International Journal of Engineering Research and Technology. ISSN 0974-3154, Volume 12, Number 12 (2019), pp. 2159-2162

A Study on Peak Power Driving Considering Speaker Characteristics

Bong-Young Kim[1], Ik-Soo Ahn[2] and Myung-Jin Bae[3*]

[1]Soong-sil University, Department of Information and telecommunication Engineering, Seoul, 06978, Korea.
Orcid Id : 0000-0002-3553-039X

[2]Soong-sil University, Department of Information and telecommunication Engineering, Seoul, 06978, Korea.

[3] Soong-sil University, Department of Information and telecommunication Engineering, Seoul, 06978, Korea.
Orcid Id : 0000-0002-7585-0400

Abstract:

Sound Fire Extinguisher is a device that suppresses conflagration using sound. In order to put the Sound Fire Extinguisher into practical use, it is necessary to increase the efficiency of each component to make it compact and lightweight. Speakers generally allow tens to hundreds of times higher peak power than their permissible RMS power. In this study, we tried to improve the speaker's output efficiency by using the RMS power and peak power characteristics allowed by the speaker. The proposed method is a method of peak power driving of a speaker, which increases the output of a portion of a signal, thereby significantly increasing the peak power compared to the increase of the RMS power. As a result of the experiment of Chapter 4 by the proposed method, the peak power driving signal with double VMAX compared to 60Hz pure tone, the RMS power is increased 2.5 times while the actual sound level is increased 4 times. These results confirm that the peak power driving method is capable of producing a larger sound output while using the same speaker.

Keyword: Sound Fire Extinguisher, Speaker, RMS power, peak power, peak power driving

1. INTRODUCTION

Sound Fire Extinguisher is a device that concentrates low frequency sounds below 100Hz to flame and leads to extinguishment. Therefore, it is very important to transmit high power sound through the speaker. In particular, if a higher output method is applied to the same speaker, it will greatly help to compact and lightweight the Sound Fire Extinguisher and put it to practical use in the fire fighting field [1-4].

A speaker is a device that outputs electrical signals as sound. The principle that the speaker outputs sound is to cause the diaphragm to vibrate with the kinetic energy generated when a current flows through the coil in the magnetic field. One speaker does not have to output the frequency components of all bands. Speakers have different frequency ranges which are advantageous for reproduction depending on the applied sound output principle, structure, size and shape. In the case of the cone speaker, the frequency characteristics are generally flat in the frequency domain of all bands and reproduce sounds with complex frequency components well. On the other hand, the horn speaker is advantageous to increase the sound output of a frequency component of a single frequency or a simple configuration. Due to the characteristics of each speaker, the horn effect was applied to the Sound Fire Extinguisher, which outputs a pure tone of less than 100 Hz [5-6].

Each speaker manufacturer provides the specifications of RMS power and peak power allowed per speaker. In general, since the speaker outputs a sound composed of various frequency components, it is not a big problem considering only the RMS power of the output signal. However, the Sound Fire Extinguisher has the purpose of outputting a specific sound as much as possible, so that the output efficiency can be effectively compacted and lightweight by using the peak power characteristics of the speaker [5-6].

In this study, we tried to realize high power output by adjusting peak power in sing mode sound of single frequency or simple frequency components. In Chapter 2, the sound generation principle of speaker and RMS, peak power of speaker are explained. Chapter 3 describes the peak power driving method to increase the sound power. Chapter 4 describes the experiment and the results, and concludes in Chapter 5.

2. DRIVING PRINCIPLE & RMS, PEAK POWER OF SPEAKER

2.1 Driving principle of speaker

A speaker is a device that converts an electrical signal into a sound. It makes a sound by generating a pressure change in the medium by ringing a diaphragm. There are dynamic speaker, electrostatic speaker and piezoelectric speaker according to the driving method for vibrating diaphragm. Dynamic speaker uses the interaction of magnetic fields made from permanent magnet and voice coil, and electrostatic speaker uses diaphragm principle to place diaphragm in electrostatic field formed between two metal plates. The piezoelectric speaker uses the piezoelectric effect of generating a current when a force is applied to ceramic crystals. Among the driving methods, the dynamic speaker is most used due to the output efficiency and economic efficiency [5-6].

The dynamic speaker applies the principle that the voice coil moves the diaphragm under the influence of force when current flows through the voice coil in the magnetic field according to Fleming's left hand rule. Fig. 1 shows the Fleming's left hand rule that explains the direction of force generation along the direction of magnetic field and current [5].

