A hybrid Room Equalizer with Smart Modules using Variable Bass Traps for High-quality Audio

Soon-Koo Cho [#1], Esther Rhee[*2] and Jae-Pyung Kim[#3]
[#1]Inter-M R&D Lab., Gyeunggi-do, Korea
[*1]skcho@inter-m.com
[*2]Department of Music Production, Keimyung University, Daegu City, Korea
[#2] esther@kmu.ac.kr
[#3]Department of Broadcasting Sound & Visual, Daelim University College, Gyeunggi-do, Korea
[*3] jpkim@daelim.ac.kr

Abstract—This research is about adjusting indoor frequency response by using room equalizer based on portable variable absorbing plate. Room equalizer is an equalizer that can be applied to different places. For graphic equalizer or parametric equalizer which are used generally in the field if it is equalized to adjust frequency response sound signal gives similar effect to that of going through electronic devices such as condenser or coil. At this time, phase shift of signal takes place and this influences on sound quality. The purpose of this research is to make frequency response that has no distortion of original sound. This is done by reducing phase shift and equalizing by adjusting response of absorbing plate. Therefore, to overcome these problems, this research suggest room equalizer which can be applied to different places and time by using outstanding space matching with high sound sustainability.

Keyword-Room equalizer, Resonance frequency, Bass trap.

I. INTRODUCTION

In this complex and various industrial society, there are more and more electronic devices that use electronic frequency. The requirement for sound is moving from removing noise to obtaining high quality service. Many technical researches are done to satisfy this need, however, most of these techniques are focused on sustaining constant frequency sound pressure in zone of audibility which is done by using electronic echo signal based on analysis of frequency response. Nevertheless, as these techniques apply changes to electronic response, it is difficult for them to consider variety of spaces. As this is the case, many researches are done on these problems as well as reducing artificial distortion of certain frequency. Especially, the existing absorbing plate had fixed absorbing rate and frequency range indoor. If temperature changes sound speed changes and this leads to variation in sound wavelength. As a result, frequency response inside varies because standing wave turns into resonant frequency and therefore, auditor cannot have the wanted frequency response. In Chapter 2, it explains about theory and problem of equalizers and in Chapter 3, it discusses about study and realization of multi-applicable equalizer suggested in this research. In Chapter 4, it describes experiment on equalizer and its result and conclusion is provided in Chapter 5.

II. ROOM EQUALIZING METHOD

In terms of general transfer of sound signal, ear plays a role of transformer which turns sound wave into electronic signal of acoustic nerve. It is divided into outer, middle, and inner ear and each takes part in collecting sound and breaking down sound elements to deliver them to the brain. Usually size of sound is determined by magnitude of amplitude. Sound with large amplitude is perceived big and one with small amplitude is perceived small. However, there is little difference between sound sense felt by human and its physical quantity. Physical quantity measures changes of pressure and determines unit but a man's ear recognizes sound linearly in decibel (dB) unit. The ear has ability to cognize sound by breaking down its frequency elements but its cognition varies depending on frequency zone like Loudness Curve instead of perceiving stably in all frequencies. As loudness is finalized by magnitude of amplitude sound with large amplitude is heard big and small is heard quiet. Sound size felt by man is sensational quality perceived by auditorial sense its physical size is not the same.

The size of sound felt by auditorial sense is referred to as volume and one that is measured physically is called sound pressure. Also, sound pressure is variable caused by changes in atmospheric pressure. As sound size felt by auditorial sense of man and physically are different it is necessary to express it in measuring unit that is same with auditorial sense of human. This measuring unit is called decibel (dB). Decibel is a comparative value expressing physical strength of two sounds in logarithm. It means comparison of logarithm of standard value and measuring value. Here, equalizer takes a role of maintaining frequency response of space constant in

zone of auditorial frequency, therefore, pressure of sound signal becomes even. Most of existing methods apply electronic devices.

