Pemanen Energi Piezoelektrik Tersinkronisasi Induktor Berbasis Konverter Boost Pulsa SatuTembakan

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Pemanen Energi Piezoelektrik Tersinkronisasi Induktor Berbasis Konverter Boost Pulsa Satu Tembakan

One-Shot Pulse Boost Converter-Based Inductor-Synchronized Piezoelectric Energy Harvester

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Abstrak – *Paper ini bertujuan meninjau metode pemanenan energi saat ini, berfokus pada pemanenan energi piezoelektrik. Untuk mengoptimalkan penggunaan perangkat piezoelektrik dalam aplikasi, diperlukan model untuk mengamati kinerja yang dihasilkan dari piezoelektrik. Dari beberapa sumber diketahui sistem sederhana memanen energi terdiri atas rangkaian penyearah dan kapasitor. Untuk mencapai performa yang lebih baik, sistem penyearah dan kapasitor tersebut dihubungkan dengan rangkaian konverter DC-DC. Metode lainnya adalah menggunakan metode Synchronized Switch Harvesting Inductor (SSHI). Penelitian ini menciptakan alat lantai pemanen energi listrik dengan memanfaatkan piezoelektrik berupa alat pemanen yang bertujuan untuk mengetahui cara kerja piezoelektrik dan untuk mendapatkan rangkaian dengan karakteristik yang paling efisisien sebagai pembangkit energi listrik piezoelektrik menggunakan SSHI dan boost konverter. Penelitian ini membandingkan karakteristik dari rangkaian seri, parallel dan seri-parallel pada lantai pemanen energi piezoelektrik yang paling optimal menghasilkan tegangan. Hasil penelitian ini menghasilkan tegangan pengoptimal sebesar 16,77V dengan 16 keping piezoelektrik dirangkai seri-parallel terhubung SSHI yang di kontrol oleh PWM Module NE555 dengan pengujian diberi pijakan sebanyak 60 kali. Pada paper ini pemanen energi menggunakan rangkaian SSHI memberikan tegangan lebih stabil pada lantai pemanen dibandingkan boost konverter dengan memberikan 16 keping piezoelektrik yang dirangkai seri-parallel. Lantai pemanen energi dengan konfigurasi seri-parallel yang terhubung SSHI mendapatkan hasil paling optimal dibandingkan menggunakan konverter boost.*

Kata Kunci*: Piezoelektrik, SSHI, Pemanen Energi, Boost Konverter*.

Abstract – *In this paper, we aim to review current methods of energy harvesting, focusing on harvesting piezoelectric energy. This phenomenon is known as the piezoelectric effect. To optimize the use of piezoelectric devices in applications, a model is needed to observe the performance generated from piezoelectricity. From several sources, it is known that a simple energy harvesting system consists of a series of rectifiers and capacitors. To achieve better performance, the rectifier and capacitor system is connected to a DC-DC converter circuit. Another method is to use the Synchronized Switch Harvesting Inductor (SSHI) method. This research creates an electric energy harvesting floor device by utilizing piezoelectricity in the form of a harvester, which aims to find out how piezoelectric works and to obtain a circuit with the most efficient characteristics as a piezoelectric power generator using SSHI and a boost converter. This study compares the characteristics of series, parallel and series-parallel circuits on the* *floor of the most optimal piezoelectric energy harvester to generate voltage. The results of this study produce an optimizing voltage of 16.77V with 16 piezoelectric plates arranged in a series-parallel connected SSHI which is controlled by the PWM Module NE555 with a grounding test of 60 times. In this paper, an energy harvester using the SSHI circuit provides a more stable voltage on the harvester floor than a boost converter by providing 16 piezoelectric pieces arranged in series-parallel. Floor energy harvester with a series-parallel configuration connected to SSHI get the most optimal result compared to used a boost converter.*

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Keywords*: Priezoelectric, SSHI, Energy Harvesting, Converter, Boost Converter.*

1. Introduction

The need for electrical energy which continues to increase in use can find a way out to minimize energy scarcity. At this time we often use energy that comes from fossils which are the mainstay of which use must be reduced. Therefore, we must provide other alternative solutions by producing renewable energy which is of course more environmentally friendly than fossil fuel energy. Without realizing it, all this time we have been ignoring one of the mechanical energies that we generate ourselves, namely mechanical energy in the form of vibrations generated from footsteps when walking. Piezoelectric is a component that can be used to harvest the results of wasted mechanical energy.

