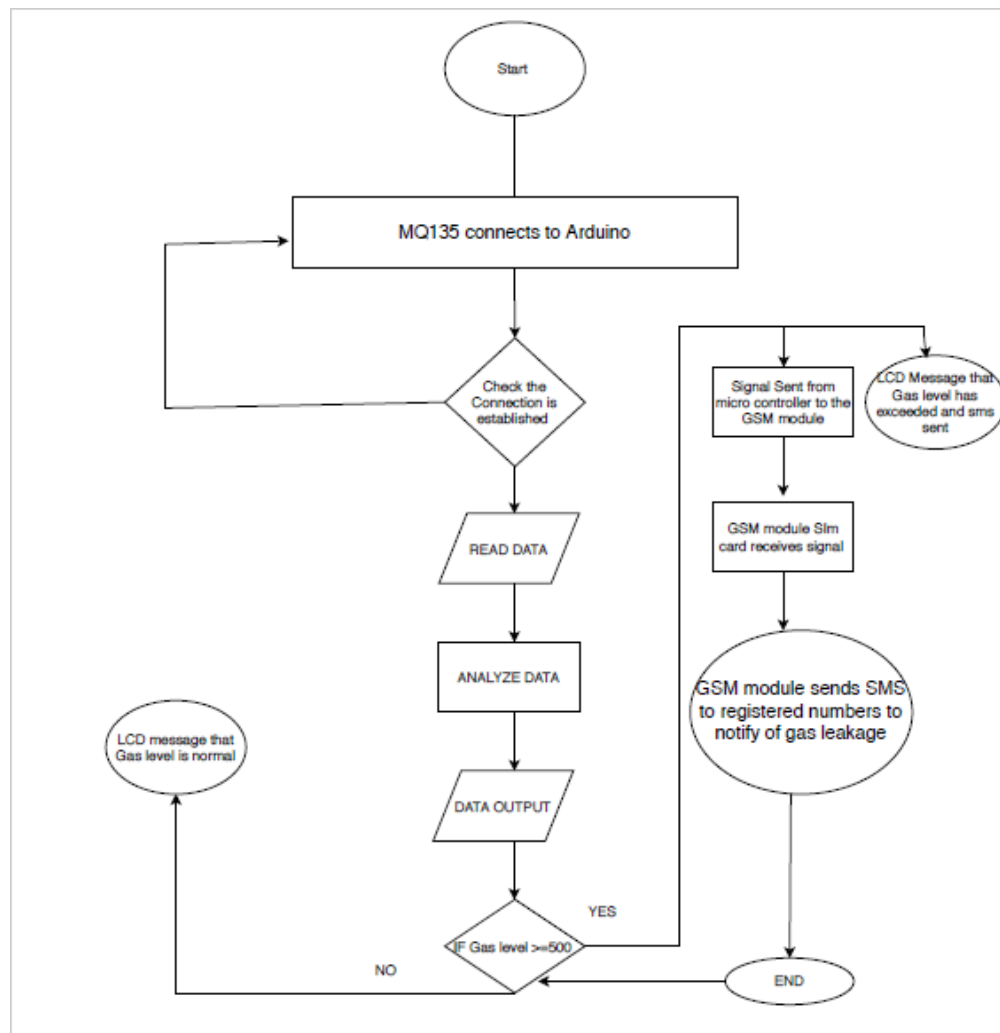
Figure 39: Gas detection flowchart

We will be creating a code to implement this logic and we are setting a limit at which the gases could be present. If the gas level is below 500, it is considered normal and a message will be displayed on the LCD screen that indicates the level of the gas. If it exceeds 500, a signal will be sent to the GSM module that sends an SMS alert through the SIM card that we have inserted to various numbers that are integrated within the program, alongside a message that will be displayed on the LCD screen that shows that the level of gas has exceeded.

3.7.3. Temperature monitoring system

This part of the project is created to make it convenient for the user to know about the current temperature of the home. Through an LCD screen and LED indicators the user will be able to identify the current temperature of his home and he can resort to the appliances to open the FAN that acts as an AC unit. The logic behind this will act under certain conditions in which different temperature ranges will be decided and corresponding to that you get a LED indicator ON with a certain color. This provides easiness and innovation by providing alternative ways to know the current temperature rather than just relying on the LCD screen that prints the temperature and humidity values of the room.
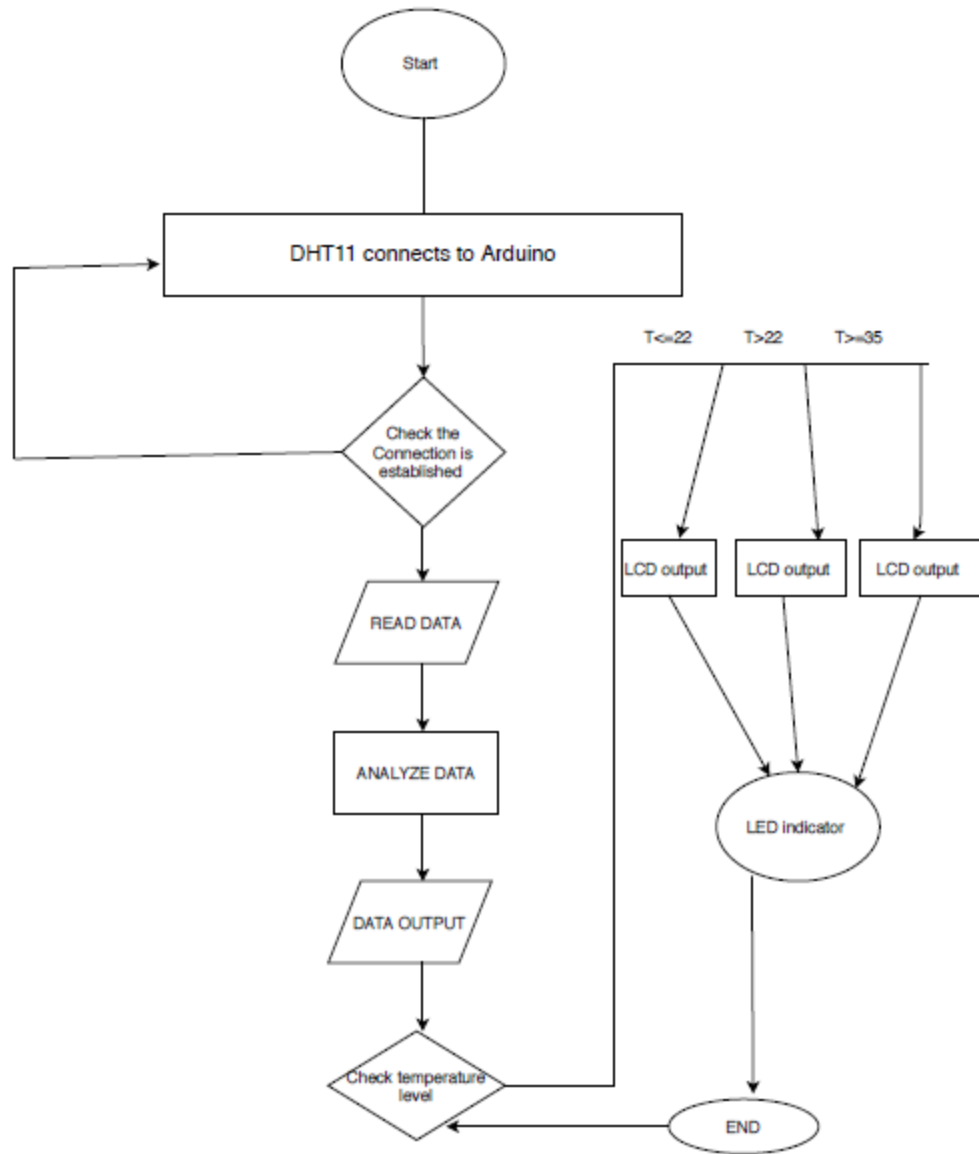
Figure 40: Temperature Sensor Flow Chart

3.7.4. PIR Motion detection security system

The idea behind this aspect in our smart home model is to create a security system that acts through a keypad which enables the user to insert a password that is already set through the program that we will be building. If the user enters the right password, the system gets disabled and of course this system is triggered with a motion sensor. If the password entered is incorrect later on while motion is detected and then the intruder goes away from the sensor, the Arduino sends a signal to the buzzer to alarm and in that way, we know there is an intruder or a suspect who is not considered to be trusted. If the right password is entered after the alarm has been buzzed the system is then reset and shuts down. The idea behind this is to make a representation of a keypad security system for the user while entry of their homes.
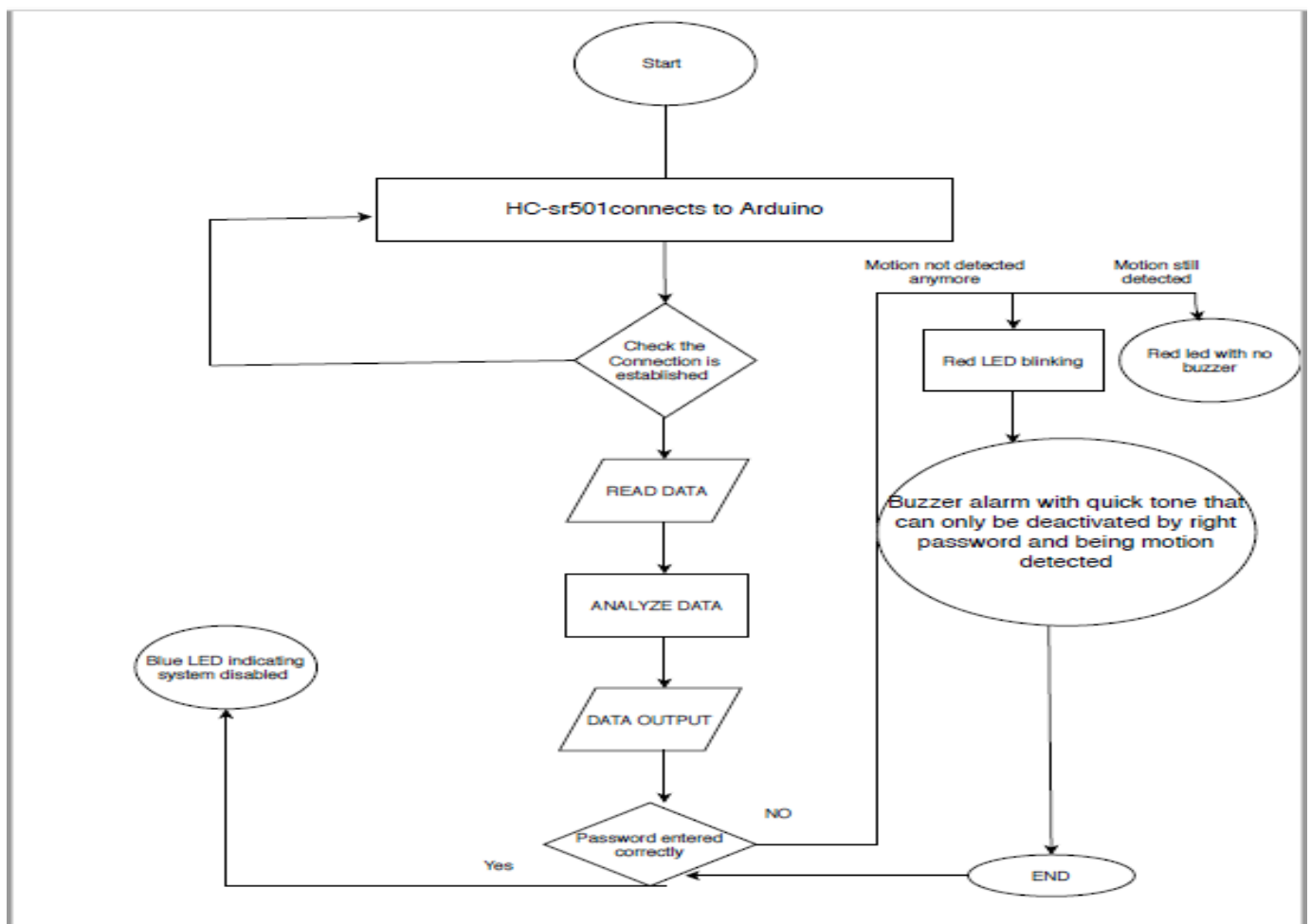
Figure 41: Keypad security system Flow Chart

