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A Study of New Room Equalizer using Non-electronic Matching Method

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Abstract

This study proposes a room equalizer which uses a movable and variable acoustic board and revises frequency response, and is also applicable to a variety of places. When equalizing frequency response, commonly used electric graphic equalizers or parametric equalizers have the same effect as the sound signals such as audio passing through electrical elements like condenser or coil, and phase shift of audio signal occurs at this time. Accordingly, they secure frequency response by adjusting and equalizing the characteristics of sound-absorbing materials without any distortion of the original sound. Therefore, this study proposes a room equalizer that does not use these electrical characteristics, but uses non-electronic spatial matching with an excellent sound persistency rate to enable its application to various changes in space and time.

Keywords: *Equalizer, Sound-absorbing module, Frequency response*

1. Introduction

In a complex and diverse industrial society, the uses of electrical devices which use electrical frequency are increasing daily. At this present time, the demand of sound is changing from merely eliminating noise to gaining high-quality sound. Although there are various technology and researches that are under progress in order to satisfy these demands, the majority are only able to analyze the frequency response and use the electric echo signal to maintain a stable frequency acoustic pressure of the zone of audibility of the space the user is in. However, this has been modified from electrical characteristics, which makes it very difficult to apply all variations of space. Therefore, there are many researches being carried out in order to reduce these problems as well as arbitrary distortion of specific frequencies. Particularly, in the existing method, the range of sound absorption ratio and sound absorption frequency are fixed after the acoustic board is installed indoors. When the temperature changes, the speed of sound also changes, and when the speed of sound changes, the wavelength of the sound changes with it. This leads to a further change in standing wave and resonant frequency that occurred in the area, which ultimately leads to a change in the frequency response of the indoor space. Therefore, the listener is not able to gain the desired frequency response.

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At this time, when the electric equalizer is adjusted in order to revise the tone according to the listener's preference, the phase distortion of the signal must be put up with. Consequently, it is about changing the absorption response of the acoustic board from a wall to variable elements, and naturally adjusting the basic frequency, the Q value, and harmonic content on the movable and variable acoustic board in order to play the sound the listeners listen to as its original sound without any distortions. Chapter 2 of this essay explains the principles and problems of existing equalizers, and Chapter 3 describes the research and implementation about a space-free equalizer proposed in this study. Next, Chapter 4 explains the tests and results of the newly created equalizer, and the last page, Chapter 5, is the conclusion of the paper.

2. General Equalizing Method

Generally, when it comes to the delivery of sound signals, our ears correspond to a converter which converts sound waves to an electrical signal of the acoustic nerve. They are divided into the external ear, the middle ear, and the internal ear. Each part plays an essential role in gathering and delivering sound, decomposing the sound component in order to deliver them to the brain. The loudness of sound is commonly decided according to the size of the amplitude. Sound with a high amplitude is perceived as loud, and sound with a small amplitude as soft. However, the sense of pitch felt by humans is somewhat different from the physical quantity of sound. The physical quantity measures sound as variations of pressure and decides its unit, but the human ear linearly perceives sound by decibel(dB) units. The human ear has the ability to decompose and perceive frequency component of the sound. It does not perceive all frequencies evenly, but rather perceives them by frequency bands like a equal loudness curve with different sensitivities. The loudness of sound is decided by the size of the amplitude. As a result, high amplitude is heard as a loud sound, whereas a low amplitude creates a softer sound. However, the size of the sound felt by the human is different from the size of the physical sound in that it is perceived by hearing. The sensually felt sound is the volume, and the physically measured sound is called sound pressure, which is a pressure variation of air pressure. The size of the sound felt by the human by hearing and the size of the physical sound are different. Therefore, there is a need to express this size with the measurement unit that corresponds to the hearing sensation of humans. The measurement unit used for this purpose is known as dB or decibel. dB is the comparison value that expresses the physical dynamics of both sounds as a logarithm, and signifies an algebraic comparison between the existing value and the target value of measurement. Here, the equalizer plays the role of stabilizing the spatial frequency response to the audible frequency band, which helps even out the sound pressure of the sound signal. Particularly, the existing method mostly uses electronic devices.