Piezoelectricity is a phenomenon discovered by the Curie brothers in 1880 in which electricity is generated from crystals subjected to mechanical pressure [1], [2] The word ipiezo itself is a Greek word which means pressure. The piezoelectric effect results from the linear electromechanical interaction between the mechanical and electrical parts present in the crystal [3]. Ipiezoelectric materials when they are not polarized because no pressure is applied. iMeanwhile, after the piezoelectric gets pressure, the piezoelectric will experience polarization and generate electricity [4]–[6]. The ability of one piezoelectric chip is around 5µA for the output current and 5 VAC for the output voltage. In general, piezoelectric materials on the market are circular (piezoelectric disks) with different diameters.

Piezoelectric is a material which when given pressure or vibration will generate electrical energy, research related to piezoelectricity was also carried out by [7]–[10] to utilize vibrations obtained from mechanical energy. In research conducted [11], [12] by utilizing piezoelectricity and boost converters as energy harvesters. To test this piezoelectricity with a pressure test and vibration test to see the effect on the surface area on its performance in producing electrical energy. This research is expected to assist engineers in choosing the right piezoelectric for manufacturing energy harvesting systems in order to produce greater electrical energy [13], [14].

Synchronized Switch Harvesters on Inductor (SSHI) [15]–[18] is one of the most efficient interfaces for pulsed piezoelectric energy harvesters. In research on SSHI [19]–[21] it can show the ability to increase high voltage. To activate the piezoelectric SSHI must issue a higher voltage than the capacitor [22]–[24].

In this research, low-power Energy Harvesting Floors are made that can be utilized and developed later to be used to supply low-power electronic devices. This research creates an electric energy harvesting floor tool by utilizing a piezoelectric as a harvester that is integrated with the SSHI circuit.

2. Method

In this study the design of a piezoelectric energy harvester utilizes the energy obtained from footsteps by utilizing piezoelectricity as the main component. To maximize the energy harvested, the use of the SSHI series is very helpful in optimizing the energy generated from the harvesting process from the harvester floor. Therefore, a circuit design needs to be created and implemented in this system to maximize the harvested energy from the harvesting floor.

2.1. Piezoelectric

Piezoelectric is formed from a ceramic material that has been polarized so that it is negatively charged which forms electrodes attached to opposite sides, in order to produce an electric material field that can change due to the influence of mechanical forces. Linear electromechanical interaction between the mechanical and electrical parts present in the crystal can produce the piezoelectric effect.

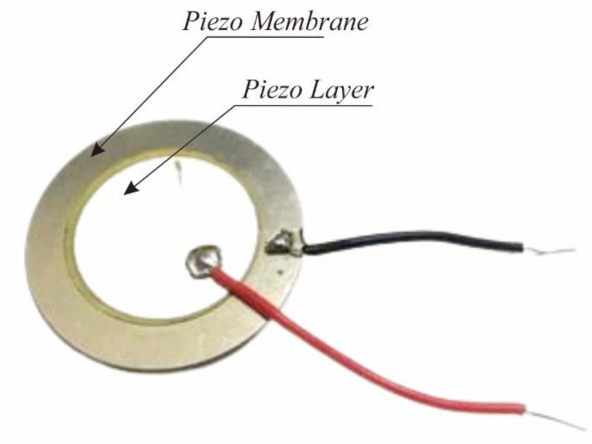

Figure 1. Piezoelectric

In this study using the piezoelectric in Figure 1, which is connected in series and parallel attached to polyfoam, and plywood as a cover later when the human footrest is not damaged.