3.8.   Standards

The global standards established by research institutes such as IEEE, aim to set a list of criteria that can be applicable on components from different manufacturers with the goal of setting quality and reliable standards met by all related products. One can say that it is a document that provides us with the necessary specifications and guidelines in order to help us operate said devices in proper form to utilize their best capabilities. Henceforth, we shall discuss the standards that we used in our own project. [57]

3.8.1.   IEEE 802.11

This is one of the most used standards of the industry and even in residential and commercial sectors, it is known by the well-known term 'Wi-Fi'. This standard enables faster connection speeds, up to 54GB/s for the 802.11b standard used in most devices such as the ESP 32 microcontroller that we are using. [57]

3.8.2.   IEEE 2700-2017

A typical standard used for setting the performance specification of sensors including all of its types such as light and temperature sensors. This standard specifies the conditions, units and distributions for each sensor. Furthermore, it includes all the performance parameters used in the industry for different types of sensors. [58]

3.8.3.   IEEE 310-1969

This standard applies to exactness electrical resistors showing a high level of dependability and planned for use as reference benchmark in precise approximations of direct-current resistance. [59]

3.8.4. IEEE 1703-2012

This standard is applied for all messages that are transported over a range of networks through a GSM over several medias that is considered to be the protocol of media communication through multiple devices. [60]

3.9.   Project Constraints

The Theory of Constraints is a method used to underline all the possible issues that may be a limiting factor which can cause a lot of delays and hardships that stands in the way of completing the set target. The theory argues that every constraint can be improved upon, and by applying certain measures, one can solve the issue that poses this constraint as a limiting factor. Therefore, a prior complete analysis of the proposed project must be undertaken and documented, preferably ahead of the start of the project, in order to search for plausible solutions to these said constraints, henceforth, increasing the efficiency of progress in the implementation period by eliminating all factors that can cause hiatus or interruption in the building phase.

Nevertheless, not all constraints interrupt the process of the project, as some of them can be restrictive but not fully preventing. Consequently, it is those restrictive factors that hinder and limit your project from showcasing its full potential and various features. The following section shall discuss the constraints present in our project and the methods used to counter them.

3.9.1. Covid-19 Outbreak

The eruption of the Coronavirus has resulted in a lock down on education facilities, gathering places and even caused a curfew to be placed at night. Thus, these factors prevented us team members from gathering and working on implementing our prepared design, especially due to the far distance between where each member of the team lives. In this dire situation, we found ourselves lucky to have foresaw the possibility of such accidents happening. As we have successfully utilized methods such as online-conferencing, and prior distribution of tasks, to ensure our ability to proceed with the implementation regardless of being separated due to self-quarantine.

3.9.2. Unsuitable testing environment

With the concept of our project revolving around smart home systems, it is quite challenging to implement such system without being privy to a home as a subject for our testing and implantation. Although this constraint it may sound largely hindering, there are many ways to overcome such restriction, one of them is through building a small house 3D model to act as a housing for the system, or using a flat board divided into sections and laying the components on top accordingly.

3.9.3. Financial Costs

The funding of the project was a major concern as we're after all but students without any source of income, coupled with the high budget required to build a complete project can be a strain on the empty pockets of a non-working student. Nonetheless, between dividing the cost on four team members and choosing cost-efficient equipment that will achieve more with less. Gave us much leeway and reduced the burden placed on the individual.

3.10. Risk Assessment

It is evident that each project carries a certain probability of risk. Understanding the types of risks that could occur and being able to demonstrate them beforehand is essential. Understanding a plausible risk and calculating the probability of its occurrence is the first step to be ready to handle that risk at any given time. [61]

Due to the small scale of our project, there are few risks that could occur in this situation. Most notably, the burning of the electrical components such as the microcontrollers, board, sensors and modules. These types of accidents can cause harm in the case of fire, additional costs to the far-stretched budget of the project and delay in the implementation period due to the wait for new components to arrive. Henceforth, precaution should always be maintained when connecting new components, and most importantly, applying the appropriate voltage to the circuit depending on the equipment used.

Another risk that can befall, the lack of time to complete the entire system. It is without doubt that certain problems can arise during the implementation of the design, such issues can cause interruption in the process flow, subsequently, creating a delay and messing up the time schedule made to complete each phase. Hence, result in an unfinished project when the deadline of the submission date draws near.

3.11. Alternative Design

There are multiple methods to tackle any current day issue, design or project. These methods differ in their planning, design and execution. And by exploring the multitude of methods that can incorporated in any design, one would gain a wider perspective on the subject itself. Thereby, we have deduced and gathered additional design features that could be utilized in our project if the need may arise.

The first prospect that could be incorporated is the addition of a camera to the security system, with the function of monitoring the outside premise. Undoubtedly, to incorporate this new feature, a separate flow chart must be designed to create the operating process of the security camera. This is a necessary step to exploit all the benefits and features that can be drawn out from the camera module, one such feature is connecting it to the internet which allows access to security footage from anywhere, anytime. Additionally, one can expand further on this idea by incorporating a recording feature to save the footage locally, hence, it can be reviewed whenever one might desire.

Secondly, building a suitable environment to accommodate our system is an ingenious idea that will help create a representation and give perspective to the viewer of how the system could be integrated into a full-fledged household. This synthetic environment is composed of a small 3D house model, with separate rooms and a dedicated kitchen. Where the components could be placed according to their purpose and function. For example, lights will be mounted on the sealing, security keypad attached to the door, gas detector placed inside the kitchen and last but not least, the proposed camera could be positioned on the outside gate. 3D printing capabilities could also be employed to create this house model which will ensure accurate and precise measurements.

After the decision over all the design aspects that we have done and the intensive research over the components that we are going to use for our home model we will be foregoing into our implementation stage which is considered to be the most important stage as it is where the project will be formed and connected.

We will be introduced to various aspects in the implementation stage such as the circuit designs, the codes developed that will be uploaded into our microcontroller unit and the connections that we have made for our project. Keeping in mind that we could add and neglect things that were mentioned in the design stage and it will be mentioned clearly in the later parts of the report.

4. Implementation Phase

Now that we have spoken about the design phase and all the block diagrams that we have visualized are project on and the flowcharts that will help us to build our code in order to implement it, it is time to speak about the implementation phase which will consist of 3 major aspects for each part of the project which are:

- Circuit Design
- Code Design
- Connection of components

Each of the three aspects will be included for each component separately to give a concrete understanding how each one is going to be built. Alongside the connections we are going to speak in a separate section about the home model that we will build out of Wood or carton to act as a containment for all the components that we have built and to give a visual aspect to our project. In this section we might have added or removed components that were decided upon in the design phase due to new ideas being brought or not able to find specific components for implementation. All circuit diagrams were designed using fritzing software.

4.1. Temperature monitoring system

As we have mentioned earlier that we are going to build a system that monitors the temperature and humidity within the home through a DHT11 sensor and the readings would be viewed through an LCD alongside with LED indicators that would light up at certain ranges of temperature and this will make it convenient for the user at the home to see the current temperature.

Circuit Design

We have designed the circuit diagram through the Fritzing application that is an application that enables you to design your circuits on breadboards in a very sophisticated way. The DHT11 reads analog data as temperature and humidity are considered continuous which is why it is connected to the analog pin. The Other components such as the LCD and the LEDs are connected to the digital pins as they are computed by the microcontroller.
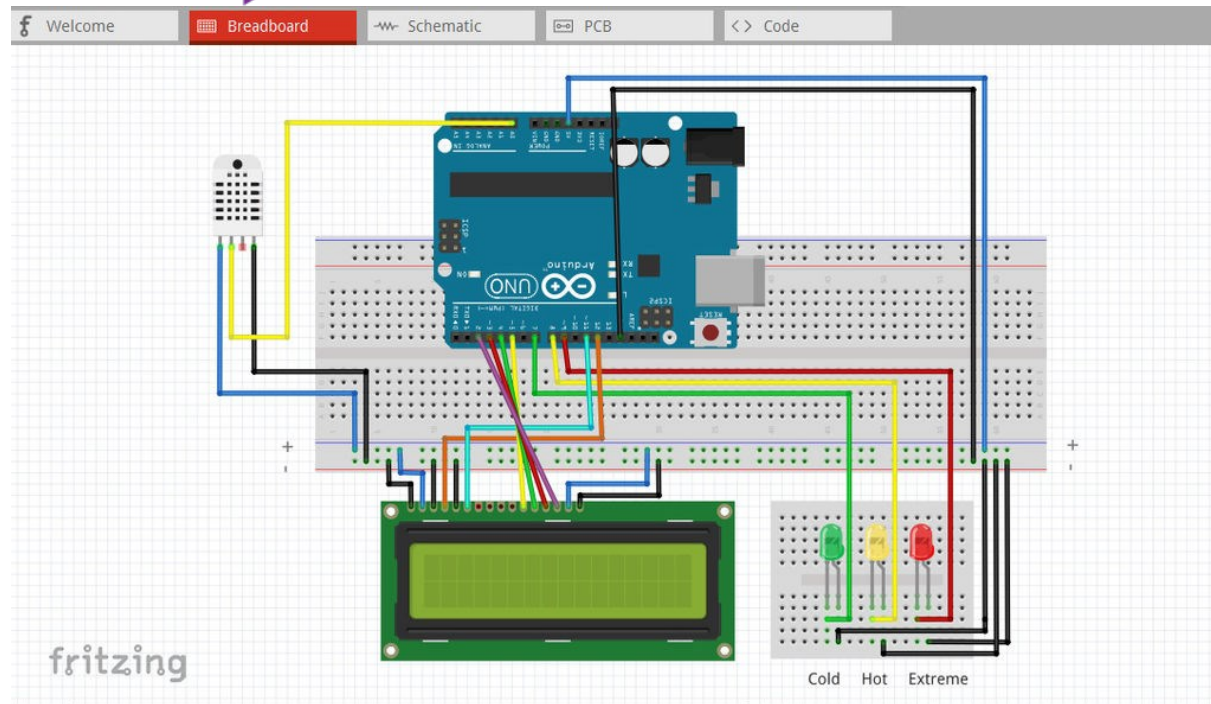
Figure 42: Circuit Design for Temperature monitoring

Code Design

```
temperature
#include <LiquidCrystal.h>

#include <DHT.h>

#include "DHT.h"

#define DHTPIN A0      // what pin we're connected to

#define DHTTYPE DHT11    // we are using the DHT11 sensor

LiquidCrystal lcd(12, 11, 5, 4, 3, 2);

DHT dht(DHTPIN, DHTTYPE);

void setup()
{
  Serial.begin(9600);
  for (int DigitalPin = 7; DigitalPin <= 9; DigitalPin++)
  {
   pinMode(DigitalPin, OUTPUT);
  }
   lcd.begin(16,2);   //16 by 2 character display

dht.begin();
}
```

Figure 43: Initialization of Pins and LCD display

```
void loop()
{
  delay(1000);
  // Reading temperature or humidity takes about 250 milliseconds!
  float h = dht.readHumidity();

  float t = dht.readTemperature();  // Read temperature as Celsius (the default)

  lcd.clear();
  lcd.setCursor(0,0);
  lcd.print("Temp: ");
  lcd.print(t);   //printing temperarture to the LCD display


  lcd.print("'C");

  lcd.setCursor(0,1);
  lcd.print("Humid: ");
  lcd.print(h);   //printing humidity to the LCD display
  lcd.print("%");
```

