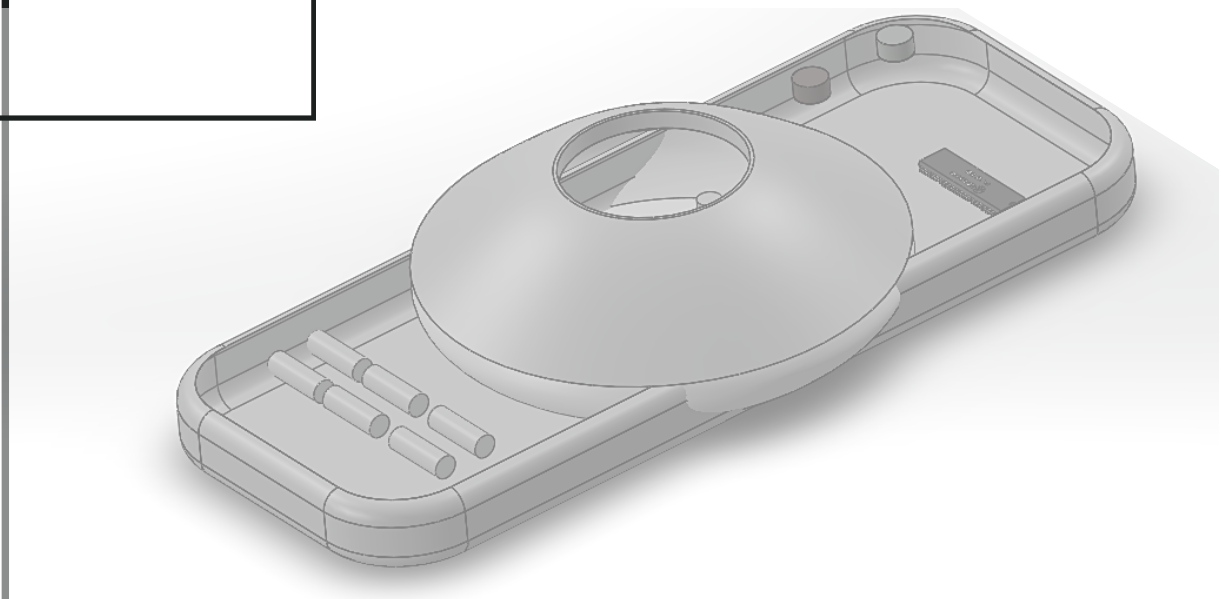
TEAM 18



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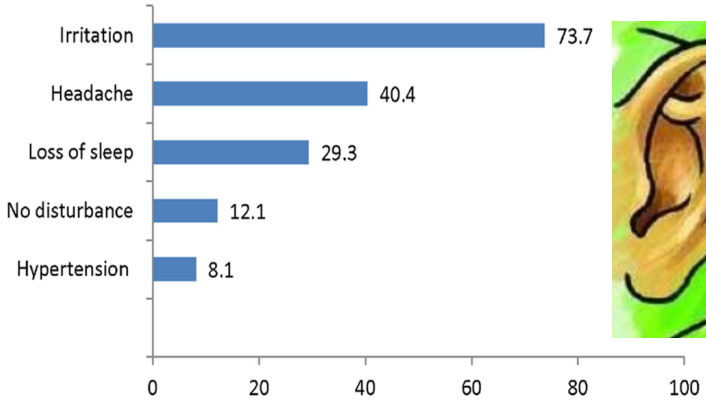
Introduction

Noise pollution is a growing problem in today's world as urbanization and industrialization continue to increase. It affects the quality of life of millions of people, making it difficult for them to concentrate on work, relax, or even sleep. The sources of noise pollution are numerous, ranging from traffic and construction sites to the sounds of people talking and moving in public spaces. It can be particularly challenging for those living in urban areas to find a moment of peace and quiet amidst the constant noise. To address this problem, we propose a portable room noise-cancelation device that can be used on any surface. This report outlines the design and implementation of this device, including its features, benefits, and potential impact on reducing noise pollution in urban environments.

