

# An Experimental Investigation of Noise Energy Generation

Byung-Wan Jo, Dong-Yoon Lee, Jung – hoon Park and Chang -Yeol Yeom

**Abstract**—In this study noise energy harvesting is proposed for green infrastructure development. Infrastructures such as railroad, subway, and road are taken into consideration as sources of noise which provides energy through certain wave forms. As the need of recycling noise energy became reasonable due to the increase of infrastructure usage, the capacity and property of the noise energy generating device used in this study, which uses electromagnetic induction for electricity generation, are analyzed in this paper

**Keywords**—noise energy, energy harvesting, noise energy generating device

## I. INTRODUCTION

GLOBAL CO<sub>2</sub> reduction technology through the use of renewable energy.

Governments all over the world are in effort to alternate fossil fuels which discharge CO<sub>2</sub> in numbers of fields including fuel cell and solar, wind, geothermal, bio, waste-to energies that have infinite potential as a higher value-added resource in the future. With such movement, it is very necessary to make an effort for energy-harvesting to use dissipating energy which is being wasted in our environment. [1].

Therefore, the present study is planned to perform basic research for sound energy-harvesting from the noise of the road, rail, airport, tunnel facilities which pertain to the infrastructure of green society by analyzing the applicability of noise energy-harvesting, property of noise depending on each infrastructure, change in production of power and also in voltage according to the oscillation frequency and sound pressure of the noise as the factor of energy-harvesting which converts sound and vibrational energy from traffic facilities into electrical energy to ultimately study energy-harvesting technologies directed to use the energy from living, industrial, of construction and traffic noises which have increased by rapid economic development. [2], [3].

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## II. ELECTRICITY GENERATING EXPERIMENT FOR THE NOISE-ENERGY HARVESTING

### A. Mechanism of noise-energy generating

Sound is a certain form of energy which is transferred as a form of wave through the air used as medium. Direction of wave is aligned to the same direction of vibration of the medium and such form of wave is called longitudinal wave. In this wave, the physical force occurs from sound pressure made through the air as a medium. This property of sound pressure allows to change sound energy into kinetic energy by transferring the sound energy on to the vibrational diaphragm and change the kinetic energy into electrical energy by using vibrational nature of kinetic energy.

In the present study, electromagnetic induction of which method is to induce electricity by repeating change of magnetic field through vertical vibration of inducing coil around the magnet of the diaphragm during the transformation of kinetic energy which is formed by sound energy into the electrical energy is used. This is the mechanism which is applied to the real Moving-coil microphone. Fig 1 shows the schematized process of the noise-harvesting generator used in the experiment.

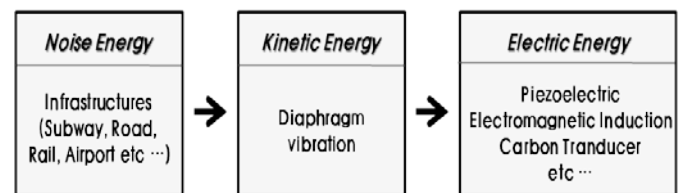


Fig. 1 Noise-Electricity Transferring Process

Diaphragm in Fig 2 are formed by thin film which can move along with the pressure of the sound wave. This movement of plate makes inducing coil surrounding the magnet to move up and down repeatedly, finally producing electricity induced by fluctuation of magnetic field around the coil. The induced electricity has alternating current, so the Bridge circuit has been used to change the alternating current into the direct current.

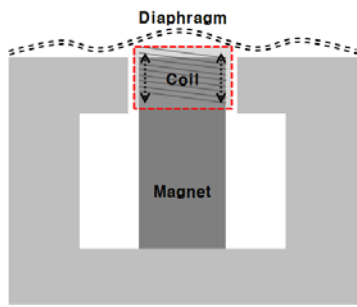


Fig. 2 Noise Energy Generating Device

*B. The function and property of noise-energy harvesting generator s*

In the present study, two kinds of noise energy harvesting generator devices in Fig 3, Fig 4 made by domestic acoustic company for the noise energy experiment are used. Also difference in resistance values were made which affect electromagnetic induction by making diameters of coil inside each devices different, as represented in Table 1.



Fig. 3 Device #1

Fig. 4 Device #2

TABLE I  
NOISE ENERGY GENERATING DEVICE CAPACITY

Type	Coil Diameter (mm)	Resistance ( $\Omega$ )
Device #1 (Copper)	0.03	600 $\pm$ 15%
Device #2 (Copper)	0.05	40 $\pm$ 15%

Resistance value is affected by the length of coil as well as the material property of coil. #2 device has wider diameter than #1 device and reducing the resistance value by making fewer winding frequency was focused. Not only for that, by reducing winding frequency and forcing the weight of the small size coil on the diaphragm, the plate made with thin film could be produced properly to react sensitively even to the small noise.