Figure 44: Assigning variables of temperature reading and Printing of data on LCD display

```
//the 3-led setup process
  if (t<=22)
  {
  digitalWrite(7, HIGH);
  digitalWrite(8, LOW);
  digitalWrite(9, LOW);
  }
  else if (t>22)
  {
  digitalWrite(8, HIGH);
  digitalWrite(7, LOW);
  digitalWrite(9, LOW);
  }
  else if (t>=35)
  {
  digitalWrite(9, HIGH);
  digitalWrite(7, LOW);
  digitalWrite(8, LOW);
  }

}
```

Figure 45: Conditional process for 3 LED setup

Connection

Here below we have connected the circuit diagram that we gave designed as per our planning and we will be powering it using 9V batteries. The Sketch that we have designed will be uploaded on the Arduino Board and we will be evaluating the results when we run it and this will be more clear in the results and discussion section where we will see if we get the verified outputs that we desire or not.
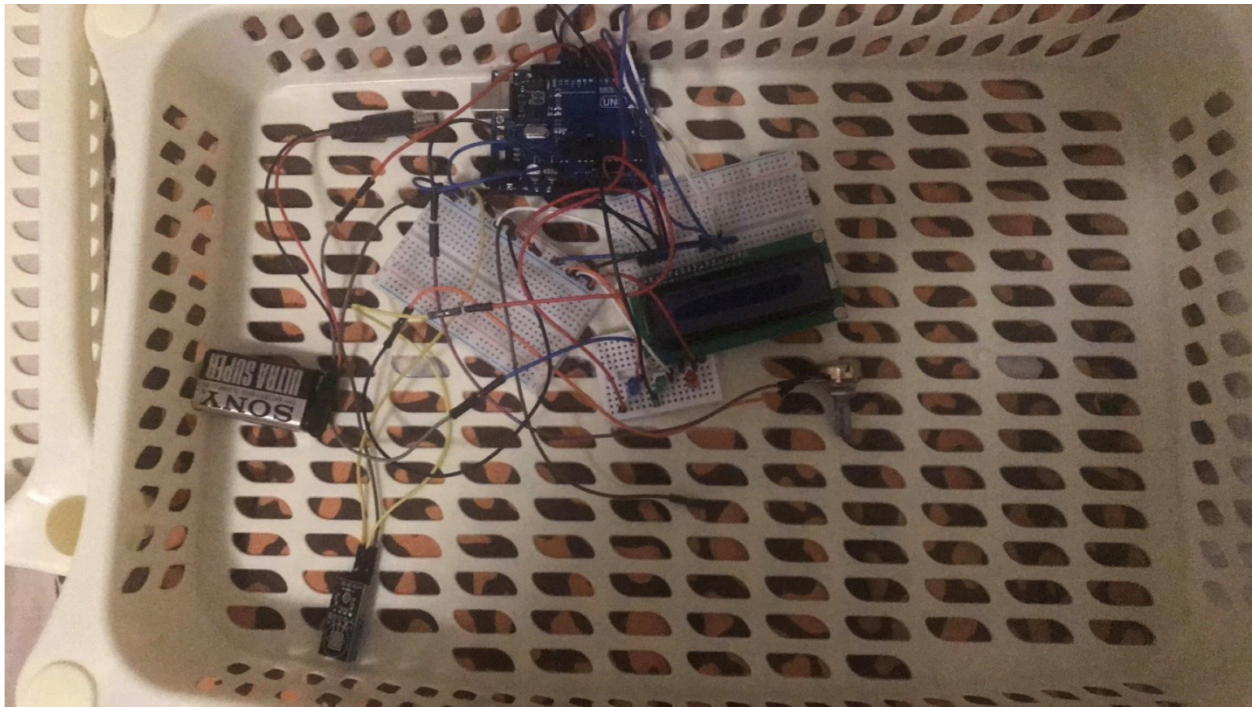
Figure 46: Connection for temperature monitoring

4.2. Gas leakage system

As we mentioned in the design stage, this system will be built to detect the gas level within the home and area and through the MQ135 sensor which is classified as an air quality sensor this task will be done. The Gas level will be measured and displayed through the LCD and if the gas level exceeds 500 then a signal is sent to the GSM module that we have connected with a SIM card to send an alerting SMS to the phone numbers that we have registered within the code. We have opted for the SMS alert and it is the fastest way to alert the user to check the condition of the room and to open the windows if necessary.

Circuit Design
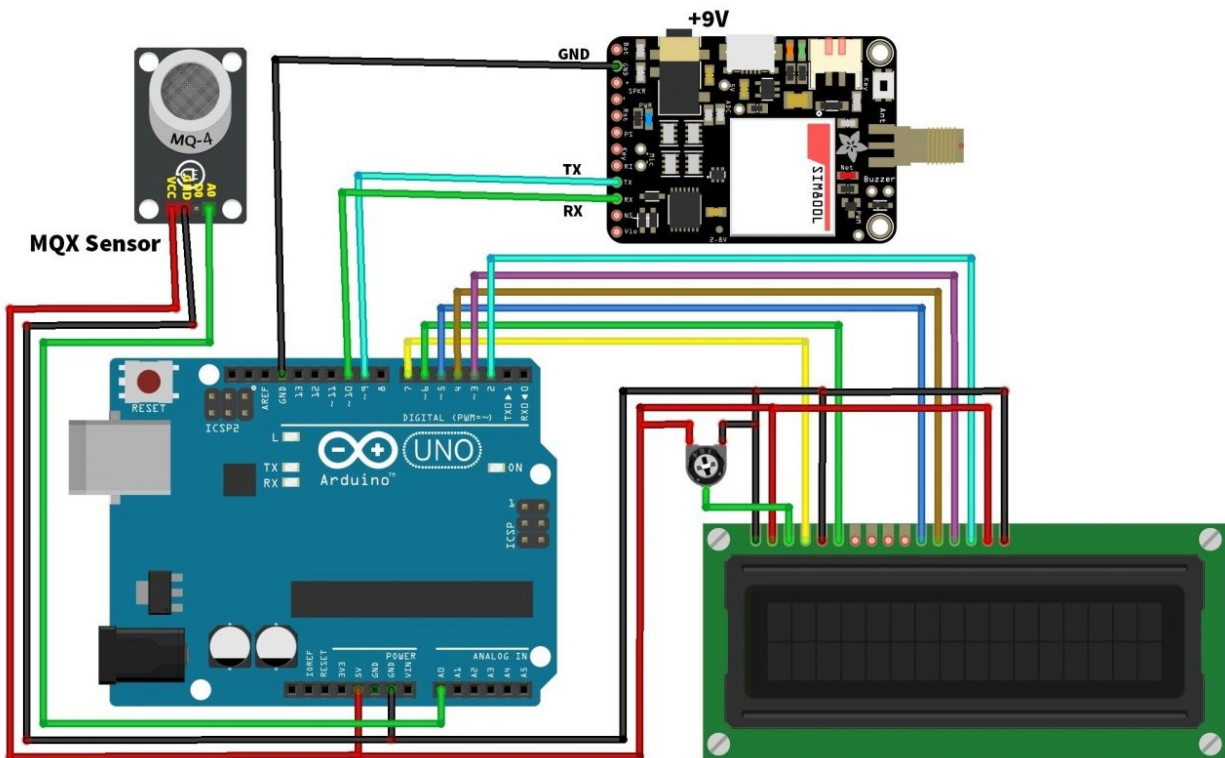
Figure 47: Gas Detection system Circuit Design

Similar to the DHT11, the MQ135 reads analog data which makes us need to connect the data pin to the analog pins within the Arduino board. The GSM module that we are going to use which is the SIM900A will be connected to the digital pins alongside the LCD display. We intend to use two Batteries one for the Arduino and one for the SIM900A and the reason being is that GSM module is considered to draw a high amount of current and that would not make it sufficient if we use only one battery supplied at the Arduino. This will be clear later on when we connect the Circuit.

Code Design

```
#include <LiquidCrystal.h>
LiquidCrystal lcd(7, 6, 5, 4, 3, 2);
#include <SoftwareSerial.h>

SoftwareSerial mySerial(9, 10);

int gasValue = A0; // smoke / gas sensor connected with analog pin A1 of the arduino / mega.
int data = 0;

void setup()
{
randomSeed(analogRead(0));
mySerial.begin(9600); // Setting the baud rate of GSM Module
Serial.begin(9600); // Setting the baud rate of Serial Monitor (Arduino)
lcd.begin(16,2);
pinMode(gasValue, INPUT);
lcd.print (" Gas Leakage ");
lcd.setCursor(0,1);
lcd.print (" Detector Alarm ");
delay(3000);
lcd.clear();
}
```

Figure 48: Setting LCD pins and MQ135 input pin and initialization

```
void loop()
{

data = analogRead(gasValue);

Serial.print("Gas Level: ");
Serial.println(data);
lcd.print ("Gas Scan is ON");
lcd.setCursor(0,1);
lcd.print("Gas Level: ");
lcd.print(data);
delay(2000);
```

Figure 49: Gas Scan Initialization

```
if ( data > 500) //
{
SendMessage();
Serial.print("Gas detect alarm");
lcd.clear();
lcd.setCursor(0,0);
lcd.print("Gas Level Exceed");
lcd.setCursor(0,1);
lcd.print("SMS Sent");
delay(2000);

}
else
{
Serial.print("Gas Level Low");
lcd.clear();
lcd.setCursor(0,0);
lcd.print("Gas Level Normal");
delay(2000);
}

lcd.clear();
}
```

Figure 50: Conditions of Gas levels and declaration of SMS message

```
void SendMessage()
{
Serial.println("I am in send");
mySerial.println("AT+CMGF=1"); //Sets the GSM Module in Text Mode
delay(1000); // Delay of 1000 milli seconds or 1 second
mySerial.println("AT+CMGS=\"+971557971494\"\r"); // Replace x with mobile number
delay(1000);
mySerial.println("Excess Gas Detected. Open Windows");// The SMS text you want to send
delay(100);
mySerial.println((char)26);// ASCII code of CTRL+Z
delay(1000);
}
```

Figure 51: Setting up Text message and inclusion of receiver number

Connection

We have successfully connected the circuit diagram designed and uploaded the code onto the Arduino board. We will be supplying 9V batteries one for the GSM module and one for the Arduino board to make sure that sufficient power is provided to all the components. We have purchased a Sim card that will be equipped inside the SIM900A that will alert the user when needed. The results will be discussed in the results and discussion section where we will see if desired output is obtained.
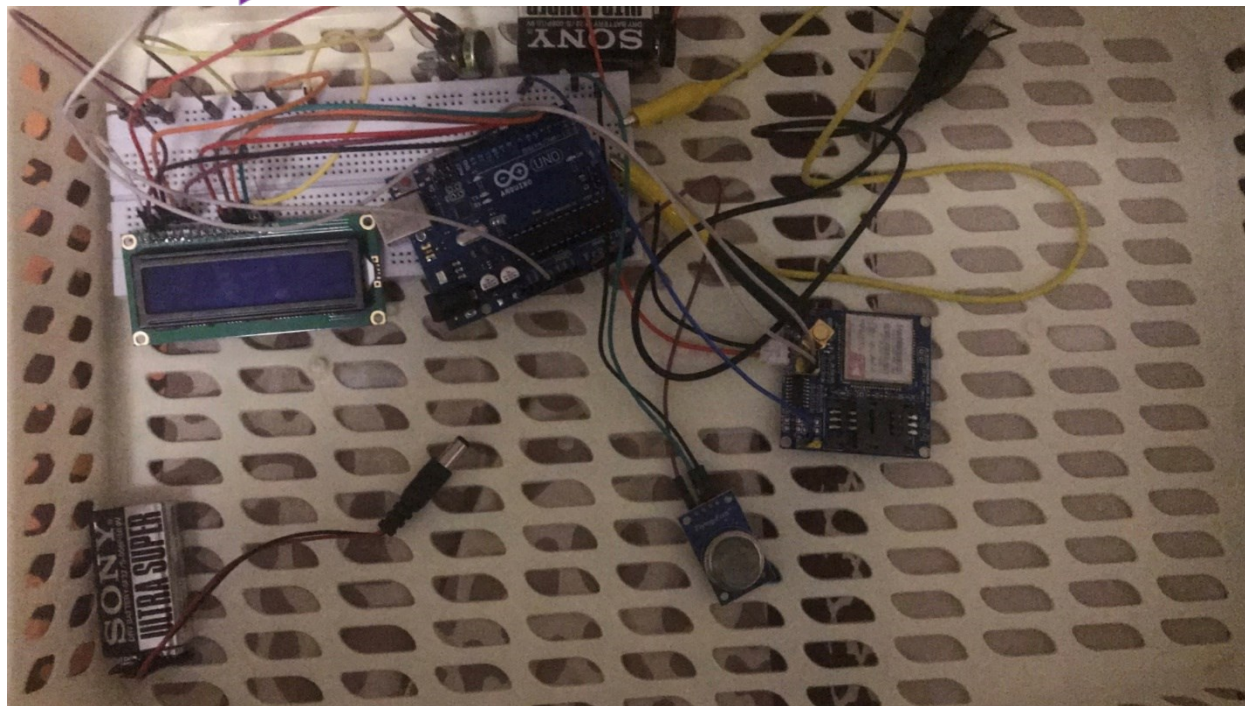
Figure 52: Gas Leakage circuit connection