2.2. *Synchronized Switch Harvesters on Inductor* (SSHI)

SSHI is one of the most efficient interfaces for piezoelectric energy harvesters with vibration, the SSHI circuit has several components that will be connected to each other to be able to influence each time a current will enter the SSHI circuit so that the current waveform is more stable, components that are interconnected in the SSHI circuit namely the Inductor winding, Mosfet IRF530N.

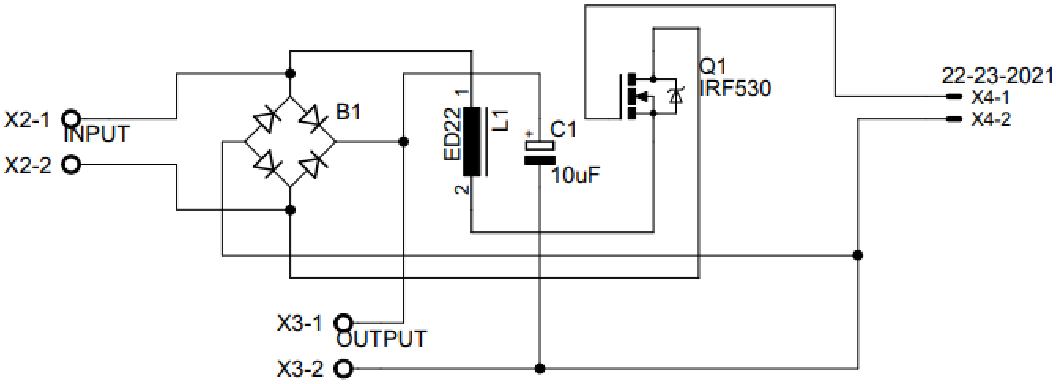

Figure 2. SSHI circuit schematic.

2.3. Block Diagram of the SSHI Connected System

In the block diagram of the process system Figure 3, the floor of the electric energy harvester uses a piezoelectric connected to SSHI, the vibration generated from mechanical energy is converted by the piezoelectric into AC electrical energy, the use of the SSHI circuit in the harvesting system to optimize the energy conversion generated from piezoelectricity maximally and more efficiently. In the SSHI series there is the NE555 module as a generator pulse circuit for switching. From the conversion process through the SSHI circuit, it is then directed so that the resulting AC voltage is converted to a DC voltage that can be consumed by low-power DC loads.

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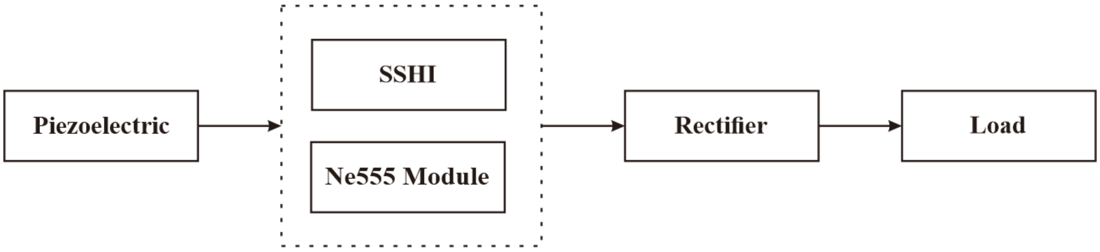

Figure 3. System block diagram of a floor SSHI-connected piezoelectric energy harvester.

2.4. Block Diagram of the SSHI Unconnected System

In the system block diagram Figure 4, the floor process of the electric energy harvester uses a piezoelectric not connected to SSHI, in this system the voltage generated from the mechanical energy process resulting from the piezoelectric footing is directly forwarded to the rectifier to convert AC to DC voltage which can then be consumed by low-power DC loads.

Figure 4. System block diagram of an SSHI disconnected piezoelectric energy harvester floor.