Figure 2-1 and 2-2 show the effect of equalizing which evens out the sound pressure through the delay of signal using electronic elements. Accordingly, electronic characteristics have a disadvantage of not being able to adapt to changes in time and space when they are made constant. If there is no clear definition of spatial and temporal variabilities about the audio signal, it can actually increase the distortion rate.

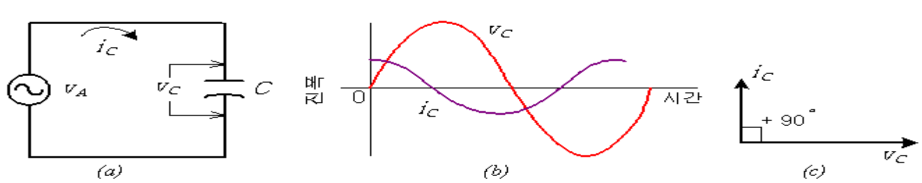


Figure 2-1. A Effect of Delay with a Condenser

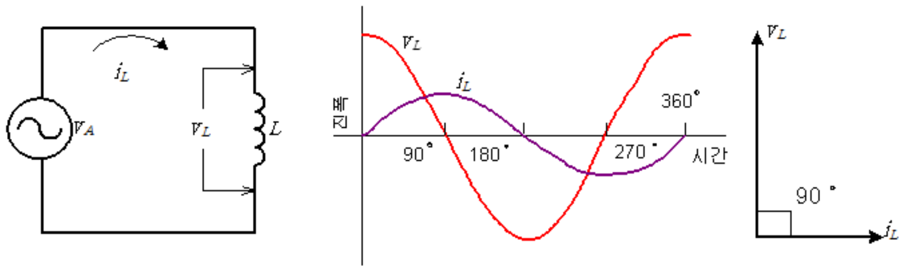


Figure 2-2. A Effect of Delay with a Coil

3. Proposed Room Equalizer using Non-electronic Matching Space Methods

This study focuses on enabling the control of frequency response of sounds in space according to user preferences by avoiding problems of electric equalizers. In particular, unlike equalizers which use electronic characteristics, acoustic board's sound absorption characteristics are controlled and equalized dynamically to maintain the original sound in its original space without any damage. Additionally, specific frequency responses can be made controllable by making the movement of acoustic board possible.

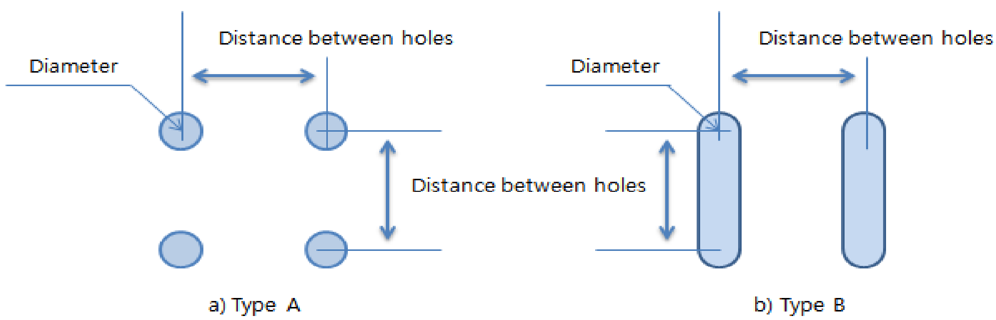


Figure 3-1. Two Sound-absorbing Module Types

In this study, in order for non-electrical matching, the proposed equalizer is classified into 4 elements to emphasize their characteristics. Because the Q (bandwidth) value changes according to the acoustic module, module width, module height, and module depth, a fixed-shape hole is used in order to induce these arithmetical values. In addition, for accurate expression of the sound, a detachable sound-absorbing material is used on the back of the acoustic module, which aims to prevent the unstability of the Q value as well as the loss of sound. The purpose of creating a movable acoustic board on the acoustic module is to change the fixed value that maintains the sound bandwidth to a spatial composition. Therefore, it may be created differently according to changes in time and space. Also, in order for these single modules to prevent the unstability of frequencies, the acoustic board can be connected to the front, back, left, right, top, and bottom in a variety of ways to prevent it. The desired equalizing range of the given space can be found by measuring the frequency response of the space and then analyzing the frequency desired for equalizing. Here, the movable acoustic module's diameter or slide width, and the hole of the movable board or the distance between slides can be gained. This study maintained a fixed distance of 3mm and 16mm. Using the resonance characteristics of helmholtz, modeling is possible like the figure below.