International Journal of Engineering Research and Technology. ISSN 0974-3154, Volume 12, Number 12 (2019), pp. 2159-2162

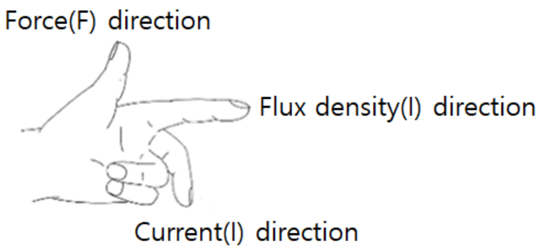

Fig 1. Fleming's left hand rule [5]

Changing the direction of the current flowing through the voice coil also changes the direction of the force applied to the voice coil. That is, as the direction of the force applied to the voice coil is repeatedly changed, the voice coil vibrates the diaphragm. Fig. 2 shows the structure of a dynamic speaker whose diaphragm is moved by a voice coil. The strength of the force received by the voice coil is shown in Equation (1). Equation (1) shows that the magnitude of the force received by the diaphragm is proportional to the magnitude of the current flowing through the voice coil and is proportional to the magnitude of the voltage according to Ohm's law [5].

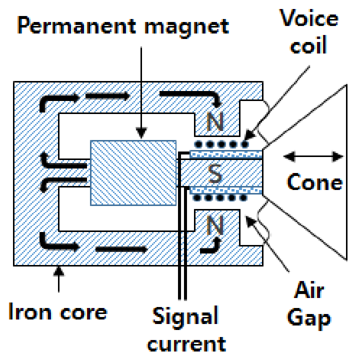

Fig 2. Structure of dynamic speaker [5]

$$F[N] = B[T] \cdot I[A] \cdot L[m] \tag{1}$$

2.1 RMS power & peak power of speaker

The speaker has a limit to how each unit can operate. If too high current flows, the voice coil may be broken or the cone or edge may be broken. Accordingly, the speaker has a limit of RMS power, which is an output that can drive normally. It also defines the limit of peak power that speaker units can withstand in an instant. When sound is output through the speaker, the average power of the input signal must not exceed the RMS power limit, and the instantaneous peak power of the input signal must not exceed the peak power limit. If a signal exceeding the allowed RMS power or peak power is input, the speaker may be damaged [5].

For example, the PV-6210 speaker consists of a woofer with a rated capacity of 15W and five satellite speakers with a rated capacity of 3W, and their total rated capacity is 30W. On the other hand, the peak power, the instantaneous maximum input allowed by this speaker, allows up to 4000W. It can be seen that the PV-6210 speaker allows about 133 times the peak power compared to the allowed RMS power. In other words, this means that VMAX is allowed to be about 11.5 times larger than the VRMS limit introduced into the speaker [7].

3. PEAK POWER DRIVING METHOD

The speaker moves the diaphragm by the force generated in proportion to the amount of current flowing through the voice coil. The sound is determined by the change in pressure applied to the medium, so the loudness is determined by the size of the diaphragm's movement. In the case of continuously outputting a very simple signal such as Sound Fire Extinguisher, it can affect the speaker output by processing the signal according to the circuit change [5-6] [8].

In this study, the proposed method to increase the output of the speaker is a speaker driving method by the peak power, while the RMS power of the signal is small while increasing the peak power of the signal to achieve high power even in the same speaker. Most speakers allow for a few tens to hundreds of times the allowable peak power compared to the allowed RMS power. Therefore, if the input signal increases the peak power without exceeding the allowed RMS power, high sound pressure can be formed. Fig. 3 shows the peak power driving method proposed in this study [5] [7].

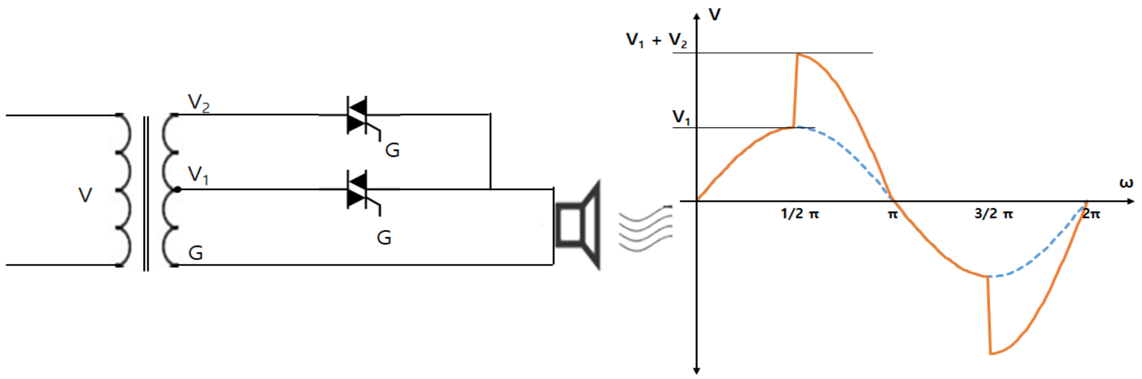

Fig 3. Peak power driving method of speaker

International Journal of Engineering Research and Technology. ISSN 0974-3154, Volume 12, Number 12 (2019), pp. 2159-2162