2.5. System Flowchart

In the flowchart of this study, two approaches are used. The first floor system is a piezoelectric energy harvester that is connected to the SSHI circuit and the second is without being connected to SSHI as shown in Figure 5.

In Figure 5, the system flow diagram (a) is a harvester system that is connected to SSHI which is synchronized with the NE555 module and aligned with a rectifier for AC to DC voltage conversion whose conversion results can be consumed by low-power DC loads.

In Figure 5 the system flow diagram (b) is a harvester system that is not connected to SSHI. The voltage generated from the piezoelectric is then directly rectified by the rectifier to convert the harvested AC voltage to be converted into DC voltage and can be consumed by low-power DC loads.

In this study, the data collection method used a trial method for several circuits, namely series, parallel and series parallel connected to SSHI and a circuit without SSHI by trying several human weights and the number of footings.

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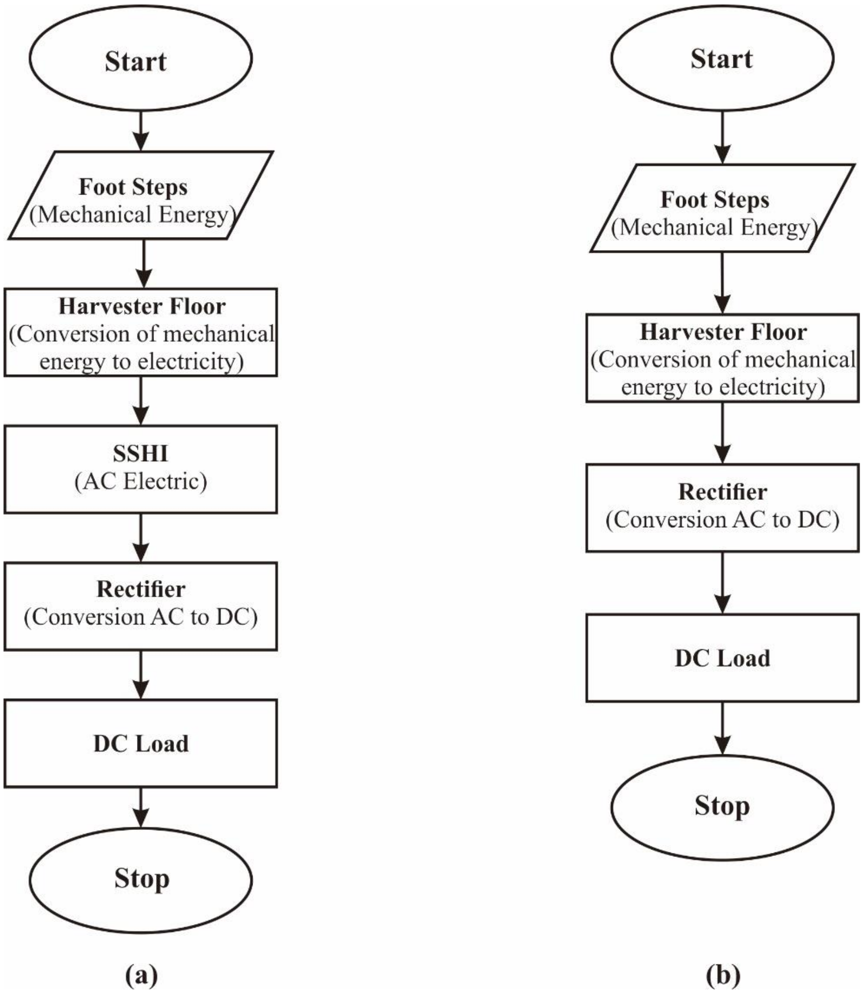


Figure 5. Flowchart of SSHI-connected and disconnected harvester systems.