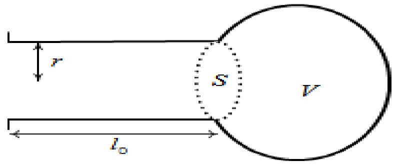


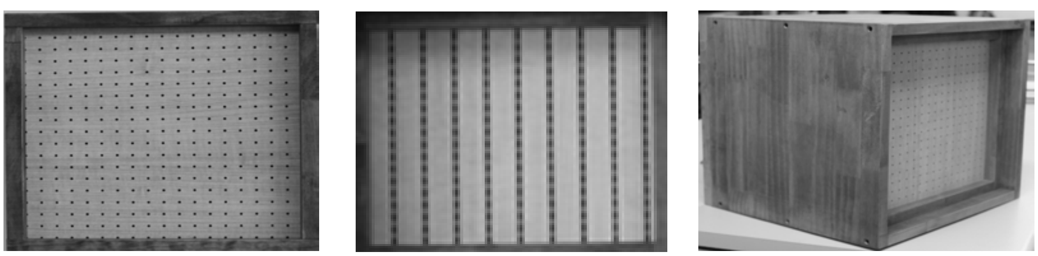
Figure 3-2. A Resonance Characteristics of Helmholtz Modeling

Like Figure 3-2, modeling is possible using helmholtz sound absorptivity.

$$\omega = \sqrt{\frac{c^2 S}{V l}} \quad (2\text{-}1)$$

$$l = l_0 + 0.7r \quad (2\text{-}2)$$

Here, C is the speed of sound, 340 m/sec, S is the cross sectional area of the hole, V is the volume of the resonator, and l represents the equivalent length of the hole. The Figure 3-3 is a composite map of the equalizer materialized through these modeling.



a) Type A b) Type B c) Module of Type A

Figure 3-3. Resonance Characteristics of Non-electronic Sound-absorbing Module

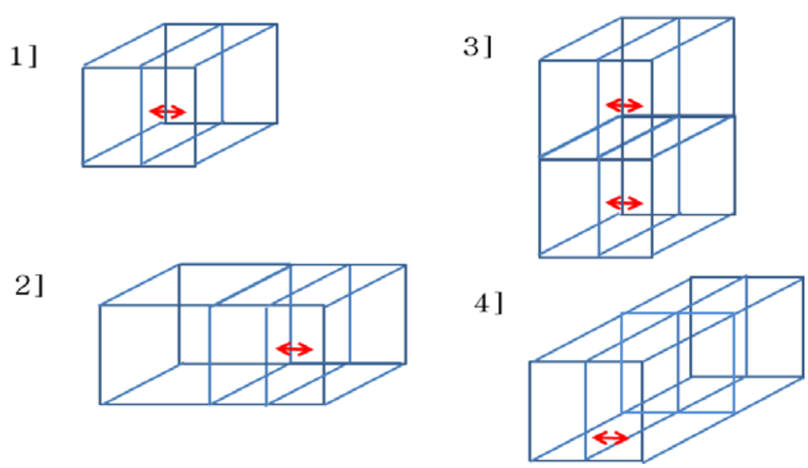


Figure 3-4. Various Matching Space Methods using Sound Absorbing Module

Sound absorption frequency of each hole can be found. Because these characteristics change according to time and the location of the sound signal, the location of the sound extinction and the characteristics of the hole must be taken into consideration when creating an equalizer. Consequently, this study uses a variety of holes and modules, which allow the composition of a non-electronic equalizer.

