Final Year Design Project

Final Report

[EEE 400C]

Active Noise Cancellation

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CHAPTER 1: INTRODUCTION

1.1 Introduction

Noise is defined as a "Loud and unpleasant" sound that exceeds acceptable levels and causes annoyance. Noise is an information-carrying signal that conveys information about the noise's sources and the environment in which it propagates. Nonetheless, with the growing urban population and motorized transportation, noise levels are rising on a daily basis. As a result, noise is a major issue affecting the quality of life in urban areas around the world. Rapid urban growth and a lack of urban design and planning, in particular in developing countries, have been accompanied by urban poverty and environmental changes that have a direct impact on human health. According to the Centers for Disease Control and Prevention (CDC), sound levels greater than 120 dB will cause immediate damage to human ears. According to the World Health Organization (WHO), noise pollution affects approximately 5.0 % of the world's population. The safe sound level is 45 dB [1]. Noise is the "New second-hand smoke issue", According to Bradley Vite, who advocated for regulations in Elkhart, Ind., that carries some of the U.S. state's harshest fines. "It took decades for people to be educated about the dangers of secondhand smoke and it may take decades to demonstrate the impact of secondhand noise" [2].

1.1.1 Problem Statement

Exposure to high decibels of sound for an extended period of time in environments with ambient noise can be distracting during communication and cause physical and psychological harm to humans. Again, excessive noise can cause physical and mental illness and is linked to an increased risk of heart disease, stress, and insomnia. According to the European Environment Agency (EEA), noise causes approximately 12,000 premature deaths in Europe each year, while it also contributes to approximately 48,000 cases of ischaemic heart disease. Furthermore, a study found that noise interferes with birds' ability to communicate and can prevent them from mating [3]. In Bangladesh, people are frequently subjected to dangerously loud noises both at work and in their leisure time. Bangladesh is the noisiest country in the world, according to the World Air Quality Report 2021. Dhaka has now ascended to the top of the list of noisiest cities. According to the UN Environment Programme's newly issued report "Frontiers 2022: Noise, Blazes, and Mismatches," Dhaka stands at the top of the list [14]. Moreover, Due to growing unplanned urbanization, the use of various types of vehicles has expanded dramatically throughout the Dhaka district in recent decades. Similarly, metropolitan regions in other emerging countries around the world are also experiencing the same problem. Users of this large number of vehicles, particularly drivers and assistants, have a variety of demographic features that may encourage them to employ electric and hydraulic horns, particularly in Bangladesh. In Dhaka and other Bangladeshi cities, traffic noise pollution caused by electric horn "barking" has increased by a factor of two over the standard limit.

Dhaka is the largest of Bangladesh's eight metropolitan cities. Transportation, automobile horns, especially hydraulic horns, loud audio systems, and commercial operations, as well as certain other human activities, are the principal environmental causes of noise pollution in Dhaka city [5]. But unfortunately, we do not have any active solution to reduce these kinds of noises. We can apply some passive noise control measures for example transferring the noise source to somewhere else or keeping the noise source covered by a soundproof material. But we can not apply these kinds of solutions all the time and there are some drawbacks as well. So, control technology like occupational hazards should aim to reduce noise to acceptable levels in the workplace through action. This action entails putting in place any measures that will reduce noise generation or noise transmission through the air or through the workplace structure. Such measures include changes to machinery, workplace operations, and workroom layout. Indeed, the best approach for noise hazard control in the workplace is to eliminate or reduce the hazard at its source of generation, either directly or indirectly.

1.1.2 Background Study

There are mainly two types of solutions to prevent noise pollution. The first and most common one is passive noise cancellation. This traditional method of acoustic noise control employs passive techniques such as enclosures, barriers, and silencers to reduce unwanted ambient sound. But these passive noise cancellations do not perform well when low-frequency noise comes into place. In theory, another way to cancel noise is to invert the noise signal and add them to cancel each other. This is the fundamental concept of active noise cancellation which is the second solution. The "Apparent sound translator" of Atal and Schroeder, which applies head-related crosstalk cancellation to a stereo set-up with two loudspeakers, was the first application of active sound cancellation before 1970. The sound from the left loudspeaker should only reach the listener's left ear if it is fed by a signal recorded with the left channel of a stereo microphone. A compensation signal superimposed on the right loudspeaker cancels the component still arriving at the right ear, and vice versa. Filtering with transfer functions derived from the transfer functions from the loudspeakers to the ears yields the compensation signals from the loudspeaker input signals (head-related transfer functions, HRTF) [6].

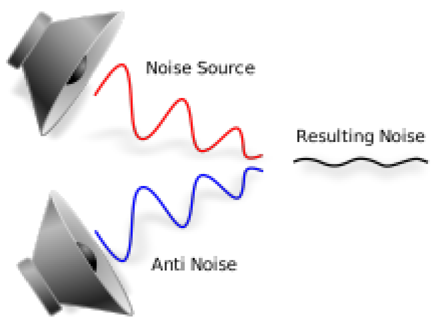

Figure 1: Active Noise Cancellation

Active noise cancellation (ANC) aims to minimize the volume of noise incident on the receiver or ear. The undesired sound is reduced by the destructive interference pattern that results in significant improvements in control theory and the advent of flexible, programmable, high-speed digital signal processing processors has made it possible to build and implement more complicated active noise reduction systems in the recent two decades. Active Noise Cancellation (ANC) approaches provide an intriguing addition to dealing with low-frequency noise. Acoustic anti-phase correction is the foundation of ANC. Furthermore, manufacturers such as Analog Devices and Qualcomm are developing integrated circuits (ICs) incorporating ANC capabilities, making ANC techniques more realistic. These solutions usually use time-invariant filtering that is tailored to the unique headphone. As a result, they scarcely respond to time-varying circumstances, such as being stuck in traffic. The direction-of-arrival (DOA) will be highly time-variant, especially when dealing with ear-mounted devices and head motions. Considering the head's research field [7]. In most situations, the experiment software employs MATLAB to simulate the hardware circuits, as well as other techniques such as signal filtering and the least mean squares algorithm. The hardware solution necessitates highly qualified equipment such as Texas Instruments TMS320C25, speakers, Dayton audio microphones, and Omnidirectional DPA Microphones 4006A, all of which are expensive and difficult to come by, as well as the circuit's inherent time delay [8]. This approach works well with periodic noise, but not so well with non-periodic noise. Active Noise Cancellation is rarely implemented in hardware since it is very expensive and difficult to implement. So, the purpose of this project is to create a low-cost prototype design for pure tone (electric horn) to reduce noise in real-world situations where the electric horn is a source of noise. We've created reverse noise to cancel out the source noise again, and we've recorded sound and played with the source noise at the same time to avoid the time delay. Since this is a prototype design, our goal in the future will be to develop this prototype in real life for a mixed tone like a Fan, Ac, Generator, Motor, etc. with error calculation.

1.1.3 Literature Review

Literature 1:

Active noise control is the process of an anti-noise using a secondary source(s) that disastrously obstructs the primary noise source. As a result, the ANC unit is introduced on top of the commotion boundary or in the cut. The low-recurrence noise that breaks through the barrier can be extensively diminished with the ANC framework. Continuing on toward the strategy, we can see that due to its sluggish following limit, the standard sifted reference least mean square (FxLMS) method has a greater sound decrease in the nonstationary clamor. ANC is a likely answer for the issue of commotion invasion that has happened because of the rebound of normal ventilation reception, notwithstanding sound decrease [9].

Literature 2:

In this paper, the basic algorithm for Active Noise Cancellation is developed and analyzed through a different controlling approach which is single-channel broad-band feedforward control. The algorithm is modified later on. It was modified for narrow-band feedforward and adaptive feedback control. Flexible channels change their coefficients to restrict a mix-up signal and can be recognized as (transversal) Finite Impulse Response (FIR), (recursive) Infinite Impulse Response (IIR), lattice, and change space channels. The most by and large used ANC structure with the adaptable get over the channel and the FXLMS estimation was first developed and separated considering single-channel cases for wide-band feedforward, limited band feedforward, and flexible information control. These single-channel ANC computations were then reached out to different channel cases for controlling the uproar field [10].

Literature 3:

An artificially created acoustic field of identical amplitude and frequency can actively cancel (or control) an undesired auditory field throughout a zone of interest. Adaptive ANC systems can only mitigate the effects of traditional adaptive ANC systems. This paper focuses on adaptive active noise cancellation as Adaptive noise cancellation technologies, for example, are unable to construct 3-D zones of silence. This issue is taken into account when developing adaptive ANC algorithms. 3-D adaptive ANC systems are the result of the development of revolutionary adaptive ANC systems. On the other hand, an additional controller is linked to the adaptive filter in the adaptive filter series. The deployment of an FxLMS-based solution [11].

Literature 4:

The performance of three lightweight earbuds with integrated DSP-based ANC systems was compared to three commercial ANC headphones and earphones in this paper. They proposed and tested the use of pleasant audio signals instead of irritating white noise for secondary path modeling. Moreover, in this paper, they compared commercially available ANC earphones and headphones to real-time experimental findings showing noise reduction achieved by the ANC earbuds. Furthermore, the created lightweight ANC earbuds simply have an error microphone and an ANC filter, which is identical to the setup seen in commercial headsets. As a result, the earbuds developed in this research should be affordable as consumer electronic equipment [12].

Literature 5:

According to this research, ANC systems can be divided into two types: feedback systems and feedforward systems. The former only uses residual signals at the location of interest, limiting their application to narrowband scenarios. Both the reference signal generated by the noise source and the residual signals are used in the latter, making it effective in attenuating wideband and narrowband disturbances. Moreover, This study offers an adaptive IIR filter based on an enhanced EE model that uses an offline secondary path modeling method to improve convergence speed and noise reduction. The model suggested in this study is suitable for processing noise signals in the low-frequency region, which is typical of industrial equipment with loud noise signals [13].

1.1.4 Literature Gap

In the study, literature gaps in the literature refer to missing components or insufficient information. These are areas where more research is needed because they are under-researched, undiscovered, or outdated. When we discuss the gaps in our instance, it is evident that a noise cancellation system for a home office or a home appliance has yet to be determined. In reality, there is not such an informative article or journal on it. As a high level of noise is a life-threatening concern, further study is required to improve the noise-canceling technology. Though some ANC research has been done on transformers in the power sector, those who have worked with it didn't report properly on their hardware part as they mostly focused on theoretical research [14]. As, a result, the key question remains unanswered as to how the system operates. It is critical to address the issues on a worldwide scale in order to increase the use of the ANC system. There are multiple types of research on headphones in this area, but none on household appliances or other industries [15]. Moreover, there have been no studies on how city noise has changed over time, whether it is getting worse or by how much. Experts, on the other hand, point to an increase in complaints, litigation, and persons with hearing impairments, as well as research proving that noise has significant health consequences. As a result, it's critical to solve noise issues in certain situations, as well as enhance the research methodology and project plans.

1.1.5 Relevance to Current and Future Industry

"Work for a Better Tomorrow Bangladesh" conducted a survey of 2,500 people, including members of the general public, students, and drivers. It has been discovered that 86% of the general public considers noise pollution to be a major issue. Noise pollution causes a variety of problems, with 78% mentioning annoyance, 71% headaches, 49% bad temper, and 43% having difficulties concentrating and sleeping. Worryingly, 97% of students said that car horns interfere with their studies. Furthermore, doctors reported that noise pollution not only causes hearing loss but can also dangerously aggravate the condition of heart patients [16]. Since Bangladesh has been identified as a polluter in recent studies, it is the best time to raise awareness and reduce noise pollution. Traffic horns like hydraulic horns and electric horns cause a large portion of pollution in our county, and every time passive noise cancellation can not be used to reduce it. Here is our project to use ANC to reduce the intensity of noise. The Bangladesh Environment Conservation Act, 1995, established a set of guidelines for noise regulation and control, as well as the establishment of "silent zones" around educational and medical institutions. On March 27, 2002, the Bangladesh High Court issued a ruling prohibiting the use of hydraulic and other excessively loud horns in vehicles [17]. This project is just a small prototype to reduce noise pollution (made of pure tone) using ANC, but with proper funding and research, it can be a real-time noise-canceling system where synchronous machine noise can be reduced by up to 10% or more. So, our noise reduction system can be used for electrical horns and similar types of single tone noise to reduce noise in medical, educational, and industrial settings. Not only that but it can also be used to enforce rules and regulations.

1.2 Objectives, Requirements, Specification and Constant

1.2.1. Objectives

The final aim of this project is to reduce unwanted ambient sounds that pass through the air and are created by vehicles like buses, trucks, cars, motor-cycle, etc. According to the research by Banglapedia, the noise level on any busy street in Dhaka is believed to be between 60 and 80 decibels, with autos emitting 95 decibels, scooters, and motorcycles emitting 87 to 92 decibels, and trucks and buses emitting 92 to 94 decibels. So, our main goal is to reduce these noise levels up to 10 dB minimum. Then, if we talk about the scope of utilizing this project after fulfilling all the objectives, this project can be applied in different places like in the hospitals for the patients, where sound is a great problem for the patients for a sound sleep. Then, this can be implemented in the schools for students so that they can focus on their studies even better. Moreover, we can use this in our living rooms so that we can stay in a place that is as comfortable and quiet as possible for a sound mind and sound sleep.

1.2.2 Functional and Nonfunctional Requirements

Functional Requirements:

1. The ANC system should not use a lot of energy.

2. Noise should be reduced by at least 5 to 10 decibels.

3. The error values should be calculated in a short amount of time.

Non-Functional Requirements:

1. The system's size should be kept to a minimum.

2. The system should not be overly noticeable.

3. It should be good-looking.

4. It must be transportable.

5. It should be simple to put into action.

1.2.3 Specifications

1. Receiver: Microphone*2

Figure 2: Microphone

Table 1: feature of microphone

Features	Range
Frequency	65Hz to 18 kHz
Sensitivity	-30dB +/- 3dB / 0dB=1V/Pa, 1 kHz
Output Impedance	1000 Ohm/ less
Dimension	18.00mmH x 8.30mmW x 8.30mmD

2. Raspberry Pi 3B microcontroller is used as the controller.

Figure 3: Raspbian OS

Figure 4: Raspberry Pi 3B

Table 2: feature of raspberry pi

Features	Range
Clock frequency	1.2 GHz
Chipset (SoC)	Broadcom BCM2837
Processor	64-bit quad-core ARM Cortex-A53
Number of USB 2.0 ports	4
Port extension	40-pin GPIO
Audio outputs	3.5 mm stereo jack or HDMI
Data storage	MicroSD card
Network connection	10/100 Ethernet, 802.11n Wifi and Bluetooth 4.1
Dimension	85.60 mm × 53.98 mm × 17 mm
Weight	45g

3. Amplifier: Speaker

Figure 5: Speaker

Table 3: feature of speaker

Features	Range
Caliber size	2 inches
Impedance	4 Ω
Undistorted power	5W
Effective frequency	118 Hz-20KHz
Sensitivity:	88dB

4. Power Supply:

Table 4: feature of power supply

Features	Range
Raspberry Pi 3 power/ adapter	5V 2.5A

5. Soundproof Box

Figure 6: Soundproof box

Table 5: feature of soundproof box

Feature	Size
Wooden-made square shaped	1 square meter (height, width)

1.2.4 Technical and Non-technical consideration and constraint in design process

Technical consideration:

- Accessible user interface and the availability of components.
- Options that can be swapped out.
- Interfacing of components is simple.
- It is economical.
- Simple to maintain.

Non-technical Consideration

- Advertisement.
- To ensure legal permission, needed to hire a lawyer

Constraints in the design process:

1) Economic Constraints:

a) We had a total budget of 10k BDT. We had to manage the total price of all the components and transportation within the range.

b) The final project will be kept under 10k BDT if it were ever to be offered to sell. Which will also be economically feasible.
c) Due to budget constraints, high-end precise devices could not be bought.

2) Environmental Constraints:
a) Our prototype should be able to withstand voltage and current input without overheating.
b) Our prototype should not catch fire as this would be extremely dangerous.
c) This device must be able to withstand a high temperature.

3) Manufacturing Constraints:
a) This prototype will have to be mobile, functional, and easy to assemble.

4) Ethical Considerations and Constraints:
a) All parts of our prototype when manufacturing must be produced in a workforce that follows the Fair Labor Standards Act (FLSA.
b) The product has to follow all types of legal requirements in manufacturing, usage, and marketing.

1.2.5 Applicable compliance, standards, and codes

Codes and requirements for the right processes and materials to be used in a given product, building, or process are known as a code. Local governments will have to adopt the codes, and they may have legal effects. The basic goal of codes is to ensure public safety by defining the lowest allowable level of risk for buildings, products, and procedures. It's mostly a formal document that ensures consistent engineering. Standards allow parts to be interchanged and systems to communicate with one another, ensuring a safe environment.