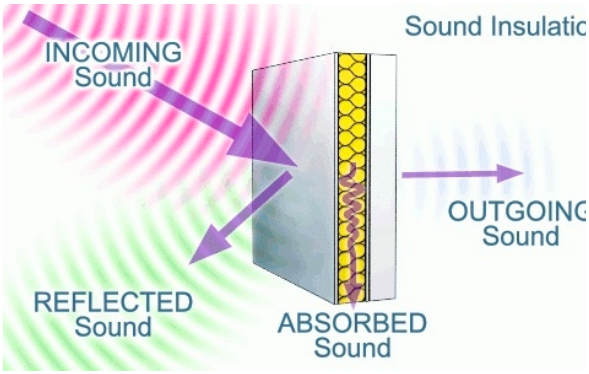


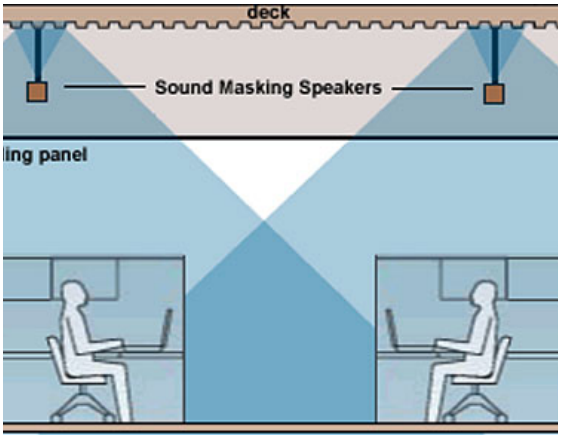
Problem Overview

Noise pollution is a pervasive problem in modern society, impacting the quality of life for millions of people. The constant noise from traffic, construction sites, and other sources can be disruptive, causing stress, sleep disturbances, and other health problems. While noise-canceling headphones have been available for some time, they are not always effective in eliminating noise in a room setting. To address this issue, we propose a noise cancellation device that measures the ambient noise in a room with a microphone and produces exact opposite vibrations to cancel out the noise. This device offers a portable and effective solution for individuals who need relief from noise pollution in their homes or workspace. In this report, we will outline the design and development of this device, including its key features, benefits, and potential impact on reducing noise pollution in indoor environments.

Current Solutions

One of the most common solutions for canceling outside noise is sound insulation. This involves adding a layer of material to walls, ceilings, and floors to reduce the amount of noise that can pass through. Materials commonly used for sound insulation include fibreglass, foam, and cellulose, which can be installed as batts, blown-in insulation, or panels. While sound insulation can be effective at reducing noise, it is only sometimes practical or affordable, especially in existing buildings.





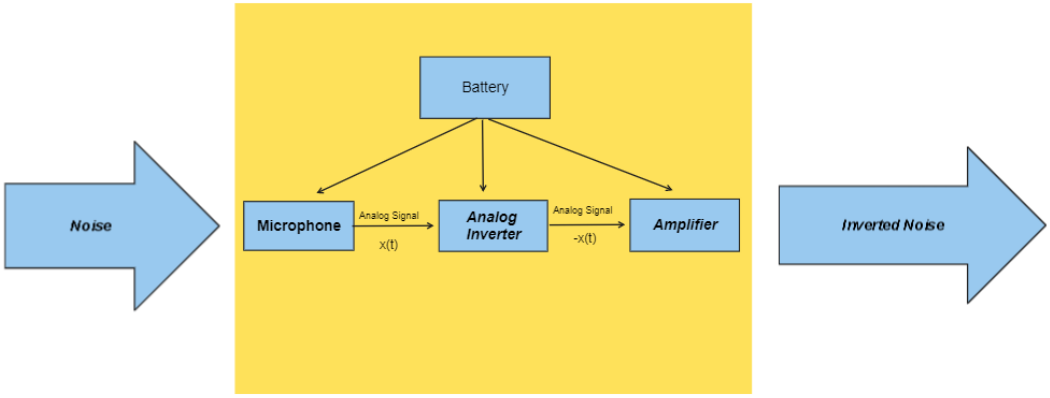
Another solution for canceling outside noise is the use of sound-absorbing materials. These materials are designed to absorb sound waves, reducing the amount of noise that can reflect back into a room. Sound-absorbing materials include acoustic ceiling tiles, carpets, curtains, and wall panels. These materials are often used in spaces where noise reduction is essential, such as recording studios, theatres, and conference rooms.

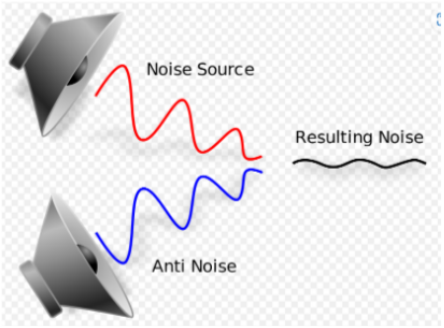
Active noise-canceling technology is another solution that uses microphones to pick up external sounds, which are then processed and used to generate a sound wave that is the exact opposite of the unwanted noise. These cancel each other out, effectively reducing the amount of noise that can be heard. Active noise-canceling technology is commonly used in headphones and earbuds but cannot cancel noise in open spaces.
Finally, sound masking is another solution, adding low-level background noise to mask unwanted noise. These solutions, along with sound insulation and sound-absorbing materials, can effectively cancel out outside noise in indoor spaces.