III. PROPOSED ROOM EQUALIZER

In this paper, before coding using the peaks and valleys of the non-uniform sampling method, the signal is pre-filtered by frame. This minimizes the distortion of recognition information as well as increase the compression efficiency by applying the filter differently for voice sounds, voiceless sounds, and noise. Generally non-uniform sampling using peaks and valleys is represented as equation 1. The peak and valleys of the inputted frame is searched and their amplitude and interval is saved. The unnecessary samples in between the peaks and valleys are removed. This way, the compression rate is increased. 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 and 3-2 show effect of equalizing which makes smooth sound pressure through signal delay using electronic devices. Therefore, the disadvantage of having constant electronic response is that it cannot be adapted to changes of space and time. If no clear definition of audio signal is made, variety of space and time may cause bigger distortion.

The most important part of this research is to make frequency response of sound in space to be adjustable to taste of user by avoiding problems of electronic equalizer. Different from equalizing method using electronic response this has advantage of sustaining the sound in place without any distortion by equalizing absorbing response of plate variably. Furthermore, response of certain frequency can be adjusted by making portable front-back absorbing plate.

This research suggest room equalizer by dividing it into 4 factors to match with spaces and emphasizing their characteristics. This kind of structure has different Q value depending on absorbing module, width, height, and depth. Therefore, certain type of holes are used to make arithmetic figure. Also, for accurate expression of sound, detachable absorbing material is used on the back plate of absorbing module. This prevents sound loss and unstability of this Q value. Forming front-back movable absorbing plate in absorbing module is to change certain value for sustaining amplitude into spatial structure. This can vary by different space or time. Moreover, connecting absorbing module in front, back, left, right, up, and down directions with this single module can prevent frequency unstability. If frequency to be equalized is examined after measuring frequency response of space, targeted equalizing range in the given area can be identified. During this process, diameter or slide width of absorbing module and hole or slide interval of portable absorber can be obtained. In this research, it has maintained a fixed interval of 3mm and 16mm.

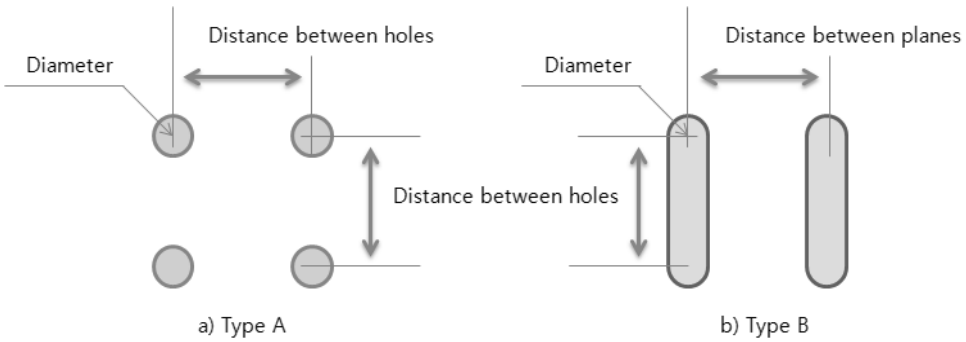
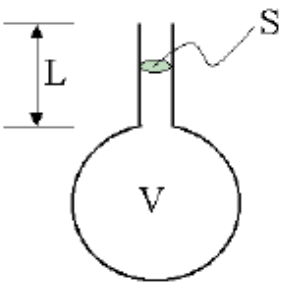


Fig. 3-1 Two sound-absorbing module types

resonance characteristics of helmholtz, model is possible like the figure below.



$$f_0 = \frac{c}{2\pi}\sqrt{\frac{s}{lV}}$$

Fig. 3-2 A resonance characteristics of Helmholtz modeling.

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. This is a composite map of the equalizer materialized through these modeling.