4.3.   Motion Detection with Keypad

Here in this aspect of the project we will be building a security system that works based on a motion sensor which is PIR sensor as mentioned in the design section and a keypad which allows the user to insert the right code in order to disarm the system. While the system is disarmed if the password detected is wrong and the user gets away from the motion detector the buzzer will start to produce a siren that alerts that there is a breach and it would only be disabled through the correct password.

Circuit Design
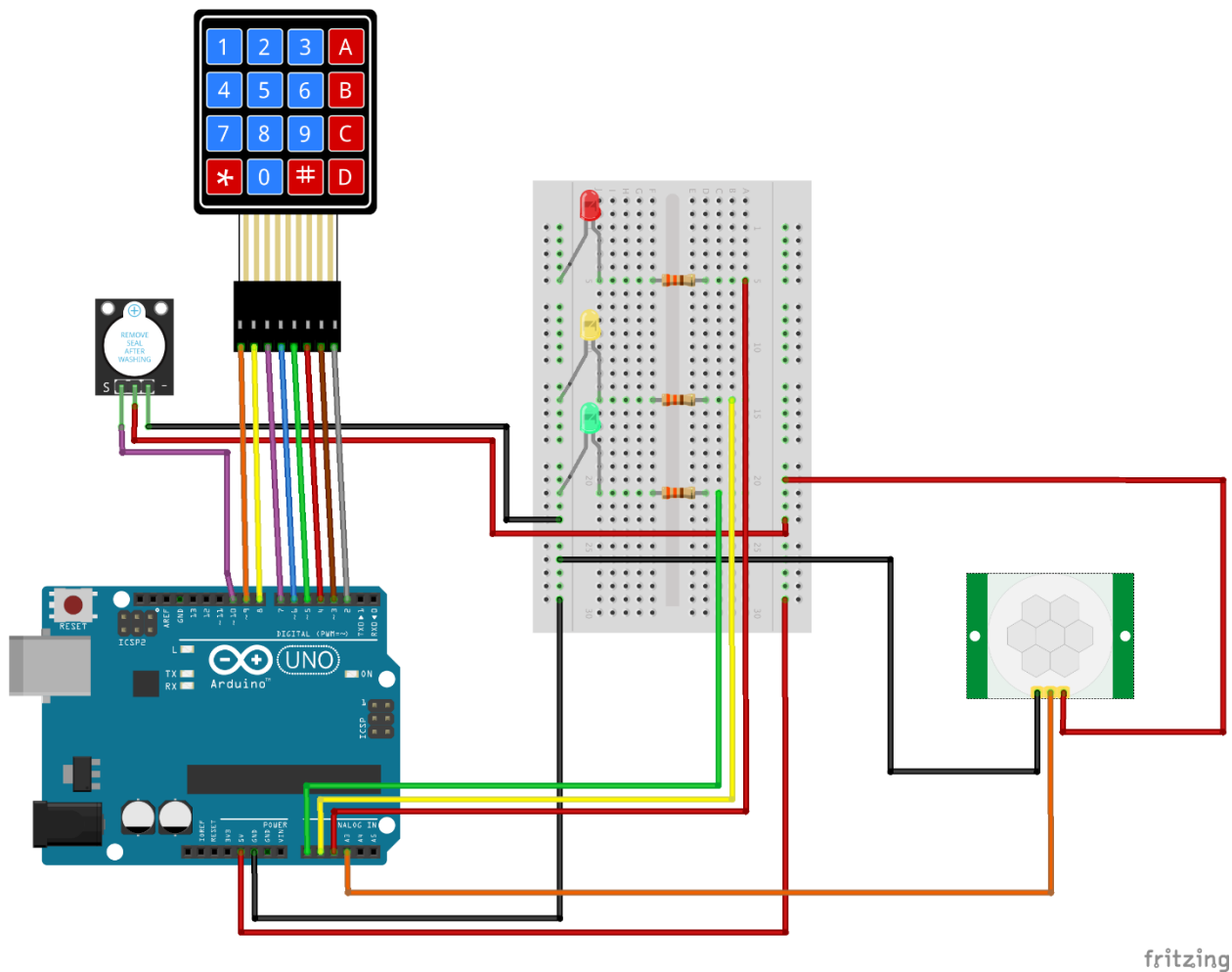
Figure 53: Motion Detection Circuit Diagram

Code Design

```
#include <Password.h>
#include <Keypad.h>


Password password = Password( "1234" );   // password

const byte rows = 4;                        // four rows
const byte cols = 4;                        // three columns
char keys[rows][cols] = {                   // keys on keypad

{'1','2','3','A'},
{'4','5','6','B'},
{'7','8','9','C'},
{'*','0','#','D'},

};

byte rowPins[rows] = {9,8,7,6};
byte colPins[cols] = {5,4,3,2};
Keypad keypad = Keypad(makeKeymap(keys), rowPins, colPins, rows, cols);
```

Figure 54: Defining of Password and Keypad buttons

```
int sensorzData;
unsigned long ceas, timpmemorat;

int intarziereactivare = 20;     // To delay for standby to armed
int intarzieredezactivare = 10;  // To delay for triggered to alarm activated
int timpurlat = 10;              // Time of alarm is on

// This is the variable for states "0"
char caz = 0;

int sistem = 0;      // system is 0 for off and 1 for on


/*
States for

  0. - off
  1. - stand-by
  2. - waitting
  3. - countdown
  4. - alarm
```

Figure 55: Deciding the states

```
void setup()
  {
  keypad.addEventListener(keypadEvent); // an object is created for tracking keystrokes

  Serial.begin(9600);   //Used for troubleshooting
  pinMode(alrm, OUTPUT);
  pinMode(sensorz, INPUT);
  pinMode(contact, INPUT);
  pinMode(redLed, OUTPUT);
  pinMode(yellowLed, OUTPUT);
  pinMode(greenLed, OUTPUT);
  digitalRead(contact);
  Serial.println("System startup"); //Used for troubleshooting
  Serial.println("Alarm button status:"); //used for troubleshooting
  Serial.println(digitalRead(contact)); //used for troubleshooting
  }
```

Figure 56: Deciding Input and output variables

```
void loop()

  {

  ceas = millis();      // read the internal clock
  val = digitalRead(contact);

keypad.getKey();


    if (sistem%2 == 0)
    {
    // alarm is off
    digitalWrite(greenLed, LOW);
    digitalWrite(redLed, LOW);
    digitalWrite(yellowLed, HIGH);
    //Serial.println(contact); //Used for troubleshooting

    digitalWrite(alrm, LOW);
    caz = 0;
   // Serial.println("System is OFF !"); // Used for troubleshooting

    }
```

Figure 57: Declaration of Conditions part 1

```
else
  {
  // alarm is on
  if(caz == 0)
    {
    caz = 1;
    timpmemorat = ceas;
    digitalWrite(yellowLed, HIGH);
    }

  if(caz == 1)                 // system waiting
    {

    if ((ceas%1000)<500) digitalWrite(greenLed, HIGH);
    else digitalWrite(greenLed, LOW);
keypad.getKey();
    if(ceas >= timpmemorat + intarziereactivare * 1000) {caz = 2;}
    //Serial.println("System is arming !"); // Used for troubleshooting
    }

  if(caz == 2)                 // system is armed
    {
    digitalWrite(greenLed, HIGH);
keypad.getKey();

    sensorzData = digitalRead(sensorz);
    //Serial.print("sensorzdData = "); //Used for troubleshooting
    //Serial.println(sensorzData); //Used for troubleshooting
```

Figure 58: Declaration of Conditions - Part 2

```
//      if(sensorzData > 600) {caz = 3; timpmemorat = ceas;}
     if(sensorzData == HIGH)
       {
       caz = 3;
       timpmemorat = ceas;
       digitalWrite(greenLed, LOW);
       }
       Serial.println("System is armed !"); // Used for Troubleshooting
       }

   if(caz == 3)               // system is triggered and countdown
       {

       if ((ceas%500)<100) digitalWrite(redLed, HIGH);
       else digitalWrite(redLed, LOW);
 keypad.getKey();
       if(ceas >= timpmemorat + intarzieredezactivare * 10) {caz = 4; timpmemorat = ceas;}
       Serial.println("System is triggered and is countdown !"); //Used for troubleshooting
       }

   if(caz == 4)               // siren (buzzer) is active
       {
       //digitalWrite(alrm, HIGH);
       digitalWrite(redLed, HIGH);
       Serial.println("Siren is active !"); //Used for troubleshooting
```

Figure 59: Declaration of Conditions - Part 3

```
// For siren

   //tone( 10, 10000, 100);  // Simple Alarm Tone
   for(double x = 0; x < 0.92; x += 0.01){  // Elegant Alarm Tone
       tone(10, sinh(x+8.294), 10);
       delay(1);
       }


 keypad.getKey();
       if(ceas >= timpmemorat + timpurlat * 1000) {caz = 2; digitalWrite(alrm, LOW); digitalWrite(redLed, LOW);}
       }
     }
   }

   //take care of some special events
void keypadEvent(KeypadEvent eKey){
  switch (keypad.getState()){
    case PRESSED:
  Serial.print("Pressed: ");
  Serial.println(eKey);
  switch (eKey){
    case '*': checkPassword(); break;
    case '#': password.reset(); break;
    default: password.append(eKey);
    }
  }
}
```

Figure 60: Siren Activation and password insertion

```
void checkPassword(){
if (password.evaluate()){
   Serial.println("Success"); //Used for troubleshooting
sistem++;
password.reset();
   Serial.println("Disarmed");//Add code to run if it works
}else{
   Serial.println("Wrong"); //Used for troubleshooting
   //add code to run if it did not work
   ledBlink = 0;
   while (ledBlink <= 5){
   digitalWrite(redLed, HIGH);
   delay(100);
   digitalWrite(redLed, LOW);
   delay(100);
   ledBlink++;
   }
   password.reset();
  }
}
```