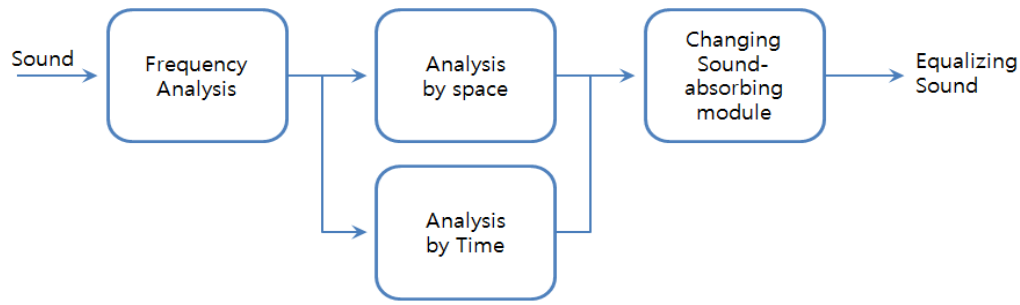


Figure 3-5. A Processing of Sound Equalizing

4. Experimental Results

This study materialized an equalizer applicable to changes in space. This is made possible by applying the helmholtz's sound absorption model, and it is also applicable to special environments because it changes properly and diversely to changes in space composition. In order to test this equalizer, performance of the sound absorption module and pure tone generator were compared and assessed using a measuring device. In particular, a sound space of 4m x 2m, which allows changes in space, was installed for assessment, and time was divided into day and night. The reason for using a changeable space is because the sound absorption module is materialized as a single size to allow application to various locations, and the reason for dividing the time into day and night is to find the error of measurement rate and change it freely.

Figure 4-1, which appears as a spatial frequency response, is an image that used 200Hz to apply sound absorptivity of the sound. From here, it is evident that a change of 2dB occurs according to changes in the module, and this allows a random frequency to play a sound absorbing or emphasizing role.

