A STUDY ON NOISE REDUCTION OF AUDIO EQUIPMENT INDUCED BY VIBRATION --- EFFECT OF MAGNETISM ON POLYMERIC SOLUTION FILLED IN AN AUDIO-BASE ---

Masahide Kita and Kiminobu Nishimura

Kinki University, 1 Takaya Umenobe, Higashi-Hiroshima, Hiroshima, 739-2116, Japan
e-mail:k.masahide.hiro.kindai@gmail.com

Recently, though multi-channel audio technique provides surround representation, conventional standard stereophonic reproduction could recreate three-dimensional sound field by perfect reproduction of sound without losing any of information involved in sound source. Unfortunately, it is known that when music is reproduced by audio equipment, sound quality degrades because of noise or distortion produced in equipment by various factors. One of above factors, vibration induced on equipment is remarkable one. To adjust the replay sound, various kinds of audio-bases are on the market, but their effect or work is not clarified. In the previous studies, new style of audio-base was proposed which constructed with spike installed in a cup poured with polymeric solution (e.g., Polyethylene Glycol (abbr. PEG)). When the PEG molecule in vibrates at right angles to magnetism, it will rotate and absorb the vibration energy more strongly under reinforced magnetism. On the other hand, as vibration on audio equipment causes electromagnetic induction noise, degrease in vibration becomes effective to reduce noises.

In this study, to clarify the qualitative relationship between the magnetic field strength and vibration reduction, we have carried out two experiments. First, induced noise on amplifier vibrated by sinusoidal sound excitation without signal input is observed for with and without strong magnetism around audio-base. Next, to evaluate the ability of vibration reduction under strong magnetism, we observed the vibration caused on the amplifier under usual music representation. Consequently, it is clarified that the vibration and electromagnetic noise induced on amplifier can be reduced well under reinforced magnetism around audio-base. Especially, harmonic distortion is effectively about 1.5 dB by reinforced magnetism.

1. Introduction

Though, the recent digital technology provide high quality sound signal free from noises, we can’t escape the influence of noise because we hear it finally as sound wave radiated from loudspeaker or head phone through analogue devices. Unfortunately, the analogue system contains several kinds of noises like as high frequency pulse noise coming from external power supply, harmonic distortion and etc.. So, the reproduced sound quality of analogue system degrades its quality because of these noises. Almost of noise origin is related to electrical one like as external power supply, electric devices and so on, so many methods are directed to electrical technique to reduce electrical noises. Another noise is electromagnetic induced noise originated in mechanical vibration caused on the devices or chassis of equipment excited by vibration on a power transformer, a driver unit of CD and radiated sound from loudspeakers as the result of interaction between oscillatory motion and external magnetism like geomagnetism. Furthermore, for a speaker system, the vibration caused on the magnet of speaker unit becomes severe because the speaker corn is excited by music signal based on the fixed magnet. The magnet fluctuates slightly by reaction of vibrating corn and vibration on baffle, and then this fluctuation superfpose on the radiated sound of music especial-
ly in higher frequency region.

Then, to improve the represented sound, a user attempts audio-bases to audio equipment and try to control sound quality, but it is not clarified whether the sound quality has been changed and improved by using them or not. In the previous studies [1] [2], the works of audio-bases was clarified that they are effective to reduce inevitable vibration and electrical noise caused on audio equipment and to improve the sound quality and summing localization of reproduced stereophonic sound. These effects increase by use of polymeric solution especially PEG (Polyethylene Glycol) solution. The effect of PEG seems to be caused by electromagnetic induction between velocity of electric dipole and external magnetism.

In this study, to clarify the qualitative relationship between the effect of PEG solution poured in audio-base and magnetic field strength, we have carried out several experiments. First, to evaluate the effect of magnetism to the audio equipment through PEG solution, the induced vibration and noise of amplifier were measured under sinusoidal excitation by sound wave without signal input to the amplifier. Next, to clarify the qualitative relationship between decrease in vibration and decrease in noise under increase in magnetism, we observed the vibration caused on the chassis of amplifier under sinusoidal input. Finally, we evaluated the amount of harmonic distortion contained in output signal. Furthermore, to evaluate the tendency between decrease in noise and improvement of sound quality, we carried out a hearing test. Consequently, it is clarified that the vibration and electromagnetic noise induced on equipment can be reduced well under reinforced magnetism around audio-base. Especially, harmonic distortion is effectively reduced about 1.5 dB by using permanent magnets.