2.6. Piezoelectric Energy Harvester Floor Test

This test has several stages, namely:

a. Testing the AC-DC voltage of 8 and 16 piezoelectric pieces based on human weight, testing the AC-DC voltage on this piezoelectric circuit will be tested in series, parallel and series parallel, by connecting 8 piezoelectric pieces arranged in series, parallel and series parallel, tests are carried out by tapping a person's feet on the floor of a piezoelectric energy harvester, data collection was carried out on 10 people with different weights, namely 47kg, 50kg, 53kg, 55kg, 58kg, 60kg, 68kg, 70kg, 72kg and 98kg.
b. Testing the NE555 Module. In testing the NE555 Module, a frequency matching is carried out that will be used on the NE555 Module. This test uses an oscilloscope to display frequency waves.
c. Testing the DC Voltage of 16 pieces of piezeoelectric based on the number of footings, this test was carried out by looking at the voltage generated by the piezoelectric energy harvester floor with the number of footings 4x, 8x, 12x, 16x, 20x, 24x, 28x, 32x, 36x, 40x, 44x, 48x, 52x, 56x and 60x footing each data capture.

3. Results and Discussion

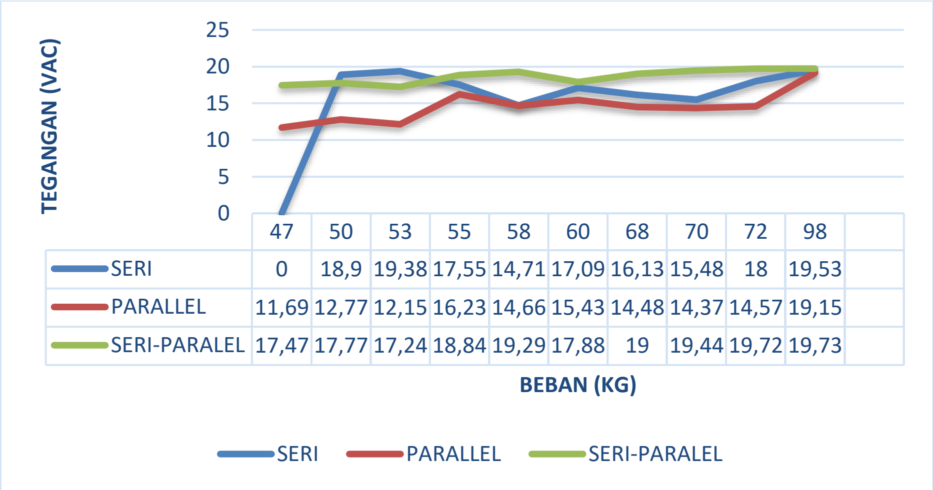
The results of this study are to determine the high efficiency and maximum power extraction from the floor of the piezoelectric energy harvester using SSHI and not using SSHI and to know the characteristics of the circuit and the work of the piezoelectric as a generator of electrical energy. In this test the focus is on finding voltage data with the most efficient circuit on the floor of a piezoelectric energy harvester which is connected to the SSHI circuit and which is not connected to SSHI.

In this study, the test is to see a comparison of the circuit on the floor of the piezoelectric energy harvester, namely:

1. Testing the AC-DC voltage of 8 piezoelectric plates.
2. Testing the AC-DC voltage of 16 piezoelectric plates.
3. Testing the DC voltage of 16 plates without connecting SSHI.
4. Testing the DC voltage of 16 pieces connected to SSHI.

3.1 AC-DC Circuit Comparison of 8 Piezoelectric Chips

The results of data collection in this test are based on the human body weight on the floor of the piezoelectric energy harvester, in this test it compares the AC-DC voltage output from 8 piezoelectric chips which are arranged in series, parallel and series-parallel. Comparison of the voltage results is presented using the graphs in Figure 6 and Figure 7.



	47	50	53	55	58	60	68	70	72	98
SERI	0	18,9	19,38	17,55	14,71	17,09	16,13	15,48	18	19,53
PARALLEL	11,69	12,77	12,15	16,23	14,66	15,43	14,48	14,37	14,57	19,15
SERI-PARALEL	17,47	17,77	17,24	18,84	19,29	17,88	19	19,44	19,72	19,73

Figure 6. Graph 8 AC Voltage Piezoelectric Chips.