Engineering Standards:

i. First of all, we are using the dB scale for measuring sound level.

ii. The components which we chose are all up to necessary electrical standards

iii. All measurements on the device will follow ANSI standards and be in metric units.

Codes:

We will try to adhere to the following International Organization of Standardization (ISO) codes:

i. ISO 12001:1996, Acoustics — Noise produced by apparatus and hardware — Rules for drafting and introducing a commotion test code

ii. ISO 5725 (all parts), estimation technique, and result exactness (truth and accuracy)

iii. ISO 1683, Acoustics — Preferred reference values for acoustical and vibratory levels [18].

Table 6: noise levels influencing the human well being brought about by different sources

Level OF Noise	Outcome	References
30 dBA (L_{Amax})	Sleep disturbance	WHO
45 dB	Aggravation of focus and obstruction in learning	EPA WHO
The average daily_55 dB	effects on health that are not audible	WHO
60 dBA (L_{Amax})	Speech interference for the deafeningly deafening	Molder for U.S. Architectural and Transportation Barriers Compliance Board
70 dB daily average ($L_{Aeq(24)}$)	problems like hearing loss	EPA
70 dBA (L_{Amax})	Speech comprehension is hampered for persons with normal hearing.	EPA
85 dBA ($L_{Aeq(8)}$)	Noise exposure in the workplace	NIOSH
85 dBA ($L_{Aeq(1)}$)	To avoid hearing loss, the following is the recommended exposure level.	WHO

- WHO: World Health Organization.
- EPA: Environmental Protection Agency.
- NIOSH: National Institute for Occupational Safety and Health.
- $L_{Aeq(8)}$: A-weighted, equivalent continuous sound pressure level for 8 hours. L_{dn}: Day night weighted sound pressure level.
- L_{den}: Day-night-evening weighted sound pressure level.
- L_{Amax}: Maximum time-weighted and A-weighted sound pressure level. $L_{Aeq(24)}$: A-weighted, equivalent continuous sound pressure level for 24 hours.
- $L_{Aeq(1)}$: A-weighted equivalent continuous sound pressure level for 1 hour [19].

1.3 Systematic Overview/summary of the proposed project

The framework will begin in a wooden made soundproof box which will incorporate receivers to receive noise from the source. Moreover, To generate the system we have used Raspberry Pi 3B for fast processing and Python programming language to generate the code. And in the second part of the system is associated with speakers. The speakers will be placed in such a way that whenever the source noise comes from the other side it will produce the anti-noise. As we are doing this system of noise cancellation for real-time simulation that's why the actual noise will be deducted after a certain period of time. And approximately the time will be 15-20 seconds because it will take some time to generate the opposite phase of the actual noise as it needs some to process the input sound. At last in the season of execution, we trust that the framework will diminish commotion by at least up to 5 decibels.

1.4 Conclusion

The ANC system cancels the undesirable noise by creating anti-noise of a contrary stage and equivalent amplitude through the sources. To develop our task we have zeroed in on the down-to-earth parts of the ANC system concerning executions. The principal issues and various kinds of answers for online auxiliary ways of demonstrating have been talked about to foster the framework as well as if there should be an occurrence of execution. We planned the prototype so that it lessens noise to a base level. Ethically, active noise-canceling can be beneficial, since both inordinate noise and consistent low-level clamor can prompt medical issues like harm to hearing, obstruct rest, raise the circulatory strain, etc. Since our system is for indoor use, it can lessen these issues.

CHAPTER 2: PROJECT DESIGN APPROACH

2.1 Introduction

Active noise control includes an electroacoustic or electromechanical framework that drops the essential (undesirable) noise based on the rule of superposition. In particular, an anti-noise of equivalent sufficiency and the inverse stage is created and joined with the essential noise, subsequently bringing about the dropping of commotions. Since the qualities of the acoustic noise source and climate are time-differing, our proposed ANC framework should be versatile continuously and ought to adapt to the difference in sound. After some literature reviews, we sorted out different ways to do this adaptive real-time filtering of noise, and finally, we fulfilled two approaches. Since the main part of our project lies in the algorithm through which the signal will be processed in the controller, we only tested different algorithms this semester. Other subsystems remain the same for whichever algorithm we choose. Therefore, we are considering different algorithms as different design approaches.

2.2 Identify Multiple Design Approach

Design 01: Using MATLAB and Least Mean Square (LMS) algorithm

Design 02: Using MATLAB and Filtered Least Mean Square (FxLMS) algorithm

Design 03: Using Microphone along with source noise.

Design 04: Using speaker along with recorded source noise

2.3 Describe Multiple Design Approach

Design 01: Using MATLAB and Least Mean Square (LMS) algorithm [20] .

The Least Mean Squares(LMS) Algorithm was employed in this first technique to make precise measurements of the gradient vector at each iteration. Based on the mistake, the LMS adjusts each coefficient on a sample-by-sample basis.

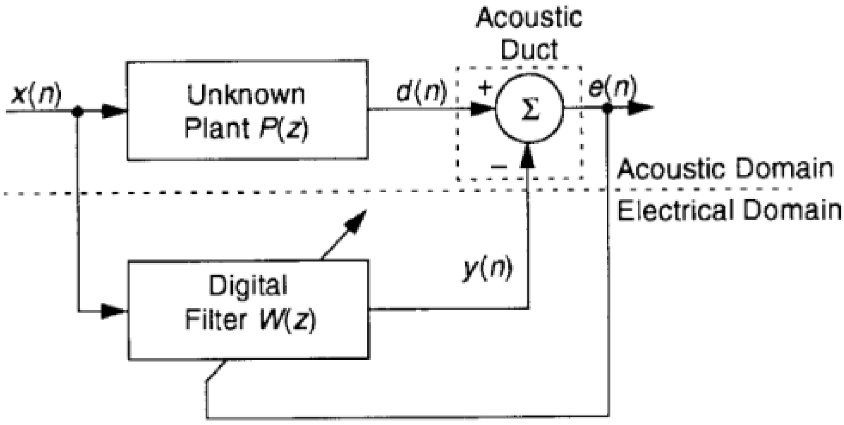

Figure 7: LMS block for ANC

Unidentified plant The noise source's and humans' transfer function is P(z). W(z) equals P(z) when e(n) approaches 0.

- $e(n) = d(n) - w^T(n)x(n)$
- $w(n+1)= w(n)- \mu x(n)e(n)$

The Least Mean Square (LMS) algorithm, which is simple and powerful, uses stochastic gradient descent to minimize e(n). Then we attempted simulating this model in MATLAB using Simulink.

Functional Verification:

Echo cancellation and acoustic noise reduction are two DSP applications that can benefit from the Least Mean Squares (LMS) Algorithm.

The LMS Equation is as follows:

Based on the error e, the Least Mean Squares Algorithm (LMS) adjusts each coefficient on a sample-by-sample basis (n)

- $Wk\ (n + 1) = Wk(n) + \mu.\ e(n)x\ \ k(n)$

This equation reduces the mistake of e's power (n).

LMS Filter Inputs and Outputs:

The LMS Filter's output starts at 0 and gradually increases. LMS Error causes part of the sine wave information to be lost at first.

Model Adjustment: The "Step size ()" is an important variable in the LMS Filter. This determines the LMS filter's rate of convergence. Filter Outputs for () = 0.1 Step Size When the "Step size ()" is increased, the "Step size ()" increases as well.

Switching the Delay: The delay is a component of the Acoustic Noise Algorithm. In order for the two inputs to the LMS Filter to have different random noise, the delay should be at least half a wavelength. We tried with various delay values to see how they affected the LMS's operation. Here the Simulink block diagram is given below:

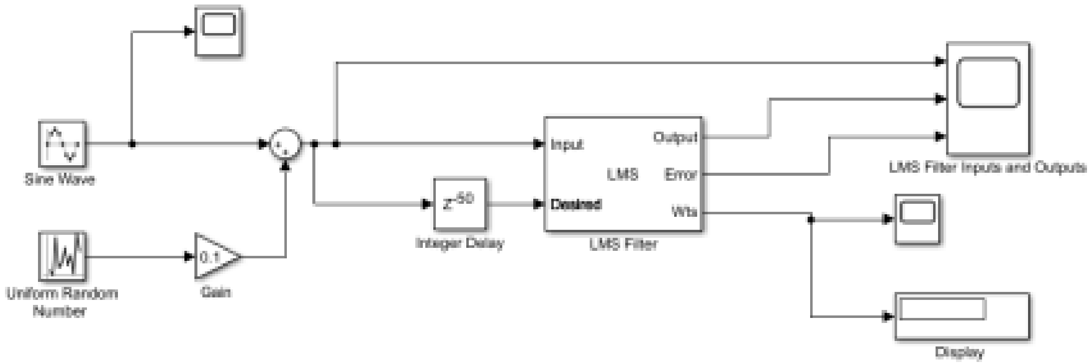

Figure 8: LMS algorithm Modeled in MATLAB Simulink

Design 02: Using MATLAB and Filtered Least Mean Square (FxLMS) algorithm [21]

One thing missing from the LMS model in practical ANC application is the path from the speakers to the ear for the correction signal. That is called the secondary path or *S(z)*. The FxLMS algorithm takes care of the secondary path.

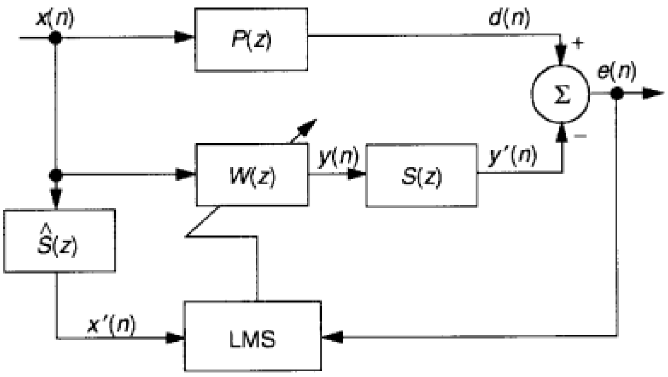

Figure 9:FxLMS block diagram

The general broadband ANC system can be described as this versatile channel where W(z) is utilized to assess the obscure plant *P(z),* to compute the control signal *y(n)* that will reduce the noise at the control microphone (error, *e(z)*). The noise here is measured by a reference microphone (signal *x(z)*). Thus, the unknown plant or primary path can be seen as an acoustic transfer function between the reference and the control microphone like *Design 1* where the noise has to be reduced. In other terms, this path will transform the reference signal *x(z)* to another signal *d(n)*, which would be the noise measured at the control microphone due to the primary source *x(z)*. The weights of the adaptive filter *W(z)* are computed by an LMS algorithm, depending on the error signal e(z). A linear convolution between *x(z)* and *W(z)* will compute the control signal *y(n)*, such as $d(n) - y(n) = e(n) = 0$, if the filter *W(z)* converges. As the environment between the control and reference microphone changes through time, the acoustic properties of the medium are generally not steady and justify the need for an adaptive filter to track time variations of the primary path.

The calculation puts the auxiliary way gauge in the reference sign to the weight update of the calculation. The optional sign is produced as,

$$e(n)= d(n)- w^T(n)x(n)$$

Where $w(n)=[w_0(n)\ w_1(n)\ \ldots\ w_{L-1}(n)]^T$ and $x(n) = [x(n)x(n-1)\ldots x(n-L+1)]^T$ are the coefficient and signal vectors respectively. L is the filter order being used.

Functional Verification:

We simulated this approach through MATLAB coding. The following simulation was originally developed and can be found on the MathWorks website. But we varied the values and conditions greatly to meet our requirements.

The optional propagation way: To plan the reproduction, the auxiliary engendering way should initially be mimicked. The optional spread way is the way the counter clamor takes from the resulting amplifier to the mistake receiver inside the calm zone. The accompanying orders create a noisy speaker-to-mistake amplifier drive reaction that is bandlimited to 200-2100 Hz and with a channel length of 0.1 seconds. A testing recurrence of 6k Hz is picked to test at a rate fitting for human discourse. Correspondence over phones and mouthpieces all happens with an examining pace of 6k Hz.

The code is given below:

```
Fs      = 6e3;  % 6 kHz
N       = 600;  % 600 samples@6 kHz = 0.1 seconds
Flower   = 200;  % Lower band-edge
Fhigher  = 2100; % Upper band-edge
delayS = 7;
Ast     = 20;   % 20 dB stopband attenuation
Nfilt  = 8;
 % Design bandpass filter to generate impulse response
filtSpecs = fdesign.bandpass('N,Fst1,Fst2,Ast',Nfilt,Flower,Fhigher,Ast,Fs);
bandpass = design(filtSpecs,'cheby2','FilterStructure','df2tsos', ...
           'SystemObject',true);
 % Filter noise to generate impulse response
secondaryPathCoeffsActual = bandpass([zeros(delayS,1); ...
                      log(0.99*rand(N-delayS,1)+0.01).* ...
                     sign(randn(N-delayS,1)).*exp(-0.01*(1:N-delayS)')]);
secondaryPathCoeffsActual = ...
   secondaryPathCoeffsActual/norm(secondaryPathCoeffsActual);
 t = (1:N)/Fs;
plot(t,secondaryPathCoeffsActual,'b');
xlabel('Time [sec]');
```

```
ylabel('Coefficient value');
title('True Secondary Path Impulse Response');
```

Output Result:

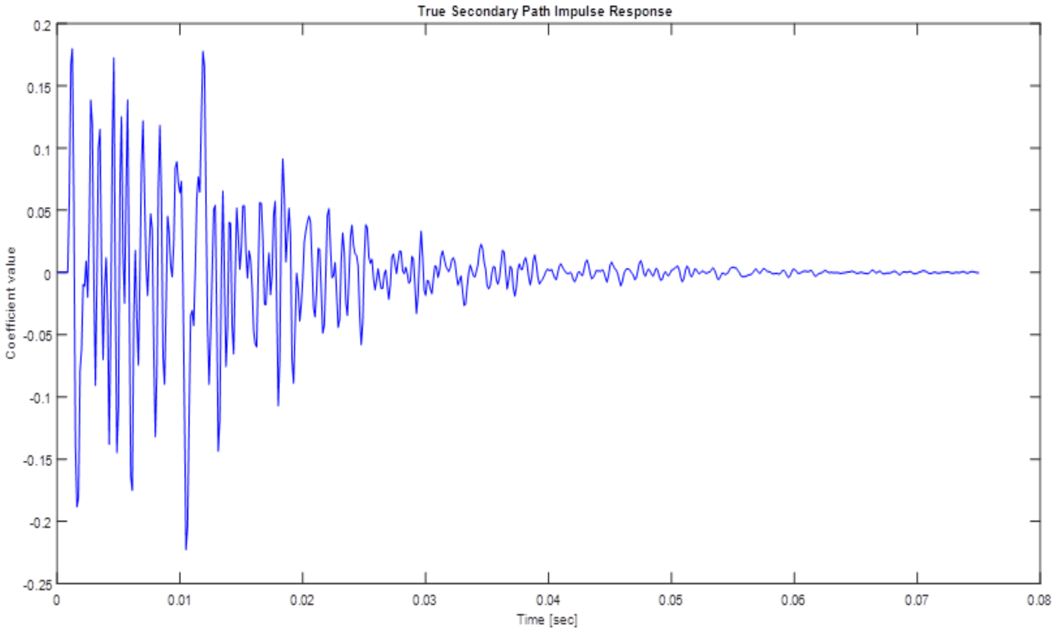

Figure 10: Genuine Secondary Path Impulse Response

Assessing the Secondary Propagation Path: When planning a framework for dynamic commotion crossing out, the principal task is assessing the motivation reaction of the spread way. This progression is performed before the dynamic noise retraction happens and is achieved by playing an arbitrary sign through the resulting speaker while the undesirable commotion is absent. The accompanying MATLAB code produces an irregular sign that is played for 3.75 seconds and measures the sign present at the blunder mouthpiece.

Planning the Secondary Propagation Path Estimate: In this progression of reenacting dynamic commotion scratch-off, an auxiliary spread way gauge is created. The length of the secondary way channel gauge is decided to be more limited than the real optional way. Satisfactory noise dropping is as yet accomplished by doing this. A secondary way channel length of 250 taps was decided to relate to a drive reaction length of 31 ms. We utilized the NLMS calculation because of its straightforwardness.

