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AFRICAN CENTER OF EXCELLENCE IN INTERNET OF THINGS

Research Thesis Title:

IoT BASED SOUND GOVERNOR

A dissertation submitted in partial fulfillment of the requirements for the award of the degree of M.Sc. in Internet of Things/Wireless Intelligent Sensor Networking.

Submitted By:

MUNYANA Raphael (Reg. No: 219013693)

November 2023

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Supervised By:

-Name of Main Supervisor: Dr Frederick NZANYWAYINGOMA

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November 2023

DECLARATION

I declare that this Dissertation contains my work and that it is original work. I also declare that, as required by rules I have fully cited and referenced all material and results that are not original to this work.

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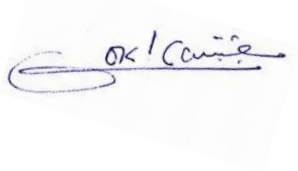
Signature: 

Date:27th November 2023

CERTIFICATE

This is to certify that the project work entitled **"IoT based sound governor"** Is a record of original work done by **Raphael MUNYANA** with registration number: **219013693** in partial fulfillment of the requirement for the award masters of science in internet of things in college of science and technology, University of Rwanda during the academic year 2019-2020.

This work has been submitted under the guidance of Dr Frederic NZANYWAYINGOMA and Prof. KAYALVIZHI Jayavel.

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Co-supervisor: Prof. KAYALVIZHI Jayavel

Signature:

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ABSTRACT

In Rwanda, the government of Rwanda tried to avoid the noise disturbance from public and private institutions mainly caused by bars, night clubs and religious churches by fixing soundproof, moving religious churches in the non-residential area but the outcomes were not fully successful. In this project, a feasibility study is presented on a new monitoring system in which an acoustic pattern classification algorithm running in circuit actuators is used to automatically assign the measured sound level to the different noise sources. For monitoring the variation of parameters like sound pollutionlevels from their normal levels; in this case, the actuator devices are connected to the embedded computing system and build a system called IoT-based sound governor. IoT-based Sound governor will help the substandard soundproof to monitor the level of sound in bars, churches and nightclubs according to the regulations of government. The actuator called sound cuter which is a sound compressor will be connected to the audio mixer which generates sound and make an automatic regulation of sound to be not greater than normal level and when it will get closer to 90 the sound compressor will automatically reregulate to a normal level. This case study is going to give to the concerned institutions, a sustainable solution of sound pollutionmonitoring in those different areas using Internet of things innovations. IoT-based sound governor of an efficient building requires monitoring and measures the condition in case of exceeding the established level of noise.

LIST OF ACRONYMS

dB: Decibel

CPU: Central Processing Unit

GB: GigaByte

GPS: Global Positioning System

GSM: Global System for Mobile Communication

HDD: Hard Disk Drive

IoT: Internet of Things

LED: Light-emitting Diode

LCD: Liquid Crystal Display

RAM: Random Access Memory

RSB: Rwanda Standards Bureau

SDM: System Development Method

WHO: World Health Organization

WSN: Wireless Sensor Network

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CHAPTER 1: GENERAL INTRODUCTION

1.1 INTRODUCTION

In general, WSN can be defined as a network that has nodes and can cooperatively sense and may control the environment enabling interaction between persons or computers and the surrounding environment. The WSN architecture consists of three components namely: sensor node, gateway and user. sensor nodes and gateways constitute sensor fields.[1]. These nodes can be linked via wireless media. The WSN design consists of sensor nodes, which interconnect a digital sound noise level meter with a microcontroller, a Global Positioning System (GPS), and a communication channel device capable of transmitting data in real-time [2][3]. Wireless sensor networks (WSN) have started to attract researchers' interest. These nodes include embedded CPU, limited computational power and some smart sensors. With these sensors, nodes are used to monitor the surrounding environment including sound pollution[1]. In the past, controlling pollution in a particular area was a very difficult and tedious task. With the increase in noise and the development of technology, new technologies have been introduced to ensure faster and more efficient pollution. The Internet of Things is one of the most recent developments in this process. An increase in the use of the Internet and human interaction with machines has given rise to IoT. It allows the exchange of information in various devices such as refrigerators, washing machines, cars, watches and more. Information exchange is carried out using multiple devices[4].Sound pollution is one of the main constituents that have the most adverse effect on humans as well as the entire earth. Therefore it is very important to check and control it. Traditional methods involve manual work in which data loggers are used to visiting the site to collect the data, analyze it and perform comparisons to provide the output which was very lengthy and time-consuming besides being inefficient. The monitoring system uses sensors that detect sound pollution concentration[5]. In this project, the wireless embedded computing system is proposed. This system will use a sound cuter relay to monitor and control the level of the noise inside the building (indoor) which can detect and measure the level of sound. If the sound level is greater than the normal level the system will monitor and cut the output data that goes into the speaker. The sound cuter will turn off decibels in the speaker (output).

1.2 BACKGROUND AND MOTIVATION

The sound pollutionis one of the obstacles for residents near nightclubs and churches due to loud music. Regulating the sound level and knowing how much sound level they play is difficult for them therefore the music can be tooloud. This difficulty allows the RSB National Standards Board to establish regulations and measurements of sound pollution that should be followed[6]. As a result of these difficulties; there is a way to prevent sound pollutionfrom bars, nightclubs, and even churches. This is to create an IoT-based system that will detect the sound level and be able to stop it when it is going to make a noise level refer to the Rwanda Standards Bureau regulations.

1.3 PROBLEM STATEMENT

One of the disagreeable conditions every individual may interfere with the comfort of hearing is the noise. They are many health problems that can be caused by noise in terms of communication, psychological, physiological, and hearing. The report of WHO estimates 1.1 billion young people worldwide could be at risk of hearing loss caused by sound pollution[7]. Nearly half of all teenagers and young adults in middle and high-income countries are exposed to sound pollutionfrom different areas like clubs, discotheques, bars and churches[7]. There is no surgical or medical cure for noise-induced hearing loss with that damaged hear cells cannot regenerate. Once hearing loss starts, its progression can be halted by avoiding further exposure to noise pollution[8]. In daily life, human beings can hear many kinds of voices like conversation, vehicles, industrial machinery, and the sound of music. If those kinds of voices are high and interfere with the hearing comfort, is called noise. If there is a sound of music in one building and that sound works with the vibration frequency exceeds the threshold of hearing, then the problem will appear to the people inside the building and will disturb the people outside the building. A single point noise measurement is rarely representative for a whole neighborhood and several sensor locations are needed[9]. WHO report of 2015 shows that at least 15% of adults have permanent hearing damage due to noise pollution[10]. Here in Rwanda, the government institutions resolve the noise disturbance problem in bars, night clubs and religious churches by fixing soundproof, moving religious churches in the non-residential area but the results were not fully fruitful. Rwanda National Police advises the concerned people to acquire decibel-sound masters so that they can help them regulate their sound