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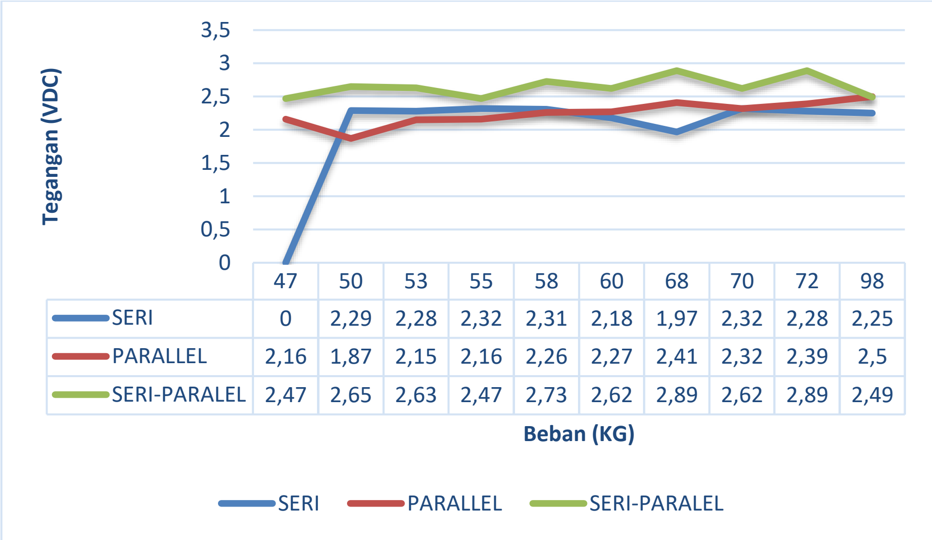

Figure 7. Graph 8 Piezoelectric Chip DC Voltage.

In Figure 6 and Figure 7 a comparison graph of series, parallel, series-parallel circuits of 8 AC-DC piezoelectric chips, the highest AC voltage output is 19.73VAC with a weight of 98kg in the series-parallel circuit, the highest DC voltage output is 2.49VDC . It can be concluded from the comparison test of 8 AC-DC chips weighing 98 kg that the most optimal output voltage is a series-parallel circuit.

3.2 AC-DC Circuit Comparison of 16 Piezoelectric Chips.

In Figure 6 and Figure 7 a comparison graph of series, parallel, series-parallel circuits of 8 AC-DC piezoelectric chips, the highest AC voltage output is 19.73VAC with a weight of 98kg in the series-parallel circuit, the highest DC voltage output is 2.49VDC . It can be concluded from the comparison test of 8 AC-DC chips weighing 98 kg that the most optimal output voltage is a series-parallel circuit.

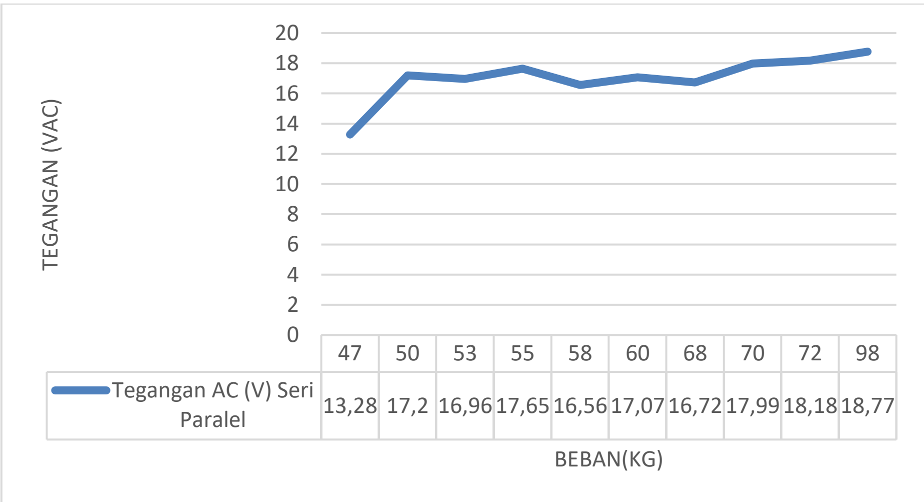

Figure 8. Graph 16 AC Voltage Piezoelectric Chips.