Code for this:

```
M = 250;
muS = 0.1;
```

```
secondaryPathEstimator = dsp.LMSFilter('Method','Normalized LMS','StepSize', muS, ...
          'Length', M);
[yS,eS,SecondaryPathCoeffsEst] =
secondaryPathEstimator(randomSignal,secondaryPathMeasured);
n = 1:ntrS;
figure, plot(n,secondaryPathMeasured,n,yS,n,eS);
xlabel('Number of iterations');
ylabel('Signal value');
title('Secondary Identification Using the NLMS Adaptive Filter');
legend('Desired Signal','Output Signal','Error Signal');
```

Output Result:

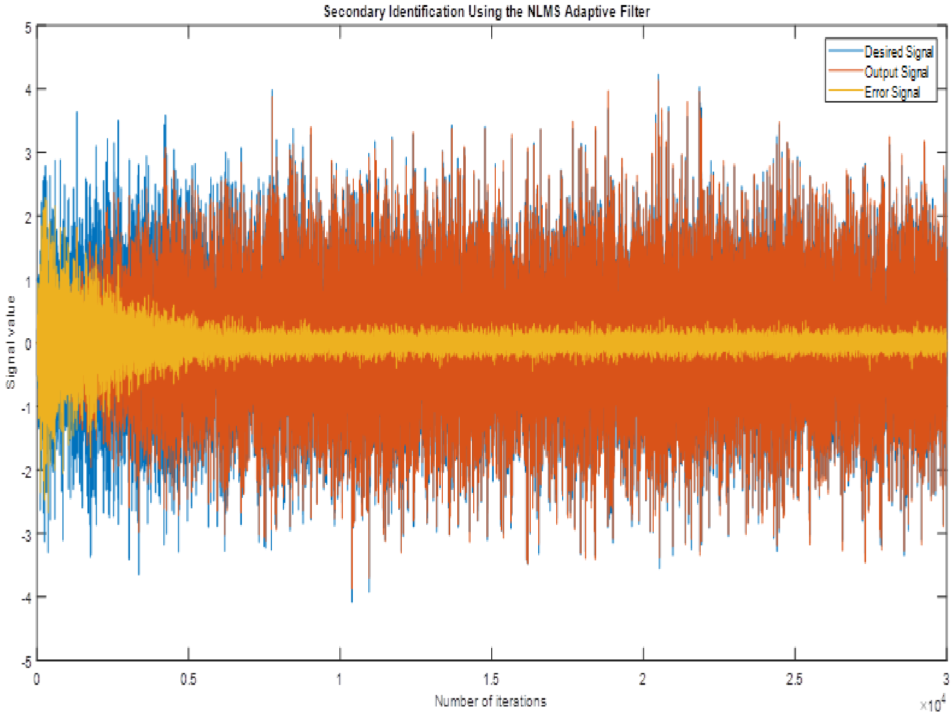

Figure 11: Secondary Identification Using the NLMS Adaptive Filter for 10000 Iterations

The Principle, Transmission Path: The engendering way of the noise to be dropped can likewise be described by a direct channel. The accompanying orders create a contribution-to-blunder amplifier drive reaction that is bandlimited to reach 200-800 Hz and has a channel length of 0.1 seconds. we came by the outcomes after reproduction. After That starts

Introduction of Active Noise Control: Through the accompanying codes, we at long last executed the FxLMS calculation. The reference signal is a loud rendition of the undesired sound estimated close to its source. We utilized a regulator length of around 44 ms and a stage size of 0.0001.

Design systems 3 and 4

As our previous simulations were based on software so we did not face many difficulties doing the simulations. But as we progressed to implement our system in a real-time hardware system some difficulties arose to set it up. First of all, we did some research and found that noise is a mixture of different types of notes and it changes its direction frequently and that's why its frequency, intensity, noise amplitude, intensity, impedance, interference with the doppler effect, and diffraction changes along with it. So it’s hard to implement any mixed notes in real-time as time delay is related to that system. So, we did some further research on it and found that vehicles with electronic horns emit warning signals generated by an electrical circuit. To produce the fundamental frequency and force the diaphragm to vibrate, a solenoid is magnetized and demagnetized. This creates a lot of pressure inside the trumpet horn, which produces a sound. Moreover, electric horns have a specific pattern of frequency range which starts from 440 Hz to 783.99 Hz. Again, this range can be divided into 7 notes which are: A, B, C, D, E, F, and G, and its sound pressure level is 108 dB to 118dB which causes noise pollution severely. So that's why we choose to work with the electric horn. So,for this purpose, our design system 3 is done with source noise directly taken as input (tuning notes), and system 4 is done with recording files of tuning notes.

Here a table is given for tuning notes names and frequencies [22]:

Table 7: tuning notes and frequency

Tuning Notes	Frequency notes (Hz)
A	440
B	493
C	523.25
D	587.33
E	659.26
F	698.46
G	783.99

Design 03: Using Microphone along with source noise.

As our prototype system is a closed system so it will begin functioning in a wooden made soundproof box which will incorporate receivers to receive noise from the source. Moreover, To generate the system we have used Raspberry Pi 3B for fast processing and Python programming language to generate the code, and the second part of the system is associated with speakers. Inside the system, the speakers will be set equal so real noise and inverted noise can counterbalance one another. Additionally, to create the framework we have utilized Raspberry Pi 3B for quick handling and Python programming language to produce the code.

Functional Verification:

First of all, we started our experiment by taking input of electric horns (tuning notes) noise as source noise and playing it for approximately 180 sec. After that, by using Python we recorded the audio sound for 20 sec and we created an audio file from the recorded audio. Then we generated a code through Python to invert the audio and played the inverted audio with one speaker in the loop 10 times with the source audio in another speaker at the same time which is placed parallelly. After that, we got the desired output by reducing the noise level. Here the reduced noise level will be measured by using decibel meters. The flow diagram of the above-mentioned process is given below:

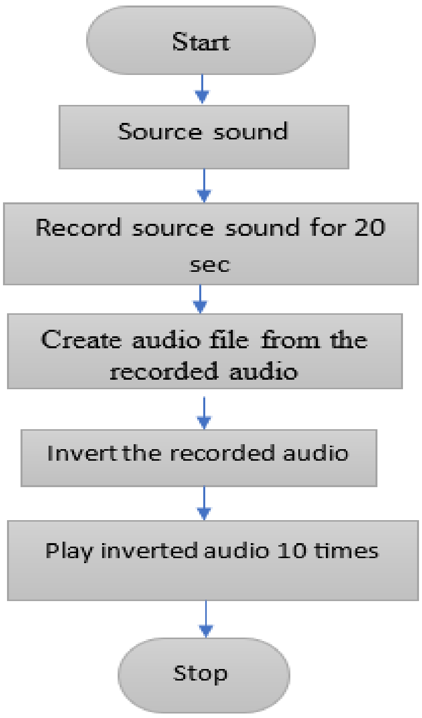

Figure 12: Flow diagram of design system

Here is the visual representation of design system 3

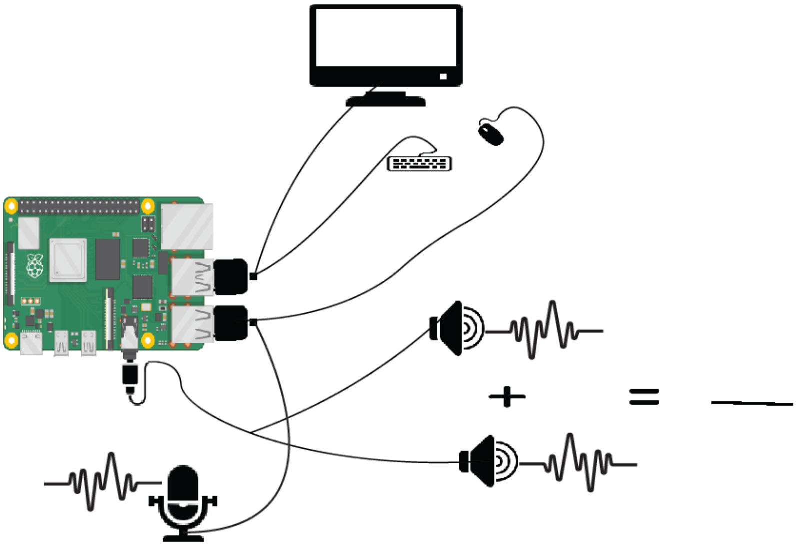

Figure 13: Design of system 03

Python code:

```
import pyaudio

import wave

import time

from pydub import AudioSegment

from pydub.playback import play

#import numpy as np




# wav_file = AudioSegment.from_file(file="gnote.wav", format="wav")

# sound1 = AudioSegment.from_wav("gnote.wav")

# sound2 = sound1.invert_phase()#inverting the audio here

# panned1 = sound1.pan(-1)#left

# panned2 = sound2.pan(1)# right

# panned = panned1.overlay(panned2)
```

```
# print("playing source")
# play(panned1)
# print("playing source+ inverted")
# play(panned)



#from playsound import playsound

CHUNK = 1024
FORMAT = pyaudio.paInt16
CHANNELS = 2
RATE = 44100
RECORD_SECONDS = 15
WAVE_OUTPUT_FILENAME = "output_final.wav"

p = pyaudio.PyAudio()

stream = p.open(format=FORMAT,
                channels=CHANNELS,
                rate=RATE,
                input=True,
                frames_per_buffer=CHUNK)

print("* recording")

frames = []
```

```
for i in range(0, int(RATE / CHUNK * RECORD_SECONDS)):
    data = stream.read(CHUNK)

    frames.append(data)

print("* done recording")

stream.stop_stream()
stream.close()
p.terminate()

wf = wave.open(WAVE_OUTPUT_FILENAME, 'wb')
wf.setnchannels(CHANNELS)
wf.setsampwidth(p.get_sample_size(FORMAT))
wf.setframerate(RATE)
wf.writeframes(b''.join(frames))
wf.close()

# playsound("output_final.wav")
# plt.plot(outdata[0], outdata[1])
# show a legend on the plot
# plt.legend()
# function to show the plot
# plt.show()
# print(frames)
wav_file = AudioSegment.from_file(file="output_final.wav",
```

```
                        format="wav")
sound1 = AudioSegment.from_wav("output_final.wav")
sound2 = sound1.invert_phase()#inverting the audio here

for number in range(10):# creating loop to play the inverted audio for 10 times
    print(number)
    play(sound2)
    time.sleep(1)
```

Design 04: Using speaker along with recorded source noise

As our prototype system is a closed system so, in this process, the system will begin in a wooden-made soundproof box that will incorporate two speakers. Inside the system, the speakers will be placed in parallel so that actual noise and inverted noise can cancel out each other. Also, to generate the system we have used Raspberry Pi 3B for fast processing and Python programming language to generate the code.

Functional Verification:

In our system, we'll be working with pure frequencies of electric horns. Individual notes can be made out of these frequencies. A, B, C, D, E, F, and G, for example. As a result of this approach, any of the notes will be quieter. First of all the process will be started by accessing the audio wave file of one of the seven notes using the Python library. Then we have to invert the audio phase. The next step will be splitting the audio channels between the speakers and playing the non-inverted audio file in the left channel and inverted audio in the right channel. After inverting we got the desired output by denoising the noise level. Here the reduced noise level will be measured by using decibel meters. The flow diagram of the above-mentioned process is given below:

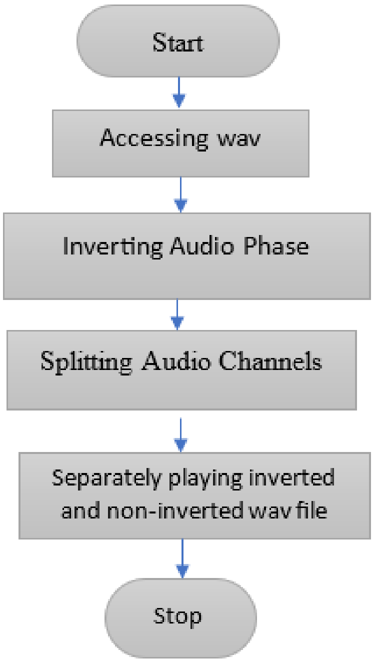

Figure 14: flow diagram of system 04

Here is the visual representation of design system 04:

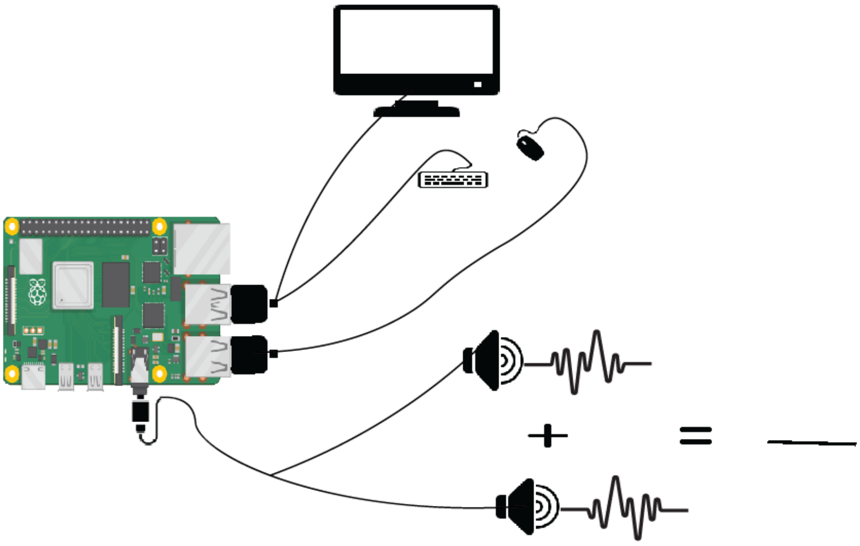

Figure 15: design system 04

Python code:

```
from pydub import AudioSegment

from pydub.playback import play


wav_file = AudioSegment.from_file(file="C.wav", format="wav")

sound1 = AudioSegment.from_wav("C.wav")

sound2 = sound1.invert_phase()#inverting the audio here

panned1 = sound1.pan(-1)#left

panned2 = sound2.pan(1)# right

panned = panned1.overlay(panned2)

print("playing source")

play(panned1)

print("playing source+ inverted")

play(panned)
```

2.4 Analysis of Multiple Design Approach

Design 01 Result:

The result from the LMS channel begins at nothing and develops gradually. At first, a portion of the sine wave data is lost as an LMS blunder. The LMS channel loads all beginning at nothing and takes a few cycles to arrive at their last qualities.

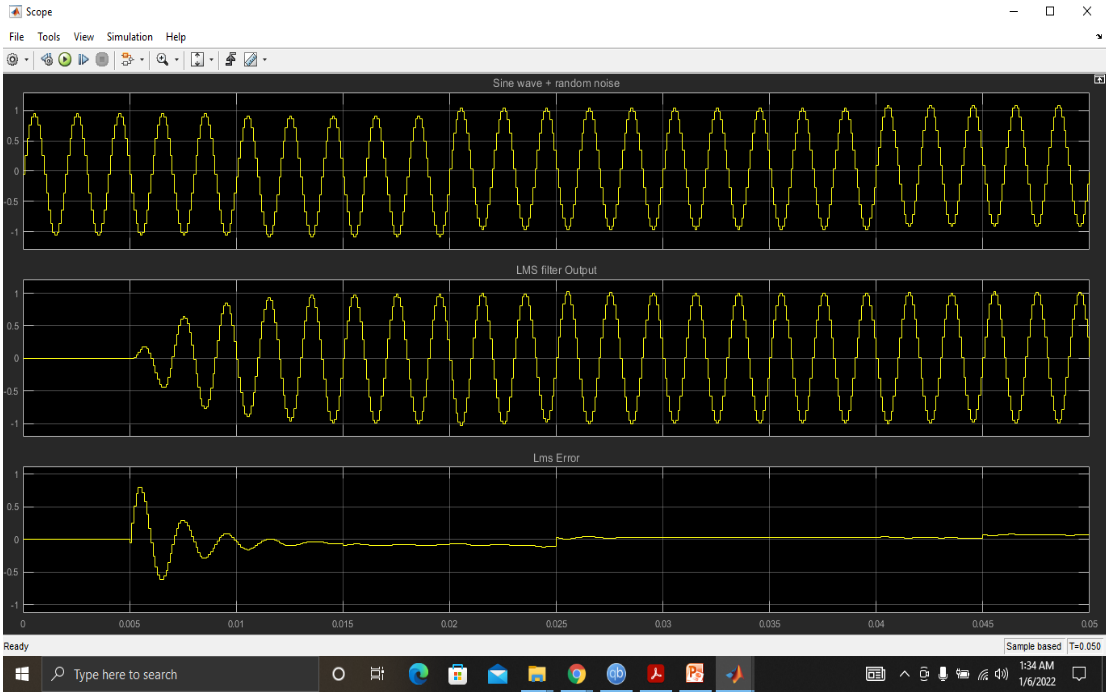

Figure 16: LMS Algorithm Simulation

Part of the Acoustic Noise Algorithm is the postponement. The deferral ought to preferably be to some degree around 50% of a frequency so the two contributions to the LMS channel have different irregular commotions. We fluctuated the deferrals with various qualities multiple times and noted them down.

Design 02 Results:

Accuracy of the Secondary Path Estimate: We generated a secondary path function before and then through MATLAB coding we visualized the difference between the true and estimated paths.

