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AN EFFICIENT DEVICE TO CONTROL THE OCCURRENCE OF NOISE-INDUCED HEARING LOSS IN THE ARMED FORCES

VinothKumar G [# 1], Simreet Behera *[2] , T.Venkatakrishnan *[3] , Ashish Nawani*[4] , Sripriya*[5]
[#1]*Assistant Professor, Department of Electronics and Communication Engineering, SRMIST Ramapuram*
[*2,3,4,5] *IV[th] Year B. Tech Students, Department of Electronics and Communication Engineering, SRMIST Ramapuram*
gvinothece@gmail.com
simreetbehera18@gmail.com

***Abstract*— Every day, we experience sounds in our environment, such as the sounds from television and radio, household appliances, and traffic. Normally, these sounds are at safe levels that don't damage our hearing. But sounds can be harmful when they are too loud, even for a brief time, or when they are both loud and long-lasting. These sounds can damage sensitive structures in the inner ear and cause noise-induced hearing loss (NIHL). NIHL can be prevented by avoiding excessive noise and using hearing protection such as earplugs and earmuffs. The excessive noise can be screened using two methods, active and passive. The passive method will suppress the whole noise. We are going to implement an active method in which the loud sounds will not be suppressed fully, but it will be reduced so that the person is aware of the sounds around him/her.**
This device is mainly developed for the Armed Forces, where the exposure to loud sounds will be very high.

***Index Terms*— ADC (Analog-to-Digital Converter), BPF (Band Pass Filter), BRF (Band Reject Filter), CDC (Centers for Disease Control and Prevention), DAC (Digital-to-Analog Converter), NIHL (Noise-induced hearing loss)**

I. INTRODUCTION

This paper discusses in detail about the measures that can be used to prevent noise-induced hearing loss. This can occur due to a number of factors, like excessive headphone usage, or continued exposure to loud sounds. This paper mainly discusses prevention methods for people who work in the Armed Forces. This is because these people are generally the most exposed to loud sounds like grenades and bomb explosions, flight landings and take-offs, etc. which are way above the normal hearing level.

Prevention devices for this symptom are crucial because the damage is irreversible. There have been attempts to create prevention devices, but passive methods have been implemented. Due to this, the loud sounds are fully muted which can be problematic for people working in the Armed Forces. If the active method is used, then the sound will be reduced, and not fully muted, which is exactly what is needed for this specific purpose.

Designing this kind of device will increase awareness about the 2nd most common hearing deficit and also help in the prevention of this irreversible damage. This device will be very handy to use in emergency situations as well as for normal purposes like for headphone users.

II. PROBLEMS CAUSED BY NIHL

Our hearing is 10 times more sensitive than eyesight. [1] This is all the more reason to be aware of the problems caused by NIHL.

Every day we experience a range of sounds in our environment, like sounds from the TV, household appliances, traffic, construction work, etc. Usually most of the sounds are at a safe level but there are some which go beyond the normal range of hearing. We don't pay much heed to them but they can cause permanent damage if not treated in the primary stage because the effect can be long-lasting and irreversible. Moreover, these sounds can damage the sensitive structure of our ear, causing NIHL.

According to CDC, in the year 2011-12, about 40 million Americans aged 20-69 years old have NIHL. [1]

The first symptom of NIHL may be difficulty hearing a conversation against a noisy background. In addition to hearing loss, other symptoms include tinnitus, physiological response to cochlear overstimulation and it affects the quality of life.

Tinnitus is described as hearing sound when an external sound is not present. It is the largest single category for disability claims in the military, with hearing loss a close second.

One of the physiological response includes broken and "bent" hairs of the hair-cells; damaged hair-cells degeneration. In humans, dead hair-cells are never replaced; the resulting hearing loss is thus irreparable.

The quality of life deteriorates because it hinders everyday activities. Challenging social interactions can negatively lead to decreased self-esteem, shame, and fear. Such psychosocial

states, regardless of age, can lead to social isolation, which is known to negatively impact one's overall health and well-being.