Product Overview

PRINCIPLE:

The technology used in our product is called **active noise-cancelation** or **ANC**, and it has been used in headphones and earbuds for several years. However, we have taken this technology to the next level by introducing it to indoor spaces to offer a practical solution to people who live or work in noisy environments. Our innovative product includes a contact microphone that is attached to each window. This microphone measures the vibrations of the unwanted noise that hits the window surface, such as traffic or construction noise. The microphone then sends this information to a processor that analyzes the sound waves and generates a precisely matched, opposite sound wave.



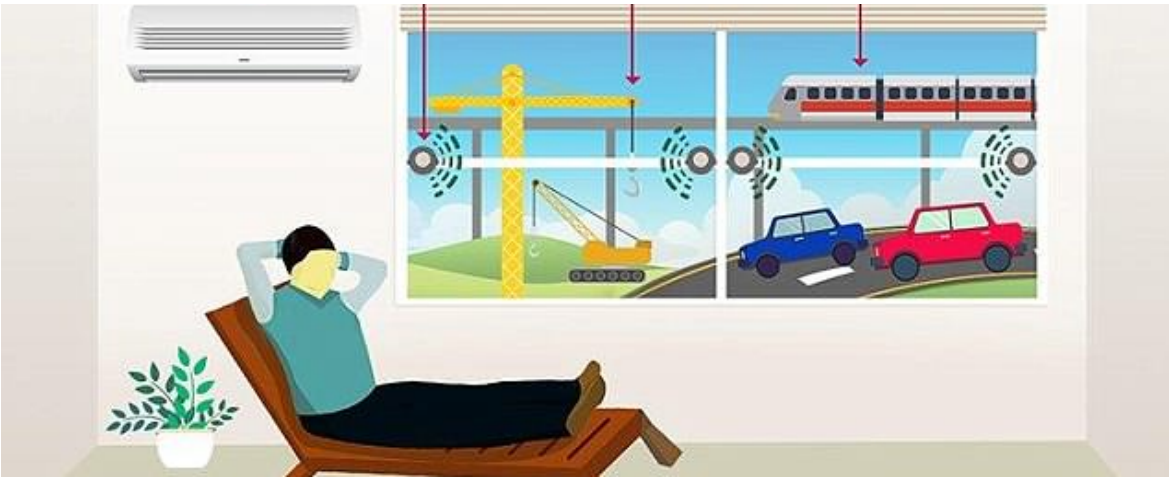


This generated sound wave is then transmitted by a speaker on the window, and it cancels out the unwanted noise by effectively neutralizing it. When a sound wave is superimposed with another wave with a phase difference of 180 degrees, the resulting wave is nullified or cancelled out. This process happens in real-time, and the result is a peaceful and comfortable environment for the user. The device will be easy to install and operate. It will require minimal power consumption, and it can be customized to suit different types of environments and noise levels. Additionally, the device is designed to be unobtrusive and does not interfere with the natural lighting or views from the window.

Product Overview

Product Market Fit:

Our target audience includes individuals and organizations. Operate in noisy environments like construction sites, airports, and busy urban areas. Additionally, our product can be used by individuals who work or study from home and are looking for a quieter environment. By understanding the specific needs of our target audience, we can tailor our product to meet those needs and effectively address their pain points. Furthermore, our product can be tailored to meet the specific needs of different industries. For example, healthcare facilities require a quiet and comfortable environment to promote healing and recovery. Our product can be used in waiting rooms, recovery rooms, and other hospital areas to create a calm and peaceful environment for patients and healthcare professionals. Similarly, educational institutions such as schools and universities require a quiet environment for effective learning. Our product can be used in classrooms, libraries, and study areas to create a distraction-free environment that promotes learning and concentration.



Unique Selling Point:

Unlike the products existing in the market, in our product, we have considered the most minimalistic design for noise cancellation using superposition, which makes the device very cost-effective and affordable. According to the target audience, we can also bring new advancements like filtering only noise that is undesired and allowing pleasant noise from nature.

Product Overview

Product Use Cases:

- Meeting rooms: It can help to reduce background noise and make it easier for attendees to hear each other during important discussions.
- Classrooms: Reducing noise distractions can help students to focus on their studies and improve their learning outcomes.
- High Traffic areas: It can help to reduce the impact of noises coming from roads due to heavy traffic.

- Libraries: By reducing ambient noise, it can create a quieter study environment.
- Hospitals: Reducing noise levels can improve the quality of sleep and rest for patients, which can aid in their recovery.
- Open-plan offices: Iactions and improve productivity in shared workspaces.
- Home offices: By reducing noise distractions, it can help remote workers to stay focused and productive.

Components

Contact Microphone:

By design, a contact microphone picks up audio vibrations in a room through contact with solid objects. Its main advantage is that it does not require a (pin) hole in the wall or floor, which improves security. Unlike a regular microphone, a 10-watt contact microphone is almost entirely insensitive to air vibrations.