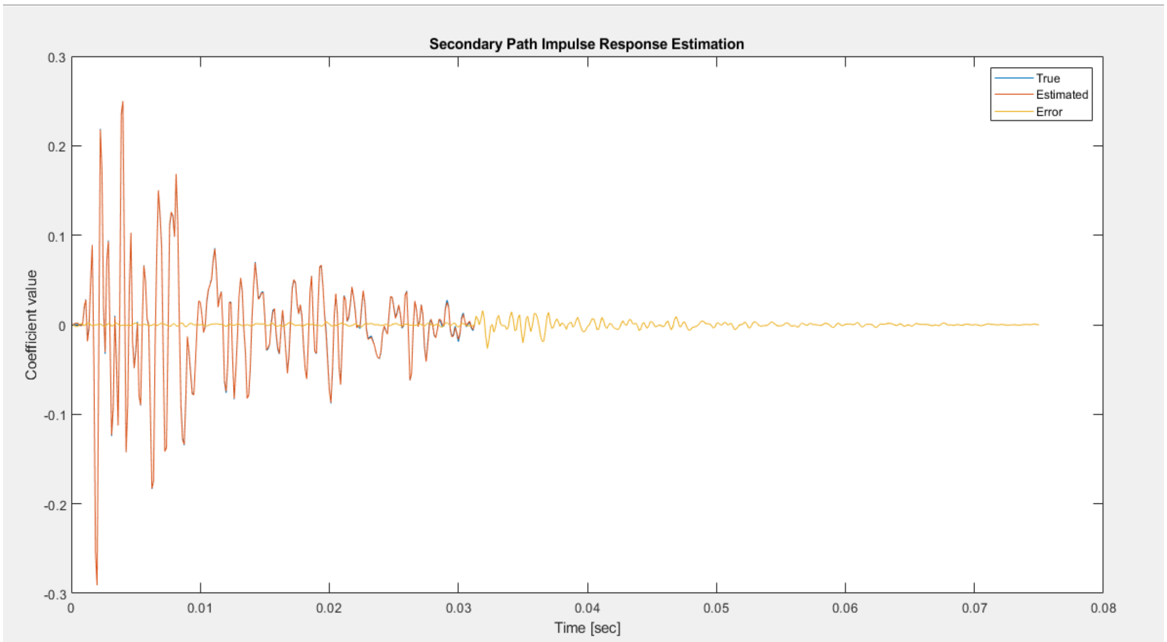

Figure 17: Accuracy of the Secondary Path Estimate

This lingering error doesn't essentially disturb the exhibition of the dynamic noise control framework during its activity in our assignments.

Reenactment of Active Noise control utilizing the FxLMS Algorithm:

To make the reenactment, MATLAB's range analyzer is utilized. The range analyzer shows the first uproarious sign and the lessened noise. The noise is played at first through the speakers of the PC and afterward, dynamic noise scratch-off happens and offsets the noise as shown by the last picture of the range analyzer. It was utilized to follow codes:

```
for m = 1:400
    % Generate synthetic noise by adding sine waves with random phase
    x = sine();
    d = primaryPathGenerator(x) + ...
    0.1*randn(size(x)); % measurement noise
    if m <= 200
    % No noise for first 200 iterations
    e = d;
    else
    % active noise control after 200 iterations
    xhat = x + 0.1*randn(size(x));
    [y,e] = noiseController(xhat,d);
    end
    player(e);
    scope([d,e]);
```

```
end
release(player);
release(scope);
```

Output result:

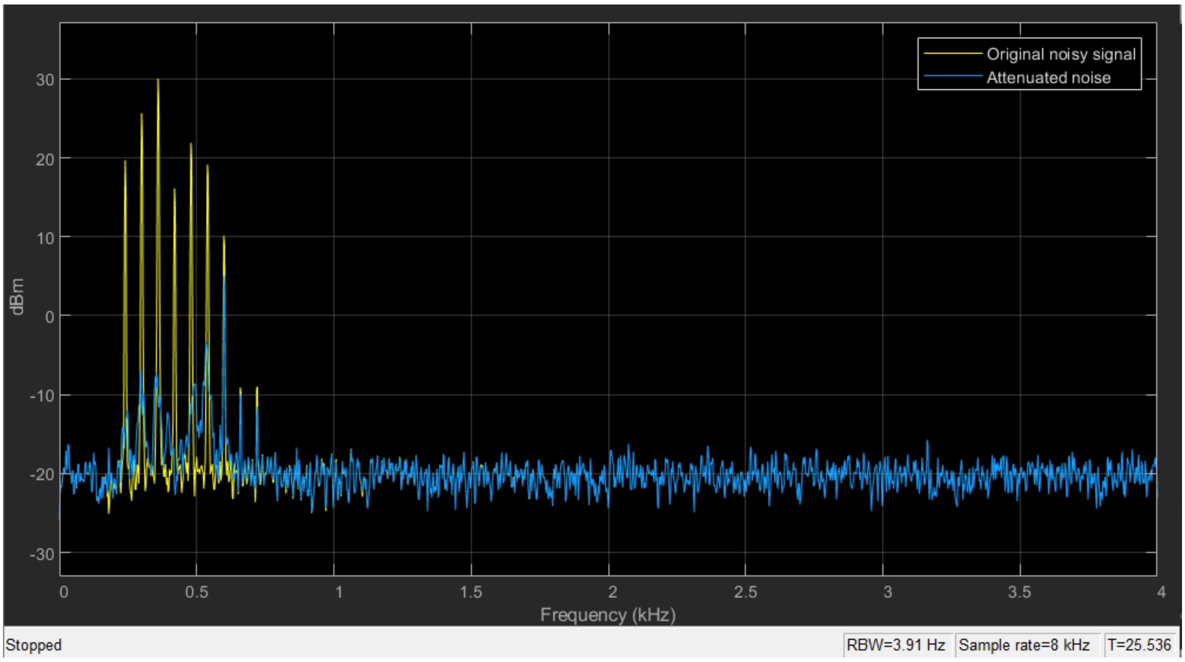

Figure 18: FxLMS Simulation

This is a range analyzer that is created by the last segment of the MATLAB code. When the versatile channel is empowered, it shows the Filtered-x LMS calculation dropping noise after roughly 200 cycles. The first boisterous sign is the repetitive sound used to drop the constricted noise as shown by the high cross-over of the first uproarious sign over the lessened noise.

Design 03 results:

After doing the hardware simulation we found that the audio file takes time to change the loop that's why delay occurs in that system. Furthermore, as in this process, we are recording the source noise and then inverting it so it takes time to process the whole system which creates delay and doesn’t invert the noise properly. As a result, it creates an echo as two noises add together which makes the system unable to reduce noise. Moreover, as we are using a cheap quality microphone it doesn't give a proper output when the recorded audio is inverted. In that case, if you use a higher quality microphone like a condenser microphone it will give better results. If we want to continue the system by this process we will need a higher processing processor like TMS320C25 which can really be helpful.

Design 04 results:

In this system, we are working with seven notes which are A, B, C, D, E, F, and G. Here we are attaching results for tuning note C as it gives more accurate results.

After doing the hardware simulation we found that the audio file doesn't take time to change the loop as the recorded audio file is directly played in that system. That's why delay doesn’t occur in that case. Furthermore, it doesn’t take time to process the whole system which helps to invert the noise properly. As a result, it can reduce the noise level up to 13 dB. Here graphs are given for better performance:

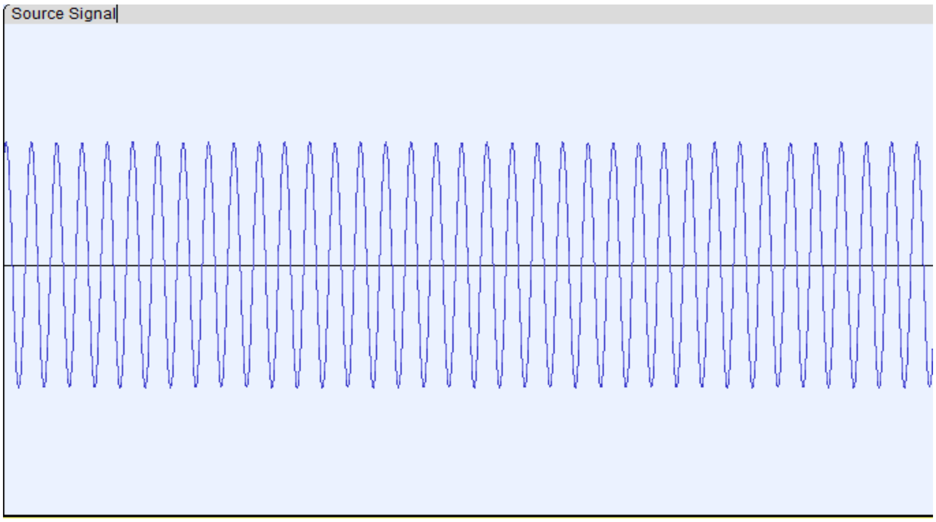

Figure 19: source noise

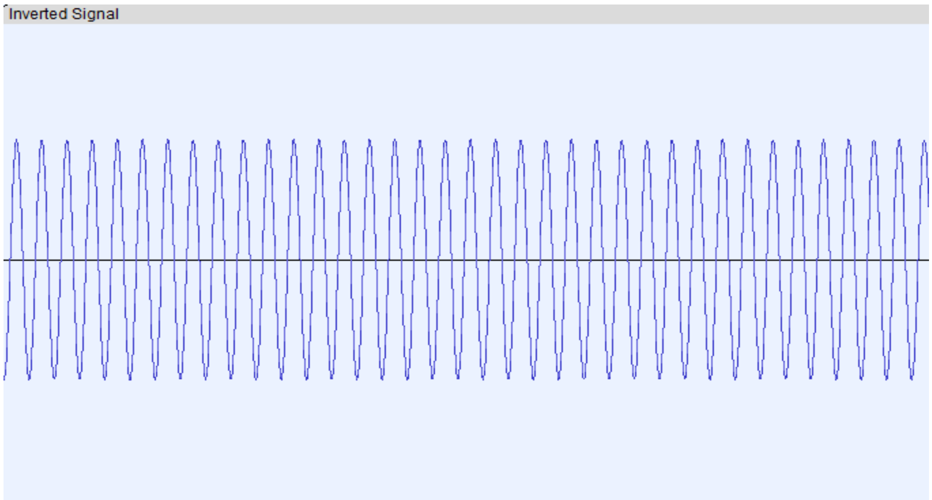

Figure 20: inverted noise

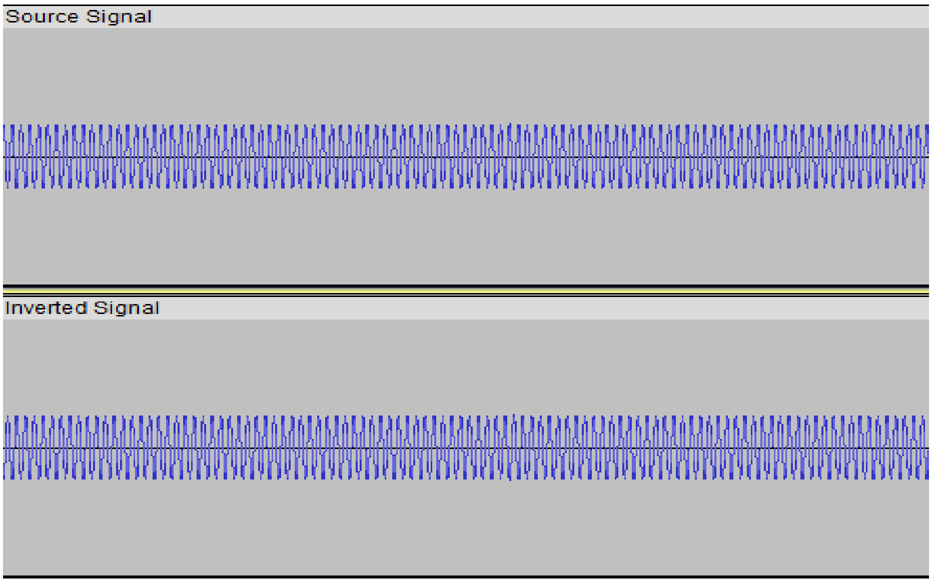

Figure 21: source noise with inverted noise

After simulating each of the pure notes we have got the result of a reduced level of that notes. The results are shown below in the table:

Table 8: reduced level of tuning notes

Tuning Notes	Frequency notes (Hz)	Reduced level (dB)
A	440	7
B	493	10
C	523.25	13
D	587.33	4
E	659.26	6
F	698.46	10
G	783.99	4

So, we can say that design system 4 is better than any other system as it reduced noise level minimum upto 5 dB.

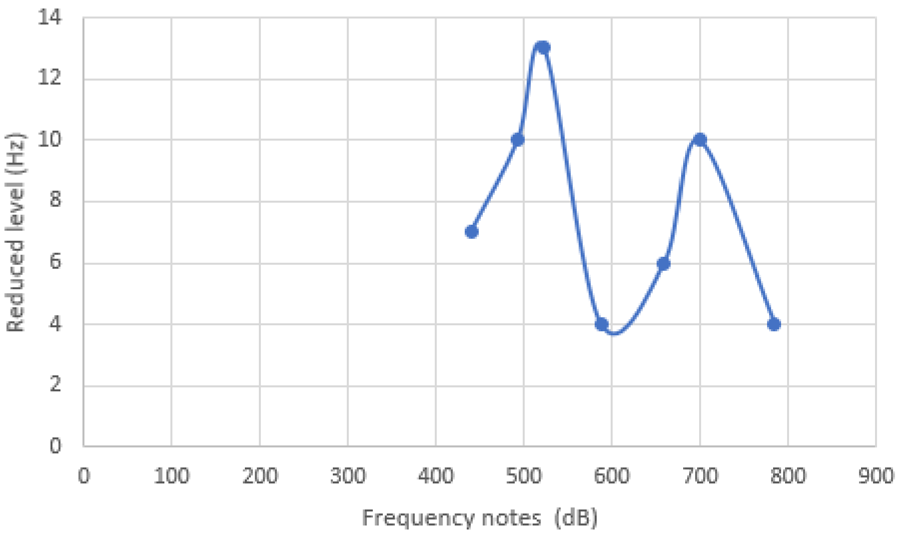

Figure 22: Graph of Frequency vs Reduced level

2.5 Conclusion

Multiple design approaches have been available by following the desired objective, requirements, and restrictions. Each one expresses special satisfaction in achieving those conditions, and a component specification has been chosen based on further research and development to complete the comprehensive design. Later on, each design has its own set of advantages and disadvantages, which is why they've all been scrutinized deeper to fulfill many criteria.

CHAPTER 3: USE OF MODERN ENGINEERING AND IT TOOL

3.1 Introduction

Multiple design approaches were addressed in the previous section, along with their objectives, requirements, and constraints. Now, in order to assess them, we'll need to think about a few key instruments. A detailed table is provided below; as can be seen, there are two sections, one for software and the other for hardware. To complete the hardware analysis, we'll need all of the hardware tools we'll need to get the job done well. Then there's the software.

3.2 Select Appropriate Engineering and It Tools

The tools that have been used are used to develop complex engineering projects. The table is given below:

Table 9: tools and purpose of use

Name	Purpose
Raspberry Pi 3B	This is the master controller in this device. This device will process the whole system and will be linked to a speaker, microphone, and monitor.
Microphone	It will receive noise as input and will record noise
Speaker	To produce a sound result for the audience. The electromagnetic waves are changed over into sound waves through the speaker.
Power source	For delivering input & output
Resistor	To design speaker
Electric cable	To transport electricity
Soldering Iron	To connect sensors
Soundproof box	To make the system noise and echo-free

3.3 Use of Modern Engineering and It Tools

Simulation software helps us analyze and predict the behavior of a system. Since we were mainly testing different types of algorithms for canceling noise efficiently, we needed software that is easy and fast for digital signal processing. Moreover, we needed to do different types of mathematical calculations. First of all, in the designing stage, we decided to do it using Matlab but in the case of implementation, we faced some difficulties. So, after some analysis and research, we found that Raspberry Pi and Python will be the best solution to design and implement the project in real-time. That is why we chose Raspberry Pi 3B as our main simulation tool along with Python as a programming language. Raspberry Pi 3B is a multipurpose processing system with a proprietary programming language. It is built to handle mathematical operations easily. Standard loops of programming can be written within it. We also did work with audio files. We also worked with Illustrator for designing and visualizing the systems in addition.

In a different design system microphone is used to record and receive noise. Anti-noise will be generated using a speaker. The entire system will be housed in a soundproof box with pipe, which will reduce noise levels and improve the effectiveness of the ANC system. And a decibel meter will be used to measure the noise levels.

3.4 Conclusion

To summarize, we will design efficiently using all of the methodologies and tools listed above. However, due to the limited library and impractical findings, we will not be able to test every single one of our solutions in that software.

CHAPTER 4: OPTIMIZATION OF MULTIPLE DESIGN AND FINDING THE OPTIMAL SOLUTION

4.1 Introduction

Now that we've chosen our engineering tools for putting our concept into action, we must choose the best solution from among several options. To accomplish so, a table is provided, which contains several conditions each with a specific point. The design that receives the most points will be considered the best option. Following the selection of the best solution, we must run some test cases to ensure that the best design has been chosen.