2. Effect of audio-base shaped in exponential horn with cup poured PEG solution

There are many kinds of audio-bases on the market. The most typical one is shaped conical and used the vertex on the floor. Furthermore, in previous study [3], we proposed more effective one having exponential horn shape with cup poured with PEG solution as shown in Figure 1 (a). And, we could clarify that the audio-base is effective to reduce inevitable vibration and electrical noise on stereophonic equipment. Then, we came to a conclusion that the proposed audio-base works as mechanical diode as shown in Figure 1 (b). Furthermore, we could clarify that it can improve the sound quality and summing localization of reproduced stereophonic sound. That is, as the vibration caused on a circuit of equipment induces electric noise based on Lorentz force under geomagnetism, the reduction of vibration on equipment by audio-base is effective to reduce electric noise and improve the sound quality.

Here, PEG is a polymer constructed by single-strand binding of n unit of C₂H₄O having OH and H at its both ends. PEG is high polymer with high conductivity and strong polarity. In aqueous solution, the long chain molecules have H⁺ and OH⁻ at the both ends and form an electric dipole. Then, the mechanism to absorb the vibration energy by PEG solution is assumed that the PEG molecule repeats rotary motion by electromagnetism induction effect with geomagnetism.

![Cross-section of audio-base.](image1)

![Vibration transmitting characteristic of audio-base.](image2)

Figure 1: Structure of audio-base employed in this study.
3. Experimental study on the effect of magnetic field strength to the PEG aqueous solution

In this study, we employed audio-base used in previous study [3] shaped in exponential horn with cup poured PEG solution. To clarify the effect of external magnetism to PEG solution poured in audio-base, we have carried out several experiments on induced vibration and noise in audio equipment. First one is designed to evaluate the effect of vibration absorption. Second one is designed to evaluate the qualitative relationship between induced vibration by external excitation with sound and induced noise by electromagnetic induction in electric circuit. Third one is designed to evaluate the effect on the reduction of harmonic distortion in signal output of amplifier. Each experiment is carried out for three situations of setting the equipment as normal use of equipment without audio-base, set up on audio-bases and set up on audio-bases with permanent magnets around it. The permanent magnets are attached around audio-base as shown in Figure 2 (a) and (b).

3.1 Effect on the vibration control of audio equipment

To evaluate the effect of magnetism to reduce the vibration caused on audio equipment, we employed a CD player as objective equipment because of its flat top panel. The position of three audio-bases under the equipment is shown in Figure 3 (a), and the schematic diagram of experimental arrangement is also illustrated in Figure 3 (b).

Figure 4 shows the power spectrum of vibration velocity caused on the chassis of CD player. In this figure, the average level of vibration decreases about 1.9 dB by use of audio-base comparing with normal use of equipment. Furthermore, the vibration level still more decreases about 0.5 dB by using permanent magnet around audio-base. Figures 5 and 6 show comparisons on the distribution of vibration amplitude on the flat top panel of CD player. Figure 5 shows the vibration distribution for 118.75 Hz in which the observed level showed most significant mode. Figure 6 shows that at 7 kHz. Vibration in 118.75Hz is related to power supply or power transformer. From these figures, the area of high vibration level decreases by installation of audio-base. Furthermore, the area of low vibration level region expanded larger by using permanent magnets. From these figures, it is clear that the magnetism increases the effect of vibration absorption by PEG solution.

![Figure 2: The applying method of permanent magnets around audio-base.](image)

(a) Setting method of permanent magnet around insulator. (b) Application to audio-base.

![Figure 3: The arrangements of audio-bases and experimental equipment.](image)

(a) Position of audio-bases under CD player. (b) Schematic diagram of experimental arrangement.
3.2 Qualitative relationship between induced vibration and output noise

To find out the qualitative relationship between induced vibration and output noise, we employed an amplifier as objective equipment. The amplifier is excited by sinusoidal sound wave of n kHz where n equals from 1 to 20 radiated by another system. The output of amplifier is loaded by resistor of 8 Ω under no signal input. Figure 7 shows schematic diagram of experiment.

Figure 8 shows decrease in the vibration velocity and the output levels as the difference between with use of magnet and without magnet under sinusoidal excitation by sound. In this figure, as the positive values show the decrease in induced vibration on chassis and output by use of magnet, the
use of magnet is effective to reduce the vibration and noise especially in the frequency band from 4 kHz to 12 kHz. From this figure, there seems to be some qualitative relationship between magnetic field strength and vibration absorption ability of PEG solution. Furthermore, there seems also to be the tendency of magnitude of vibration and induced electric noise at the output.

To find out the factors for improvement in sound quality from underlying slight change in noise level, we evaluated the decrease in averaged noise level. Table 1 shows the decrease in induced vibration and noise levels between without magnet and with use of magnet for several frequency bandwidth including spectra cue or important keys to recognize summing localization. Based on this table, the PEG aqueous solution increases in the effect to reduce vibration approximately 25 dB and noise approximately 2.8 dB by use of magnet.