Price: 300 rupees range

Speaker Exciter:

A speaker exciter is a device that converts electrical signals into mechanical vibrations to produce sound waves. It typically consists of a voice coil, a magnet, and a diaphragm or cone. Depending on the design, a speaker exciter can be capable of producing up to 10 watts of power, which can be sufficient for many applications, such as portable devices, automotive audio systems, and home theatres.

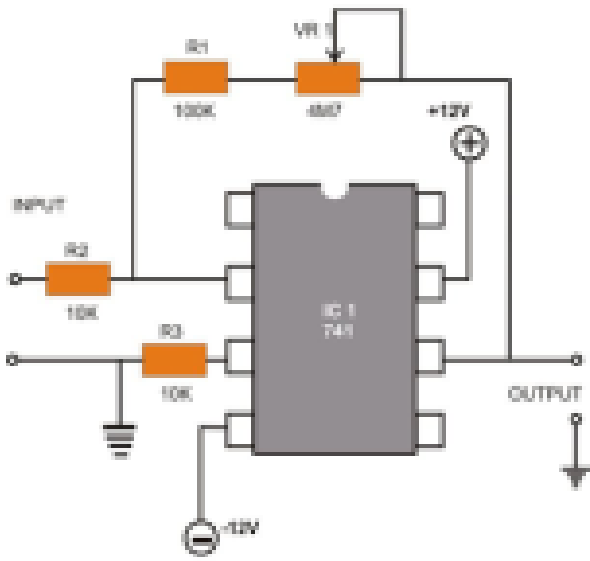
Price Range: 400 rupees

Battery:

Calculations to determine the cost and battery requirements for powering a device for 12 hours at 20W. The cost is 3000 rupees for 50 rechargeable batteries. To meet the energy requirement of 240Wh at 12V, a battery with a 20Ah capacity is needed. This equates to approximately 12 batteries to ensure sufficient power for the entire 12-hour period.

Price range: 50 rupees each *12= 600

Components



Inverter OP-AMP:

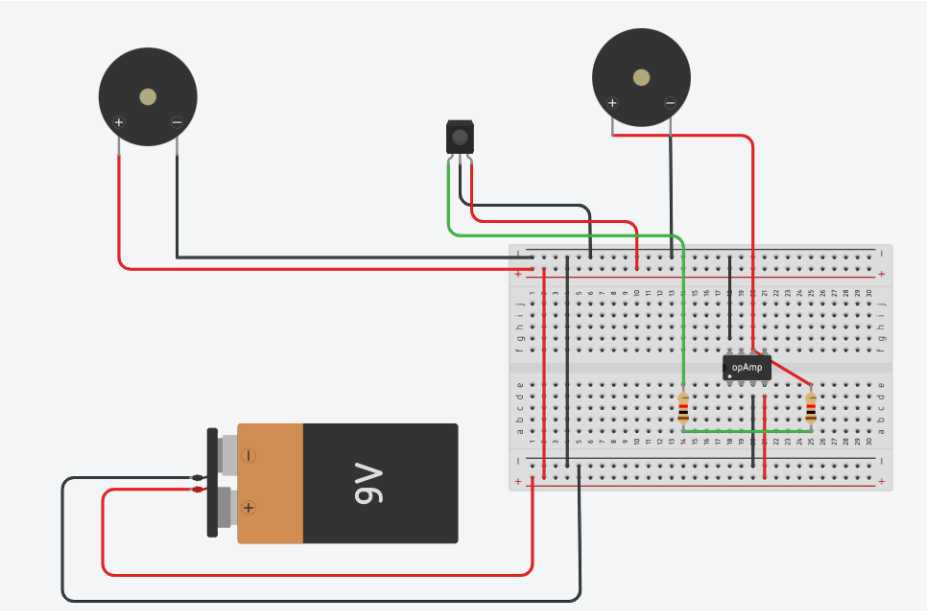
The 741 operational amplifier, also known as an op-amp, is a versatile and widely-used integrated circuit designed for use in many electronic circuits. It has a high gain and provides a stable output that can be used for various signal-processing applications like audio amplifiers, voltage regulators, and many other electronic circuits.
It can be configured in different ways to amplify or attenuate and perform mathematical operations on signals.

Other Components:

Hardware casing = 60 rupees
Suction cup = 60 rupees
Push button = 5 rupees

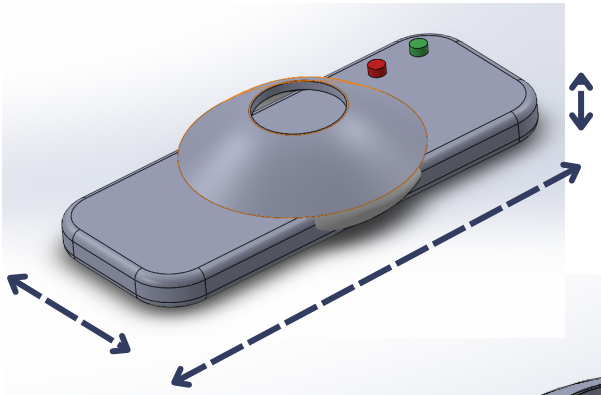
Circuit Diagram:

The circuit diagram in rough is shown below; we can see the design is very simplistic with minimum elements: speaker, microphone, battery, and PCB.

