

The Potential of Mechanic Vibration for Generating Electric Energy

Muhammad Afta Dzikril Hakim^{1*}, Muhammad Amiruddin¹, Ken Hasto¹, Margono¹, Imadudin Harjanto¹, Carsoni², Irna Farikhah², Yuris Setyoadi², Harto Nuroso³, Ummi Kaltsum³

¹Department of Electrical Engineering, Faculty of Engineering and Informatic, Universitas PGRI Semarang, Jl. Jalan Sidodadi Timur No. 24-Dr. Cipto, Karang Tempel, Semarang Timur, Kota Semarang, Central Java, Indonesia

²Department of Mechanical Engineering, Faculty of Engineering and Informatic, Universitas PGRI Semarang, Jl. Jalan Sidodadi Timur No. 24-Dr. Cipto, Karang Tempel, Semarang Timur, Kota Semarang, Central Java, Indonesia

³Department of Physics Education, Faculty of Mathematic, Natural Sciences and Information Technology Education, Universitas PGRI Semarang, Central Java, Indonesia

*hakimaftal@gmail.com

Abstract. The purpose for this study is to convert mechanical vibration into electrical Power. Our target is to provide enough power for 1.2 V rechargeable battery having 160 μA . The investigation was conducted experimentally in electrical mechanical engineering laboratory. Four piezoelectric was connected to circuits in series mode called 1 module. In order to recharge the battery having voltage 1.2 volt, the measurement of the intensity of the loudspeaker was verified. According to table 1, it was found that at 2 m/s^2 of vibration is best because the value is 1.4 V nearest to 1.2 V. It was found that the mechanical vibration can be converted into electric power. It was found that to recharge 160 μA having 1.2 V, the 20 modules are needed.

Keywords: piezoelectric, vibration, electric energy

(Received 15 August 2020, Accepted 10 September 2020, Available Online by 30 September 2020)

1. Introduction

An energy source is something around us that is capable of producing energy both small and large. Energy sources can be broadly divided into 2, namely renewable and non-renewable energy sources [1]. Energy demand in Indonesia is growing with the rapid increase in development in the fields of technology, industry and information. With the increase in energy consumption in Indonesia and the decreasing reserves of fossil energy, Indonesia is ready to develop non-renewable energy. Various new

forms of energy have developed, including wind power, steam power, biomass, and so on [2].

Today there is a shortage of energy sources and at the same time the load of modern electricity and devices based primarily and directly on electric power is increasing. This reality is a major challenge facing the government. Using multiple sources of energy instead of relying on a single source, especially if this source is a conventional source, is a necessary step. Conventional energy sources such as fuel and natural gas will end with time, so researchers are trying hard to develop and explore renewable energy sources such as the sun [3], wind [4], vibration [5], and thermal energy [6].

Most of the energy used is inaccessible energy so that accessible energy and / or other alternative energy sources are needed.

Noise is noise pollution that generally occurs in dense residential areas, industrial areas, and others. Hence, that is wasted energy. Psychological and health effects caused by the smell of deafness, feeling depressed, hypertension, and others. To prevent this, workers who are in areas with a high level of protection are required to be obliged.

Sound or oil is one of the most widely available sources of energy. Sound in fact is a mechanical wave generated from pressure oscillations through several media. Sounds that can be heard by the human sense of hearing with a frequency from about 20 Hz to 20,000 Hz are called audiosonics. In air at standard temperature and pressure, sound wavelengths range from 17 m to 17 mm.

Sound energy is the energy produced by sound vibrations as it travels through air, air, or other space. The frequency of the first sound energy source is infrasonic. Infrasonic is a very weak sound because the vibrations produced in infrasonic waves are less than 20 vibrations per second. Audiosonics is a type of sound that can be heard by humans. Ultrasonic waves are waves with sound vibrations of more than 20,000 vibrations per second [7].

Noise is noise pollution. Therefore, noise pollution needs to be minimized or used for energy sources. In this research, noise pollution is stated by a sound signal that is predicted to have the potential to be converted into energy.

2. Methods

3.1 Development Model

This research was conducted by means of experiment. This research was conducted to investigate the potential for mechanical vibrations for a source of electrical energy.