*C. Experimental method of noise-energy generation*

Change in voltage and power depending on the oscillation frequency and sound pressure was analyzed using the noise-harvesting generator. This procedure was carried by a

method to record data via tuning the spacing between the diaphragm of the speaker and the diaphragm of the noise-energy generating device.

The first experiment is performed to measure the change in voltage and power along with the variance in noise oscillation frequency by using Function Generator in Fig 5. The change is measured at the constant distance of 10cm far from the speaker's diaphragm, increasing oscillation frequency with 2Hz as a unit within the bandwidth of 70~220Hz of low oscillation frequency. The second experiment is performed to measure the voltage and power according to the distance from the source of noise with constant oscillation frequency and constant sound pressure and the third experiment is carried to measure the voltage and power with respect to the variation of sound pressure, analyzing the relation between them.

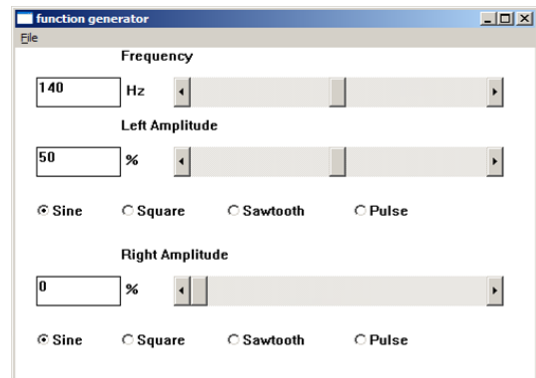


Fig. 5 Structure Function Generator

III. INVESTIGATIONS OF NOISE ENERGY HARVESTING EXPERIMENT

*A. Electrical values depending on noise oscillation frequency*

Energy characteristics of noise are basically determined from oscillation frequency and sound pressure. oscillation frequency is represented as Hz, and sound pressure level as dB or the volume commonly used to represent the scale of the sound. After transformation of sound energy into kinetic energy, the property of sound is changed to the property of electricity. Such electrical properties include voltage(  $V$  ), current(  $I$  ), resistance(  $R$  ) and power(  $W$  ). These electrical properties have relation for each other as following;

$$I = \frac{V}{R}, W = \frac{V^2}{R} \tag{1}$$

Based on assumption that major oscillation frequencies of noises are different by types and locations of social infrastructures, the result of the analysis on the characteristics of oscillation frequencies of the two devices used in the experiment shows that as seen from Fig.6, there is a specific oscillation frequency producing the maximum voltage in those

two devices. The reason why a maximum voltage value is coming from this specific oscillation frequency is because the oscillation membrane of the device vibrates maximum at the specific oscillation frequency, and the relevant oscillation frequency is called as a natural frequency of the noise-energy generator. This natural frequency varies according to characteristics of oscillation membranes, and a maximum voltage and power could be produced by varying characteristics of oscillation membranes.

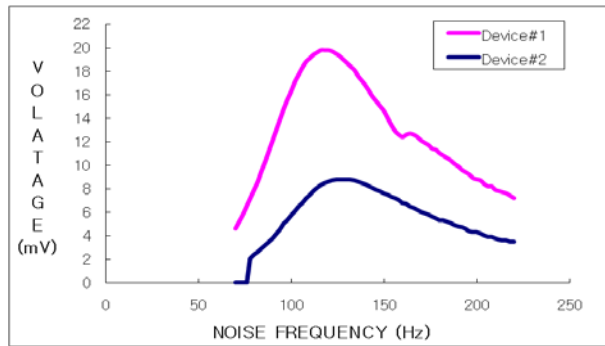


Fig. 6 Voltage Generation According to Noise Frequency

This means that it is possible to maximize energy harvesting effects by setting a natural frequency on each device suitable to each characteristic of social infrastructure's noise developing oscillation frequency when noise-harvesting generators are applied to social infrastructures such as railroad or subway tunnel etc.