level and install sound proofs[11]. Based on Rwanda National Police has intensified their operations against sound pollutionby ensuring that sound level is controlled and monitored in a way that does not affect the beliefs and wellbeing of others in the neighborhood. This implies the enforcement of the law on environment 48/2018 (official gazette of 21/09/2018) determining the modalities for protecting, conserving and promoting the environment in Rwanda[10]. One of the barriers to monitoring environmental noise is how to make enough measurements at the right time and in various ways[9]. Sound pollutionin Rwanda has become a critical challenge especially in some different public places like nightclubs, bars and churches. According to the government guidelines, sound pollutionis defined as a level of disturbance or excessive noise that may harm the activity or balance of human or animal life. Many churches and bars in Rwanda are built in residential places, thus they make sound pollutionboth day and night to the surrounding human beings. In 2018 Rwanda local authorities has closed around 700 churches due to the failure of complying with building regulations and creating noise pollution[12][13]. Rwanda National Police has strengthened operations against noise disturbance to ensure that the regulations as well as the rights of other people are respected[10]. The national police advised the churches, bars and nightclubs to install soundproof that will avoid sound pollutionwhen they are shouting and playing music inside the building[11]. Although they also advised the concerned people to install soundproofing systems it has not produced enough to some churches, bars and nightclubs since it has been done in a substandard manner and has been not done by standard guidelines on how soundproof is made. It has not brought changes to the proliferation of noise in some churches, bars and nightclubs. This project is going to give to concerned government institutions, a sustainable solution to sound pollution monitoring those different areas using Internet of things innovations by providing a system which will control and monitor the sound level in the nightclubs, bars and churches. It will also bring a sustainable solution that will help to avoid noise pollution, this project will avoid sound pollutionby monitoring and controlling noise using the IoT system, which will be able to detect sound pollution from people providing noise and notify concern people.

1.4 STUDY OBJECTIVES

1.4.1 AIM

To design an IoT-based Sound governor where a sound cuter can control the sound level, analyze it and give the real-time solution when the sound is making noise.

1.4.2 GENERAL OBJECTIVES

To introduce the IoT with a real-time solution to the hearing loss caused by sound pollutionand facilitate safety in the city of Kigali.

1.4.3 SPECIFIC OBJECTIVES

- Analyze sound level provided by the churches, bars and nightclubs.
- Regulate automatically the sound level of these above areas. Simplify the relief operations with automatic regulation

1.5 HYPOTHESIS

IoT-based Sound governor is coming to solve the noise caused by sound pollution from churches, nightclubs and bars. That will provide safety to the residents near churches, nightclubs and bars. Also, the police will no longer conduct inspections.

1.6 STUDY SCOPE

This system is going to focus on cutting signal decibels of the sound when it is making noise until the mixer user will reduce the volume to the normal level. The system will be able to display decibels passing through the input to the output.

1.7 SIGNIFICANCE OF THE STUDY

As described above this system is IoT-based sound governor. Which will be aimed at preventing noise from churches, bars and nightclubs in Kigali city. This will prevent top-level traders from being imprisoned and continue to work but working at the appropriate level provided by the relevant authorities. Economically due to the high noise from the aforementioned parts of the building, it was closed and thus the owners caused them financial instability. So this system will help them monitor the level of sound and regularize it so that there is no noise pollution. In the health sector, there will be a significant reduction in the number of patients suffering from sound

pollution here we may say those who are in the building from the noise and those who live near at the building from the noise (neighborhood). Furthermore, this system will simplify the work to the police where the police will be able to identify the source of the incident and who is causing it in real-time.

Decisions will be taken based on the information the system provided. And it will also lead to more sound pollution avoidance measures in the city of Kigali based on the statistics provided by the system.

1.8 ORGANISATION OF THE STUDY

This section includes all parts of the thesis. Below are the parts:

Chapter 1 gives an introduction of the research which includes the background of the study and its motivation, study objectives, hypothesis of the study, the limitation of the study, the interest and the conclusion.

Chapter 2 discusses related researches that were carried out before, its gaps and how this research is going to improve and fill the existing research.

Chapter 3 is the research methodology. It gives an overview of the research methods that will be used in this work.it also presents the requirements needed in this work.

Chapter 4 talked-about system analysis and design that includes all theories used in this research.

Chapter 5 provide results and analysis by interpreting data using graphs.

Chapter 6 finalize the research with a Conclusion and suggest some recommendation for the future work.

1.9 Research question:

1. How to measure real-time and various ways?
2. How the user will know or be able to monitor the noise pollution?

3.What an easier and smart way for regulating sound automatically?

4.When and how will the noise be known, present and reported in real-time?

1.10 CONCLUSION

In this chapter, the researcher has given an introduction of the research, background and motivation of the study, a detailed problem statement has been given in the research, scope of and limitation of the research, how this research is organized and why the researcher is interested in working on this research.

CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

In this research paper; they show how the system will provide data to users and authorities which is specific in one area. While this project will provide information from different areas and be able to differentiate sound pollutiondepending on the source[14][15].

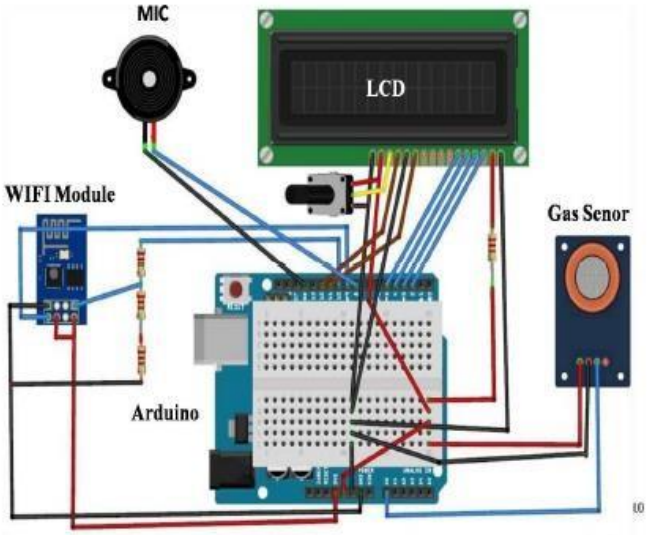

Figure 1: *IOT based Air and Sound Pollution Monitoring System*

A feasibility study is presented on a new monitoring concept in which an acoustic pattern classification algorithm running in a wireless sensor is used to automatically assign the measured sound level to different noise sources. This paper talked about monitoring sound pollutiononly while my project is also cutting the noise automatically. [9]. The main purpose of this paper was to ensure that audio pollution was controlled and monitored strategically. The system is designed to provide an idea of how the user can immediately notify the authorities. Automatic equipment, once installed, can monitor the level of pollution and analyze the detected information. This paper indicates that there will be a notification but there is no way the authorities will see it in a real-time manner. According to this project, the advanced feature is that will use a GPS sensor will be able to local the noisemaker, where the noise occurred and the level of noise[4]. Research paper on IOT based Air and Sound Pollution Monitoring System written by Lalit Mohan Joshi PhD Research Scholar describe how embedded device was made for the monitoring noise level in the atmosphere to make the environment interact with the objects through wireless communication but it did not show how the system will relegate the noise by cutting the sound level automatically. This is what my project will improve. It will regulate the sound level to the sound that comes from speakers[16]. The authors of this paper IOT Based Air and Sound pollutionMonitoring System has shown that their system will work with the noise sensor to keep measuring the noise level in the surroundings and then the data it captures can be transmitted to the mobile application so that people who are using smartphones can check transmitted data and make decisions[17]. But in fact we are based on our case study where Churches, night club and bars will barely able to stop their noise while their

people need it. So this project will come up with the solution that the noise makers will be able to monitor the sound level and stop it automaticallywhen it is getting noise.