Frequency of absorbing sound for each hole can be calculated. As this response changes based on position and time of production of sound signal it is compulsory to structured it by considering its extinction position and characteristics of hole. Therefore, this research forms equalizing of spatial response by using various holes and modules.

This research has materialized an equalizer that is adaptable to spatial changes. This can be done by applying absorbing model of HelmHoltz and as this model appropriately adjusts to changes of spatial structure it can be used in special environment as well. To test this equalizer, it function was compared and evaluated with absorbing module and pure sound generator and measuring devices. Size of 4m x 2m changeable sound space was installed and evaluated. Evaluation was done in the afternoon and evening. Space can be changed because single size absorbing module was made to adjust it to various places. Evaluation time was divided because measuring error was obvious and it can be changed anytime.

Fig. 3-3 A proposed hybrid smart room equalizer and test room

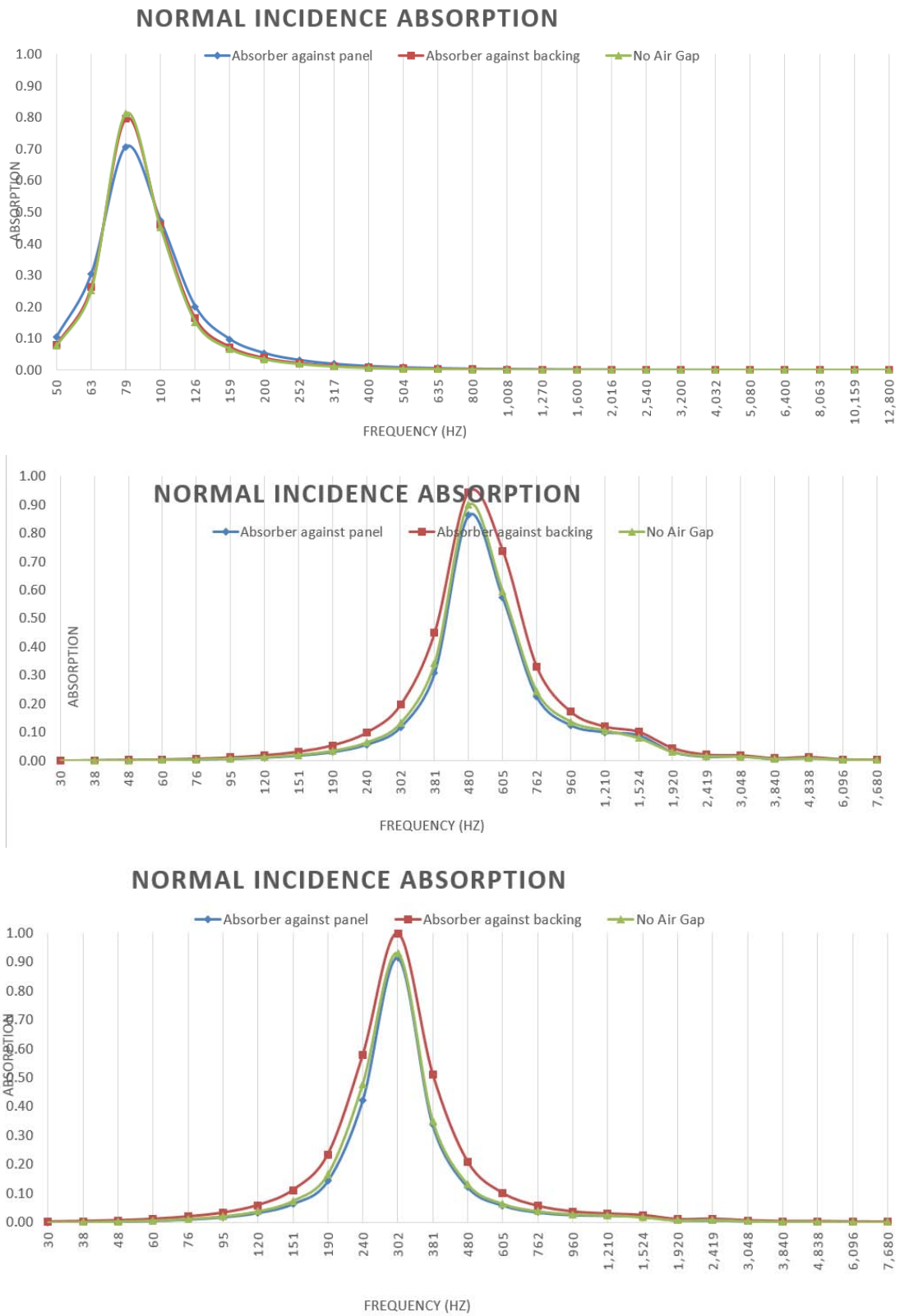


Fig. 3-4 A frequency characteristics of a non-electronic special-matching method

IV. Conclusion

The smart equalizer suggested in this research has outstanding recovering ability of pure sound and environment-friendly for changes of space and time. Especially, places like home audio room, broadcasting studio, classroom, conference room, and concert halls can have indoor purpose absorbing sound. In this indoor space where all the sounds are heard, one characteristics of it is the existence of low sound resonance. As sound environment of each auditing space and its required sound response are different, room equalizer suggested in

this research can offer individualized absorbing sound function. Usually, absorbing material has fixed response but in the suggested method, it has advantage of varying frequency response of sound as auditor wants without distortion of sound source. Also, depending on individual sound taste, one can have adjusted sound color by changing absorbing response of room equalizer.