4.2 Optimization of Multiple Design Approach

Table 10: optimization various design approaches

Designs	Range of Data	Maintenance (Easy Troubleshooting)	Accessibility (Compromising both users and system)
By Least Mean Square(LMS) algorithm	Does Not require	Moderate	Moderate
By Filtered Least Mean Square (FxLMS) algorithm	6 kHz	Complex	Not Satisfied.
Using Microphone with source noise	200-300mbps range.	Simple	Not Satisfied
Using Speaker along with source noise	200-300mbps range.	Simple	Satisfied

Optimization based on usability

One of the most ignored factors in designing engineering problems at some point can be convenient for both client and the owner side. For a plan to be ideal, the ease of use should depend on the imprints as well. According to the owner's viewpoint, the ease of use factors primarily the availability of the gadget and the information for this situation.

Optimization based on maintainability

The large number of utilizations implies a great measure of support is expected to keep the gadget functional. The expense correlation plays a major part as far as viability as it straightforwardly associates both of the devices to keep up with the cost. Likewise, the size and versatility of the device are elements too for this situation. For the project, its estimation is exceptionally crucial for placing the amplifier and speaker. As the speaker will deliver the counter noise so it is vital to put the speaker in such a way that it straightforwardly produces reverse noise. Then again, the upkeep cost is lower contrasted with the different projects because of the minimal expense of the parts in any case. At last, every one of these makes the project compact as it's not joined to something besides power.

Optimization based on manufacturability

Manufacturing is the process of formulation, component integration, software implementation, etc. The simpler a device is the easier it to manufacture, also the cost of manufacturing is much lower if the design is simple. System 4 requires communication between speakers which can be implemented properly in both hardware and software aspects. Moreover, all these components are available so it is very handy to use all these components. For systems 1 and 2, the design is much simpler and the integration is very straightforward, which makes the manufacturing much easier but not very applicable as it is not user-friendly. For system 4, the design is made in such a way that it works perfectly for software simulation. It doesn't give proper results in the case of hardware implementation.

4.3 Identify Optimal Design Approach

We have tried different types of design approaches but among them design 4 gives us optimal result.

4.3.1 Optimal use of widely available components

The parts that are being utilized to foster the system 4 plan are generally accessible in the market which will help us regarding creating, fabricating, and getting resources for this item significantly more without any problem. The parts that are being utilized in system 4, for example, the engineer pack are a daintily involved part in the market. Also, the assets, for example, support, OS, and libraries for Raspberry Pi have an overflow on the web where different frameworks have exceptionally less.

4.3.2 Cost-benefit analysis:

For systems 01 and 02:
As system simulations for these two approaches were done in software (MATLAB), that's why we didn’t include those costs in the case of analysis.

For System 03:
After making the system analysis on software we implemented this approach in hardware. We tried choosing components that are easily available and not so costly.

Table 11: total cost for system 3

Name	Quantity	Price (BDT)
Raspberry Pi 3B	1	3000
Microphone	1	1000
Speaker	1	2*300=600
Electric cable	2	200
Soldering Iron	1	200
Soundproof box	1	1200
Total		6200 TK

For System 04:
We implemented this approach on hardware after some software simulations like system 03 as well.

Table 12: total cost of system 4

Name	Quantity	Price (BDT)
Raspberry Pi 3B	1	3000
Speaker	1	2*300=600
Electric cable	2	200
Soldering Iron	1	200
Soundproof box	1	1200
Total		5200 TK

After analyzing the two systems, we have reached a conclusion that the system 04 design is the most cost-effective to implement in real life.

4.4 Performance Evaluation of Developed Solution

System 04 is the ideal plan that we have picked while beginning to push ahead in the task finish. After the fruition of the undertaking, the trials, and the different case assessments gave out a great deal of execution.

- We'll be working with pure frequencies in our system. These frequencies can be broken down into individual notes. For instance, A, B, C, D, E, F, and G notes. Any of the notes will be quieter as a result of this approach. The method will begin by utilizing the Python library to obtain the audio wave file of one of the seven notes.
- The audio phase must then be inverted. The next step is to split the audio channels across the speakers and play the non-inverted audio file in the left channel while inverting the audio in the right.
- The input audio will be dismissed after inverting the audio wave file since the inverted audio wave will have the same amplitude but in inverse form. As a result, we will achieve the desired result. We can see from the output that the previous noise level has decreased. The reduced noise level will be measured with decibel meters, and the result will be visible on the output graph. As a result, we can conclude that our approach can effectively reduce noise levels.

4.5 Conclusion

To summarize, the system was carried out independently into different segments with the goal that the responsibility can be separated. In each part, there were many issues present to acquire the ideal outcome along these lines, after a couple of preliminaries and examination; it was at last functioning true to form. Besides, it was feasible to get information and get yield. As individual parts are working in the system along these lines, it can guarantee that the whole system is working appropriately independently.

CHAPTER 5: COMPLETION OF FINAL DESIGN AND VALIDATION

5.1 Introduction

In the past section, the ideal arrangement was planned and executed independently. However, unfortunately, subsequent to coordinating each part there were a few issues. This then, at that point, brought about a significant imperfection in this incorporated plan. In this manner, a few precautionary measures were taken to work on such issues and we made our final design approach.

5.2 Completion of Final Design

The design was initially a methodology-based flowchart with the implementation of the algorithm which we intended to employ in this project. Then in order to construct the device, we needed to gather resources for hardware components and develop the overall system setup. We began by building the system block by block, then advanced to make the box soundproof. After finishing the box implementation, it was time to put everything into an embedded system so that the entire process could run simultaneously and sequentially. The programming portion was crucial in creating the gadget as a whole; it is what links the entire system together and allows it to function as a whole.

Design Diagram: Each part of the system is given below

Figure 23: Raspberry Pi Connection Configuration

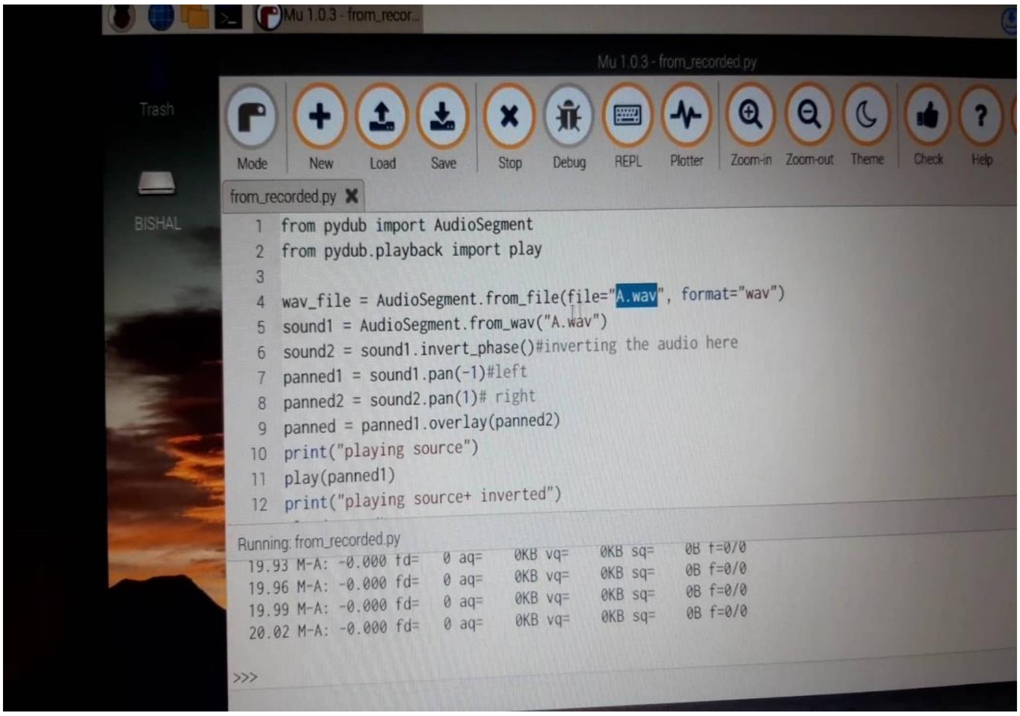

Figure 24: Running code

Figure 25: Measuring noise level through decibel meter

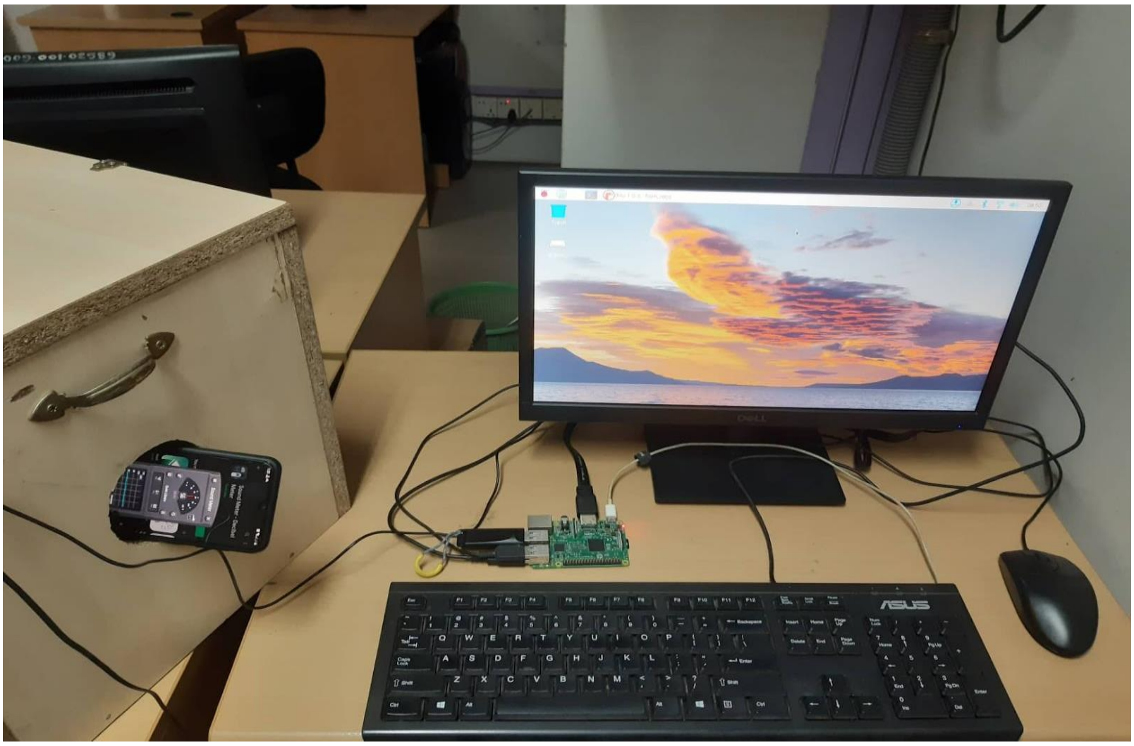

Figure 26: Complete system setup

To sum it up, this is the complete system setup for our project Active Noise Cancellation.

5.3 Evaluate the Solution to Meet Desired Need

The best system design we chose is to achieve the goals we set out to achieve in an efficient and effective manner, precisely as we expected.

- **Precisely taking input of audio wave files:** Among the seven notes A, B, C, D, E, F, and G, we have chosen note C to reduce noise as the reduced noise level is higher in that note. The method will begin by utilizing the Python library to obtain the audio wave file of that note.
- **Accurately inverting noise:** The next step is to split the audio channels across the speakers and play the non-inverted audio file in the left channel while inverting the audio in the right.
- **Systematic work to get output (reduced noise level):** The input audio will be dismissed after inverting the audio wave file since the inverted audio wave will have the same amplitude but in inverse form. As a result, we will achieve the desired result.
- **Budget limit:** Any complicated technical device necessitates study and development. Because there are always some risk considerations when trying new things, the budget allocation for a newly built system must always be higher than the existing one. So,

based on the whole development and evaluation of the system, it can be concluded that the project's lower bound should not be surpassed; otherwise, the system may fail to perform as planned, as specific standards of components are required to provide the best results.

5.4 Conclusion

As a result, we may conclude that the system we wish to build satisfies all of the criteria we defined previously. Because this project involves a health protocol, the system's high integrity was always a top priority throughout the research and development process. Any lack of discipline could endanger people's health, which would defeat the project's main goal. As a result, several tests have been performed on the system to determine its integrity, characteristics, and optimal operating conditions. Hence, this will look precisely like an eventual outcome.

CHAPTER 6: IMPACT ANALYSIS AND PROJECT SUSTAINABILITY

6.1 Introduction

Noise pollution is a health hazard that is often overlooked. It's not visible, but it's there nonetheless. Any undesired or irritating sound that impairs the health and well-being of humans and other organisms is considered noise pollution. People who live in polluted areas may become irritated or frustrated. The human brain is constantly listening for indicators of danger. As a result, a lot of noise can make you feel anxious or stressed at any time. Unwanted noises might cause a spread of condition symptoms as well as a change in bodily state.

6.2 Assess the Impact of Solution

Because we are designing a system that will produce a noise-free, comfortable environment, our project will have a significant impact on a variety of circumstances in our daily lives. People will be able to avoid hearing loss and many other life-threatening losses if there is less noise disruption. All of these noise-reduction measures will yield these results:

6.2.1 Health Impact

Impact on the psychological state

1. Active noise cancellation may help to alleviate sleep problems.

2. It has the potential to decrease the number of fast eye movements. It has a significant impact on a person's mood and ability to focus.

3. Less pollution reduces the risk of hypertension and elevated stress levels, which are life-threatening conditions for adults in their medium to late stages of life.

4. Because of the autistic spectrum, pollution may have negative impacts on adults and children. Hyperacusis, or extreme sensitivity to sound, is a symptom of Autism Spectrum Disorder (ASD). Hyperacusis can cause unpleasant emotions such as anxiety or uncomfortable sensations in noisy surroundings in people with ASD. Individuals with ASD may be forced to avoid noisy surroundings, resulting in isolation.

Impact on physical health

The physical health effects of sound pollution can occur as an on-the-spot or indirect result of pollution. In severe cases, loud noises can directly cause hearing disorders. So, if we are ready to reduce the pollution level it'll have an honest impact on physical health also. As such:

1. One of the foremost common problems with hearing disorders is prevented by this method.

2. People won't face unusual loudness perception in their day-to-day life.

3. Tinnitus which causes a persistent high-pitched ringing within the ears will be a less common disease for people.

4. Less amount of pollution will deduct the danger of cardiovascular disorders, high force per unit area, and blood viscosity. Moreover, pregnant women develop high blood pressure due to excessive exposure to sound. So, this method will make the prospect level low altogether in all these cases.

Impact on the psychological state

1. Active noise cancellation may help to alleviate sleep problems.

2. It has the potential to decrease the number of fast eye movements. It has a significant impact on a person's mood and ability to focus.

3. Less pollution reduces the risk of hypertension and elevated stress levels, which are life-threatening conditions for adults in their medium to late stages of life.

4. Because of the autistic spectrum, pollution may have negative impacts on adults and children. Hyperacusis, or extreme sensitivity to sound, is a symptom of Autism Spectrum Disorder (ASD). Hyperacusis can cause unpleasant emotions such as anxiety or uncomfortable sensations in noisy surroundings in people with ASD. Individuals with ASD may be forced to avoid noisy surroundings, resulting in isolation.

Impact on physical health

The physical health effects of sound pollution can occur as an on-the-spot or indirect result of pollution. In severe cases, loud noises can directly cause hearing disorders. So, if we are ready to reduce the pollution level it'll have an honest impact on physical health also. As such:

1 Long-term exposure to loud noise causes permanent hearing loss, which a personal hearing protective device can effectively mitigate (HPD).. One of the foremost common problems with hearing disorders is prevented by this method.

2. People won't face unusual loudness perception in their day-to-day life.

3. Tinnitus which causes a persistent high-pitched ringing within the ears will be a less common disease for people.

4. Less amount of pollution will deduct the danger of cardiovascular disorders, high force per unit area, and blood viscosity. Moreover, pregnant women develop high blood pressure due to excessive exposure to sound. So, this method will make the prospect level low altogether in all these cases.

Because we are designing a system that will produce a noise-free, comfortable environment, our project will have a significant impact on a variety of circumstances in our daily lives. People will be able to avoid hearing loss and many other life-threatening losses if there is less noise disruption.