2.2 CONCLUSION

In this chapter research focuses on the research conducted by other researchers where they showed how to prevent noise using IoT technologies. This chapter also outlines how this research is being done that will provide a solution to the gaps that have emerged in other research.

CHAPTER 3: METHODOLOGY

3.1 INTRODUCTION

This section gives an overview of the research methods that are going to be used during the work. It highlights the methods and approaches used and shows how the analyzed results were presented throughout the whole project. Mainly scientific methods for conducting research are used however both qualitative and quantitative approaches are rarely used as data analysis is the part of this research.This research approach lies under scientific research methods and it indicates that scientific type of research methods is just used for clarification.

3.2Development Research Approaches

This part describes the overview of the research approaches and the steps involved in system development from the step of gathering the idea to the final step of prototype and getting the result.

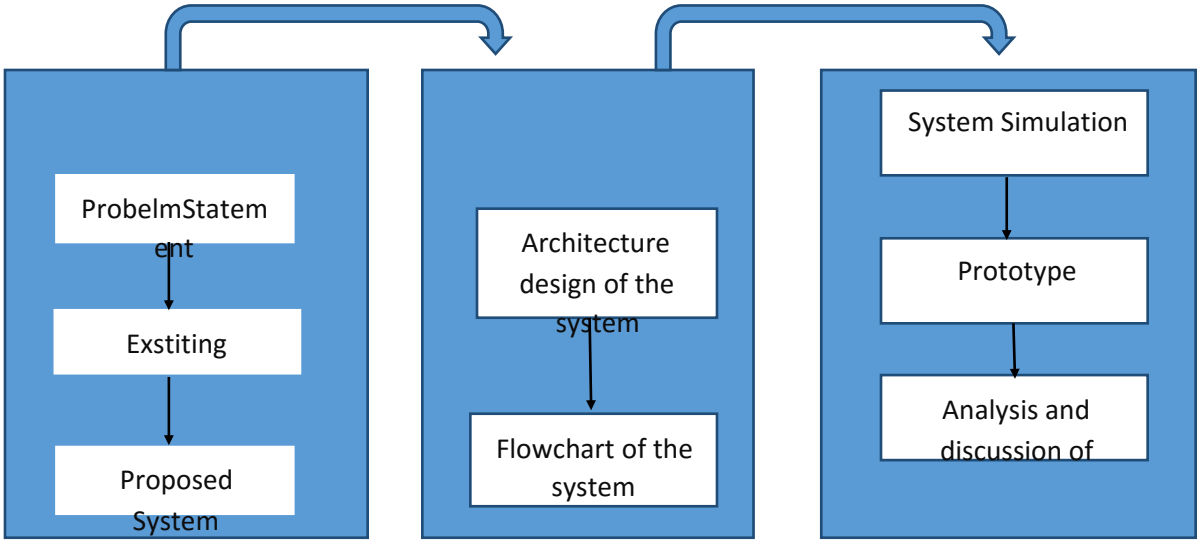

Figure 2: ***Development Research Approaches***

3.2.1 Scientific research approach

During this research, several scientific methods were used to conduct this research. The existing schemes were found in qualitative research methods and design, analysis, and simulation an experimental approach was used. It began with random ideas and slowly we come up with the objectives, statement of the problem, and proposed solution. In the existing schemes, this helped to come up with knowledge about the research ideas. In this case, the existing schemes seized the opportunity to discover the existing knowledge and to propose the solution to the stated problem.To be specific, a quantitative approach was taken to evaluate how other existing schemes work, their weaknesses to find what should be done to improve their performance. Several ideas were developed and considered as the idea of using a sound cuter circuit which will allow the system to stop the music automatically when noise appears. This requires building a sound compressor by using a sound cuter circuit.

3.2.2 Experimental approach

First and foremost, the idea of this project came with the objectives, a description of the problem statement,and its solution based on the IoT application. The designed project consistsof a sound compressor where circuit designed using a sound cuter circuit. This will cut the sound from the sound mixer when the sound level is higher than the normal level automatically.During my research, I tried to measure the level of noise using a relay driving circuit. The measurement result is shown in chapter four of this research.

3.3 System development methodology

3.3.1 Prototype model

The prototype model is a system development which does not require freezing the requirement. A prototype acts as a sample to test the process. [18]. By prototyping, the software designer and implementer can get valuable feedback from users early in the project[19]. For the research methodology of this project, the chosen software development life cycle was the Prototyping model which is a system development method (SDM) in which the project is designed, built, tested, and then repeated until it provides a valid final solution.

3.3.2 Prototyping model steps

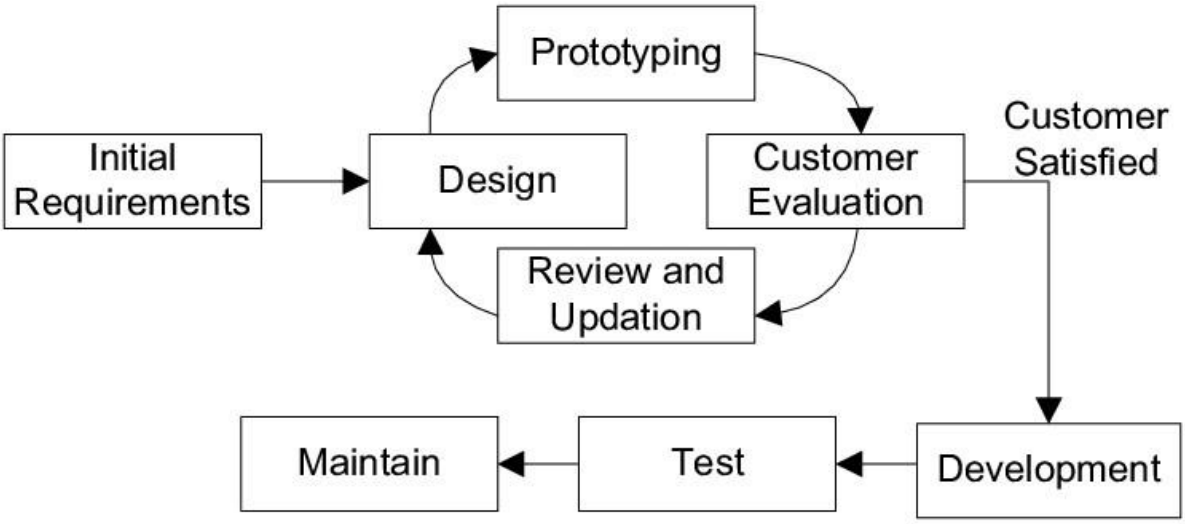

Figure 3: *Prototype model*

1. **Initial requirements:** A prototyping model starts with requirement analysis. In this phase, the requirements of the system are defined in detail. During the process of playing music;

churches, bars and night clubs are interviewed to know what their expectation from the system.