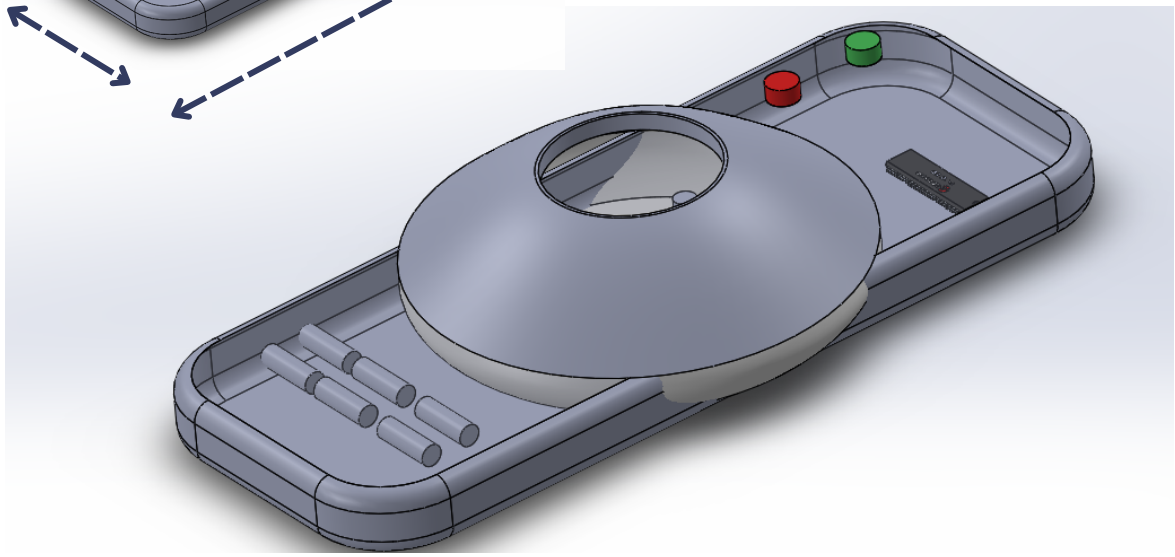


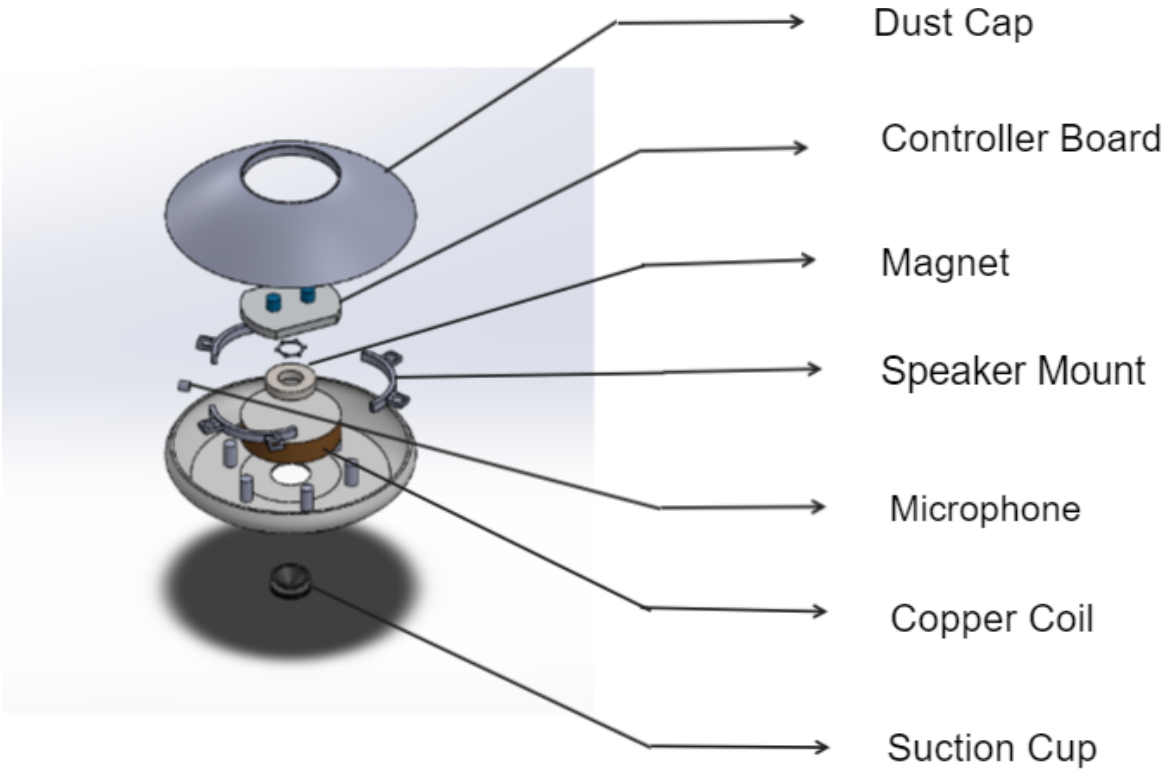
Components

Product Dimensions:



- Length 20cm
- Width 8cm
- Height 5cm





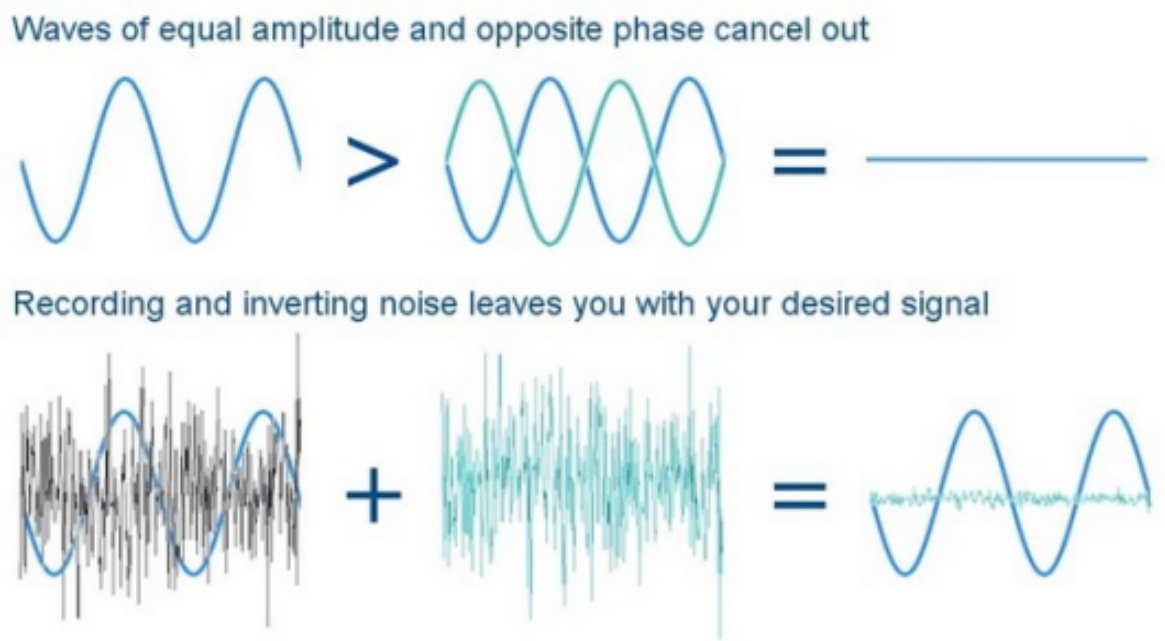
The main principle of our device is the superposition principle.

The superposition principle:
When two or more sound waves superimpose at a point, the resulting amplitude is given by the interference between all the waves.

$$A_{res} = \sqrt{A_1^2 + A_2^2 + 2A_1A_2\cos(\emptyset)}$$

Now we are generating A2 such that it is out of phase with A1 i.e. x(t) is out of phase with x(t). When these two superimpose, we get Ares=0.