This research tries to obtain auditor's wanted frequency response in any rooms without distortion of original sound. By applying absorbing module into front, back, left, right, up, and down directions change to a certain frequency becomes easy. This absorbing module is economical and convenient as it has better sound recovering and use of space compared to fixed type.

REFERENCES

[1] S.G. Bae, M.J. Bae, "A New Speech Coding using Harmonics Emphasis Filter," ISAAC 2013, AACL Vol. 1, pp. 43-44, November 2013.
[2] S.G.Bae, E. Rhee, J.K.Kim, J.P.Kim," New Room Equalizer Realization Using a Match Space Method for High-quality Audio," ICTC 2013 IEEE, pp 600-601 (2014)
[3] V.Jagan Naveen, K.Murali Krishna, K.RajaRajeswari, "Performance Analysis of Equalization Techniques for MIMO Systems in Wireless Communication", IJSH Vol.4, No.4, Oct., pp47-63 (2012)
[4] G.Manmadha Rao, K.RajaRajeswari, "New approach to MFR design with an alpha– beta filters", IJSH Vol.5, No.1, Jan.pp23-30, (2011)
[5] Woochel Park, Sangbong Lee, Sunhee Lee, "Principle of Acoustic Technique,' Chasong press (2009).
[6] Don Davis Eugene Patronis, Jr., "Sound System Engineering,' Focal press (2006).
[7] Sunghoon Kang, "Principle of Broadcasting Acoustic Theory,' kijung press (2003).
[8] U.S. Department of Labor, Occupational Safety and Health Administration. Hearing conservation. OSHA 3074(2004).
[9] F. Alton Everest, "Master Handbook of Acoustics,' McGraw-Hill press (2001).
[10] Don Davis, Carolyn Davis, "Sound System Engineering,' Focal press (1997).

AUTHOR PROFILE

Soon-Koo Cho He received the B.S. degree in Electronics Engineering from Japan in 1973. He is currently the under Ph.D. degree at Myungji University in 2015. He is currently CEO of Inter-M Company.

Esther Rhee He received the Ph.D. degree in Music Education from Kent state University in 2001. He is currently the Professor of the Dept. of Music Production at Keimyung University.

Jae-Pyung Kim He received the Ph.D. degree in Electronic Engineering from konkuk University in 1995. He is currently the Professor of the Dept. of Broadcasting Sound & Visual at Daelim University.