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Study Of Active Noise Cancelling In Headphones

Kunal wason
Dronacharya College of engineering, Gurgaon
kunalwason@yahoo.com

***Abstract*- In order to study active noise canceling headphones, a pair of Sennheiser HD 202 headphones was modified with microphones. Attenuation of low frequency ambient noise was successfully observed.**

I. INTRODUCTION

Noise cancellation technology is aimed at reducing unwanted ambient sound, and is implemented through two different methods. The first of these is passive noise cancellation: an approach that focuses on preventing sound waves from reaching the eardrum, and includes devices such as circumaural headphones or earbuds [3]. The other technique used to achieve the same – and often better – result is active noise cancellation, which uses aural overlap and destructive interference to target and attenuate background noise. While passive and active noise cancellation may be applied separately, they are often combined to attain maximum effectiveness in noise cancellation.

Although active noise canceling devices are still being integrated commercially, the concept has existed since the beginning of the 20^{th} century. In 1933, a German patent was issued to a Paul Lueg for the concept of active noise cancellation; he was the first to realize the possibility of attenuating background noise by superimposing a phase flipped wave [5]. In the 1950s, Olsen successfully demonstrated Lueg's concept in rooms, ducts, and headsets [5]. Research and development of active noise reduction (ANR) headphones truly began in 1978 after Dr. Amar Bose felt the need to develop headphones that masked the low rumbling of plane engines and other cabin noises [6]. With the invention of integrated circuits – op- amp circuits – and miniature microphones, the existence of ANR headsets became increasingly probable.

ANR headsets were first used in the Armed Forces, and constantly develop in versatility. However, they are not used in all military organizations and are only slowly being commercially released [2]. Current applications include noise propagation in industrial air handling systems, reduction of propeller noise in aircrafts and tonal noise from electric power, as well as isolation of vibration from noise radiating structures. Even with these applications, the transition of active noise control from the laboratory to the market is far from complete [4].

A hands-on implementation of noise canceling headphones provides for a strong understanding of the conceptual framework of both passive and active noise canceling. In addition, it allows an introduction to the basic components and operations of analog circuits. In particular, attention is given to the theory behind resistor networks, op-amp circuits, and filtering circuits. Secondary goals of the project include learning about the importance of circuit design, using oscilloscopes to understand and test circuits, and mastering the skills involved in building circuits.

II. BACKGROUND INFORMATION AND RELATED WORK

The Original Headphones

The constructed implement both passive and active noise cancellation via the modification of a pair of Sennheiser HD 202 headphones .

Figure 1: Sennheiser HD 202 Headphones

The Sennheiser headphones come equipped with passive noise canceling components such

as closed,
Semi-circumaural ear pads [10]. In order to achieve active noise cancellation, a circuit mainly comprised of a series of op-amps and microphones was added to the headphones for active noise cancellation.

Circuit Laws
Before constructing the noise canceling circuit, a general comprehension of circuitry was required to fully understand how the specific noise canceling circuit operates. Every circuit contains various components, each of which have correlative quantities; these quantities are often measured during circuit construction and may be altered in order to produce the proper results. The most common of such quantities include the voltage, current, and resistance of the circuit components. The voltage represents the potential difference needed to move a unit of charge across any circuit component. The current specifies the rate at which a unit of charge flows through a given component of the circuit. The resistance of a component describes the impedance against the current for that specific component.
The relationship between these measurements – voltage, current, and resistance – in a circuit is commonly known as Ohm's Law. Ohm's Law states that the voltage drop across two points is the product of the current and the resistance (V=IR, where V is the voltage, I is the current, and R is the resistance).

Active Noise Canceling
The headphones use active noise cancellation to eliminate any low- frequency noise from the environment, leaving the music to play from the headphones without the noise waves. To do this, the device produces a wave identical in frequency to the noise wave, but phase-flipped by a phase-shift of 180 degrees [1]. Afterwards, the generated wave is superimposed onto the noise wave, and the addition of these two waves – destructive interference – causes them to mutually cancel (Figure 2). Though the headphones play the music, the noise waves, and the generated waves, the destructive interference allows only the music to be heard by the listener.

Figure 2: Two waves are shifted 180 degrees with respect to each other so that the waves destructively interfere. [5]

This method of active noise cancellation is achieved by superimposing generated anti-noise with the noise signal. The system also includes other additional components in order for the active noise cancellation to function properly. A microphone, which is placed externally on the headphones, is needed to detect and obtain the raw noise signal from the outside environment . The circuit generates an anti-noise signal that destructively interferes with the noise signal. A speaker – in this case, the headphones – then required feeds the generated wave to the music and the noise wave in order for the generated wave and the noise wave to destructively interfere with one another. An external source of energy supplies the system with the ability to operate, which is also the reason for the term "*active* noise cancellation" – active meaning the need for an external source. Theoretically, active noise canceling is capable of reducing ambient noise up to 70 percent, and is most effective when used for air travel or other low-frequency sound waves [5].

III. FUTURE SCOPE

The relatively simple circuit for noise cancellation that was implemented leaves many opportunities for improvement. The first improvement possible is miniaturization, in which the noise-canceling circuitry could be placed in the headphones themselves.
The noise-canceling technology could also be applied to other areas of audio hardware. For

example, a microphone filter that removes static from a microphone signal could be constructed. Another field that could benefit from noise canceling is telecommunications. Currently, noise cancellation is used to filter out ambient noise from telephone conversations.

IV. RESULT

The noise canceling headphones were tested by observing their effect on various sources of noise such as an air conditioning vent, human voice, and a fan. In all cases, low frequency sound waves were attenuated. However, this means that certain sounds are not cancelled. For example, fan noise will not be entirely cancelled; instead, the fan takes on a higher-pitched sound, as if the diameter of the fan were reduced. Also, when noise canceling is turned off, the circuit acts as a noise amplifier, giving the auxiliary input a static-like effect. Some undesired results occur in our circuit, such as occasional feedback from the microphones

V. CONCLUSION

Active noise cancellation has been successfully studied with the help of modified sennheiser headphones. The study has proven very affective at low frequency signals by removing ambient noise from the signal.

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