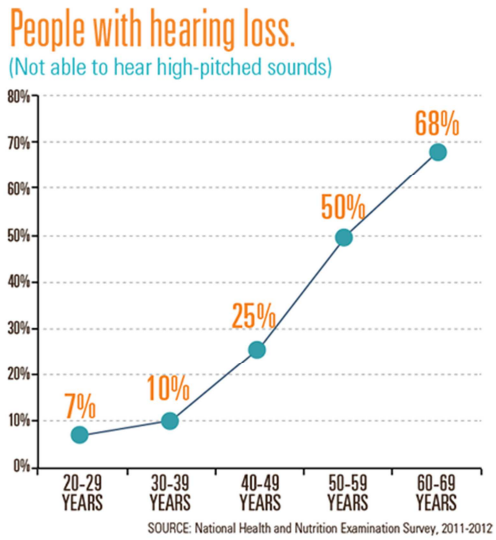

Fig. 1. Statistics for people with hearing loss

III. Previous Research Work and Solutions

Several types of research have been done to study the impact of noise on human ear earlier. But most of them are only with respect to occupational noise exposure like factories or industries. For example, Occupational Safety and Health Administration of United States do not allow exposure to 90db for 8hours per day for those working 5days per week. While most of the countries have set limits only for occupational exposure, a few European countries have imposed limits for personal music players. France has banned personal listening devices that produce sound greater than 100db and Portugal have proposed to limit at 89db and give a warning from the device itself on prolonged use [2]. But a proper solution for the problem is not yet found or implemented.

There have been many attempts to design a device that cancels noise out. Some devices are named as noise-cancellation headphones, sound attenuating ear cup, protective device against effects of noise and many more. Many earlier projects have been implemented using software's like LabVIEW and are used as an Android Application. The application consists of a timer and comparator which warn the user if the noise exceeds the limit. These do not satisfy the definition of an earpiece, a safety apparatus that controls the output of device according to sound in ambient space as in"[3]". It has not been implemented commercially till now.

It has been found that the damage caused to the ear is not just dependent on volume level but also the duration of exposure and frequency of audio and studies have found that they are not dependent on other factors like age, sex, race, etc. [4].

IV. Proposed System

The proposed system for the problem is to reduce the noise instead of fully canceling it. The purpose of reducing the noise is to tell the direction of the attack as well as the origin. External sounds include grenades, gunshots, military tanks, airplane take-offs and landings which are crucial in the Armed Forces. It will make the wearer aware of the crucial sounds. Also, the commands given will be considered as a necessary parameter and will be passed unfiltered by multiplying with unity gain parameter. The external noise will be multiplied with the suitable gain parameters so that the noise is reduced. The data are given in "Praeger Guide to Hearing and Hearing Loss by Susan Dalebout" as in "[5]" is taken as reference for the valid range of sound that can be heard without any adverse effects on the ear.

Table. I Percentage of volume vs time limit

%of Volume	Time Limit
100	5minutes
90	18minutes
80	1.2hours
70	4.6hours
60	18hours
10 to 50	No limit

V. Proposed System Explanation

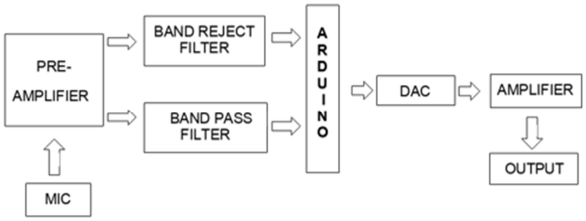

Fig. 2. Block diagram of the proposed system

An electret mic is used since it is sensitive. The preamplifier is used to amplify the voice signal/message that frequencies from 350Hz to 4000Hz and the BPF is designed to pass the frequencies ranging from 350Hz to 4000Hz. The range has been fixed by experimenting with male and female voice. It has been noticed that male voice frequency at the maximum level reached 2350Hz while the female voice reached 3200Hz. Since there might be a deflection of ±100Hz we have rounded the voice signal to 3500Hz. Both the filters are second order and designed with the following formulas