The stress of this research can be obtained from the measurement of the oscilloscope which comes from mechanical vibrations. The current is obtained by adding a load in the form of a resistor. Then the power is obtained from the multiplication of voltage and current.

3.2 Research Procedures

The research procedure in this thesis is as follows:

Piezoelectric Sensor Testing. Firstly, the sensor is installed and the vibration is set at 0.5 m/s^2 by adjusting the volume. Later on, the output (voltage) sensors 1, 2, 3 and 4 were measured. It is measured twice. After that the voltage multiplier module is installed and measured the voltage. The module consists of 4 circuits. The circuits which represent the multiplier voltage are connected to the piezoelectric sensors in series mode. The multiplier voltage is arranged from 2 Capacitors and 2 Diodes. The detail procedures are shown in Figure 1.

3.3 Population and Sample

The population in this study was the Electrical Engineering Laboratory Campus 3, Universitas PGRI Semarang. The samples in this study are several piezoelectric sensors to be used as research objects.

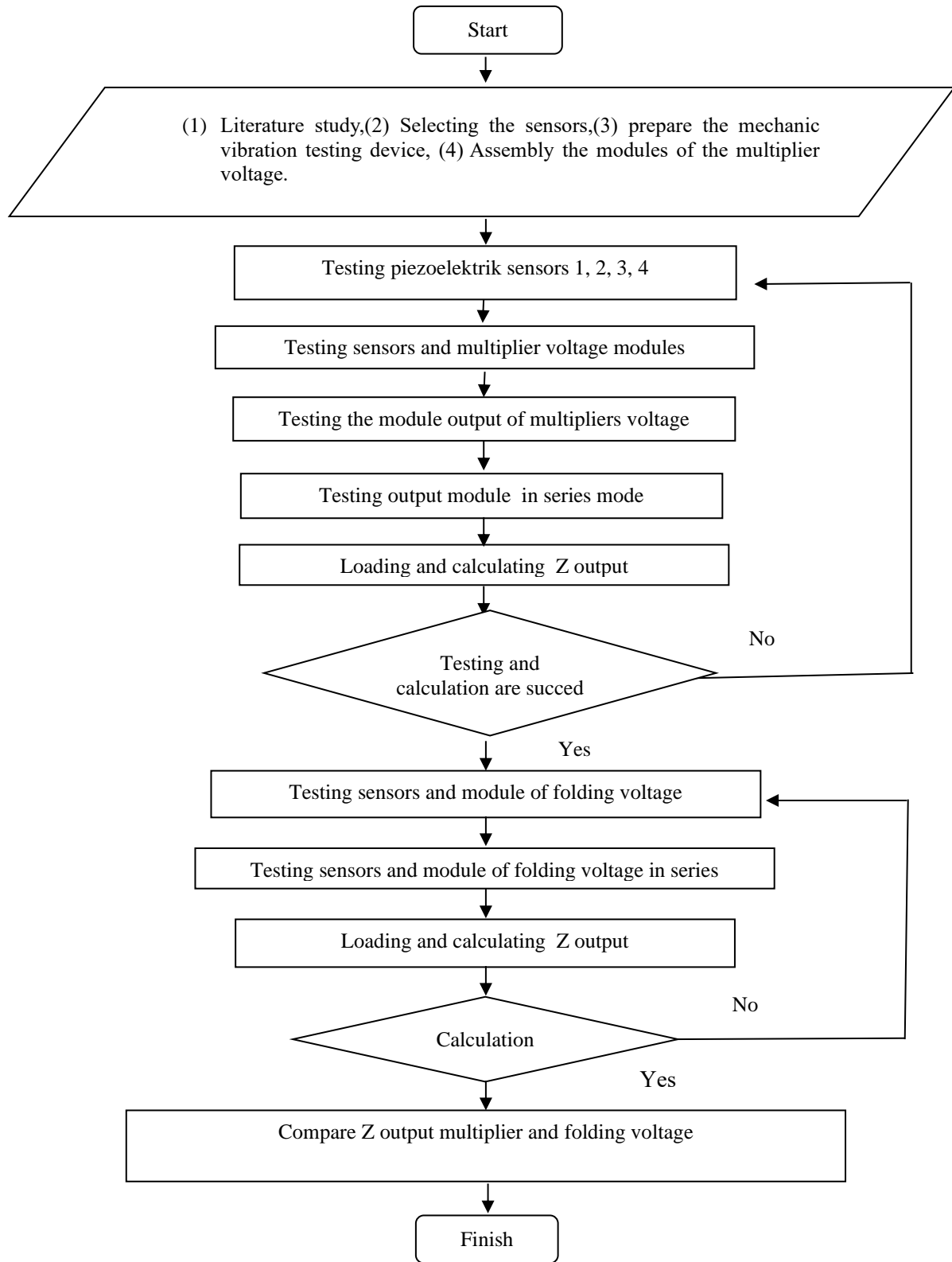


Figure 1. Flow chart of the research

3. Results and Discussion

As can be seen in Fig. 2, the experimental device is set up. It consists of loudspeaker, 4 piezoelectric sensors, voltage multiplier and loads. The mechanic vibration resulted by the electrodynamic loudspeaker converted into the electric power.



Figure 2. the experimental device

Table 1 shows the sensor testing which are arranged in 4 series circuit piezoelectric and voltage multipliers [Figure 1] for generating the electric power. These are called as a module. It is clear that the varied number of the vibration, which is the source of the energy, is five. They are 0.5 m/s^2 , 1 m/s^2 , 1.5 m/s^2 , 2 m/s^2 and 2.5 m/s^2 . The output of the vibration resulting low voltage. To increase the voltage, a voltage multiplier is needed. It was measured and conducted three times as shown at table 1. Thus it was found the average output (output AVG) is 1.4 V for vibration 2 m/s^2 .