2. **Design**: I can say is a quick design.After knowing all the requirements of the IoT-based Sound governor;the second phase is a preliminary design. In this stage, a simple design of the system is created. However, it is not a complete design. It gives a brief idea of the system to the users. The design helps in developing the prototype.
3. **Prototype:** In this phase, an actual prototype is designed based on the information gathered from quick design. It is a small working model of the required system.This also where all the equipment will be used in the prototype. We can say microcontroller, sound cuter, relay as an actuator, LED, LCD, gateway, cloud storage, ESP8662 and other accessories.

4. **Customer evaluation:** In this stage, the proposed system is presented to the user for an initial evaluation. It helps to find out the strength and weaknesses of the working model. Comment and suggestions are collected from the customer and provided to the developer.
5. **Review and update:** At this phase,if the user is not happy with the current prototypeall the feedback that users have been giving and the additions by the state guidelines on sound pollutionare all collected from the user to be added to the project for making it better.

6. **Development**: After the user has successfully accepted the project, in this phase, the designed prototype is coded and developed. Here including code building and connecting to devices. where the sound cuter will be connected to the microcontroller and then the command codes will allow us to see the output in real-time

7. **Test:** Testing a system after development method in which a prototype is built, tested and then reworked as necessary until an acceptable outcome is achieved from which the complete system or product can be developed.

8. **Maintain**: Once the final system is developed based on the final prototype, it is thoroughly tested and deployed to production. The system undergoes routine maintenance for minimizing downtime and prevent large-scale failures.

3.4 Data collection methods

These are the methods used in my research. Interview and documentation. we interviewed bars/ night club managers, church administrators about sound management. We used electronic books (from the internet),various journal articles, and conference papers.

3.4.1 Interview

In this phase, an unstructured interview method is used. Where few questions are asked aimed at better understanding the existing methods used in sound management. We asked also questions to gain as much information as they possibly can about their noise pollution.

3.4.2 Documentation

Documentation is the evidence provided for information and ideas borrowed from others. In this method, as pointed out above; Electronic books, journal articles, conference papers were usedand cited in this project.

3.5 Proposed system requirements

3.5.1 Functional requirements

Functions that the user requires from the system are known as Function requirements. IoT-based sound governor possesses the following functional requirements such as:

1. Converting AC to decibels
2. Activate the sound cuter circuit
3. Sensing output decibels from the microcontroller
4. Display all signals being processed
5. Sending converted signals (data) to the cloud storage and monitoring platform.

3.5.2 Nonfunctional requirements

The following are also the non-functional requirements of the developed Adaptive Algorithm for IoT based avoiding noise disturbance:

1. **Reliability:**The IoT-based sound governor monitorsthe level of decibels coming into the speakers, cutting automatically the sound depending on the level it reaches when it makes noise.

2. **Usability:** No more important knowledge is needed after the installation of this system. Except to know how to view data on the cloud. Here anyone with knowledge in ICT can look at this.
3. **Scalability:** IoT-based sound governor is scalable because it caninclude other parameters depending on the purpose. Here we can add other sensors that will make the performance better.

3.5.3 Hardware and Software requirements

Hardware requirement: The following are minimum hardware requirements for running Adaptive Algorithm for IoT based avoiding noise disturbance:

1. Computer with 4 GB RAM
2. 500GB free space of HDD
3. CPU: Core i3

3.5.3.1 Hardware User in this system

1. **Arduino nano microcontroller:** Arduino Nano is a microcontroller board designed by Arduino.cc. The microcontroller used in the Arduino Nano is Atmega328, the same one as used in Arduino UNO. It has a wide range of applications and is a major microcontroller board because of its small size and flexibility[20].

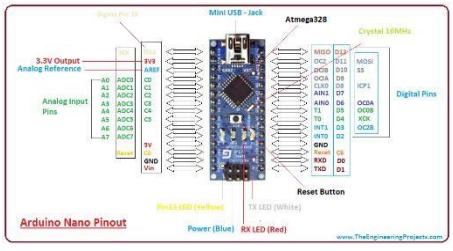

Figure 4: ***Arduino Nano***

Description	Pin No.	Name	Type
Digital input/output port 0 to 13	1-2, 5-16	D0-D13	I/O
Reset (active low)	3, 28	RESET	Input

Supply ground	4, 29	GND	PWR
+3.3V output (from FTDI)	17	3V3	Output
ADC reference	18	AREF	Input
Analog input channel 0 to 7	19-26	A7-A0	Input
+5V output (from on-board regulator) or +5V (input from external power supply)	27	+5V	Output or Input
Supply voltage	30	VIN	PWR

Table 1: *Arduino nano specifications*

2. **ESP 8266-01E module, Wi-Fi module:** The ESP8266 is a really useful, cheap Wi-Fi module for controlling devices over the Internet. It can work with a microcontroller like the Arduino or it can be programmed to work on its own[21].

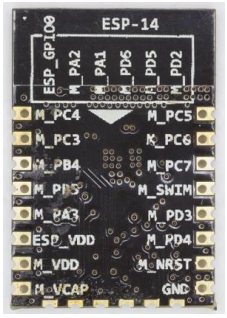

Figure 5: *Wi-Fi Module*

ESP8266 Wi-Fi module specification

n	Name	Alternate Functions	Notes
1	GND	Ground Pin	(Pin 1 is in the corner close to the crystal and away from antenna)
2	UTXD	SPICS1, GPIO1, CLK_RTC	Typically used as serial uart0 TX

3	URXD	I2SO_DATA, GPIO3, CLK_XTAL	Typically used as serial uart0 RX
4	GPIO16	XPD_DCDC, RTC_GPIO0, EXT_WAKEUP, DEEPSLEEP	Connected to XPD_DCDC ESP pin, can also be connected to ESP EXT_RSTB (reset) pin by closing jumper near pin 8; Reset pin is active low and has an internal weak pull-up; Connecting jumper is required to wake-up ESP from deep-sleep: RTC produces pulse on XPD_DCDC pin that needs to be fed into EXT_RSTB pin
n	**Name**	**Alternate Functions**	**Notes**
5	CH_PD		Power-down: low input powers down chip, high powers up; tie high for normal operation or module will not function
6	ANT		Wifi Antenna, do not connect
7	VCC		3.3V input (pin 8 is between antenna and ESP chip)

Table 2: *ESP8266 Wi-Fi module*

3. **LCD screen**: A liquid-crystal display (LCD) is a flat panel display, electronic visual display, or video display that uses the light modulating properties of liquid crystals. Liquid crystal does not emit light directly. Here, we are going to use a monochromatic 20x4 alphanumeric LCD. 20x4 means that 20 characters can be displayed in each of the 4 rows of the 20x4 LCD, thus a total of 80 characters can be displayed at any instance of time[22].