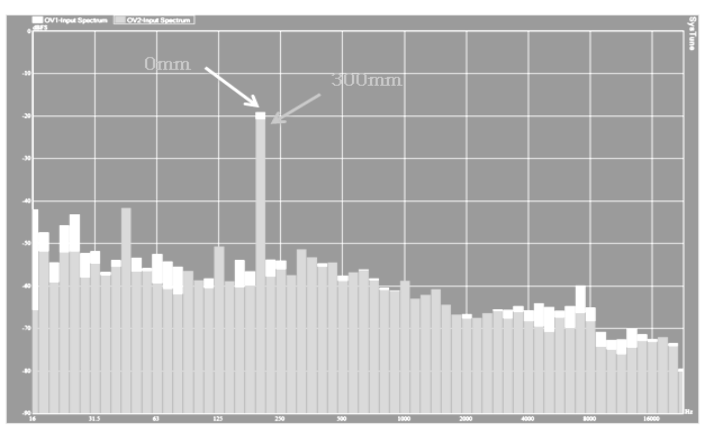


Figure 4-1. A Resonance Characteristics of a Single Tone 200Hz

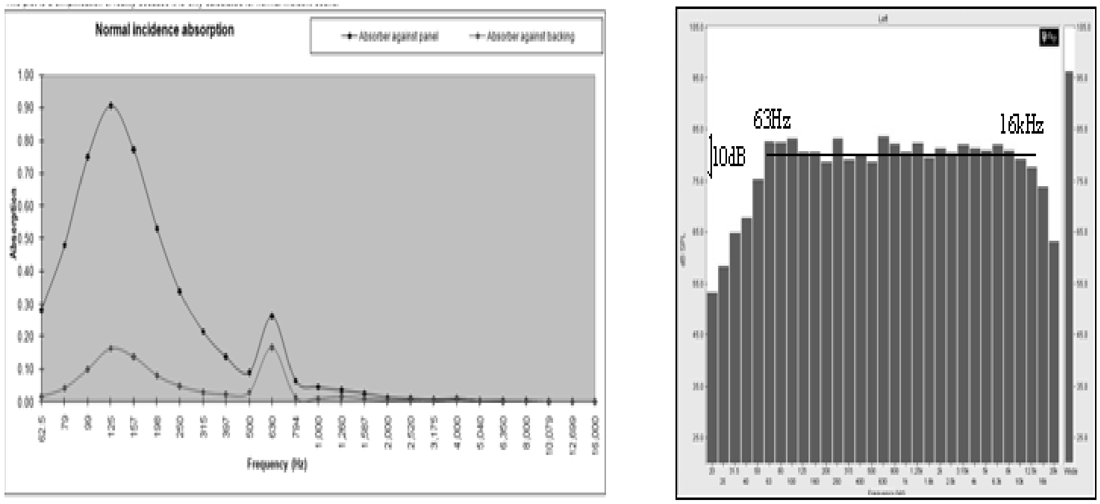
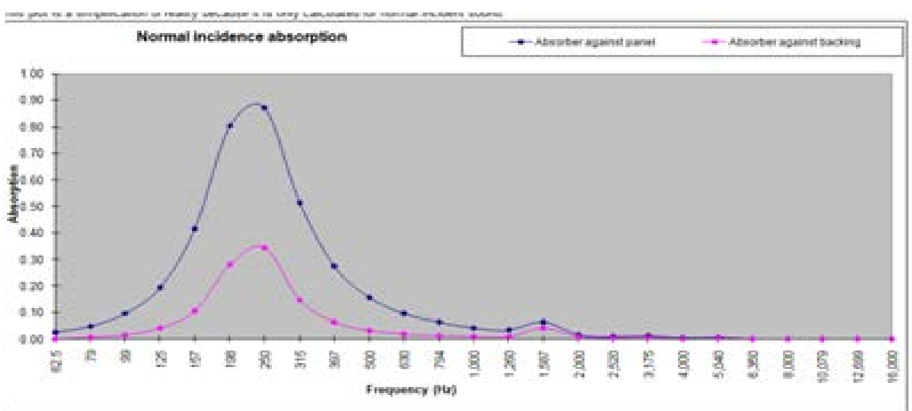
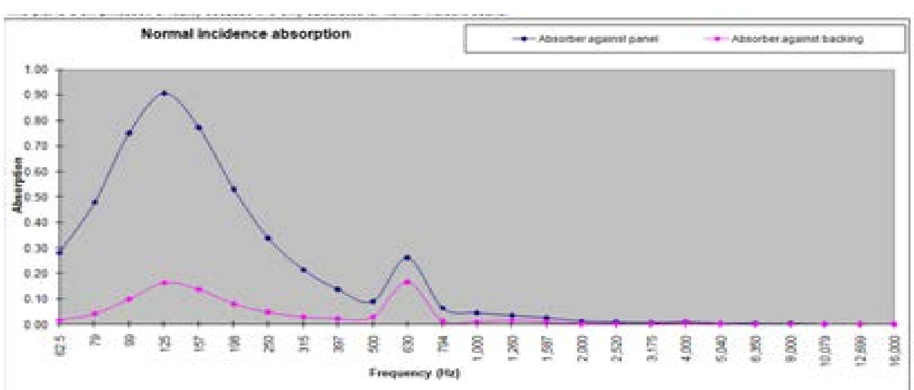


Figure 4-2. A Frequency Characteristics of a Non-electronic Special-matching Method



a) Case 300mm, no space



b) Case 100mm, distance from a front to a absorbing panel.

Figure 4-3. A Resonance Characteristics of a Non-electronic Room Equalizer

5. Conclusion

The equalizer that uses non-electronic characteristics has excellent dynamic stability of the original sound, and is environmentally friendly according to changes in time and space. Particularly, it is applicable to sound absorption of indoor sounds including audio room, broadcasting studio, lecture room, meeting room, and concert hall. As a characteristic of indoor space, a low-tone resonance exists in indoor spaces where all sounds are heard. This study preserved the original sound without distortion in any type of room and gained the frequency response desired by the listeners. In a listening space where sound absorption is desired, the sound absorption module can be applied front, back, left, right, top, and bottom according to the need, and the materialization or change of specific frequency is simple. The sound absorption module materialized in this way faces less spatial and negative stability restrictions compared to the fixed type, making it economical and convenient. Especially, sound environment differs by listening space and the sound absorption characteristic that is being demanded also differs; therefore, the room equalizer proposed in this study can provide a sound absorbing performance suitable for each characteristic. Typical sound absorbing materials have a fixed set of sound absorption characteristics. However, the proposed method has an advantage of controlling these characteristics and varying the frequency response of the space to fit the listener's needs without distortion of the original sound. Additionally, the room equalizer's sound absorption characteristics can be changed to allow the experience of a controlled tone and sound according to the acoustic preference of each individual.

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