In order to recharge the battery having voltage 1.2 V , the measurement of the intensity of the loudspeaker was verified. According to table 1, it was found that at 2 m/s^2 of vibration is best because the value is 1.4 V nearest to 1.2 V , which is the voltage of the rechargeable battery.

Tabel 1. Testing the sensors.

Module	Vibration (m/s^2)	Output 1 DC (Volt)	Output 1 DC 2	Output DC 3	Output AVG
4 series circuit	0.5	0.24	0.24	0.24	0.24
	1	0.6	0.6	0.6	0.6
	1.5	1	1	1	1
	2	1.4	1.4	1.4	1.4
	2.5	2	2	2	2

It was found experimentally that the Output voltage V_{out} from the module shown in table 2 is as follows

Table 2. Vibration source for 2 m/s².

Vibration (m/s ²)	Voltage without load (V_{tb})	R (Ω)	V_{out} (V)	Z_{out} (Ω)
2	1.4	83300	0.47	164827.7
		76900	0.45	163412.5
		71400	0.43	161065.1
		66700	0.41	161056.1
		62500	0.40	158459.6

Based on table 2, we can find that the average of the output impedance Z_{out} is 161764.2 Ω using the equation below

$$Z_{out} = \left(\frac{V_{tb} - V_{out}}{V_{out}} \right) R \tag{1}$$

where Z_{out} is the output of impedance, V_{tb} is Voltage without load, V_{out} expresses voltage output and R is resistance. To recharge battery having 160 μA , the maximum current I_{max} must be found. Using equation 2, we calculated I_{max} .

$$I_{max} = V_{tb} / (Z_{out} + R_l) \tag{2}$$

Figure 3 shows the diagram module. It consists of four piezoelectric and circuits. The piezoelectric is connected to voltage multiplier called circuit. The mechanic vibration resulting voltage. However, the voltage is low. To increase it, the circuit is needed.