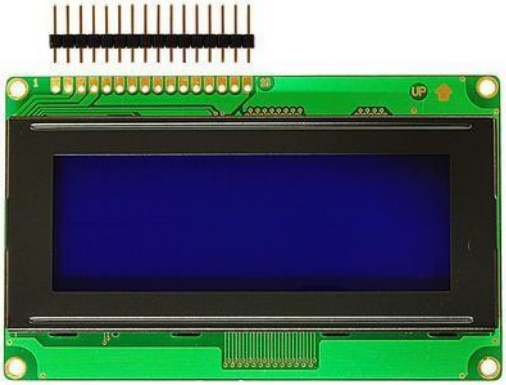

Figure 6*: 20*4 LCD*

4. **Relay driving circuit:** Relays are electromechanical devices that has an electromagnet to operate a pair of movable contacts from an open condition to a closed condition. The advantage of relays is that it takes a relatively small amount of power to operate the relay coil, but the relay itself can be used to control AC circuits and devices like motors, heaters, lamps which themselves can draw a lot more electrical power[22].

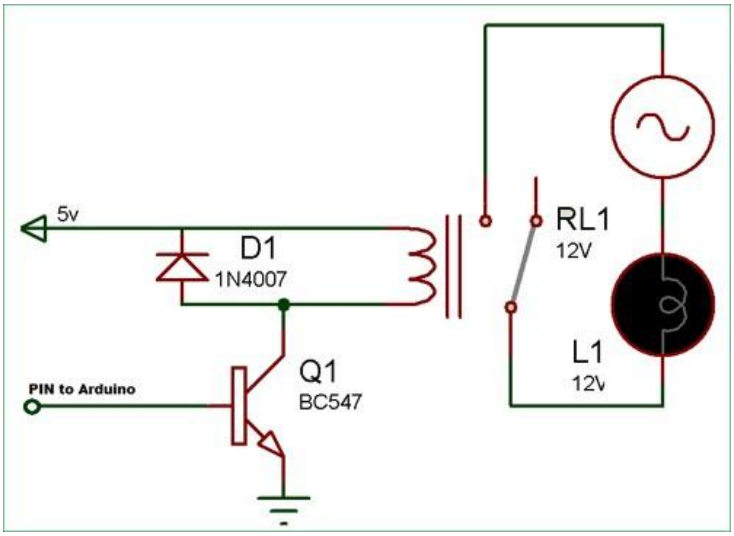

Figure 7: *A relay driver circuit*

5. **Relay:** The basic principle of relays is to use an electromagnet to operate a mechanical switching mechanism and are used for the control of circuits through small power signal as well as provide electrical isolation between the actuator and the controlled circuit[23].

Figure 8: *Relay 5vdc*

6. **Sound signals divider:** In electronics, a voltage divider (also known as a potential divider) is a passive linear circuit that produces an output voltage (V_{out}) that is a fraction of its input voltage (V_{in}). Voltage division is the result of distributing the input voltage among the components of the divider.

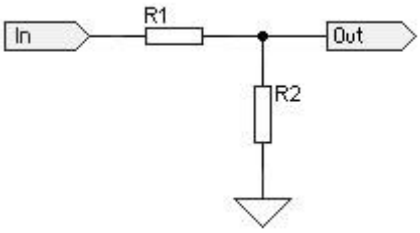

Figure 9: *Sound signal divider*

Pin Number	Pin Name	Description
1	Coil End 1	Used to trigger(On/Off) the Relay, Normally one end is connected to 5V and the other end to ground
2	Coil End 2	Used to trigger(On/Off) the Relay, Normally one end is connected to 5V and the other end to ground

3	Common (COM)	Common is connected to one End of the Load that is to be controlled
4	Normally Close (NC)	The other end of the load is either connected to NO or NC. If connected to NC the load remains connected before trigger
5	Normally Open (NO)	The other end of the load is either connected to NO or NC. If connected to NO the load remains disconnected before trigger

Table 3: ***Sound signals divider***

Software requirement: The following are minimum software requirements for running Adaptive Algorithm for IoT based avoiding noise disturbance:

1. Windows 7 OS
2. Proteus 8
3. **Arduino IDE**

This part of hardware and software requirements has three main parts such as:

1. Circuited actuators: This part consists of all the tools used in this project. Including actuators used as relays, the Arduino (nano microcontroller) helps us to program the embedded system. Including LCD, potentiometer for LCD constraint, REDs, ESP 8266-01Emodule as a Wi-Fi module, sound signals divider help us to lower input power voltage.
2. Data Processing: in data processing, the focus is on signals from the input divider to the microcontroller. The work is done by the input divider and the microcontroller that does the data processing.
3. Cloud storage: Cloud storage is one way to store data that has been processed by a microcontroller and to go to the cloud using the Wi-Fi module of the ESP 8266-01 module to take it to thingspeak cloud storage to store, display in the database, and in graphs.

3.6 Process design

The design of the new proposed IoT-based sound governor was an important phase after gathering the requirements and conducting the feasibility study. The design was specifically done after analyzing the existing schemes and then proposes a new scheme that was intended to archive our objectives. As it was done in chapter 5, this scheme performed better than the existing scheme hence our goal was achieved.

3.7 Conclusion

This chapter includes methods for conducting research, data collection methods, information summaries, their analysis and activities to be undertaken during system design and prototype. Based on this chapter outlining the nature of the project and what it will be used to implement, this project is going to be solved and give a solution to the people concerned.The system of analysis and design is going to be explained in the next section.

CHAPTER 4: SYSTEM ANALYSIS AND DESIGN

4.1 Introduction

This chapter presents the purpose of control sound pollution by introducing a sound governor embedded system. Many methods have been used in this chapter to provide a description and showing all the components of a system. This chapter will outline how the voice will be controlled by the system and provide measures that are consistent with government expectations.