As shown in Fig. 3, the input signal is output as V1 in the 0 ~ 1/2 π section and V1 + V2 in the 1/2 ~ π section using the TRIAC characteristic. In this way, the increase in the peak power while increasing the RMS power is small. If V1 = V2, 0 ~ 1/2 π interval is output as V1, 1/2 ~ π interval is output as 2V1. When this output is compared with the V1 signal, the RMS power of the generated signal increases by 2.5 times. On the other hand, the peak power is increased four times. Using this relationship, higher sound pressure can be formed by outputting peak power within the RMS power range allowed by the speaker.

4. EXPERIMENT AND RESULT

The actual sound pressure output by peak power driving considering speaker characteristics suggested in Chapter 3 was confirmed through experiments. The experimental method is a method of measuring the strength of each signal at a certain distance by outputting a sinusoidal wave of 60Hz and the signal changed by the method proposed in Chapter 3. A pure tone of 60 Hz was generated using Adobe audition CS. The signal for peak power driving was output by changing the generated 60Hz pure tone as shown in Fig. 3. At this time, the peak voltage was doubled than the generated pure tone. The sound source used in the experiment is shown in Fig. 4.

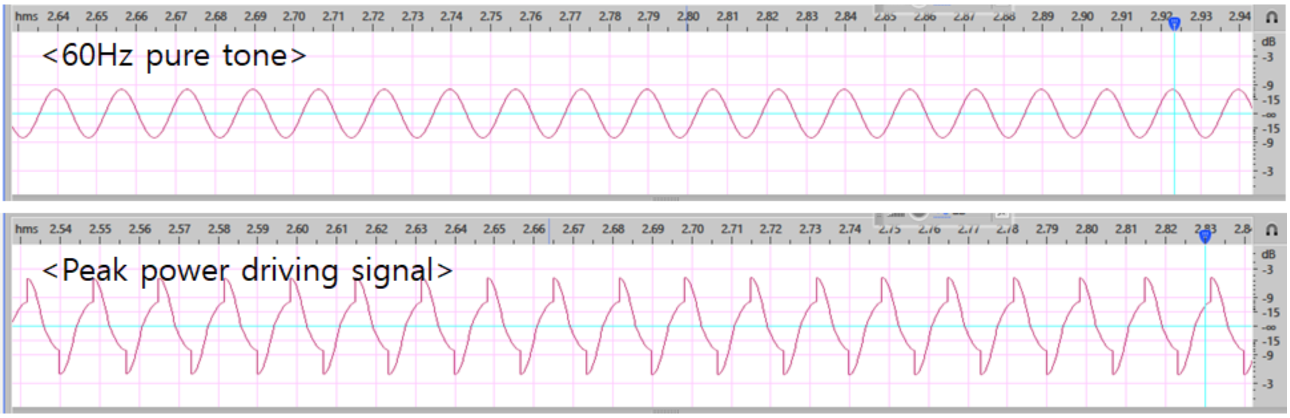

Fig 4. 60Hz pure tone & peak power driving signal

The sound source of Fig. 4 is played through the Galaxy S Note 4, a smartphone, and output through the Britz BR-5100T, a low frequency speaker. The sound level at a certain distance was measured by NTi Audio's Acoustilyzer AL1, and a C-WTD filter suitable for measuring low frequency sound was applied. The constructed experimental environment is shown in Fig. 5.

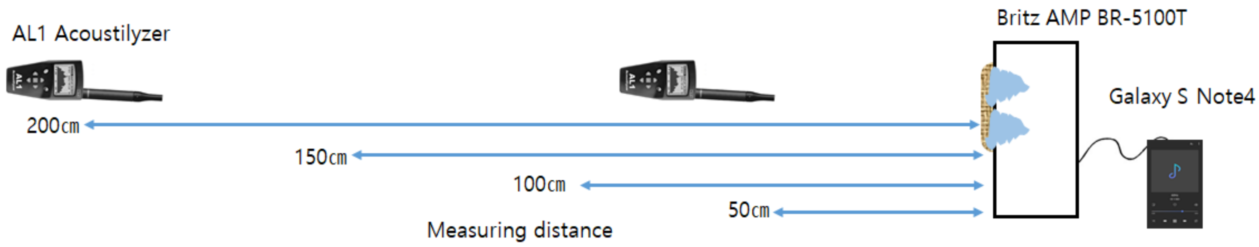

Fig 5. Experiment environment

As shown in Fig. 5, the result of measuring sound level for each sound source by distance is shown in Table 1. The results of Table 1 show that the peak power driving signal generated by the method of Fig. 3 is about 5-7 dB greater than the pure tone of 60 Hz. The peak power driving signal is expected to have 4 times the peak power because VMAX is twice as large as the 60Hz pure tone. Accordingly, a 6 dB loud sound is expected as the sound level. As a result of the actual experiment, the peak power driving signal was measured 5 ~ 7 dB larger than the 60Hz pure tone, so the actual sound pressure was output 4 times larger even though the RMS power was increased 2.5 times.