For LPF

$$R = \frac{1}{2\sqrt{2}*\pi*C*Frequency} \quad (1)$$

For HPF

$$R = \frac{1}{\sqrt{2} * \pi * C * Frequency} \quad (2)$$

Arduino is used for the ADC purpose to reduce the noise by multiplying with a gain parameter. A chart is formed from the ADC values for different types of sound to calculate the gain parameter that is to be multiplied. After reducing the amplitude of the noise, a DAC is used to transmit the audio after amplifying it.

Theoretical calculation of ADC is done using the below formula

$$\frac{Resolution\ of\ the\ ADC}{System\ Voltage} = \frac{ADC\ Reading}{Analog\ Voltage\ Measured} \quad (3)$$

Analog to digital conversions are dependent on the system voltage because we predominantly use the 10-bit ADC of the Arduino on a 5V system, hence the simplified equation is

$$\frac{1023}{5V} = \frac{ADC\ Reading}{Analog\ Voltage\ Measured} \quad (4)$$

The basic principle of this type of R-2R DAC is to split the reference currents equally through the switches.
The current sources that were used were N-type transistors with a size of W/L = 5/1.5. The current sources used a bias generator that produced 1.68V to allow $\sim 80 \times 10^{-6} A$ of current. The current sources were necessary for the R-2R DAC to work properly due to the switches and the matching of the resistors. The high poly 2 resistance (R) was equal to 4000W. The switches used a pass transistor configuration and had a resistance value of approximately 500W with the size of W/L_n = 25/0.6 and W/L_P = 50/0.6.

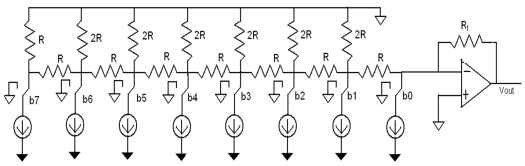

Fig. 3. Example of an R-2R design

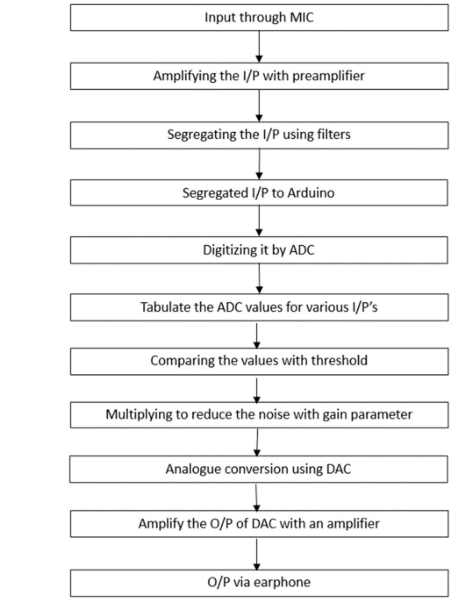

Fig. 4. The flow of working

VI. EXPERIMENTAL RESULTS

The proposed system has been designed in NI Multisim and the results have been simulated on an experimental basis.