Figure 61: Verification of Password loop

Connection

We had connected the circuit diagram that we have designed initially and it will powered through a 9V battery that is sufficient to run the whole system. This system will be evaluated through the results and discussion section where we will see it in practice and test it for its effectiveness in motion detection and password insertion.
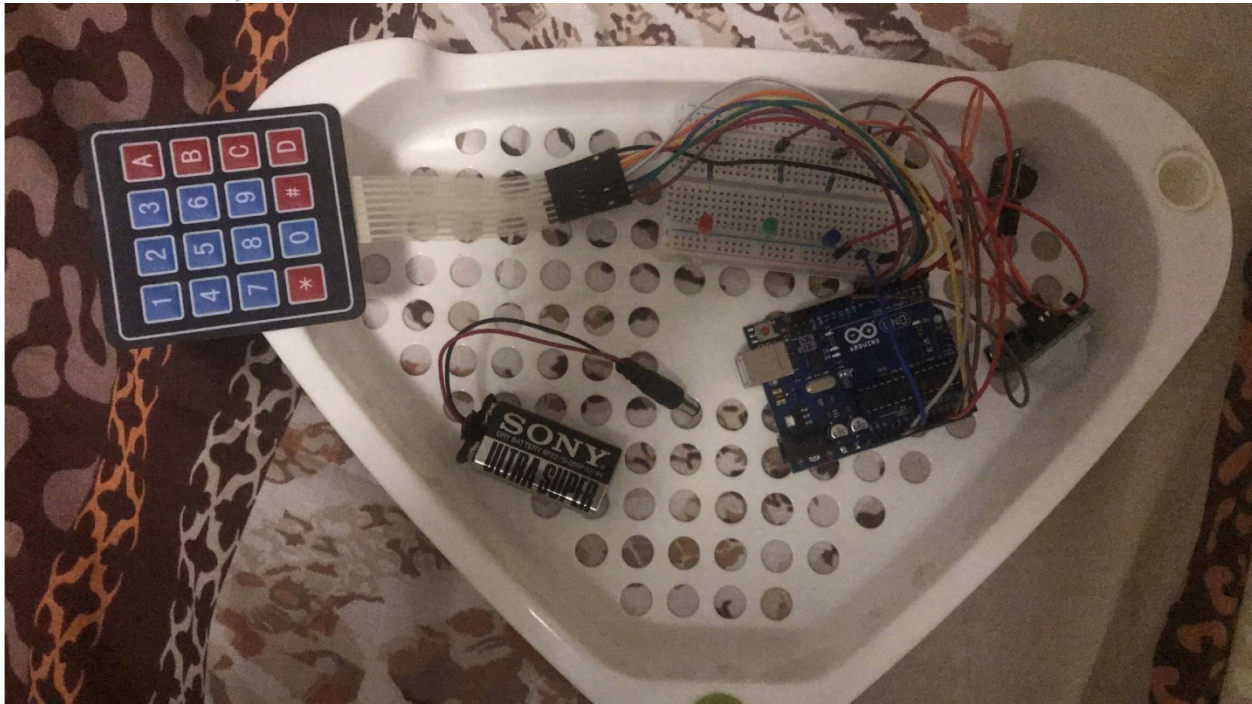
Figure 62: Motion detection circuit connection

4.4.   Appliance Control Through ESP 32

This part is considered to be very essential in our smart home model as applying appliances through your fingertips is what defines the term smart. Through WIFI technology we will be able to establish a connection with our ESP32 board which will be our microcontroller for this case and we will connect through an IP address that is generated by the board. Through Coding we will make an interface that can be opened through the IP address from any browser and you can control all your relay switches which would have Bulbs or Fans that will represent our loads.

Circuit Designed
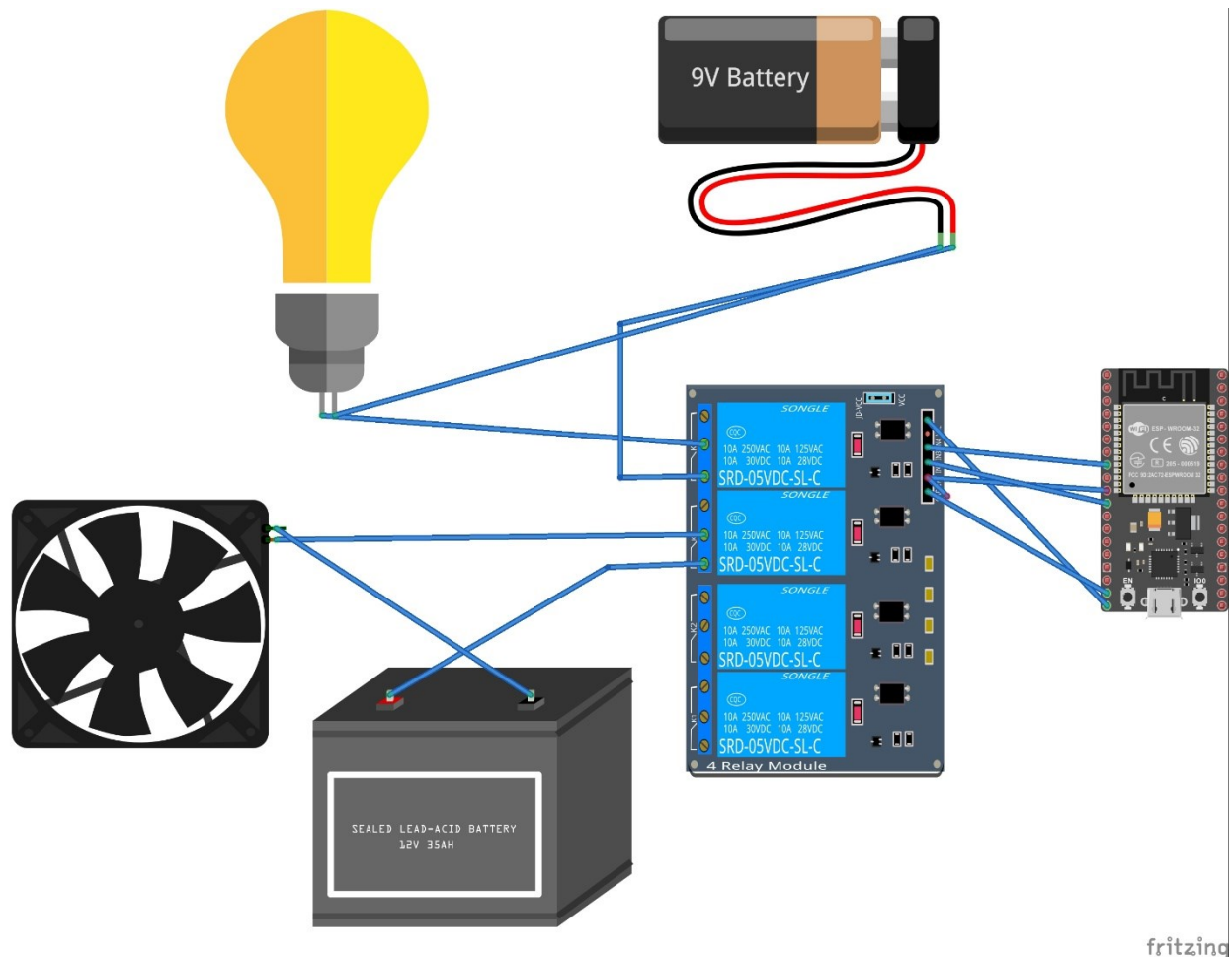
Figure 63: Appliance Control Through ESP 32

Here we have shown the circuit with two relays used but we intend to use all 4 relays but as an example we have shown only 2 relays used.

Code Designed

```cpp
#include "WiFi.h"
#include "ESPAsyncWebServer.h"

// Set to true to define Relay as Normally Open (NO)
#define RELAY_NO    true

// Set number of relays
#define NUM_RELAYS  4

// Assign each GPIO to a relay
int relayGPIOs[NUM_RELAYS] = {26, 27, 25, 33};

// Replace with your network credentials
const char* ssid = "         ";
const char* password = "         ";

const char* PARAM_INPUT_1 = "relay";
const char* PARAM_INPUT_2 = "state";
```

Figure 64: Declaration of Relays and GPIOs connected to the Relay and Network credentials

```
// Create AsyncWebServer object on port 80
AsyncWebServer server(80);

const char index_html[] PROGMEM = R"rawliteral(
<!DOCTYPE HTML><html>
<head>
  <meta name="viewport" content="width=device-width, initial-scale=1">
  <style>
    html {font-family: Arial; display: inline-block; text-align: center;}
    h2 {font-size: 3.0rem;}
    p {font-size: 3.0rem;}
    body {max-width: 600px; margin:0px auto; padding-bottom: 25px;}
    .switch {position: relative; display: inline-block; width: 120px; height: 68px}
    .switch input {display: none}
    .slider {position: absolute; top: 0; left: 0; right: 0; bottom: 0; background-color: #ccc; border-radius: 34px}
    .slider:before {position: absolute; content: ""; height: 52px; width: 52px; left: 8px; bottom: 8px; background-color: #fff; -webkit-transition: .4s; transition: .4s; border-radius: 68px}
    input:checked+.slider {background-color: #2196F3}
    input:checked+.slider:before {-webkit-transform: translateX(52px); -ms-transform: translateX(52px); transform: translateX(52px)}
  </style>
</head>
<body>
  <h2>ESP Web Server</h2>
  %BUTTONPLACEHOLDER%
<script>function toggleCheckbox(element) {
  var xhr = new XMLHttpRequest();
  if(element.checked){ xhr.open("GET", "/update?relay="+element.id+"&state=1", true); }
  else { xhr.open("GET", "/update?relay="+element.id+"&state=0", true); }
  xhr.send();
}</script>
</body>
</html>
)rawliteral";
```

Figure 65: Design of Web Server as the User interface

```
String relayState(int numRelay){
  if(RELAY_NO){
    if(digitalRead(relayGPIOs[numRelay-1])){
      return "";
    }
    else {
      return "checked";
    }
  }
  else {
    if(digitalRead(relayGPIOs[numRelay-1])){
      return "checked";
    }
    else {
      return "";
    }
  }
  return "";
}
```

Figure 66: Conditions for Relays

```
void setup(){
  // Serial port for debugging purposes
  Serial.begin(115200);

  // Set all relays to off when the program starts - if set to Normally Open (NO), the relay is off when you set the relay to HIGH
  for(int i=1; i<=NUM_RELAYS; i++){
    pinMode(relayGPIOs[i-1], OUTPUT);
    if(RELAY_NO){
      digitalWrite(relayGPIOs[i-1], HIGH);
    }
    else{
      digitalWrite(relayGPIOs[i-1], LOW);
    }
  }
}
```

Figure 67: Setting the Relays off when Program starts

```
// Connect to Wi-Fi
WiFi.begin(ssid, password);
while (WiFi.status() != WL_CONNECTED) {
  delay(1000);
  Serial.println("Connecting to WiFi..");
}
```

Figure 68: Setting WIFI connectivity

```
// Print ESP32 Local IP Address
Serial.println(WiFi.localIP());

// Route for root / web page
server.on("/", HTTP_GET, [](AsyncWebServerRequest *request){
  request->send_P(200, "text/html", index_html, processor);
});

// Send a GET request to <ESP_IP>/update?relay=<inputMessage>&state=<inputMessage2>
server.on("/update", HTTP_GET, [] (AsyncWebServerRequest *request) {
  String inputMessage;
  String inputParam;
  String inputMessage2;
  String inputParam2;
  // GET input1 value on <ESP_IP>/update?relay=<inputMessage>
  if (request->hasParam(PARAM_INPUT_1) & request->hasParam(PARAM_INPUT_2)) {
    inputMessage = request->getParam(PARAM_INPUT_1)->value();
    inputParam = PARAM_INPUT_1;
    inputMessage2 = request->getParam(PARAM_INPUT_2)->value();
    inputParam2 = PARAM_INPUT_2;
    if(RELAY_NO){
      Serial.print("NO ");
      digitalWrite(relayGPIOs[inputMessage.toInt()-1], !inputMessage2.toInt());
    }
    else{
      Serial.print("NC ");
      digitalWrite(relayGPIOs[inputMessage.toInt()-1], inputMessage2.toInt());
    }
  }
  else {
    inputMessage = "No message sent";
    inputParam = "none";
  }
  Serial.println(inputMessage + inputMessage2);
  request->send(200, "text/plain", "OK");
});
// Start server
server.begin();
}

void loop() {

}
```