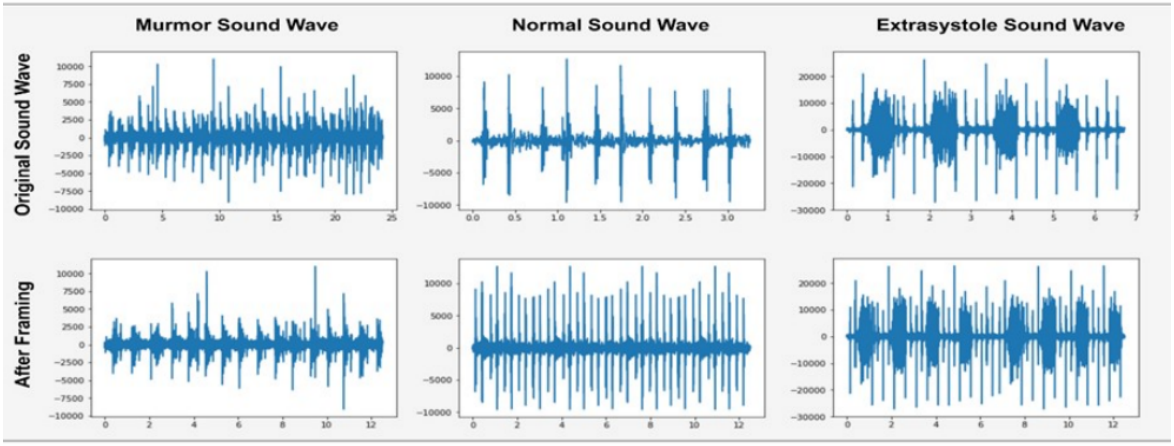
The noise from a distant source can be modelled as a plane wave at the window, and the window vibrates to that plane wave. The vibration pattern of air in front of the window is a combination of point sources mainly concentrated in the centre as the window is restrained at the edges and freer at the centre. As our speaker also exits at the location of maximum noise, we cancel out that noise. The mechanisms are briefly shown in the following image and subsequent pages.