4.2 System model

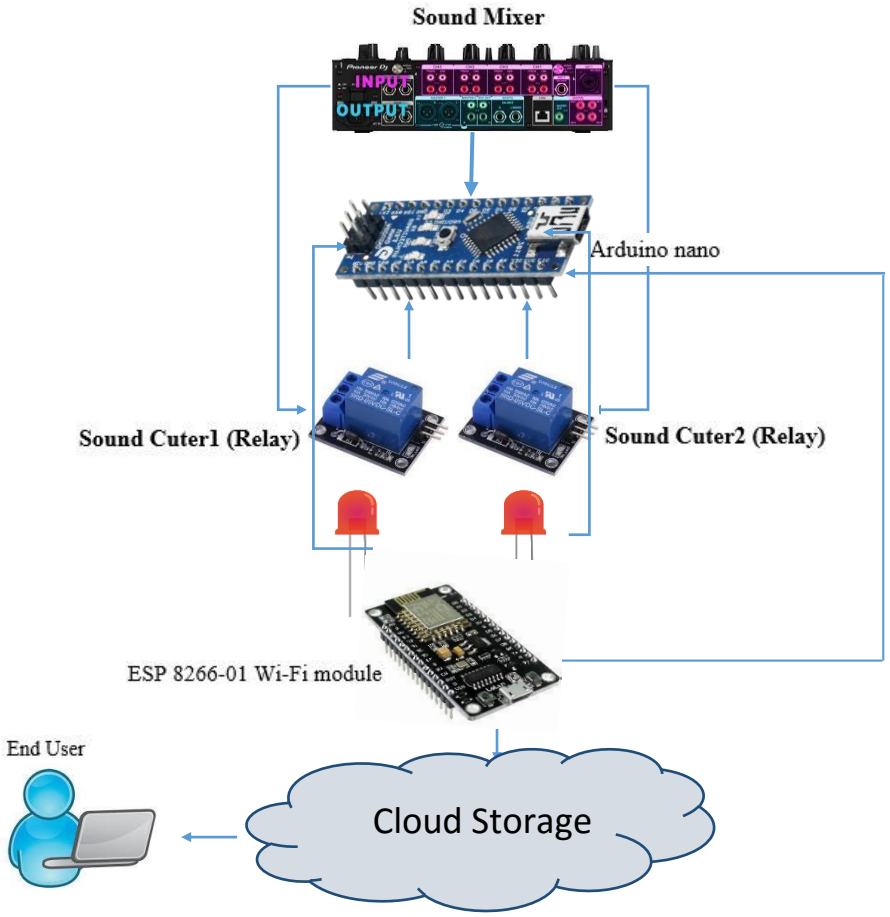

Figure 10: *System model*

Description of the above figure contains all components used in the project and how it is connected. A sound mixer will have an output that will be connected to the dB divider to convert power voltage into decibels. After the dB has reached the relay it continues in the microcontroller and be processed. The microcontroller will monitor and control data from the sound mixer and send it to the cloud using the Wi-Fi module.

After looking at system model used in this project; let us take a look on the level of noise parameters provided by public review according to the Rwanda Standards Board standarazation [24]. They provided this table based on housing and masters plan and the measures of each activity building.

Ambient air quality standards in respect of noise.

Area Code	Category of area	Limit in dB, Max.	
		Day time	Night time
A	Industrial Area	75	70
B	Commercial Area	65	55
C	Residential area	55	45
D	Silence Zone	50	40

Table 4: *Ambient air quality standards in respect of noise*

The table above shows the level of sound standards, where it should be used day and night in some areas like Industrial area, Commercial area, residential area, silient zone depending on their activity.

Maximum acceptable noise levels inside buildings

S/No	Type of building	Maximum acceptable noise levels (dB)
1	Offices	50 - 60
2	Dwellings(Houses and Flats)	45 - 55
3	Schools(Classrooms or lecture rooms)	45 - 50
4	Hospitals	40 - 50

Table 5: *Maximum acceptable noise levels inside buildings*

The table above shows the level of sound that is allowed and cannot be exceeded depending on the building in which the sound comes from.

Maximum recommandation noise dose – Exposure levels

Noise level (dBA)	Maximum exposure time per 24 h
85	8 h
88	4 h
91	2 h
94	1 h
97	30 min
100	15 min
103	7.5 min
106	3.7 min
109	112 sec
112	56 sec
115	28 sec
118	14 sec
121	7 sec
124	3 sec
127	1 sec
130 – 140	less than 1 sec
140	NO EXPOSURE

Table 6: *Maximum recommendation noise dose – Exposure levels*

The table above shows the maximum level of sound and how long the sound should last in order to avoid other hurmful effects to the hearing loss.

4.3 Activity diagram

The activity diagram is another important behavioral diagram to describe dynamic aspects of the system. An activity diagram is essentially an advanced version of a flow chart that modeling the flow from one activity to another activity[25].This activity diagram below shows how activities flow during the communication of the device in the system.

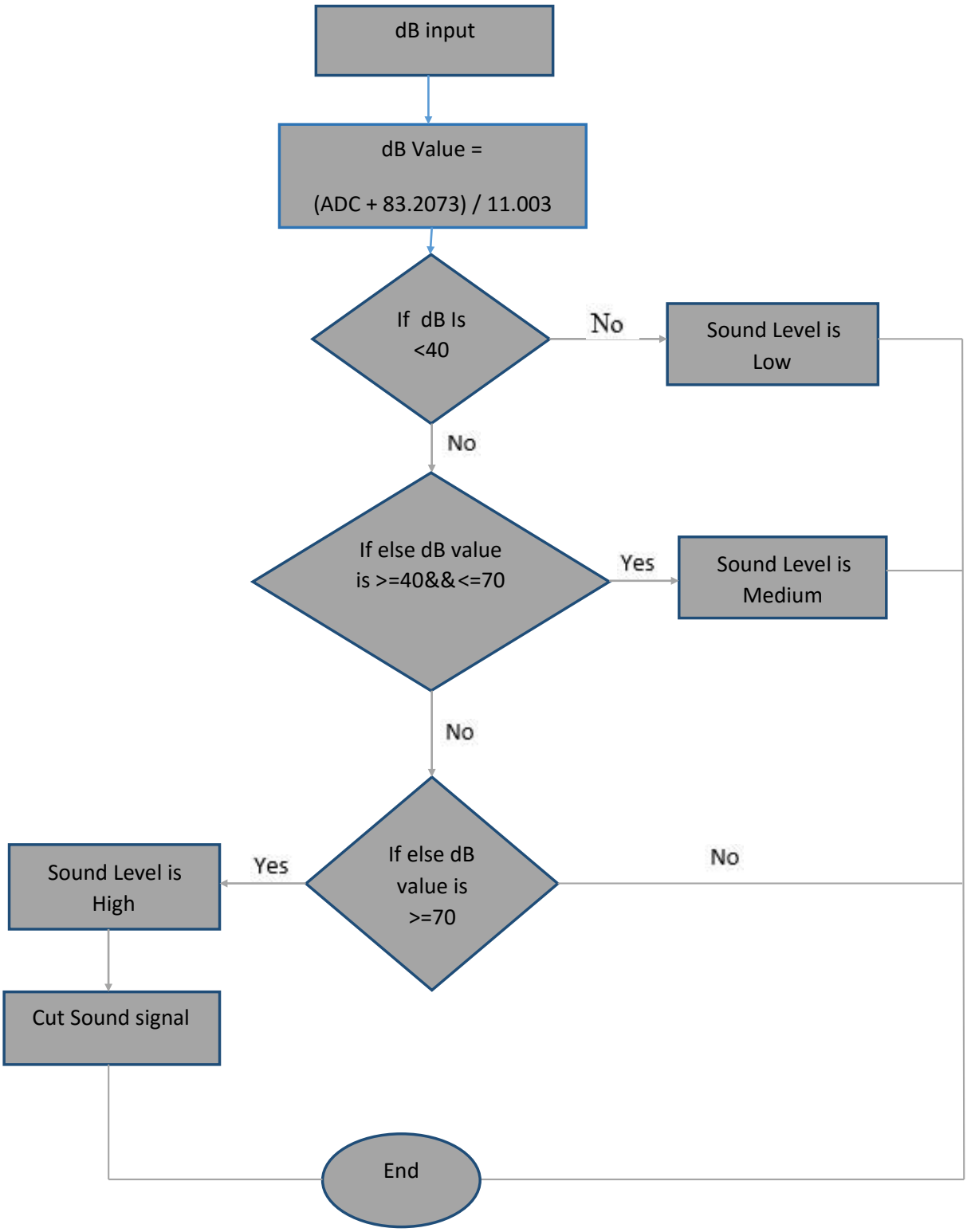

Figure 11: *system diagram* Description of figure one is that the sensor will detect, measure the level of the sound signal and divide it into three parts. If the sound signal is less than 90db then the sound is normal. If the sound signal is equal to 90db then s. If the sound signal is greater than 90db, then the noise is prohibited and will automatically be turned off to the speakers.