Out of the experimental results, maximum values of the voltage and power at bandwidth 100~140Hz are shown on Table 2. Seen on the tables, it is able to recognize that device #1 is at 118Hz, device #2 is at 128Hz producing a maximum voltage and power, and need to complement natural frequency of the devices in order to harvest noise energy coinciding to major oscillation frequency bandwidths of actual social infrastructures

TABLE 2  
GENERATED VOLTAGE OF DEVICE#1 AT 110~140HZ

Frequency (Hz)	Voltage (mV)	Ohm ( $\Omega$ )	Power (mW)
110	19.1	593.8	0.61437
112	19.4	593.8	0.63382
114	19.6	593.8	0.64695
116	19.8	593.8	0.66022
118	19.8	593.8	0.66022
120	19.8	593.8	0.66022
122	19.7	593.8	0.65357
124	19.5	593.8	0.64037
126	19.3	593.8	0.62730
128	19.0	593.8	0.60795
130	18.7	593.8	0.58890
132	18.4	593.8	0.57016
134	18.1	593.8	0.55172
136	17.6	593.8	0.52166
138	17.2	593.8	0.49821
140	16.8	593.8	0.47531

### B. Electrical properties by distance of noise sources

In this experiment, assuming a speaker as a noise source, the distance between the noise source and the noise-energy generator was measured by designating the distance between each oscillation membrane and used the natural frequency of noise-harvesting generator which is measured by voltage-power according to oscillation frequency. As seen on Fig.7, it is able to recognize that voltage and power is decreasing by non-linear rate as being more far from the noise source, and this is because the noise pressure reaching noise-harvesting generator is being lower as the distance of noise being longer due to noise wave dispersion in the air. Actually noise characteristics are varying according to external characteristics changes like location or structures of social infrastructures, application of noise-harvesting generators also varying by these changes. Also through this experiment, it is able to expect that, when applying the noise-harvesting generators to noise source of social infrastructures, placing the devices closer to noise sources would be important in order to get more effective harvesting.

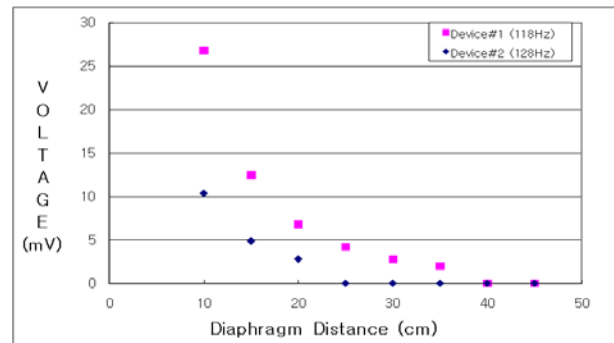


Fig 7. Generated Voltage According to the Distance from Speaker Diaphragm

### C. Electrical value by noise pressure

Sound pressure is the important element deciding the size of noise energy and being produced by pressure of air, a medium of delivering sound waves. This experiment was held keeping the volume(sound pressures)of the speaker and the computer at a fixed level, while increasing the volume of Function Generator till 50% continuously by each 5% step and found that voltage is increasing in a linear form with volume increase as seen on Fig.8

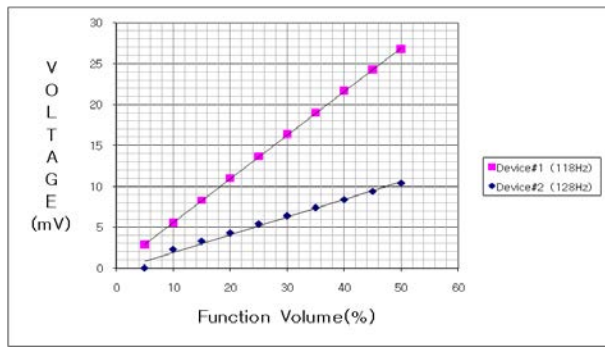


Fig 8. Generated Voltage According to Volume

With results as above, we could expect that the voltage and power producing from noise-energy generator would increase or decrease with some fixed rate according to decibel(dB) which indicates size of the noise deriving from social infrastructures, and the more effective energy harvesting will be possible in the tunnels or internal spaces where the size of noise being more reflected, bended and amplified than in normal open spaces.

#### IV. CONCLUSION

In this study, analysis on characteristics of noises deriving from social infrastructures are carried out and tried to find a way of effective development of noise energy harvesting technology by proving its application possibility and implementing a basic experiment of producing voltage and power using specially made noise energy developing device.

Noise energy harvesting technology is basically a technology to produce electricity by use of characteristics of

noise waves, and we, via experiment, have demonstrated that major two elements deciding noise energy, the oscillation frequency and sound pressure are influencing considerably on its development.

With the experiment, it has been recognized that two electromagnetic inductive noise-harvesting generator showed its best production efficiency at 118Hz and 128Hz oscillation frequency of noises, and could confirm the fact that the more effective noise energy recovery would be possible by developing natural frequencies of noise devices suitable to characteristics of noise oscillation frequency of social infrastructures.

Low carbon green development era has come and interests in clean energy is ever increasing in all over the world, and according to this trend, we shall need to study on noise energy which is wasted easily in our life surroundings, and requires more efforts to increase functions and efficiency of noise-harvesting generators to apply

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