Mechanism

The audible frequency range for humans is typically considered to be between 20 Hz and 20,000 Hz (20 kHz). This means that humans can generally hear sounds within this range of frequencies.

Hence we first use a Bandpass filter to filter out only the noise input that is within range and can be heard by humans, and the rest is ignored.

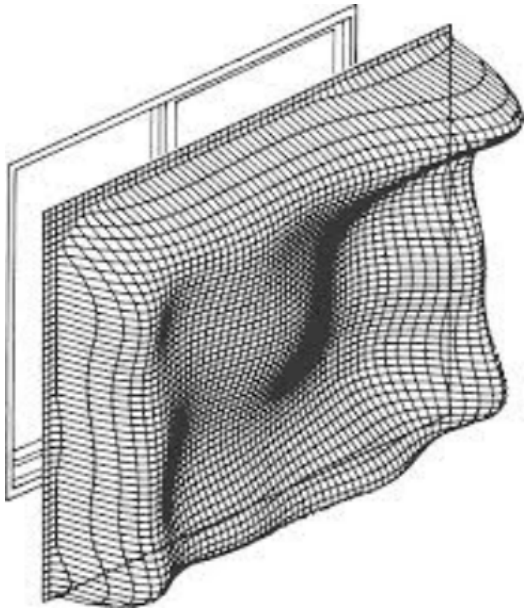


The filtered noise is framed into separate individual frequencies so each can be processed separately. The resultant noise cancellation is a linear addition of all individual waves generated.

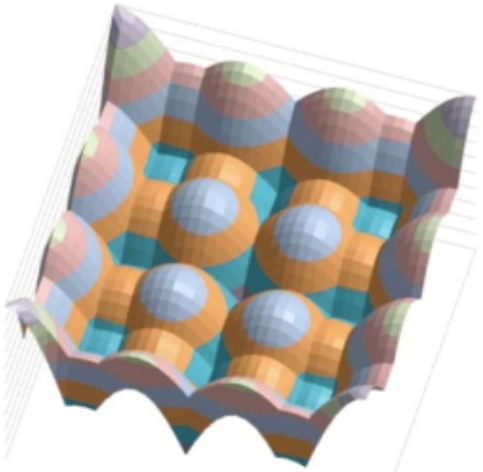
Room Dynamics

In a closed room, any window or opening is much more permeable to noise than solid walls. Hence compared to the low ambient noise levels in the room, the window behaves as a group of point sources of higher-intensity noise.

We model the noise intensity map in the room using the inverse square law to permit computations.



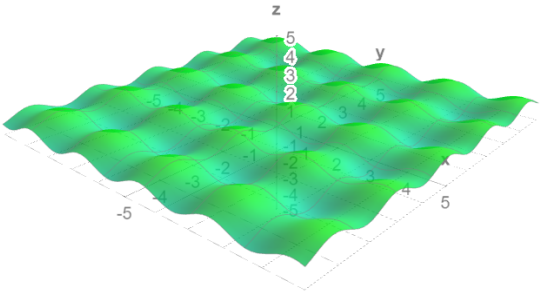
Room Dynamics



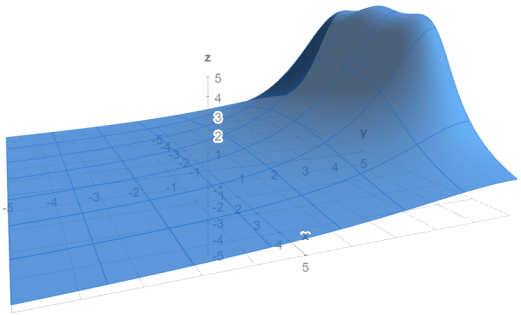
Ambient noise in the room results from each point on the boundary of the room behaving as an individual point source.

This leads to a uniform planar noise within the room that averages to be the same at any point within the room.

Now we model a 5m X 5m room with a window susceptible to both point noise and ambient noise present in the room. Both noises are shown individually below.