Figure 7: Schematic diagram of experimental arrangement to evaluate the qualitative relationship between induced vibration and output noise.

Figure 8: The level differences evaluated by subtracting the result with use of magnet from that without magnet for induced vibration and output signal.

Table 1: The sum of level differences for induced vibration and output signal by using magnets within some frequency band width effective for summing localization.

<table>
<thead>
<tr>
<th></th>
<th>2-8kHz</th>
<th>5-8kHz</th>
<th>2-10kHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>The vibration reduction [dB]</td>
<td>18.75</td>
<td>14.73</td>
<td>25.37</td>
</tr>
<tr>
<td>The noise reduction [dB]</td>
<td>1.98</td>
<td>0.91</td>
<td>2.78</td>
</tr>
</tbody>
</table>
3.3 Effect on harmonic distortion of magnet

As the audio-base with PEG solution possesses effect to reduce harmonic distortion, we evaluate the increase in its ability by use of permanent magnet around audio-bases. Amount of harmonic distortion component was evaluated by the difference between fundamental and higher harmonics of output signal under sinusoidal input from 1 kHz to 10 kHz for amplifier. Figure 9 shows schematic diagram of experimental arrangement.

Figure 10 shows decrease in harmonic distortion included in output signal by use of magnet comparing with geomagnetism. In this figure, there seems to be same tendency between vibration and output signal except for mismatch at 4 kHz and 5 kHz. Table 2 shows the decrease in induced harmonic distortion as shown in Table 1. (As the values are evaluated by sum in each bandwidth, obtained values are proportional to bandwidth.)

Table 2: The sum of level differences for induced vibration and harmonic distortion by using magnets within some frequency band width effective for summing localization.

<table>
<thead>
<tr>
<th></th>
<th>2-8kHz</th>
<th>5-8kHz</th>
<th>2-10kHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>The vibration reduction [dB]</td>
<td>10.29</td>
<td>6.07</td>
<td>14.64</td>
</tr>
<tr>
<td>The reduction of harmonic distortion components [dB]</td>
<td>1.16</td>
<td>0.80</td>
<td>1.48</td>
</tr>
</tbody>
</table>
3.4 Effectiveness on sound quality of magnet to PEG solution

Finally, the reproduced sound should have high quality to match the sound at recording site by eliminating induced noise in audio equipment from reproduced sound signal. Here, to consider the effect of noise reduction to improvement of reproduced sound, the frequency characteristic on decrease in the induced noise by vibration on chassis and harmonic distortion originated from input signal by using permanent magnet is shown in Figure 11. Both frequency characteristics show same tendency. Especially in frequency band from 4 kHz to 12 kHz, the decrease in noises is obvious. This suppression characteristic of noise seems to be effective to improve the quality of reproduced sound.

![Figure 11: The reduction of fundamental component and harmonic distortion components using magnets.](image)

4. Hearing test

To evaluate the improvement in sound quality by using permanent magnet to audio-base, hearing test was carried out in a laboratory room. Employed stereophonic equipment is fully tuned up to illustrate well the sound image under standard stereophonic representation. The subjects were 8 persons. The test signals are some music sources adopted from CD on the market. In the hearing test, we employed audio-bases to CD player and line amplifier. The each subject answers a questionnaire on nine words related with sound quality.

Figure 12 (a) and (b) show the comparisons of sound quality for two kinds of music. These figures are illustrated under the criterion of normal reproduction as point 3. The result obtained with audio-bases is marked with triangles and that with audio-bases attached permanent magnet is marked with squares. Comparing the result with audio-bases attached permanent magnet with that of just audio-bases, sound quality is improved especially “resolution”. By considering the improvement in “resolution” involves free from noises, the decrease in noises induced from vibration is effective to improve the reproduced sound quality. Especially, as the noise treated in this study is originated vibration on equipment, the proposed method seems to be effective comparing other method based on electric technique.
## Conclusions

In this study, we have studied experimentally that the effect of vibration reduction by audio-base poured with PEG aqueous solution is influenced by increase in magnetic field strength. Furthermore, the improvement in sound quality reproduced under standard stereophonic representation is confirmed by hearing test.

Consequently, audio-base which is poured PEG aqueous solution into the cup is effective to reduce vibration and noise of audio equipment. Especially, its effect increases in frequency band from 4 kHz to 12 kHz by using permanent magnet around audio-base. Then, it is clear that the works of PEG solution against to vibration absorption is connected with external magnetism.

## REFERENCES