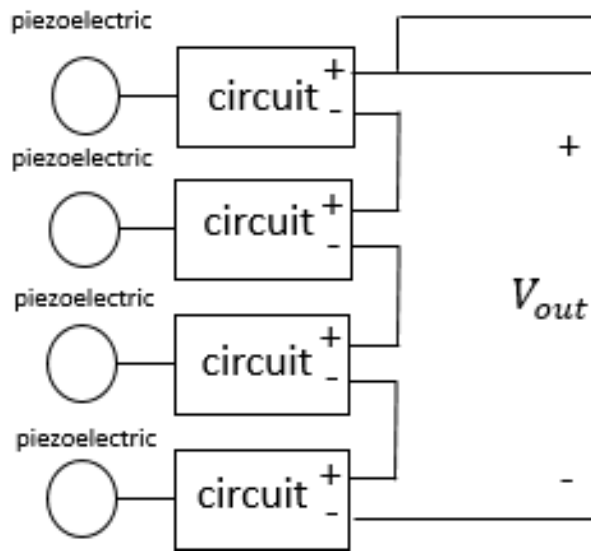


Figure 3. diagram module

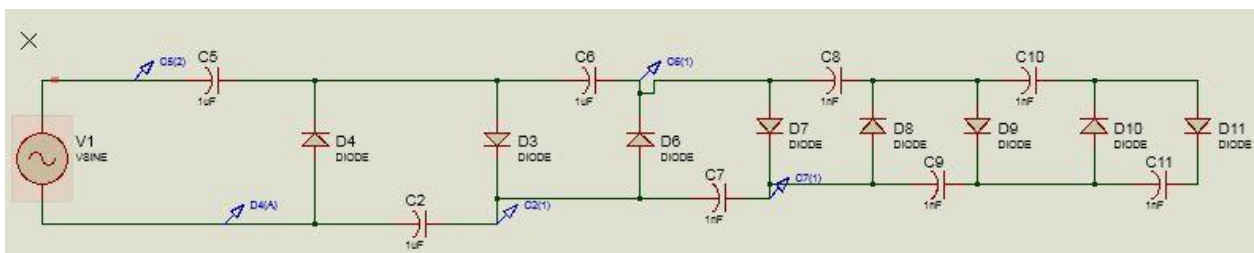


Figure 4. Schematic of Multiplier Circuit

As can be seen in Figure 4, the schematic of multiplier circuit is shown. From left side, we can see the energy source from piezoelectric having 4 series mode. It is connected to capacitor and diode. There are 8 capacitors and diodes.

Table 3 shows 1 module and 20 modules. 1 module resulting $8,65 \mu A$. It was resulted experimentally and using equation 1 and 2. The rechargeable battery need $160 \mu A$, so using calculation we need 20 modules.

Tabel 3. Sensor Testing

	1 Module	20 Module
Current	$8,65 \mu A$	$160 \mu A$

4. Conclusion

In this investigation, the mechanical vibration can be converted into electrical power. Moreover, we found that for charging 1.2 V rechargeable battery having $160 \mu A$, we need to set up 20 modules, which have four series mode of piezoelectric and circuits.

Acknowledgements

This work was supported by LPPM Universitas PGRI Semarang.

References

- [1] Tipler, P. "Fisika untuk Sains dan Teknik Jilid 1", Edisi ketiga, Erlangga, Jakarta, 2001.
Saadon, Salem, Othman, " A Review of Vibration-Based MEMS Piezoelectric Energy Harvesters", *Energy Conversion and Management*, Vol. 52 Issue 1, pp. 500-505, January 2011.
- [2] Kementerian ESDM RI, "Peluang Menawan Bisnis Energi terbarukan di Indonesia", *Kompasiana*, 2017.
- [3] D. Dondi, A. Bertacchini, D. Brunelli, L. Larcher, L. Benini, "Modeling and optimization of a solar energy harvester system for self-powered wireless sensor networks," *IEEE T Ind Electron*, vol 55, Issue 7 , pp. 2759-2766, Jul 2008.
- [4] H.J. Jung, I.H. Kim, S.J. Jang, "An energy harvesting system using the wind-induced vibration of a stay cable for powering a wireless sensor node," *Smart Mater Struct* ,vol 20, Issue, JUL 2011.
- [5] S. E. Jo, M. S. Kim, Y. J. Kim, "A resonant frequency switching scheme of a cantilever based on polyvinylidene fluoride for vibration energy harvesting," *Smart Mater Struct* ,vol 21, Issue 1 , Jan 2012.
- [6] C. Knight, J. Davidson, "Thermal energy harvesting for wireless sensor nodes with case studies," *Advances in Wireless Sensors and Sensor Networks*, vol 64, pp. 221-242, 2010.
- [7] Tipler, P. "Fisika untuk Sains dan Teknik Jilid 1", Edisi ketiga, Erlangga, Jakarta, 2001.
Saadon, Salem, Othman, " A Review of Vibration-Based MEMS Piezoelectric Energy Harvesters", *Energy Conversion and Management*, Vol. 52 Issue 1, pp. 500-505, January 2011.