The table below illustrates how noise and dB levels in everyday life can affect health [23]:

Table 13: different noise levels and its effects of everyday life

Type of sound	dB (decibels)	Intensity*	Typical Reaction (after routine or repeated exposure)
Artillery fire	130	10	Agony and ear injury
Jet engine; amplified rock music	120	1	Torment and ear injury
Blaring orchestral music	110	10^{-1}	Hearing misfortune can happen in under 5 minutes
Electric saw	100	10^{-2}	Hearing misfortune can happen in under 15 minutes
Bus or truck interior	90	10^{-3}	Hearing harm is conceivable after around 50 minutes of openness.
Automobile interior	80	10^{-4}	May feel irritated by the clamor
Average street noise	70	10^{-5}	Might be aggravated by the commotion
Normal conversation	60	10^{-6}	This degree of sound purposes no harm
Restaurant or office	50	10^{-7}	This degree of sound purposes no harm
Quiet room in home	40	10^{-9}	This degree of sound purposes no harm
Lecture hall, bedroom	30	10^{-9}	This degree of sound purposes no harm
Radio or television	20	10^{-10}	This degree of sound purposes no harm
Soundproof room	10	10^{-11}	This degree of sound purposes no harm
Absolute silence	0	10^{-12}	This degree of sound purposes no harm

*In watts per square meter

If we can implement this ANC system the all of these noise-reduction measures will yield these results:

6.2.1 Health impact

Impact on the psychological state

Active noise cancellation may help to alleviate sleep problems.

1. It has the potential to decrease the number of fast eye movements. It has a significant impact on a person's mood and ability to focus.
2. Less pollution reduces the risk of hypertension and elevated stress levels, which are life-threatening conditions for adults in their medium to late stages of life.
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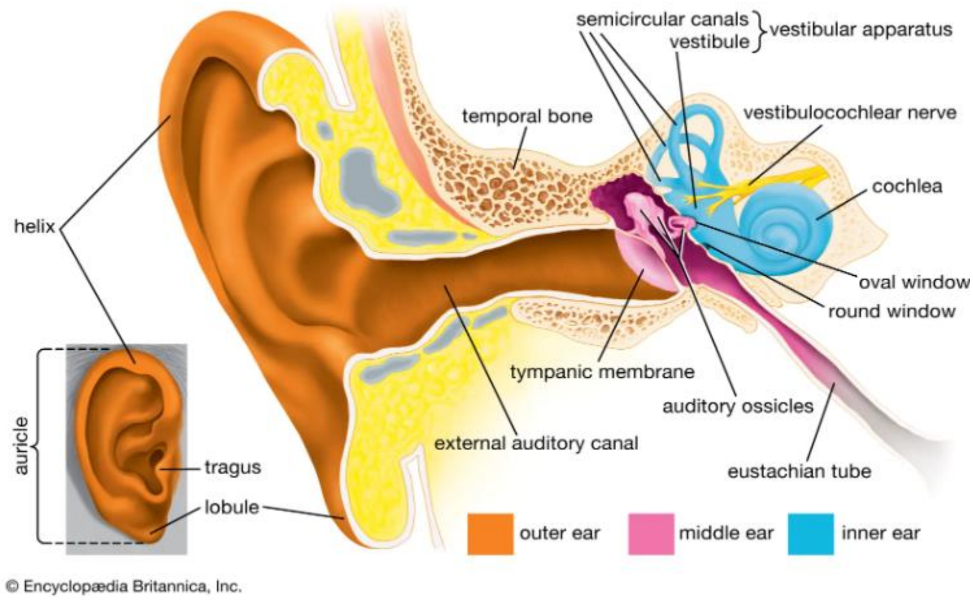

Figure 27: Effect of noise in ears

6.2.2 Legal Impact

Until we begin the design phase of our project, we are exceedingly careful and cautious about any legal ramifications. However, because our system is unrelated to personal information, we anticipate that no one will be harmed. Institutions that use our suggested system will be in charge of keeping it up to date. It will also have no legal ramifications in terms of environmental legislation. We have designed and proposed a way that will not hurt our environment but will instead contribute to its improvement, and we will continue to do so throughout the project's duration.

6.2.3 Safety Impact

Our project's main purpose in terms of safety is to create a healthy and comfortable environment free of noise hazards. We have used appropriate techniques to eliminate any potentially harmful aspects of our project until the current progress in our design. More safety concerns will be addressed before the project is done. We have yet to encounter any issues as a result of any component failure to deliver the expected outcome because we haven't utilized our system to its maximum extent. We made certain changes in terms of safety while trying to develop the project to reach the best possible result.

6.2.4 Cultural Impact

As a result, the acoustical environment of national park cultural and historic sites is a significant aspect of the setting and helps park visitors form meaningful connections. The silence of an empty cell on Alcatraz Island alludes to a former inmate's sense of isolation. Noise levels from aircraft, trucks, and construction equipment, for example, can distract from the experience. With this in mind, if active noise cancellation is used in specific areas, it will be possible to conserve the cultural and historic noises that are regarded as essential to a park's purpose.

6.2.5 Social Impact

The part of social adequacy, equity, and impact of particular hardware or new inventive advancements that will prompt a better life is alluded to as a friendly effect. Since the proposed drive is so new, certainty and agreeableness might be perhaps the main social variable. Communication is the key to social bonding and this communication starts at the early stage of life even during fetal infancy, according to Pediatrics. Children and Teenagers may also find it difficult if they are subjected to unwanted noise around them. If the ANC system is applied in different places, it will boost their communication skills and speech development and concentrate on education properly. So, children can break through the shell of poor cognitive function and live a healthy life. Moreover, Middle-aged people are also at risk of fatal diseases because of the noise threat. This will have a great impact to build a confident human society in the future. So this surrounding noise-canceling device will have an effect on the decline in the pace of those illnesses and socially an immense populace will be benefitted. These issues will attempt to draw consideration of the public and it will assist with getting societal acceptability. With our planned project, we are sure to accomplish the positive effects on society.

6.2.6. Environmental Impact

Noise pollution has an impact on the environment, especially wildlife. Sound is used by a number of species, including insects, frogs, birds, and bats, for a variety of reasons. Noise pollution can impair an animal's ability to attract a partner, communicate, navigate, find food, or evade predators, posing a serious hazard to fragile organisms. The problem of noise pollution is particularly significant for marine animals that rely on echolocation, such as whales and dolphins because much of the world's oceans are polluted by chaotic sounds from ships, seismic experiments, and oil drilling. Naval sonar equipment, whose noise can travel hundreds of miles over the ocean and is connected with some of the loudest and most harmful noises in the sea, are responsible for some of the loudest and most harmful sounds in the sea. Naval sonar equipment, whose boom can travel hundreds of kilometers through the water and is linked to large strandings of whales and dolphins, produce some of the loudest and most harmful sounds in the sea. So, if the ANC system can be implemented in certain areas, noise pollution can be reduced, and residents can be saved.

6.3 Evaluate the Sustainability

The final system will be designed to work without any battery in the system. The batteries and electronics are a finite supply of energy as we don’t need batteries so our system will run for a long period. Furthermore, microphones and speakers will continue their functionality even after a period of time. Because the system prefers low-frequency noises it will not cause any malfunction. Even changes in climate will not destroy the system outline and its internal working principle.

6.4 Conclusion

With the assistance of our venture, individuals can basically be at a little alleviation in their working environment or home. Not just that, we can see that the framework can colossally affect various situations in human existence.

CHAPTER 7: ENGINEERING PROJECT MANAGEMENT

7.1 Introduction

Project management is essential for demonstrating the overall progress of the designed plan. When a project is decided, organizing it becomes difficult because it is the backbone of any project. As a result, when a project is planned, there are multiple stages where the designed plan may not provide accurate results due to issues or risk factors. The most difficult aspect of project management is meeting all of the project's objectives within the time and budget constraints. Engineering Management is the combination of engineering and management skills with technical expertise to coordinate work in a wide range of technical sectors, including inter-disciplines and external interfaces, as well as to address technical challenges and problems. The application of engineering concepts to the optimal planning and operation of resources and technology is the focus of Engineering Management. Before beginning any project, a backup plan is developed to account for any potential risks. Everything is managed by delegating specific tasks. Teamwork is essential for resolving any risk factors and maintaining consistent output.

7.2 Define, Plan and Manage Engineering Project

The project employed both qualitative and quantitative methodologies from start to finish. The research in this project is focused on Active Noise Cancellation, and its main aspect is to reduce noise intensity by adding the noise's reverse wave. In acoustics, noise is any unwanted sound, whether it is intrinsically objectionable or interferes with other sounds being listened to. Noise is defined in electronics and information theory as random, unpredictable, and undesirable signals or changes in signals that obscure the desired information content.

7.2.1 Project definition

A project is a short-term endeavor to create a one-of-a-kind output, which can be a product or a service. The term “temporary” is not often used to describe the project's product, service, or outcome. The vast majority of initiatives are undertaken with the intention of yielding long-term results. According to noise activists, noise does not only affect hearing. According to Neitzel, the study's author, a study conducted at the University of Michigan found a link between cardiovascular disease and heart attacks. The primary goal of this project is to generate a reverse wave of a specific noise to reduce its intensity (ANC). We followed a set of principles from the beginning of the project (EEE400P) until the end of the project to achieve the desired output from our project. The primary goal of this project is to generate a reverse wave of specific noise and reduce its intensity. We followed a set of principles from the beginning of EEE400P until the end of the project to achieve our intended output from our final year design project.

7.2.2 Project planning

Project planning is a subset of project management that entails planning and reporting progress within the project environment using schedules such as Gantt charts. It entails identifying the specifics of tasks to be completed during the project as well as charting out the sequence and schedule of required activities. If a project lacks an adequate strategy, it may face the following difficulties: project delays, inaccurate project completion, team miscommunications, and poorly defined goals and objectives. We presented our first project plan in EEE400P, which includes all actions necessary to identify, integrate, and coordinate all subsidiary and complementary plans into a unified project management plan. It was difficult to select a project topic and analyze the project's timeframe. It was difficult to divide the background research task. Our main goal was to implement this project in real time with error calculation using various types of algorithms (LMS, FxLMS, NLMS) [24], but due to a lack of proper research in real-time implementation and the cost of equipment, we were unable to complete the project as planned. This issue caused us problems and exposed us to a number of roadblocks throughout the project.

Table 14: task description and duration of eee400p

Task ID	Task Description	Task Duration	Start Date	End Date
Task 1	Group Form	9	10-Jun-21	19-Jun-21
Task 2	Topic Discussion	14	20-Jun-21	4-Jul-21
Task 3	Meeting with ATC	1	5-Jul-21	6-Jul-21
Task 4	Topic Finalization	1	7-Jul-21	8-Jul-21
Task 5	Progress Presentation 1	1	8-Jul-21	9-Jul-21
Task 6	Paper Collection	3	9-Jul-21	12-Jul-21
Task 7	Literature Review	7	13-Jul-21	20-Jul-21
Task 8	Group Discussion with ATC	4	21-Jul-21	25-Jul-21
Task 9	Individual Research	9	26-Jul-21	4-Aug-21
Task 10	Preparing Draft for Progress Presentation 2	6	5-Aug-21	11-Aug-21
Task 11	Progress Presentation 2	1	12-Aug-21	13-Aug-21
Task 12	Data Collection	7	13-Aug-21	20-Aug-21
Task 13	Data Analysis	15	21-Aug-21	5-Sep-21
Task 14	Discussion with ATC	1	7-Sep-21	8-Sep-21
Task 15	Progress Presentation 3	1	9-Sep-21	10-Sep-21
Task 16	Creating Project Proposal	5	9-Sep	14-Sep
Task 17	Progress Presentation 4 and Project Proposal Submission	1	16-Sep-21	17-Sep-21

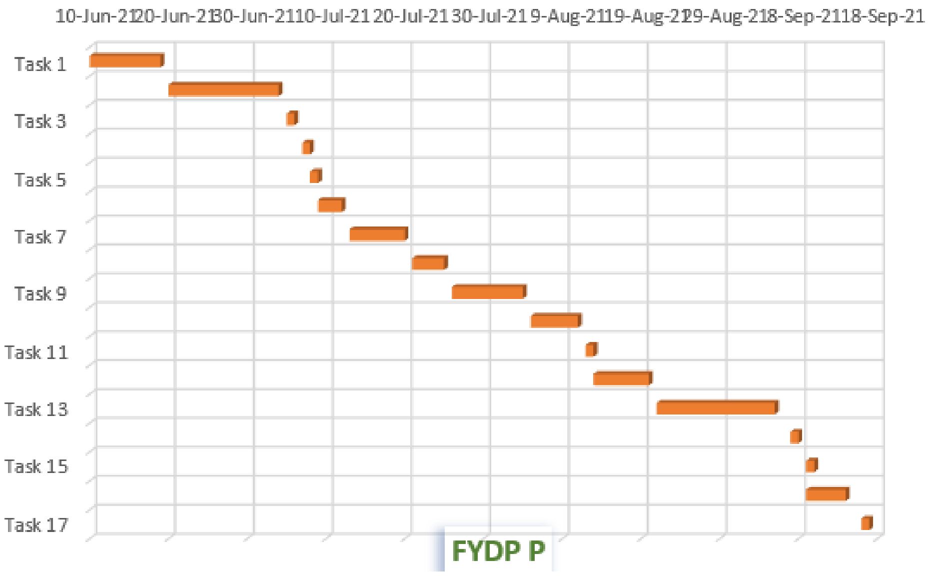

Figure 28: Time management of EEE400P

7.3 Evaluate Project Progress

All of the time-sensitive objectives were included in our project proposal. However, due to unforeseen circumstances, the start of the project's design component was postponed. Our component purchase was put on hold indefinitely due to the country's COVID lockdown stages. We also had trouble locating a suitable location to carry out our proposed design. In terms of project progress, we've divided this section into two sections –

7.3.1 Project Designing

During the conceptual design phase, various system design options are evaluated, and the parameters with the greatest impact on project implementation are finalized. These include, among other things, significant system/equipment design, energy-saving measures, system optimization, the degree of plant automation, maintenance and flexibility requirements, and future expansion planning. We used basic ANC theory and a variety of design techniques to implement the original project design. Then, while implementing the multiple design approach, we encountered a number of challenges, including relevant paperwork and hardware implementation. We did not have a real-time audio spectrum display due to a lack of funds, and visualizing the real-time inverse noise was difficult. We were also unable to complete a full multiple design approach due to funding constraints. Several hardware components were discarded due to functional flaws. However, as our project progressed, we adjusted our deadlines to accommodate changing circumstances.

Table 15: task description and duration of eee400p

Task ID	Task Description	Task Duration	Start Date	End Date
Task 1	Reading Research papers	4	14-Oct-20	18-Oct-20
Task 2	Meeting with ATC	1	19-Oct-20	20-Oct-20
Task 3	Group discussion- Choosing multiple design (preliminary)	3	21-Oct-20	24-Oct-20
Task 4	Simulation	6	25-Oct-20	31-Oct-20
Task 5	Group discussion	1	1-Nov-20	2-Nov-20
Task 6	Data analysis and tool selection	2	3-Nov-20	5-Nov-20
Task 7	Preparing circuit design (Different approaches)	2	6-Nov-20	8-Nov-20
Task 8	Progress presentation	3	9-Nov-20	12-Nov-20
Task 9	Group discussion	4	13-Nov-20	17-Nov-20
Task 10	Identifying the appropriate design solution	7	18-Nov-20	25-Nov-20
Task 11	Validation and test cases	5	26-Nov-20	1-Dec-20
Task 12	Identifying ethical consideration and prof responsibilities Project management	7	2-Dec-20	9-Dec-20
Task 13	Finalizing design	12	10-Dec-20	22-Dec-20
Task 14	Preparing final project presentation & submission	11	23-Dec-20	3-Jan-21
Task 15	Meeting with ATC	1	4-Jan-21	5-Jan-21
Task 16	Final presentation FYDP(D)	3	6-Jan	9-Jan
Task 17	Final report submission	1	10-Jan-21	11-Jan-21

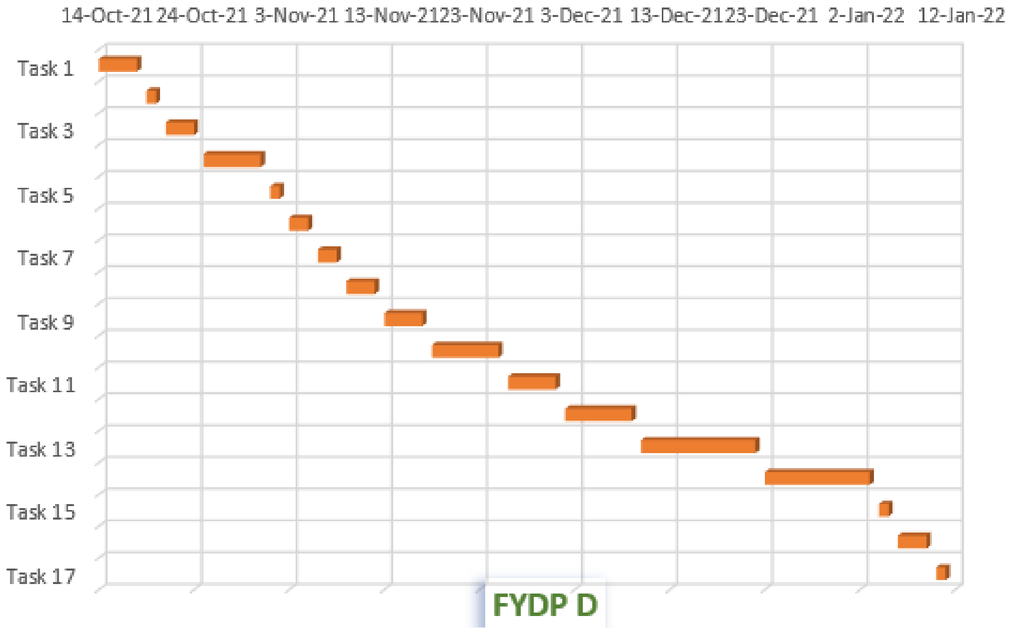

Figure 29: Time management of EEE400D

7.3.2 Project Execution

When a project is successfully implemented, project management is required. Progress is observed by completing any task in order to maintain a consistent outcome. All tasks are assigned in a systematic manner. Initially, an estimate was used to create a plan, but unfortunately, it did not go as planned due to component testing issues. As a result, a new updated plan with a new timeline has been created. This should result in more accurate project progress. Furthermore, responsibility for dividing the workload has been assigned to each member. We have put in a lot of effort over the last three months to complete the project. And we have completed our project. We began working on the hardware implementation prior to the start of EEE400C. We worked in four divisions –

1. installation and integration of the Raspberry Pi
2. design a soundproof box
3. speakers best position for noise cancellation and coding
4. Report Writing

Furthermore, because risk is an uncertain case, a backup plan is required to manage resources. While implementing our project, we encountered some component damage and troubleshooting. As a result, precautions were taken from our designed contingency plan in order to continue operating effectively.