Table 1. Interview summary for the sound of Reed Wind

Sound source	Sound level			
	50 cm	100 cm	150 cm	200 cm
60 Hz pure tone	85dB	83 dB	80dB	75dB
Peak power driving signal	90dB	88 dB	87dB	81dB
Sound level difference	5dB	5 dB	7dB	6dB

6. CONCLUSION

Since the Sound Fire Extinguisher is a device that concentrates low frequency sound into the flame and leads to extinguishment, it is very important to output high power sound through the speaker. In particular, small size and weight are essential for the practical use of Sound Fire Extinguisher, so it is necessary to increase the efficiency of each component.

The speaker is defined the RMS power and peak power allowed for prevent damage to each unit. Speakers generally allow for peak powers that are tens to hundreds of times higher than the permissible RMS power. It means that the speaker can be damaged at the continuous high power input, but the speaker will not be damaged during transient high power.

In this study, we propose the peak power driving method considering the characteristics of the speaker for high output of the Sound Fire Extinguisher. As shown in Fig. 3, the proposed method outputs the same V1 signal as the pure tone in the $0 \sim 1/2\,\pi$ and $\pi \sim 3/2\,\pi$ intervals. In addition, V1 + V2 greater than V1 is output in the intervals $1/2\,\pi \sim \pi$ and $3/2\,\pi \sim 2\pi$. In this way, the increase in RMS power is small and the peak power is increased, thereby forming a high sound pressure. As a result of comparing and measuring the peak power driving signal of 60Hz pure tone and VMAX twice, the RMS power was increased by 2.5 times, and the sound was about 4 times bigger because the actual sound level was increased by 5 ~ 7 dB.

Although the error according to the experimental environment may be reflected, the difference in the sound level measured in the same environment with respect to the two signals can be said to be a significant result confirming the relative difference in efficiency according to the signal. Through these experimental results, it was confirmed that the speaker's high power through peak power driving could be realized by using the RMS power and peak power characteristics of the speaker.

The peak power driving signal applied in this study inevitably generates harmonic distortion. Further research on peak power driving signals will reduce harmonic distortion.

REFERENCE

[1] DARPA 2012.07:: http://www.extremetech.com/extreme/132859-darpa-creates-sound-based-fire-extinguisher

[2] George Mason University youtube:: https://www.youtube.com/watch?v=uPVQMZ4ikvM .

[3] Kim, M.-S., Bae, M.-J. "A study on a fire extinguisher with sound focus", *Information (Japan)*, Vol.20, No.6, 2017, pp. 4055-4062.

[4] Yi, E.-Y., Bae, M.-J. "On a fire extinguisher using sound winds", *Journal of Engineering and Applied Sciences*, Vol.13, No.4, 2018, pp. 977-980.

[5] Sei-Jin O, *Theory and Design of Loudspeaker*, Seok Hak Dang, Korea (2011)

[6] S. T. Lee. *Principles and Application of Sound*, Cheong Moon Gak, Korea (2004).

[7] www.aionkorea.com

[8] Bong-Young Kim, Myung-Jin Bae, "A Study on High Power Amplifier of Sound Fire Extinguisher Using Pseudo Sinusoidal Wave", *International Journal of Engineering Research and Technology*, ISSN 0974-3154, Vol.12, No.7, (2019), pp.1133-1137.

[9] Yi, E.-Y., Song, U.-J., Bae, M.-J. "A study on the performance of sound fire extinguisher by anti resonance", *Journal of Engineering and Applied Sciences*, Vol.13, No.4, 2018, pp. 910-913.

[10] Kim, B.-Y., Song, U.-K., Bae, S.-G., Bae, M.-J. "A Study on the Resonance Dispersion of Candlelight According to the Change of Sound Component", *Journal of Engineering and Applied Sciences*, Vol.14, No.8, 2019, pp. 2450-2455.

[11] Bong-Young Kim, Myung-Jin Bae, Seong-Geon Bae, "A Study on a Suitability of Sound Fire Extinguisher in Duct Environment", *International Journal of Applied Engineering Research*, ISSN 0973-4562, Vol.12, No.24, (2017), pp.15796-15800.

[12] Boffard, R., "Burning issue", *Engineering and Technology*, Vol.10, No.7, 2015, pp. 48-51.