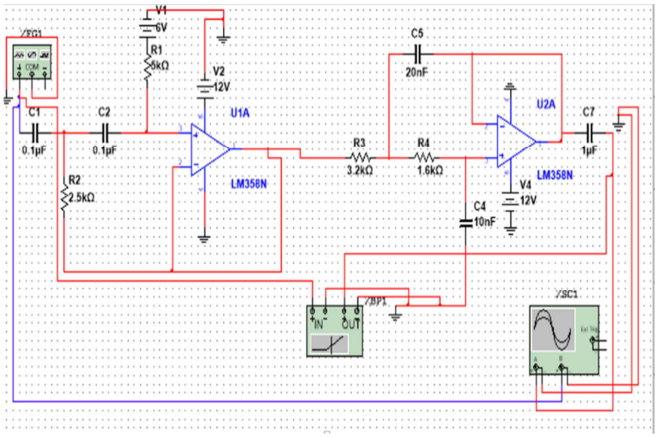

Fig. 5. Band Pass Filter Design

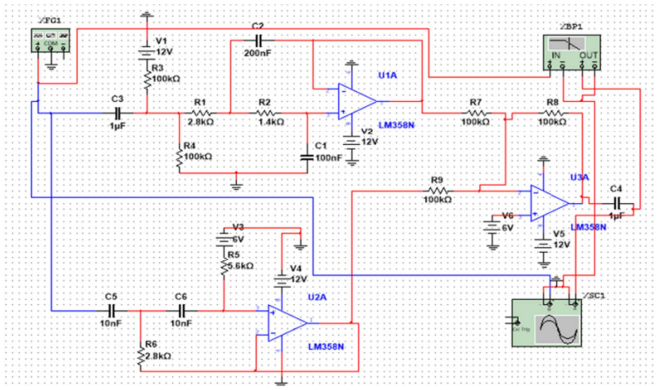

Fig. 6. Band Reject Filter Design

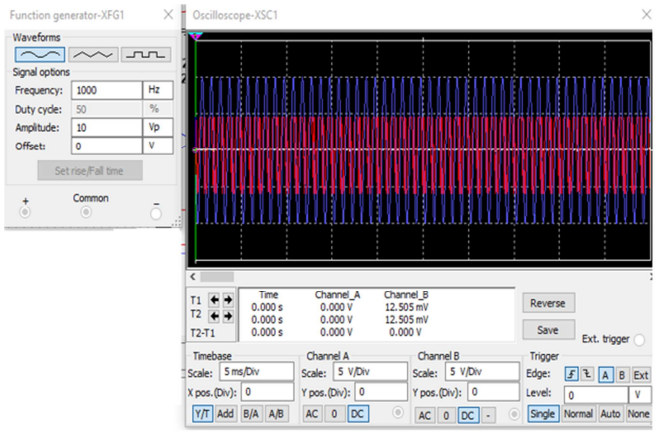

Fig. 7. Band Pass Filter Output

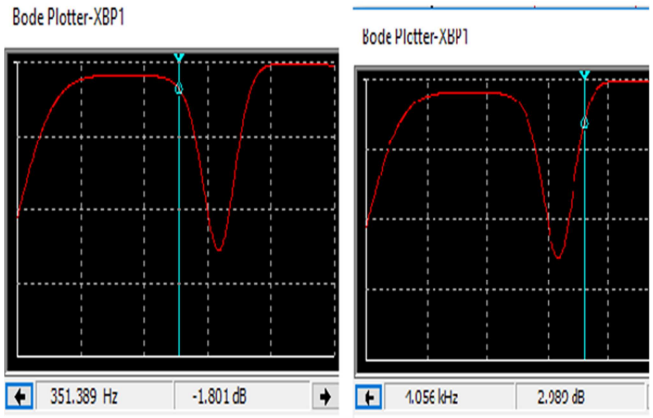

Fig. 7. Band reject filter output

Table II. Different types of sounds and their outputs

Type of sound	Input decibel(dB)	Output decibel(dB)
.357 Magnum Revolver	165	80
Shotgun	155	78
Fighter jet launch	150	75
Jet Engine(at takeoff)	130	68
Grenade	110	54
A male voice in public	60	58
The female voice in public	55	54
Male voice in a quiet environment	45	43
Female voice in a quiet environment	40	39

VII. Conclusion

The noise-induced hearing loss is a serious issue and awareness about it should be necessary. People in the Armed Forces go through this on a daily basis, mostly without any hearing aids. Although it is part of their job to deal with large amounts of noise, no proper device has been made for this specific purpose. With the initiative to make an efficient device to combat hearing loss, we can help millions of people in this profession by reducing noise and passing the human voice as it is.

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IX Acknowledgment

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