4.4 SYSTEM ARCHITECTURE

The system architecture is the conceptual model that defines the structure, behavior, and more views of a system[26].IoT-based sound governor provides an overview of the devices used in this project.

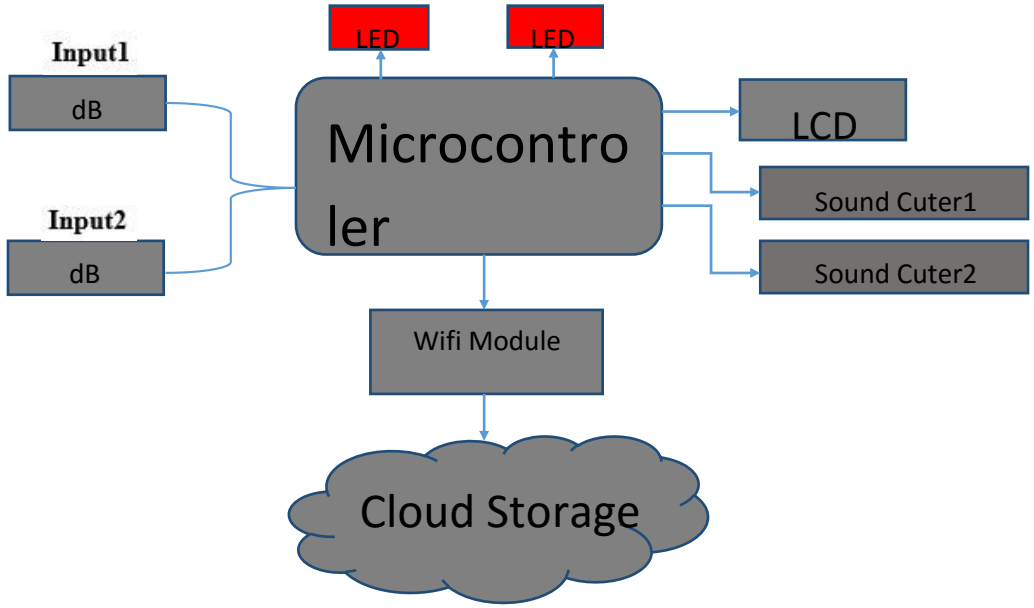

Figure 12: *system Architecture*

IoT-based Sound governor will help the substandard soundproof to monitor the level of sound in bars, churches and nightclubs according to the regulations of government. The actuator called sound cuter which is a sound compressor will be connected to the audio mixer which generates sound and make an automatic regulation of sound to be not greater than normal level and when it will get closer to 90 the sound compressor will automatically reregulate to a normal level. This sound compressor is used to compress the sound's dynamic range[27][28]. After sensing the level of the sound; the microcontroller will categorize the level of the sound according to the parameters which describe the normal sound and sound pollutionthen make some decisions according to the sound level result given by the sound sensor (output data). If the sound signal is getting closer to the level of noise; then the LED will be blinking room to give a warning to the user and if the sound level is getting higher than the normal level; then the sound cuter will cut the power from the sound mixer to the speakers. When a user reduces the volume of the sound mixer to a certain extent or less than the specified amount of time, the relay will open the dB from the mixer to the

speakers so that the sound continues to the speakers. This system will have cloud storage which is Thinkspeak which will act as cloud storage is for storing, processing and analyzing data.

4.5 Circuit diagram

A circuit diagram is a visual display of an electrical circuit using either basic images of parts or industry-standard symbols[29].This circuit diagram shows how all the devices come together and provide the same solution to reduce sound pollutionwhich is the goal of this project.

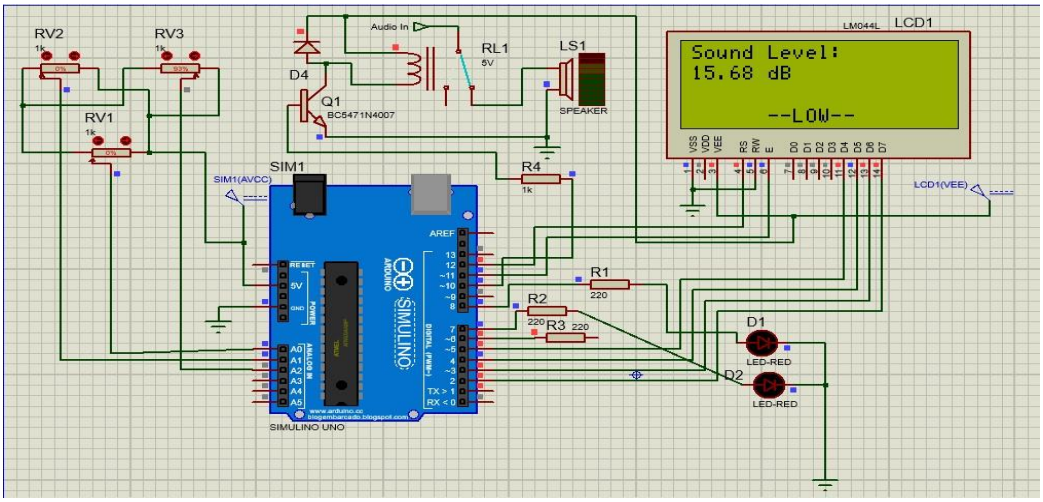

Figure 13: *Circuit diagram*

4.6 CONLUSION

in this chapter research outlines all the methods that will be used in system design. both models, system architecture, algorithms and research approaches were used. this will clearly show the picture of the research and how it will be implemented hagendewe kumiterere ya reseach ndetse na standards za RSB.

CHAPTER 5: RESULT AND ANALYSIS

5.1 Introduction

In this chapter, I tested the performance of IoT-based sound governor and looked at how audio graphs have evolved depending on the time that has taken place, how cloud storage stores information and how sound cuter stops audio when is normal even when it is Prohibited. This chapter also shows the codes used to enable this system by providing solutions based on what is shown in this project.