Figure 69: Obtaining IP address and rooting to webpage

Connection

We intend to use all 4 relays to connect multiple Bulbs and a Fan that would act as appliances within the home with each one being connected to a DC power source as we are dealing with DC appliances. We will also power the ESP32 Wroom module through a 5V power bank which would prove sufficient enough to power the whole module and supply the voltage that we need to the relays. The testing will be done in the results section and we will see the effectiveness of this and the response of WIFI.
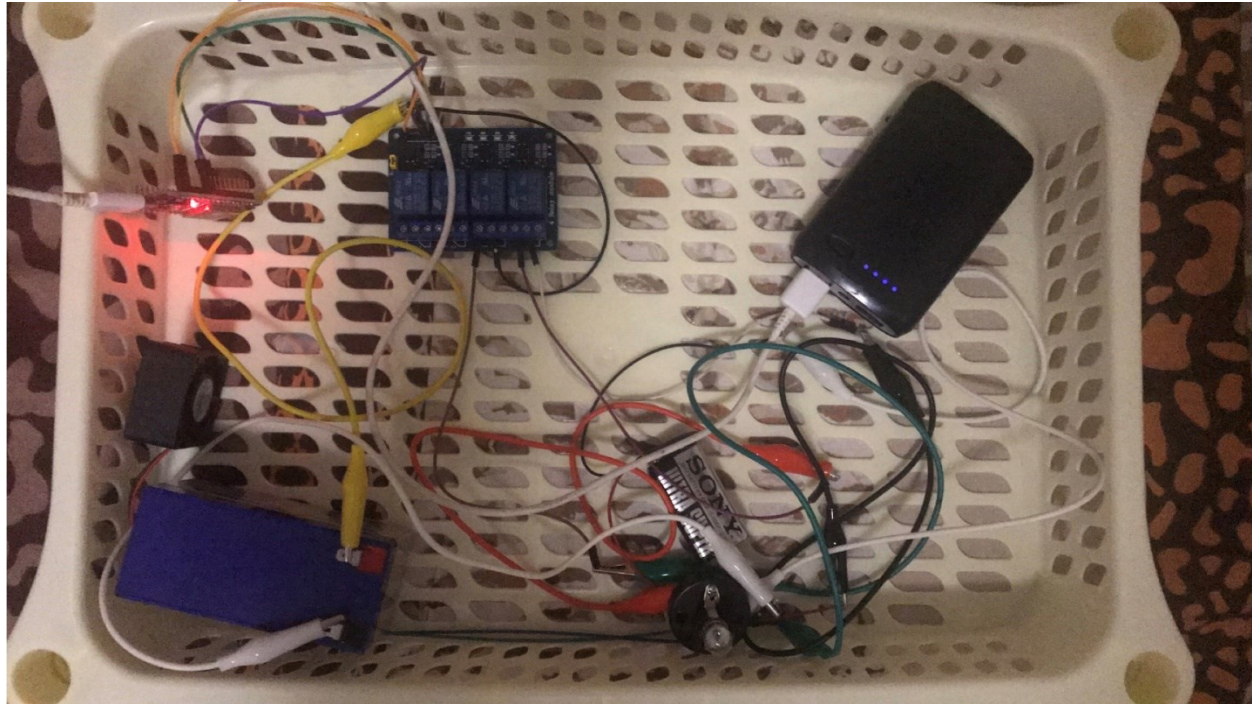
Figure 70: Appliance Control Circuit Connection

4.5. Voice Recognized LEDs using Bluetooth

This was a completely new idea that we thought of during the implementation stage and it was not mentioned during the design as we thought of putting more importance on IOT by adding Bluetooth capability to control LEDs and to make it extra special we have added voice recognition so based on certain phrases it would work but for simplicity we would make it the color of the LED itself. This is a rather simple design but it proves effective when we speak about a smart home model and it adds value to our project. These LEDs will be controlled through a readymade application.

Circuit

We designed a rather a rather small circuit diagram that serves the purpose of this part and to test its effectiveness.
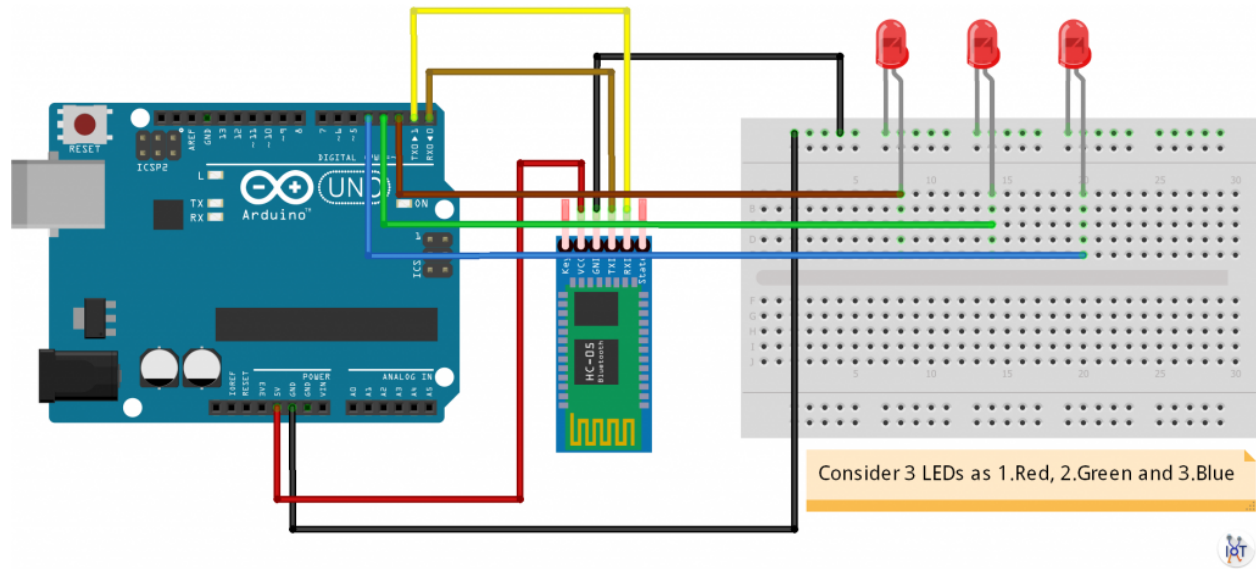
Figure 71: Voice Recognition Circuit Diagram

Code

Here in this section we will be explaining each part of the code that we have developed by its captions.

```
String voice;
int RED = 2;
int GREEN = 3;
int BLUE = 4;
```

Figure 72: Declaration of pins for each LED

```
void RedOn(){
digitalWrite (RED, HIGH);
}
void RedOff(){
digitalWrite (RED, LOW);
}
void GreenOn(){
digitalWrite (GREEN, HIGH);
}
void GreenOff(){
digitalWrite (GREEN, LOW);
}
void BlueOn(){
digitalWrite (BLUE, HIGH);
}
void BlueOff(){
digitalWrite (BLUE, LOW);
}
void allon() {
digitalWrite (RED, HIGH);
digitalWrite (GREEN, HIGH);
digitalWrite (BLUE, HIGH);
}
void alloff() {
digitalWrite (RED, LOW);
digitalWrite (GREEN, LOW);
digitalWrite (BLUE, LOW);
```

Figure 73: declaration of all the states that will make the LEDs turn on or off

```
void setup() {
Serial.begin(9600);
pinMode(RED, OUTPUT);
pinMode(GREEN, OUTPUT);
pinMode(BLUE, OUTPUT);
}
void loop() {
while(Serial.available()) {
delay(10);
char c=Serial.read();
if(c=='#')
{break; }
voice += c;
}
```

Figure 74: Bluetooth Configuration for the voice

```
if (voice.length() > 0) {
Serial.println(voice);
if (voice == "on" || voice == "all")
{
allon() ;
}
else if (voice == "off" || voice=="all off")
{
alloff() ;|
}
else if(voice =="red" || voice =="red on"){
RedOn();
}
else if(voice =="red off"){
RedOff();
}
else if(voice =="green" || voice =="green on"){
GreenOn();
}
else if( voice =="green off" ){
GreenOff();
}
else if(voice =="blue" || voice =="blue on"){
BlueOn();
}
else if(voice =="blue off"){
BlueOff();
}
voice="";
}
```

Figure 75: All conditions for All the LEDs declared based on the phrase said

Connection

We were able to connect it successfully as per the circuit diagram that was constructed and we will power it up using a 9V batter and we intend to put it in the hallway as a way for the user to choose the ambience as they like. This will be tested and the results will be discussed in the results section later on.
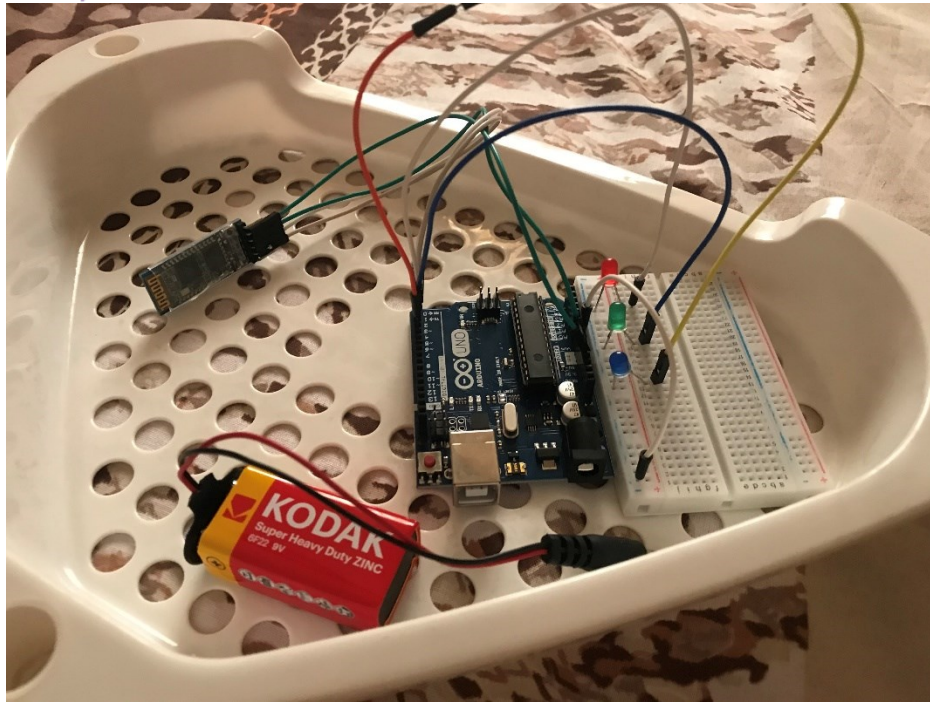
Figure 76: Connection of the voice-controlled LEDs

4.6. Distance Alert through Ultrasonic Sensing

This was also an additional aspect in our project that we thought of adding later on in the implementation phase and it is part of the security measures that could fill the gap that we have initially set on a small scale. For example you have a certain place in your home that you don't want anyone to get near to, this part of the project will sense the person approaching and it will gradually start buzzing at certain levels until the person is very close and it will buzz very loudly with LEDs set for each distance. An Ultrasonic sensor has one duty and it is to measure the distance when a body approaches through the Ultra sound waves that are produced by the body and it will send a signal to the Arduino to take an action. [62]