Table 16: responsibility representation of eee400c

Tasks	Distribution
Design Planning	Everyone
Design Report	**Kallol Sarkar Rakesh -** Multiple design approaches, Selection of modern IT tools, Functional verification of multiple design solutions, Analyze the multiple design solutions to find the optimal solution.
	Jarin Tasnin Mou - Project plan, Budget, expected impact and solutions, Project plan, Ethical consideration, Report summary
	Fabliha Rahman - Background research and survey, Objectives, Specifications, Requirements and constraints, Risk management and contingency plan.
Design and component selection	**Mohimin Al Bhuiyan -** codes and layout
	Jarin Tasin Mou - soundproof box
	Mohimin Al Bhuiyan - testing accuracy
Component procuring	**Kallol Sarkar Rakesh**
Slide Design	**Fabliha Rahman**

7.4 Conclusion

To clarify, developing something is a risky venture because user feedback can vary, causing a huge problem in project management. If everything goes as planned, this project will have a bright future. This will enable future system upgrades and plans to be made.

CHAPTER 8: ECONOMICAL ANALYSIS

8.1 Introduction

Economic analysis is a term used to describe the study of economic systems. It could also be a look inside a manufacturing process or a particular industry. The analyses' purpose is to determine how well the economy, or a segment of it, is operating. For example, an economic analysis of a firm focuses mostly on how much profit it creates. It also enables the estimation of business results using data-driven methodologies, as well as convenient decision-making and demonstrating the most efficient use of resources.

8.2 Economic Analysis

Economical, analysis is a device for aiding the better assignment of assets, which can bring about expanded pay for ventures. A monetary examination's motivation for organizations is to introduce a reasonable image of the ongoing financial condition. What impact, if any, has the ongoing financial environment had or will have on the organization's ability to monetarily work. For this venture, as a noise-canceling system is carried out thus, laying out such a framework requires immense assets on the board. This empowers a successful strategy to arrive at the ideal objective. After execution, perhaps the main viewpoint is upkeep. To give the greatest upkeep and backing to clients, new business begins. Employing new individuals considers keeping up with the assets and client assistance consistently. Ordinary client remuneration and compromise are conceivable. The total cost scenario for the prototype we have recently developed for our final year design project is presented below –

Table 17: revised budget of system 4

Name	Quantity	Unit Price in BDT (TK)
Raspberry Pi 3B	1	3000
Speaker	1	2*300 = 600
Electric cable	2	200
Soldering Iron	1	200
Soundproof box	1	1200
Total		5200 TK

8.3 Cost Benefit Analysis

By cost-benefit analysis, the feasibility verification of a project is estimated, which gives a vision for the organization in terms of the present, future, and risk factors. There are different types of components to implement our system but we have to be careful about our budget and customers' ability to purchase that product. Keeping that thought in our mind we have made a list that can help us to implement the system. For this task, the chosen configuration has a devoted strength and shortcoming in execution and the executives. Besides, the executives should be given more noteworthy accentuation as consumer loyalty, contest and systems can make an enormous effect on an association.

A table is given for additional examination:

Table 18: analyzing cost of different tools for hardware setup of active noise cancellation

Components used in other existing ANC systems			Components used in our ANC system		
Components	**Unit Price in USD($)**	**Strength**	**Components**	**Unit Price in USD($)**	**Strength**
TMS320C25	$48.2000	Digital signal processor, 16-BIT, 544 Synchronization Input for Synchronous Multiprocessor	Raspberry Pi 3B	$33.33	4-bit quad-core ARM Cortex-A53
USB Audio Interface Model: Focusrite Scarlett 2i2	$169	Elite execution converters, permitting you to record, blend and playback sound in studio quality, anyplace	Speaker	$6.67	118 Hz-20KHz. 88dB

Dayton audio microphone	$100	Low clamor FET input lessens low-recurrence mutilation, Great parts and tough development	Microphone	$11.11	65Hz to 18 kHz, 18.00mmH x 8.30mmW x 8.30mmD
LattePanda(mini pc to ANC code)	$199	Base Frequency: 1.44GHz (1.92GHz Burst Frequency) @200-500Mhz, single-channel memory.	Soundproof box	$13.33	SUpress other sources noise level

Above mentioned all components can be used to implement the system of ANC. But as our project has a low budget, overpriced components are not eligible for setting up our system. Though the components are very effective in case of features, all these are more appropriate for the vast implementation of active noise canceling systems such as automobiles, airplanes, etc. As our basic approach is to implement ANC in indoor places so less pricey components are also very useful in that case. That's why we have chosen Raspberry Pi, a microphone and speakers within our budget. These products have fast processing and effective power to reduce noise levels.

8.4 Evaluate Economic and Financial Aspects

The model rendition of our task is completely prepared. We can see from these estimates that the initial cost of setting up this hardware combination is significantly lower than the targeted aim of this project. As a result, from all views and computations, the total amount of money required by the system is less than that required by competing systems. The cost of the system using the Raspberry Pi kit is 3000 taka which is not too expensive considering that both systems have similar levels of accuracy. It is working as indicated by our assumptions somewhat. For that, we wanted an appropriate asset as the framework will consist of such electric parts. As the parts are purchased appropriately then an effective framework is guaranteed, after that overseeing it will be the fundamental need. Additionally, to give the greatest consumer loyalty, the system can offer appealing administrations with limits or comparable exercises.

8.5 Conclusion

To summarize, to foster a task execution of the project is enough as well a monetary view is necessary since it permits a dream to be created about the present and fate of that venture. This permits an assessment of asset utilization when a project is initiated and after execution. Without such administration, it becomes challenging to run the project.

CHAPTER 9: ETHICS AND PROFESSIONAL RESPONSIBILITIES

9.1 Introduction

Ethical consideration is a collection of principles and values that should be followed while doing something related to human affairs directly. Since we are dealing with noise cancellation, Ethical Considerations can be specified as one of the most important parts of this project. People prepared in designing are conceded certain advantages by society, one of which is the capacity to apply their schooling to intentional and regarded work. Engineers, then again, have a moral commitment to an assortment of givers in the public eye. Designing proficient obligations envelops the moral accountabilities of specialists in their expert associations with clients, bosses, different architects, and general society. Trustworthiness and uprightness in proficient work, classification of restrictive information, collegiality in coaching and companion audit, and, most importantly, the security and soundness of people, in general, are largely liabilities of specialists since their activities straightforwardly affect society and the local area.

9.2 Identify Ethical Issues and Professional Responsibility

Recognizing and following every one of the ethical and professional responsibilities has been one of the most focused parts of this activity's consummation. We can recognize two points of view in characterizing Professional Engineering ethics and professional responsibilities. These are

1. Engineering ethics and responsibilities all through the project plan and fruition

2. Item sending off and showcasing ethics & responsibilities.

9.3 Apply Ethical Issues and Professional Responsibility

Designing is an engineering occupation that impacts individuals' lives. At the point when morals are not followed, catastrophes emerge; these fiascos not just have gigantic money-related costs and ecological outcomes, but they likewise much of the time bring about the deficiency of human existence.

Designing morals is exceptionally fundamental and applies to all architects. Our work is fundamentally worried about the work of electronic and mechanized frameworks in our everyday life. It extends to a part of designing that arrangement with the advancement of further developed hardware. Since our development is entering an innovative time that will impact all citizens, it is very essential for electrical engineers to embrace a code of designing morals. The Electrical Engineering Code of Ethics, given by IEEE, the biggest expert society for engineers working in the disciplines of electrical, hardware, PC designing, and interchanges, is a fundamental arrangement of rules for electrical engineers.

a. First of all, our project is highly associated with speakers. So, in case of some fault speaker may produce unwanted noise which can be harmful to the ear. And if the unwanted noise level increases more than 90 decibels it will damage hearing loss. So, keeping in that mind we can say that we will be careful while implementing speakers that won't produce much noise.

b. As far as lawfulness, this project isn't being completed in an unlawful way. It is firmly observed and that applies to our methods (what we did), our data, as well as our results and data, are also modified when it is needed. Our project will not make up any data, including extrapolating unreasonably from some of its results or doing anything which could be construed as trying to mislead anyone. For, research purposes, we had to go through a lot of papers and projects which are already mentioned in our reference part. We would not publish anything which will hamper someone else's work. Furthermore, we are aware of Bangladesh's laws and regulations and also be sure that we conform to them with our project.

c. Furthermore, as already mentioned that our topic is Active Noise Cancellation and it works by generating anti-waves of the main sound so it is visible that there is no use of any animal in our project which can be harmed. Moreover, ANC emits low levels of radiation when it is used even less than a cell phone which indicates that there is no potential harm to human or animal health. Though we haven't implied this experiment yet, literature reviews have gathered information that it will have no bad or harmful impact on human or animal health.

d. We will likewise give a short manual to the partnerships who buy our item to forestall any sort of injury to the client or harm to any property. Most importantly, the code advances straightforwardness and the evasion of harming people in general or the climate.

Last but not least, we are planning to advertise our system as an item industrially. We additionally plan to send off our thoughts at institutions, medical clinics, and offices sooner rather than later. There are a few expert obligations to follow as well. At first, we need to go through specific organizations, we need to get certain.

9.4 Conclusion

To guarantee the public's well-being and prosperity, we tried meeting each moral and expert commitment with the greatest possible level of exactness and consideration. Thus, as we continue on with the improvement of our items, later on, we resolve to keep up with the most noteworthy moral and expert norms and acknowledge liability regarding settling on choices that advantage individuals.

CHAPTER 10: CONCLUSION AND FUTURE WORK.

10.1 Project Summary/Conclusion

In conclusion, active noise cancellation relies on a simple idea that combines two sound waves with equal magnitude, but opposite phases which make silence at the conjunction point. Our goal was to test this possibility of reducing sound using sound's destructive interference and we were somewhat successful. Firstly, we made multiple possible approaches to implement this. Then we tested them on Matlab. Since processing signals was the main part of our project, the multiple design approaches we had were generally using different algorithms. Initially, we chose the LMS algorithm as our preferred algorithm for signal processing. But we faced a lot of difficulties due to low-cost hardware. So, finally, we went for a simpler approach. We also had multiple hardware design approaches based on the placement of our microphones and noise-canceling speakers. We figured out the best approach for this by trial and error method. Our proposed system had a target of denoising noise up to 10 dB but unfortunately, we could not achieve this fully due to budget constraints and low quality easily available equipment. With some advanced methods like better algorithms and equipment like faster DSP boards, we hope to achieve a much better result in the future. To complete this whole project we tried to maintain our Gantt chart as much as possible which we used to create at the beginning of each semester. Moreover, we maintained a logbook to record every activity which we've done throughout the semesters.

10.2 Future Work

As there are no limits to a better system, we can consider many things as future work. All of them can not be implemented in one single prototype.

I. Process multi-directional sound in real-time:

In this project, we only were only able to work with a single directional sound that was coming from our preferred sound source in our preferred direction. But in reality, the sound is much more complex and comes from many directions and from many different sources as well. So we plan to work on that.

I. Introduce advanced algorithms:

a. LMS algorithm:

As discussed earlier, using the LMS algorithm could be implemented for better noise reduction.

a. Deep-learning algorithm:

To address the nonlinear Active Noise Cancellation problems, a convolutional recurrent network could be trained so that it can make an assumption of real and imaginary sound spectrograms of the canceling sound from the reference microphone [25]. Using the Deep learning approach limitations of LMS algorithms could further get rid.

I.Use dedicated DSP boards:

We used Raspberry Pi as our main processing machine. Raspberry Pi was actually our best choice because of its availability, ease of use, and also due to our budget. But these PIs aren't built for fast digital signal processing purposes. Even that is why we could not perfectly meet our final expectations. So, we plan to do experiments and further improvements using DSP boards.

Since we were not building a project which is directly implementable in our daily life right now, rather we were trying to prove and implement a theoretical idea that can be implemented in many ways and in many sectors. So, we can discuss the future work from many perspectives. After some literature reviews, we thought of some future possibilities for our proven project and the prospects:

I.MRI ANC system:

Firstly, Active Noise Cancellation in Magnetic Resonance Imaging in short MRI machines is possible. In simple terms, MRI machines use extremely powerful magnets combined with electromagnetic coils, which produce radio waves to produce detailed images of organs, and tissues. Noise is created when magnetic fields are cycled off and on continuously. And also when other magnets exert opposite forces on each other. After some literature reviews, we found that noises are mostly periodic. So, with precise engineering and much more advanced algorithms, it may be possible to reduce the sound of MRI machines.

I.Infant Incubator ANC system:

Though infant incubator systems are mostly quiet but sometimes because of other medical types of equipment like IV pumps, fans, and warning sounds, noise levels vary from 45 dB to 60 dB.

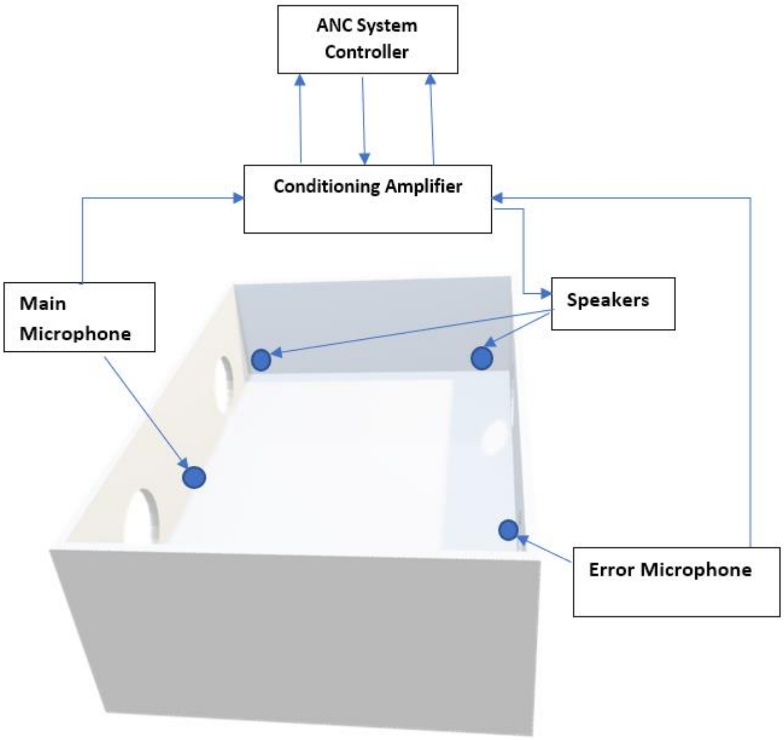

Figure 30: Example of ANC in Infant Incubators

I.ANC inside cars:

The main problem for most of the cars is engine noise which is so loud. We found a possibility of reducing this sound in the car interior through Active Noise Cancellation. This system inside cars would especially target low-frequency noises since passive sound cancellation does not block low-frequency noises. This system when implemented has to cancel a minimum of four noise sources which are engine noise, wind noise, tire noise, and HVAC noise.