5.2 Evaluation of sound cuter1 and sound cuter2 in normal level of sound

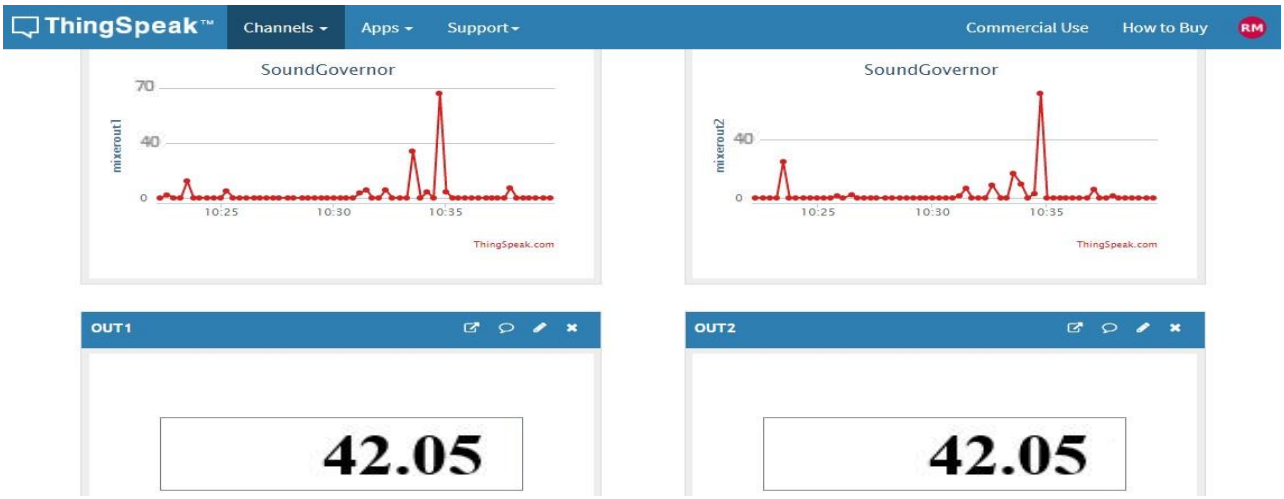

Figure 14: *Evaluation of Sound cuter1&2*

This figure of evaluation of sound cuter1 and sound cuter2 at the normal level of sound shows the audio chart taken by the mixer. It indicates the level of sound and time it was captured.

5.3 Evaluation of sound cuter1 and sound cuter2 when is prohibited

Figure 15: *Evaluation of sound cuter1 and sound cuter2 when is prohibited*

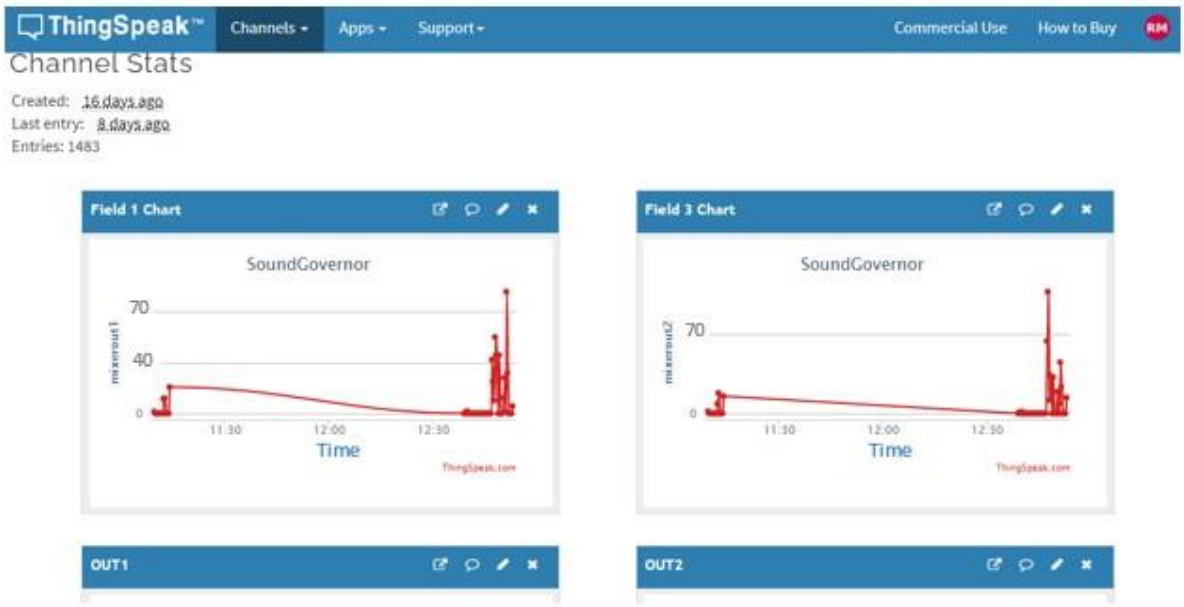

Figure 16: *Evaluation of sound cuter1 and sound cuter2 when is prohibited*

These two figures of evaluation of sound cuter1 and sound cuter2 when prohibited shows the audio chart taken by the mixer. It indicates the level of sound and time it was captured. the volume from the mixer was higher than the specified limit which is 70dB which makes the system noise.

5.4 Evaluation of sound cuter1 and sound cuter2 when is prohibited in database

created_at	entry_id	field1	field2	field3	field4
	1	0	dB_NORMAL	0	dB_NORMAL
	2	0	dB_NORMAL	0	dB_NORMAL
	3	0	dB_NORMAL	0	dB_NORMAL
	4	0	dB_NORMAL	0	dB_NORMAL
	5	0	dB_NORMAL	0	dB_NORMAL
	6	35.21	dB_NORMAL	20.44	dB_NORMAL
	7	70.59	dB_Prohibited	70.59	dB_Prohibited
	8	0	dB_NORMAL	0	dB_NORMAL
	9	79.06	dB_Prohibited	79.06	dB_Prohibited
	10	75.08	dB_Prohibited	75.08	dB_Prohibited
	11	73.45	dB_Prohibited	73.36	dB_Prohibited
	12	0	dB_NORMAL	0	dB_NORMAL
	13	0	dB_NORMAL	0	dB_NORMAL
	14	20.06	dB_NORMAL	20.06	dB_NORMAL
	15	0	dB_NORMAL	4.18	dB_NORMAL
	16	70.32	dB_Prohibited	70.32	dB_Prohibited
	17	0	dB_NORMAL	0	dB_NORMAL

Figure 17: *Evaluation of sound cuter1 and sound cuter2 when is normal and prohibited in database.*

This table is a database provided by the thingspeak cloud storage that shows all the actions performed by sound cuter 1 and 2. The level of sound that has been captured by the system.

CHAPTER VI: CONCLUSION AND RECOMMENDATION

6.1 Conclusion

The main purpose of this system was to measure the level of sound coming out of the sound mixer and to cut the sound automatically when it is making noise. All of this is done to improve the health of the people in general but especially to prevent ear damage and other body issues related to noise.The system is not expensive because all the used equipment was purchased here in Kigali. The proposed model shows how devices will be plugged in and work together to provide a sustainable solution. The proposed system will help users determine the amount of audio used daily when they would be using the system.

6.2 Recommendation

These days technology is accelerating and bringing innovations. This project will need to be expanded according to other challenges that will emerge. this project does not meet all the requirements for monitoring the sound process. due to the short duration and lack of some equipment. this project will be extended to sound monitoring, how to send an alert message to system administrators via GSM communication, properly combining the output voltage with the different sound mixers and Notification message when the system is turned off (not connected to power) by users or other things.

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