Circuit

The circuit we designed was rather simple yet we innovated by using a buzzer and multiple LEDs and to limit our LEDs from burning out and to give a smoother sound for the buzzer we used multiple resistors.
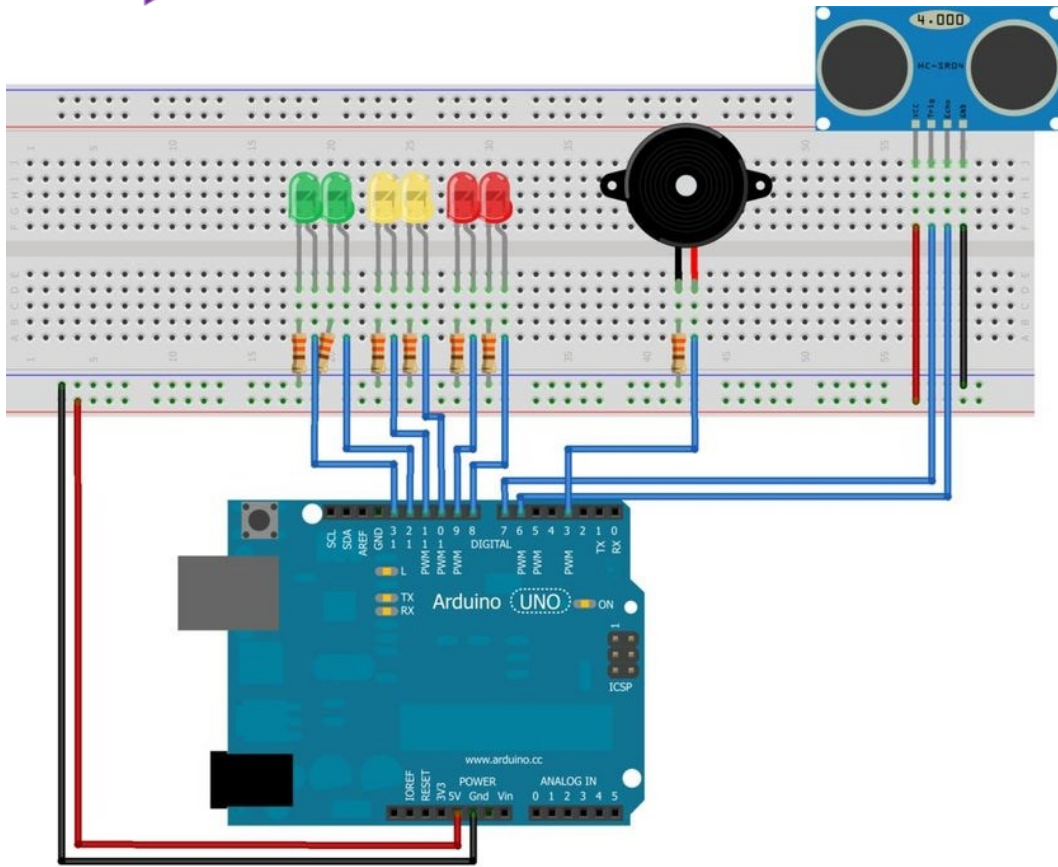
Figure 77: Ultrasonic distance detection circuit diagram

Code

The Code that we have developed will be explained through the captions that will be put for each section of it.

```
#define trigPin 7
#define echoPin 6
#define led 13
#define led2 12
#define led3 11
#define led4 10
#define led5 9
#define led6 8
#define buzzer 3

int sound = 250;


void setup() {
  Serial.begin (9600);
  pinMode(trigPin, OUTPUT);
  pinMode(echoPin, INPUT);
  pinMode(led, OUTPUT);
  pinMode(led2, OUTPUT);
  pinMode(led3, OUTPUT);
  pinMode(led4, OUTPUT);
  pinMode(led5, OUTPUT);
  pinMode(led6, OUTPUT);
  pinMode(buzzer, OUTPUT);


}
```

Figure 78: Definition of Pins and Declaring Pin Modes and Sound Declaration

```
void loop() {
  long duration, distance;
  digitalWrite(trigPin, LOW);
  delayMicroseconds(2);
  digitalWrite(trigPin, HIGH);
  delayMicroseconds(10);
  digitalWrite(trigPin, LOW);
  duration = pulseIn(echoPin, HIGH);
  distance = (duration/2) / 29.1;
```

Figure 79: Declaration of Duration and Distance variables

```
if (distance <= 30) {
    digitalWrite(led, HIGH);
    sound = 250;
}
  else {
    digitalWrite(led, LOW);
  }
  if (distance < 25) {
    digitalWrite(led2, HIGH);
    sound = 260;
}
  else {
    digitalWrite(led2, LOW);
  }
  if (distance < 20) {
    digitalWrite(led3, HIGH);
    sound = 270;
}
  else {
    digitalWrite(led3, LOW);
  }
  if (distance < 15) {
    digitalWrite(led4, HIGH);
    sound = 280;
}
  else {
    digitalWrite(led4, LOW);
  }
  if (distance < 10) {
    digitalWrite(led5, HIGH);
    sound = 290;
}
  else {
    digitalWrite(led5, LOW);
  }
  if (distance < 5) {
    digitalWrite(led6, HIGH);
    sound = 300;
}
  else {
    digitalWrite(led6, LOW);
```

Figure 80: Conditional Statements for each distance with increment in sound level

Connection

We were able to connect all the components together in the most appropriate way as per the circuit diagram that we have designed and this system will also be powered by a 9V battery which will make the system run and alarm based on the proximity of the moving body. This part will be tested and the results will be put in the results section to see how effective it is when a moving body approaches a certain parameter.
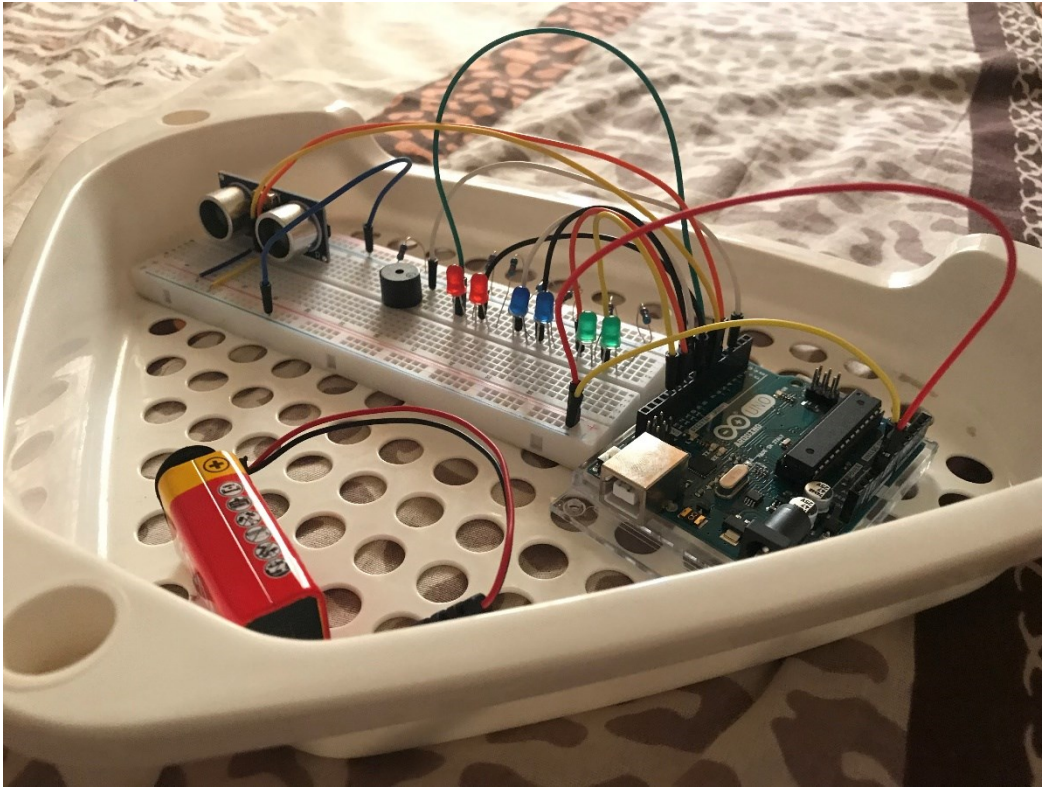
Figure 81: Connection of Ultrasonic distance sensing

4.7. Home Model Compartment

As we intend to contain all of these aspects into a single compartment, we will design a home divided into sections where we can equip them in an appropriate way for them to look more elegant and pleasing to the eyes to test them all functioning at the same time. Due to the issues of Covid-19 we were unable to make the model that will contain all our aspects by wood or 3D printing, so we resorted to using cartons that will help us to create a similar model to contain all the aspects of our home and we will model it to look as convenient as possible and to resemble the idea of all the components we have built.

You might have not seen some things implemented in the implementation section and that was due to the circumstances that we have faced and we hope to implement them in the near future and to update our project later on when all of this is resolved.

5. Results and Evaluation

Now after that we have implemented all the connections and built our model, we have tested all our aspects that are present within the smart model that we have built and they were all functioning to the level we wanted. We couldn't reach to the exact picture of what we wanted due to the limitations that we faced because of the lack of resources but we reached the fundamental idea and that is electrical components themselves functioning and a basic model that would contain all the ideas that we had made within this project. In this section we will evaluate the results of our model alongside a demonstration video that will show everything during its functioning that is going to be attached alongside the report.

We had all aspects of our project tested and we had got accurate results but we will be explaining them in brief as the demonstration video will be explaining everything and the functioning of all the components.

5.1. Temperature monitoring System

This system which is an essential part of any smart home model was tested for its functioning and it gave us accurate results in terms of temperature and humidity readings. The Readings were considered accurate and we took multiple readings to test the temperature and the LED indicators are responding at the desired outputs that we want. This system functions with 9V battery that powers everything efficiently and it doesn't burn out the microcontroller board. Below is a table that shows the readings of temperature taken as per time intervals:

Reading No.	Time in seconds	Temperature in Celsius	Temperature Level	LED indicator
1	1 sec	21	Low	Blue
2	3 sec	22.7	Moderate	Green
3	5 sec	23.0	Moderate	Green
4	30 sec	35	High	Red

Table 1: Temperature Readings

The temperature was not given much consideration but it is displayed as well on the LCD screen as the DHT11 sensor measures both variables. It will be visible at the end of the section when we view our final model.

5.2. Gas leakage detection system

As part of our safety precautions that we wanted to implement in our smart home model, we have built a system that detects the level of hazardous gaseous that could be present within your home and it would alarm the users through an SMS alert that the level of the gas is higher than the acceptable value and therefore the user will be prompted to open their windows or to check why there is a leakage of such gas at their home.

As the MQ135 that is considered to be an air quality sensor to be of high sensitivity it would detect changes in the gas levels per second and the information is present on the LCD screen alongside an SMS alert is sent as an alert. For realistic testing we have reduced the level of gas from 500 to 270 as this is an acceptable range of what we can obtain but originally as per the code we want it 500 to sense high levels of hazardous gas. For some unfortunate reasons we can't seem to obtain an SMS in our mobile phones even though the LCD alerts us.

Figure 82: Alert That SMS has been Sent to the User

5.3. Motion Detection system

As part of the security measures that we want to fulfill in this project. We have decided to build a system that detects motion and the user would have to insert a password that we have set within the program that has been uploaded on the microcontroller unit.

The system is initially not active and it is considered to be in normal mode when the password is entered correctly through the keypad, after that when a new body is detected and the password is entered incorrectly multiple times it will immediately buzz and only this alarm can be deactivated through the insertion of the correct password while being motion detected.

This system was tested for its functionality and it was working the way it was desired and we can improve it further in the future.