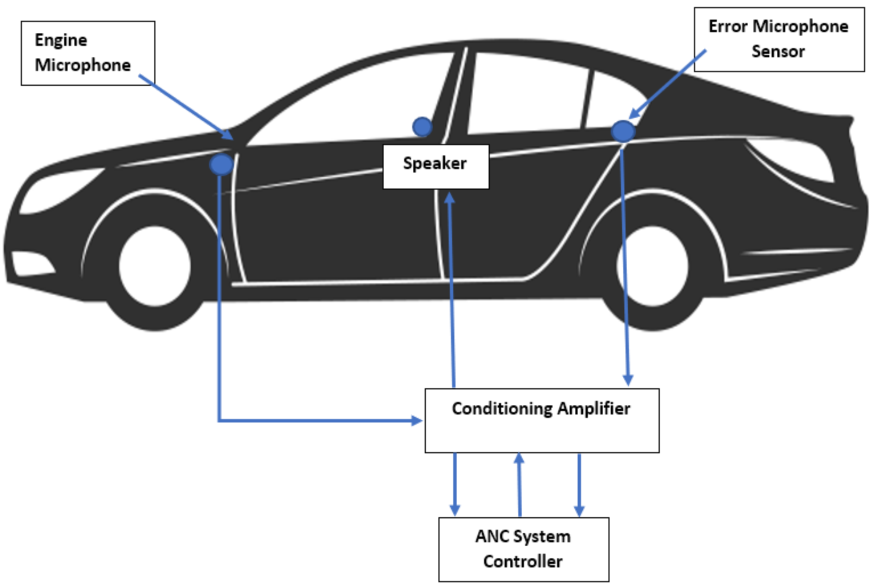

Figure 31: Example of ANC inside cars

CHAPTER 11: IDENTIFICATION OF COMPLEX ENGINEERING PROBLEMS AND ACTIVITIES.

11.1: Identify the Attribute of Complex Engineering Problem (EP)

Table 19: attributes of complex engineering problem(ep)

	Attributes	Put tick (√) as appropriate
P1	Depth of knowledge required	√
P2	Range of conflicting requirements	√
P3	Depth of analysis required	√
P4	Familiarity of issues	√
P5	Extent of applicable codes	√
P6	Extent of stakeholder involvement and needs	√
P7	Interdependence	√

11.2: Provide Reasoning How the Project Address Selected Attribute

Depth of knowledge: We gathered in-depth expertise from academics and published papers in order to accomplish our project. We can pursue a developed method with a created plan using both of these background studies.

Range of conflicting: We went through a process of satisfying many parameters in order to find the best design. One of the competing objectives was that certain designs be easy to install vs easy to use and maintain. Some concepts had a lot of potential but were quite expensive. Furthermore, several designs had problems when it came to choosing characteristics vs money.

Depth of analysis: We conducted extensive research on budget, user convenience, maintenance, efficiency, sustainability, and associated dangers in order to select the best design from a number of options. Finally, we discovered the finest design for our needs.

Familiarity of issues: Because Bangladesh is a developing country, the lack of such a well-designed system is prevalent. Because networking problems are frequent in Bangladesh, we were forced to use specific components to make the system operate.

Extent of applicable codes:

We have gathered all appropriate codes of specific components and services in order to complete the design in an orderly manner. We've gathered them all, attempting to adhere to all of their regulations and guidelines. There are also certain applications that have been tailored to our requirements.

Extent of stakeholder involvement and needs:

Project stakeholders are those individuals and institutions who are actively involved within the project and their involvement can also positively or negatively affect the results of project execution at the end. In our project we can divide our stakeholders into two types:

1. External Stakeholders: Since this project can be used universally, external stakeholders of this project can be customers like the general public who will buy ANC enabled appliances like air conditioner, ceiling fan, patients room of hospitals and students of the classrooms. Secondly, the suppliers who will provide us the equipment for implementing this project will also be the external stakeholder.

2. Internal Stakeholders: We are a team of four members along with two ATC members. We six people are the internal stakeholders for this project. Professional responsibility is such an idea that explains the duties of attorneys to behave in a professional manner, maintain the law, avoid any kind of interest from customers, and emphasize the requirements of clients ahead of our own interests. So, by keeping all these issues in mind we can say that our ANC system will not be overpriced. Secondly, we will develop it in such a way that it will not damage easily. Moreover, to make a successful project we will keep such things in our mind that:

1.Prioritizing the stakeholders

2.Understanding the stakeholders

3.Proper communication with the stakeholders

Overall, we can conclude that it is a collaborative effort. A project can be effective if communication and understanding are well defined, and all stakeholders can work together as a team.

11.3 Identify the Attribute of Complex Engineering Activities

Table 20: Attributes of Complex Engineering Activities (EA)

	Attributes	**Put tick (√) as appropriate**
A1	Range of resource	√
A2	Level of interaction	√
A3	Innovation	
A4	Consequences for society and the environment	√
A5	Familiarity	√

11.4 Provide Reasoning How the Project Address Selected Attribute

Range of resource: We are creating a prototype to fulfill our goals, and appropriate components must be considered. We purchased all of the components and, after extensive investigation, arrived at a budget-friendly conclusion. In addition, to discover the best design, we ran several analyses on various datasheets.

Level of interaction: To get the most support for our idea, we needed to communicate with a large number of experts. All of their proposals were benevolent in nature, urging people to take action at a steady pace.

Consequences for society and the environment: Because people want a better life, a system like this will give better services than before. Our system is made out of common approaches that will not make you feel uncomfortable while utilizing it. If something goes wrong, compensation is available on a regular basis.

Familiarity: Since a large portion of individuals know nothing about the danger of noise contamination causing them to notice the issue is vital. As it makes a great deal of issues it is vital to set up the framework so that it diminishes noise levels and gives an agreeable environment. Moreover, as our framework is upgradeable with less expense along these lines, greatest solace is guaranteed for the customer later on.

References

[1] M. T. Rahman, "researchgate," 26 october 2021. [Online]. Available: https://www.researchgate.net/publication/355586718_Noise_control_and_enforcement_of_Statutory_Laws_in_Bangladesh#:~:text=The%20permitted%20noise%20level%20for,and%2045%20decibels%20at%20night.&text=rules%20do%20not%20apply%20to%20religious%20events%2C%20M. [Accessed 12 april 2022].

[2] B. M. Fetterman, "Noise exposure is becoming 'the new secondhand smoke'," the washington post, washington, 2018.

[3] C. P. Ortega, "Effects of noise pollution on birds: A brief review of our knowledge - Efectos de la Polución Sonora en Aves: una Breve Revisión de Nuestro Conocimiento," *Ornithological Monographs,* vol. 74, no. 1, pp. 6-22 (17 pages), 2012.

[4] "After air, noise pollution makes Dhaka dangerous," New Age, 30 Mar 2022. [Online]. Available: https://www.newagebd.net/article/166678/after-air-noise-pollution-makes-dhaka-dangerous. [Accessed 13 April 2022].

[5] N. Akter, B. Banu and S. H. Chowdhury, "Insights on Driver's Behavior Regarding Hydraulic Horn use in Transport Vehicles of Bangladesh," *J Environ Sci Public Health,* vol. 6, pp. 069-081, 02 2022.

[6] D. Guicking, Patents on Active Control of Sound and Vibration, England: Routledge, 2009.

[7] M. B. Y. C. and Muhammad Aqib Shah', "Design and Simulation using MATLAB/Simulink," *2016 International Conference on Condition Monitoring and Diagnosis (CMD),* pp. 465-468, 2016.

[8] P. N. Samarasinghe, "Recent Advances in Active Noise Control Inside Automobile Cabins: Toward quieter cars," *IEEE Signal Processing Magazine* , vol. 33, no. 6, pp. 61 - 73, 2016.

[9] L. B. Woon-Seng Gan, DongYuan Shi, Masaharu Nishimura and Stephen Elliott, "Ten questions concerning active noise control in the built environment.," *Building and Environment,* vol. 600, p. 107928, 2021.

[10] K. . S. M. and Dennis R. Morgan, "Active noise control: a tutorial review," *Proceedings of the IEEE* , vol. 87, no. 6, pp. 943-973, 1999.

[11] A. I. T. and Waleed H. Abdulla, "Active noise control in three dimensions," *IEEE Transactions on Control Systems Technology*, vol. 22, no. 6, pp. 2150 - 2159, 2014.

[12] K. S. M. Y.-R. C. Cheng-Yuan Chang and Chien-Wen Lai, "Development and evaluation of light-weight active noise cancellation earphones," *Applied Sciences,* vol. 8, no. 7, p. 1178, 2018.

[13] Y. J. J. L. A. Z. Xiangdong Zhang and Jia Ran, "Active Noise Control System Based on the Improved Equation Error Model," *Multidisciplinary Digital Publishing Institute*, vol. 3, no. 2, pp. 354-363, 2021.

[14] M. B. Y. C. M. A. S. Y. Z. S. Wang and M. Zhang, "Design and simulation using MATLAB/Simulink on active noise control system for power transformer," in *International Conference on Condition Monitoring and Diagnosis (CMD)*, Xi'an, 2016.

[15] S.-W. F. T. N. S. and C. Averty, "Active Noise Cancellation Headset," in *IEEE International Symposium on Circuits and Systems*, Singapore, 2005.

[16] D. A. R. N. K. and D. Effroymson, "Noise pollution in Dhaka," in *Work for a better Bangladesh*, Dhaka, 2004.

[17] M. R. H. B. and Sanjib C. Chowdhury, "On the impacts of noise pollution in Dhaka," in *17th International Congress on Sound and Vibration* , Egypt, 2010.

[18] "ISO," [Online]. Available: https://www.iso.org/obp/ui/#iso:std:iso:3740:ed-3:v1:en. [Accessed 12 8 2021].

[19] D. Fink, "A new definition of noise: noise is unwanted and/or harmful sound. Noise is the new," 3 February 2020. [Online]. Available: https://doi.org/10.1121/2.0001186.

[20] K. S. K. K. and Gan WS, "Active noise control: Open problems and challenges," in *International Conference on Green Circuits and Systems*, Shanghai, 2010.

[21] N. P. P. N. P. S. Harpale V and Khurge D., "Implementation of Active Noise Cancellation for Small Confined Spaces," *International Journal of Recent,* vol. 8, no. 6, pp. 2277-3878, 2020.

[22] Hella KGaA Hueck & Co., [Online]. Available: https://www.hella.com/microsite-electronics/en/Electronic-horn-670.html. [Accessed 2020].

[23] "The Centers for Disease Control and Prevention," [Online]. Available: https://www.cdc.gov/nceh/hearing_loss/what_noises_cause_hearing_loss.html. [Accessed 2020].

[24] M. A. . A. . T. and Lwin CH., "Active noise cancellation in audio signal processing," *International Research Journal of Engineering and Technology (IRJET)* , vol. 3, no. 11, pp. 2395-0072, 2016.

[25] Z. . H. and DeLiang Wang, "A Deep Learning Approach to Active Noise Control.," in *INTERSPEECH* , Shanghai, 2020.

[26] L. B. G. W. and Shi D, Nishimura M, Elliott S, "Ten questions concerning active noise control in the built environment," *Building and Environment*, vol. 200, no. 1, p. 107928, 2021.

[27] K. S. M. and Dennis R. Morgan., "Active Noise Control: A Tutorial Review," *Proceedings of the IEEE*, vol. 87, no. 6, pp. 943-973, 1999.

APPENDIX

Table 21: logbook of team member and faculty

Final Year Design Project (P) Spring 2022			
Student Details	***Name & ID***	***Email address***	***Phone***
Member 1	Fabliha Rahman (17221023)	fabliha.rahman@g.bracu.ac.bd	01559465531
Member 2	Kallol Sarkar Rakesh (18121010)	kallol.sarkar.rakesh@g.bracu.ac.bd	01765904316
Member 3	Jarin Tasin Mou (18121078)	jarin.tasnin.mou@g.bracu.ac.bd	01837909267
Member 4	Mohimin Al Bhuiyan (18121100)	mohimin.al.bhuiyan@g.bracu.ac.bd	01613866188

ATC Details:		
ATC 8	**Name**	**Email Address**
Chair	S M Rafi-Ul-Islam	rafiul.islam@bracu.ac.bd
Member 1	Tasfin Mahmud	tasfin.mahmud@bracu.ac.bd

Table 22: work summary of eee400p

Date/Time	Attendee	Summary of Meeting Minutes	Responsible	Comment by ATC
Jun 10, 2021	Each member	Project Topic Selection	Each member	
Jun 20, 2021	Each member	Topic Discussion	Each member	
Jul 5, 2021	Each member	Meeting with ATC	Each member	
Jul 7, 2021	Each member	Topic Finalization	Each member	

Jul 8,2021	Each member	Progress Presentation 1	Each member	Should mention target audience
Jul 9,2021	1.Rakesh 2.Mou	Paper Collection	Each member	
Aug 15,2021	1.Rakesh 2.Bishal	Simulation	Each member	
Aug 28,2021	1.Rakesh 2.Bishal	Testing	Each member	
Sep 05,2021	Each member	Finalization	Each member	
Sep 9, 2021	Each member	Meeting with the ATC to discuss the proposal letter and presentation		Members of the ATC proposed that we should add a little more.
Sep 16,2021	1.Fabliha 2.Mou	Project Report Writing	Each member	The first draft of the proposal letter should be completed.

Table 23: work summary of eee400d

Date	**Attendee**	**Summary of Meeting Minutes**	**Responsible**	**Comment by ATC**
Oct 14, 2021	1. Rakesh 2. Mohimin 3. Mou 4. Fabliha	Reading Research papers	Finding information	
Oct 19, 2021	Each member	Meeting with ATC		Completion of proposal letter's first drift.

Oct 21, 2021	Each member	Group discussion- Choosing multiple designs (preliminary)	Finding design approaches	
Oct 25,2021	Each member	Simulation	Task 1-Rakesh, Mohimin Task2-Mou, Fabliha	
Nov 1, 2021	Each member	Group discussion		
Nov 3, 2021	Each member	Data analysis and tool selection	Task1-Mou, Fabliha Task 2-Rakesh, Mohimin	
Nov 6, 2021	Each member	Preparing circuit design(Different approaches)	Everyone	
Nov 9, 2021	Each member	Progress presentation	Everyone	
Nov 13, 2021	Each member	Group discussion	Everyone	
Nov 18, 2021	Each member	Identifying the appropriate design solution	Design:1-Rakesh, Mou Design 2-Mohimin, Fabliha	
Nov 26, 2021	Each member	Validation and tested the cases	Everyone	
Dec 02, 2021	Each member	Identifying ethical consideration and prof responsibilities Project management	Design 1-Rakesh, Mou Design 2-Mohimin, Fabliha	

Dec 10, 2021	Each member	Finalizing design	Everyone	
Dec 23, 2021	Each member	Preparing final project presentation & submission	Everyone	
Jan 4, 2022	Each member	Meeting with ATC	Everyone	
Jan 6, 2021	Each member	Final presentation FYDP(D)	Everyone	
Jan 10, 2021	Each member	Final report submission	Everyone	

Table 24: work summary of eee400c

Date/Time	Attendee	Summary of Meeting Minutes	Responsible	Comment by ATC
Jan 31,2022	1.Mou 2.Fabliha 3.Rakesh 4.Bishal	Meeting to discuss the prototype on an ad hoc basis	Each member	
Feb 05,2022	Each member	Meeting to discuss the prototype on an ad hoc basis	Each member	
Feb12, 2022	Each member	Meeting to discuss the prototype on an ad hoc basis	Each member	
Feb 20,2022	Each member	Meeting to discuss the prototype on an ad hoc basis	Each member	
Feb 26, 2022	Each member	Meeting to discuss the prototype on an ad hoc basis	Each member	The ATC panel advised that hardware development should be started

				as soon as possible.
Mar 01,2022	Each member	Weekly meeting for hardware setup Testing the basic codes and soundproof box	Each member	
Mar 03, 2022	Each member	ATC Meeting regarding project progress	Each member	ATC required a concise, detailed report on the project's status.
Mar 07,2022	Each member	Weekly meeting for hardware setup Re testing different noise and noted results	Each member	
Mar 17,2022		Weekly meeting regarding software	Each member	
Mar 21,2022		Weekly hardware and software meetings, as well as a prepared presentation slide	Each member	
Mar 24, 2022		presentation	Each member	
Mar 30,2022		ATC Meeting about project progress	Each member	ATC suggested that we present the proposal at the next meeting, and they also told us to get started on the report.
Apr 05,2022		Weekly meeting regarding hardware Putting the pieces of the code together and getting the prototype up and running	Each member	

Apr 07, 2022		ATC meeting With the help of audacity, the Raspberry Pi installation noise cancellation was presented.	Each member	ATC panel wanted a fully functional prototype.
Apr 09, 2022		Weekly hardware meeting; begin work on the report Replacing the g-tone with motor noise and implementing the display	Each member	
Apr 15, 2022		Reporting meeting every week Examining the status of the report authoring	Each member	
Apr 20,2022		The ATC had a meeting to discuss the project's development.	Each member	The ATC panel suggested a few minor revisions that were required for the final report.
Apr 24, 2022		Hardware-related weekly meetings	Each member	
Apr 28,2022		Final & presentation submission	Each member	