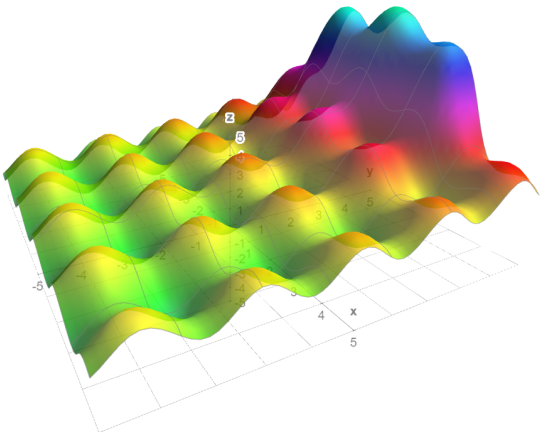


Ambient Noise

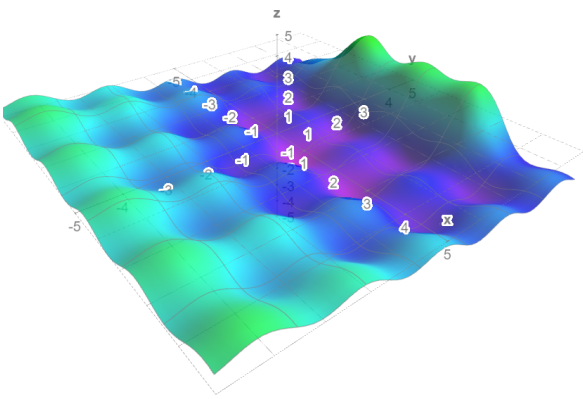


Noise from Window

After considering the resultant noise within the room, we are able to create inverse sound waves that cancel the noise in the room, creating an effective silent zone as shown within the room.



Noise field in room



Noise field after noise Cancellation

ANNEXURE

Cost Analysis

COMPONENTS	PRICE	ITEM REQUIRED	TOTAL
Contact Microphone	300	1	300
Speaker Exciter	400	1	400
Battery	50	12	600
Invertor Opamp 741	12	1	12
Suction Cup	60	1	60
Hardware Casing	60	1	60
Other Components	100	-	100
		Approximate Cost	1500

The product takes around 1500 rupees to build, which is quite competitively priced and solidly justifies its use case.

Materials

There are multiple materials available for each component. We choose each considering cost and the optimal tradeoff in specifications.

Suction cup Material:

chemical name	NBR Nitrile butadiene rubber	NR Natural rubber	SIR Silicone rubber	FKM (FPM) Fluoro rubber	PUR Poly-urethane	EPDM Ethylene propylene diene monomer rubber	CR Chloroprene rubber
trade name	NBR	natural rubber	silicone	Viton	PUR	sponge rubber	Neopren
hardness (Shore-A)	35 to 80	35 to 80	15 to 80	65	65	15	38
temperature range	-10 to 80 °C	-20 to 80 °C	-30 to 200 °C	-10 to 200 °C	-30 to 80 °C	-20 to 100 °C	10 to 80 °C
abrasion resistance	+	+	+	+-	++	+-	+
dimensional stability	+	++	+	++	+-	+	+
ozone resistance	+-	+	++	++	++	++	+-
oil resistance	++	+-	-	++	++	+-	+-
fuel resistance	+	-	-	++	+	-	-
solvent resistance	+	+-	+	++	+-	+	+
acid resistance	+-	+	+-	++	+-	++	+
suitable for food	-	-	++	-	-	-	-
weather resistance	+	+	++	++	++	++	+
main applications	universal	universal	all, with restriction	universal	universal	universal	universal

We use Polyurethane as it is suitable for workpieces with a rough surface and endure high stress/tension force.

Hardware Casing Material:

The versatility of MDF wood accomplishes three goals:
1) producing great sound in solid construction
2) speakers designed with beautiful finishes
3) a lower cost in construction that saves you money.

Magnet Material:

Neodymium magnet is commonly used as a permanent magnet in speakers because of their high magnetization and demagnetization and small-size—electromagnet, which will deform the cone more and produce more sound.

References

- Suction Cup material : https://eurotech-vacuum-technologies.com/suction-cup-material-list/
- Hardware Casing material: https://blog.fluance.com/mdf-wood-speaker-cabinets/#:~:text=MDF%20wood%20allows%20for%20the,construction%20that%20saves%20you%20money.
- Magnet Material: https://www.chem.tamu.edu/rgroup/marcetta/chem362/HW/2017%20Student%20Posters/Neodymium%20Magnet%20in%20a%20Speaker.pdf
- https://patents.google.com/patent/US20110274283A1/en
- https://www.researchgate.net/publication/333907347_Multichannel_Active_Noise_Control_in_Open_Spaces
- Silentium: https://www.silentium.com/