5.4. Appliance Control Through a Webserver

One of the most essential things that should be present in any smart home model is the ability to control any of your appliances from a distance through a smart device. We opted to go for WIFI due to the ability of being able to connect to you home anywhere around the world as long as you are connected to the internet and your ESP microcontroller is connected to the internet. We have developed the webserver as well as tested it and it was functioning very well through our 4-channel relay system. We intended to use all 4 channels but due to the corona virus challenge we were unable to fill all four switches and we used only two as the lack of resources unable us to do so. We tested on a light bulb that was 6V connected to a 9V DC source and 12 V DC fan connected to a 12V battery. The reason why we opted to go for DC and not AC is because we wanted to test in a much safer environment and not lose much of the resources, we have available so we opted to use DC components. Of course, we ran our ESP 32 microcontroller through a 5V power bank which was sufficient enough to power our chip.
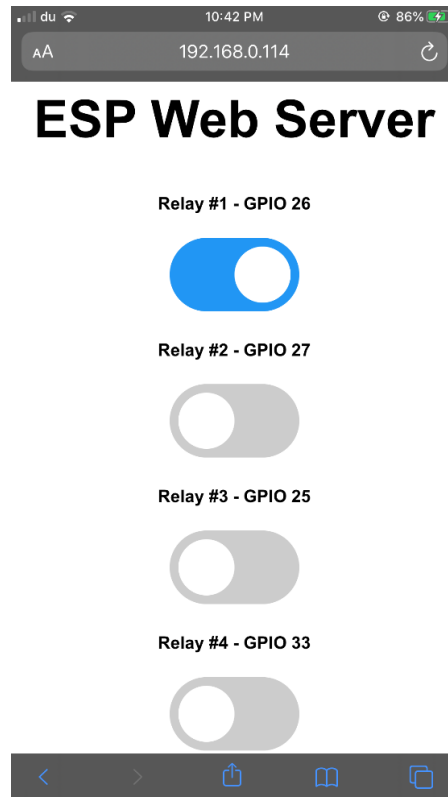
Figure 83: Appliance Control Web Server

The ESP 32 Chip generates an IP that is associated with the interface that the user can interact with the loads that are connected to the respective relays. We are only using two relays but, in our program, we have identified all four relays so in the future when we add appliances, we wouldn't have to remodify our codes but just add connections only. It is considered to be secure as this IP is considered unique and is only known by the home user. This system was well tested and it will be shown in the demonstration video. This idea helps you to keep track of your appliances in that way you create a sustainable system that reduces your power cost as well we have an IOT interface established.

5.5.   Voice Recognized LEDs

This small system might be considered to be simple from one's eye perspective but it combines security and IOT in a very small circuit yet a very effective one. Through a set of phrases that only an android app would recognize to trigger the lights you want, so we could put certain phrases that

only the user knows to open the lights. Of course, for simplicity we have used just the LED colors as the phrases to make it easier for demonstration.

This system functions within the home only so therefore, we use Bluetooth technology as we only want local access to the lights and not distant access.

Below is a table that shows the phrases that were put within the program and the appropriate result:

Phrase No	Phrase	Result
1	"All" or "On"	All LEDs turned on
2	"All off" or "off"	All LEDs turned off
3	"Blue" or "Blue on"	Blue LED turned on
4	"Blue off"	Blue LED turned off
5	"Green" or "Green on"	Green LED turned on
6	"Green off"	Green LED turned off
7	"Red" or "Red on"	Red LED turned on
8	"Red off"	Red LED turned off

Table 2: LED Phrase Results

This system also adds convenience as the user might want to change the ambience of their home and it can be improved by the addition of a lot more LEDs but we have developed the basic idea of it.

5.6. Ultrasonic Distance Sensing

Another addition that came within the implementation stage was the addition of a system that acts as both safety and security. Ultrasonic waves are sound waves present in any body and we assume this system could be put behind your room when needed or near to a place that you want no one to get next to. It would act as an alarming system that only increases in sound with the approaching of a moving body. The system would gradually increase the buzzer sound and light up the LEDs with the distance between the sensor and the body decreases. This has all been programmed and uploaded into the microcontroller and tested using a small body.

The Table below will show the results based on different distances:

SI No.	Distance (cm)	Sound level	LED Indicator
1	<= 30	250	First Green LED
2	<25	260	Both Green LEDs
3	<20	270	Both Green LEDs and First Blue LED
4	<15	280	Both Green and Blue LEDs
5	<10	290	Both Green and Blue LEDs and First Red LEDs
6	<5	300	All LEDs on

Table 3: Ultrasonic sensor configuration

This system can work for several applications it could work as a garage sensor when parking your car to make sure it doesn't hit or as a security measure in one of our personal rooms, its an idea that can be widely expanded.

5.7.   Home Model

After discussing the results of all our components that we have built and developed. We have contained all of them within an environment to see them all working at the same time, and this was done through the use of cartons as way to build the model.

Due to the corona limitations, we were unable to build the model in the perfect way but we reached to the basic concept with the intentions of improving this model after this crisis is over and to complete the project the way we vision it and to improve it much further.

Below is a picture of how the model looks like and how all the components are running appropriately.

Figure 84: Upper View of the Model
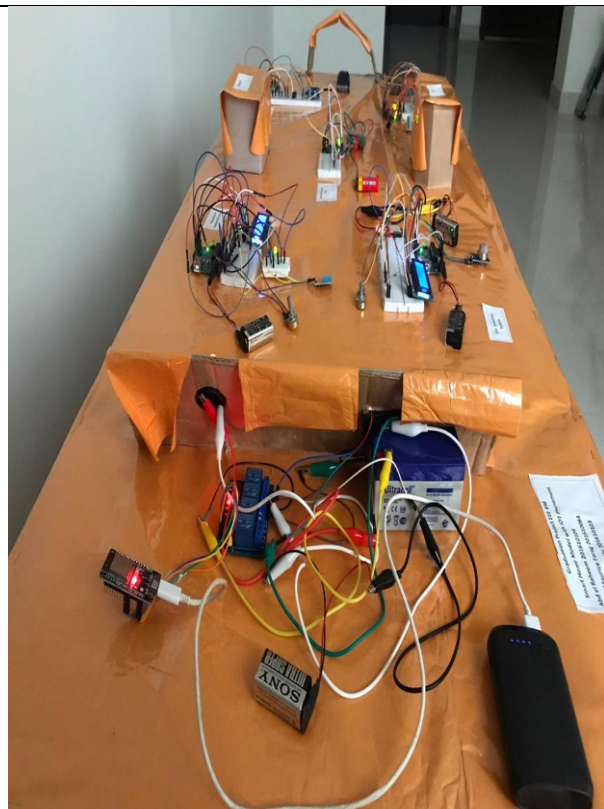
Figure 85: Back View of the model

Figure 86: Side View of the model

6. Challenges during Design and Implementation

Any project that is constructed must have a set of challenges that we will come across during its design phase as well as implementation phase, these challenges might delay the project from being in the image that it was once planned for, and it would develop it into the closest image possible. The challenges can be classified into two sections which are during:

- Design Stage
- Implementation Stage

We will list all the challenges that we faced and methods of how it could be improved in the future when improving our project further.

Challenges met in the Design Phase

The design stage is considered equally important as the implementation stage as it helps us to set a foundation on how our project will look like and the necessary components that will be needed as well as the flowcharts that will help us implement the code for our microcontrollers.

The challenges that we met were:

- Choice of appropriate components: It was necessary to choose the components that were matching the specifications that were required and the ones that would give us the best response that we need and intense research was made to gather these components correctly.
- IEEE standards declaration: It was necessary to study and see what are the standards that relate to our project to set them accordingly within our report.
- Block diagram design: it was necessary to produce a block diagram appropriately and for it to be well explained as it would resemble our project on the final look.
- Flow chart construction: It was challenging to implement the logic of our microcontrollers in the form of a flowchart and we had to study our logics very well in order to produce an appropriate flowchart that would be of the highest standards to implement the code correctly.

As mentioned, these were the challenges that were met during the design stage. The following challenges were the ones that were met during the implementation stage during the development of our project aspects and sketch implementation:

- Code implementation: It was challenging as our knowledge was very limited and we had to broaden what we have already learnt with the experience what we have to build appropriate codes for our microcontrollers.

- Design of circuits: It was challenging to draw the circuits with the components we exactly have for example the LEDs and we had different colored LEDs in the actual components we bought.

- Negligence of certain components: due to certain components not working for us specifically the camera monitoring, we had to keep it as part of our design but due to the corona virus we couldn't get a new part so we had to neglect. Luckily, we had extra resources to compensate for the camera and build new aspects that were mentioned in the implementation section of this report.

- We were unable to receive SMS messages in our Gas detection system due to SIM card issues and the limited resources that we currently had but we still get an alert on the LCD screen.

- Home model building: due to the corona virus issues, we were unable to build the perfect model and we had to resort to cartons to build a compartment that will contain all our connections.

- It was difficult to stick to the Block diagram that we have initially designed due to unfortunate set of circumstances that were not in our hand.

We intend to overcome all our challenges in order to produce the best possible outcome for the project that is visualized and for us to build the model of the smart home that we have intended to build. With the additions that we have made in the implementation stage and the negligence's that we have made we are able to balance our project to the highest extent to build a project that exceeds the biggest challenge that we currently face that is the Covid-19.

We intend to continue working on this project and to fight the challenges that made us unable to finish the project the perfect way and we look forward to adding more features into our project in the future.

7. Conclusion

In this academic paper that we have produced, we were able to model what would resemble a smart home model that could introduce several benefits to people's lives and it would create convenience to several homes that exist and people's lifestyle would change to the better as many homes rely on manual control. This model that was built and tested and evaluated will optimize several factors such as security, safety, energy efficiency, versatility and how it will be really easy to use. For all these factors to be met, components were selected based on intense research and built through the use of connections and sketches to make sure we have a robust model in place for our framework. Our project focused on filling the several gaps that were present in many home models that only focused on controlling appliances rather than focusing on other monitoring aspects that would make any home complete. Through the implementation of the initial designs made and the addition of new aspects we are able to resolve all the aspects that were neglected in past projects.

In conclusion, this graduation project is just a beginning and it has the potential to expand on the largest possible scale and reach to the highest standards. With the current challenges that we faced due to Covid-19, we were able to model a basic idea of how the model could be and we intend to work on it in the future and to make reach to all the possible aspects that we visualized to have a home model that is built with the highest standards.

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Appendix A

Initialization of Pins and LCD display

Assigning variables of temperature reading and Printing of data on LCD display

Conditional process for 3 LED setup

Appendix B

Setting LCD pins and MQ135 input pin and initialization

Gas Scan Initialization

Conditions of Gas levels and declaration of SMS message

Setting up Text message and inclusion of receiver number

Appendix C

Defining of Password and Keypad buttons

```
int sensorzData;
unsigned long ceas, timpmemorat;

int intarziereactivare = 20;    // To delay for standby to armed
int intarzieredezactivare = 10; // To delay for triggered to alarm activated
int timpurlat = 10;             // Time of alarm is on

// This is the variable for states "0"
char caz = 0;

int sistem = 0;      // system is 0 for off and 1 for on


/*
States for

   0. - off
   1. - stand-by
   2. - waitting
   3. - countdown
   4. - alarm
```

Deciding the states

Deciding Input and output variables

Declaration of Conditions part 1

Declaration of Conditions - Part 2

Declaration of Conditions - Part 3

Siren Activation and password insertion

Verification of Password loop

Appendix D

Declaration of Relays and GPIOs connected to the Relay and Network credentials

Design of Web Server as the User interface

Conditions for Relays

Setting the Relays off when Program starts

Setting WIFI connectivity

Obtaining IP address and rooting to webpage

Appendix E

Declaration of pins for each LED

declaration of all the states that will make the LEDs turn on or off

Bluetooth Configuration for the voice

All conditions for All the LEDs declared based on the phrase said

Appendix F

Definition of Pins and Declaring Pin Modes and Sound Declaration

Declaration of Duration and Distance variables

Conditional Statements for each distance with increment in sound level