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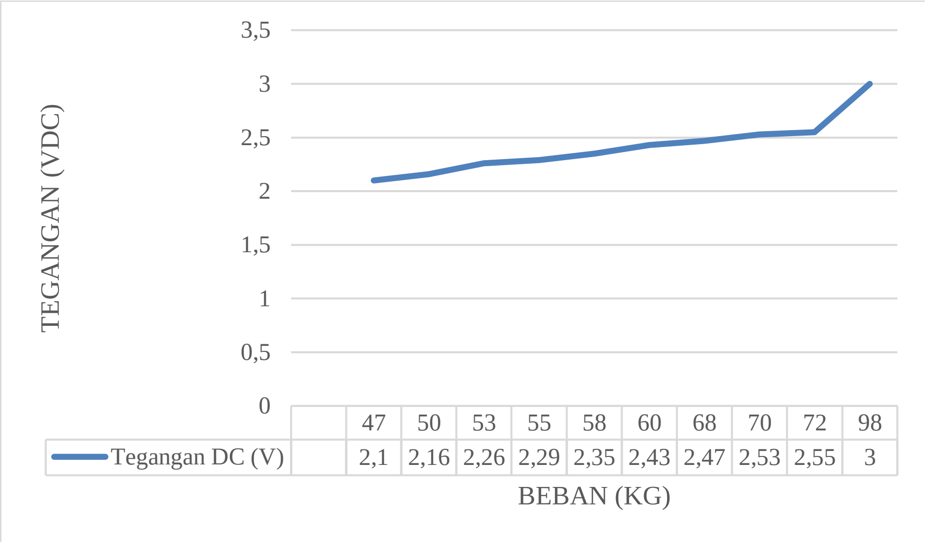

Figure 9. Graph 16 Piezoelectric Chip DC Voltage.

Figure 8 and Figure 9 compare the series-parallel AC-DC 16 piezoelectric circuits. In the AC circuit the highest voltage yield is 18.77V with a weight of 98kg, while the DC circuit the highest voltage yield is 3V with a weight of 98kg.

In Figure 8 the AC voltage graph and Figure 9 the DC voltage graph have a graphical comparison of the output voltages of AC and DC. The results of the AC voltage have unstable results even though the generated voltage is large, while the graph of the DC voltage is more stable even though the generated voltage is small.

3.3 Comparison of DC Voltage Circuits of 16 Disconnected and SSHI-Connected Piezoelectric Chips

The results of data collection in this test are based on the number of footings on the floor of the piezoelectric energy harvester. At this stage the tester compares the DC voltage output results from 16 piezoelectric chips with a series-parallel circuit configuration that is not connected to SSHI and connected to SSHI. The comparison results are presented graphically in Figure 10 and Figure 11.

In the graphs of Figure 10 and graphs of Figure 11 the results of the comparison of the DC voltage graphs of 16 pieces of floor piezoelectric energy harvester without SSHI and connected to SSHI. The results of the comparison of the configuration of the piezoelectric circuit without being connected to SSHI produce the highest value of 15.4 V with 60 steps with unstable graphic results of the rise and fall of the resulting voltage.

In the SSHI-connected piezoelectric circuit configuration, the highest value is 16.37 V at 60 steps with a steady increase in graphs as the number of steps increases. Based on the test results, it is explained that the series-parallel circuit configuration with SSHI connection has the characteristics of optimizing the floor voltage of piezoelectric energy harvesters.

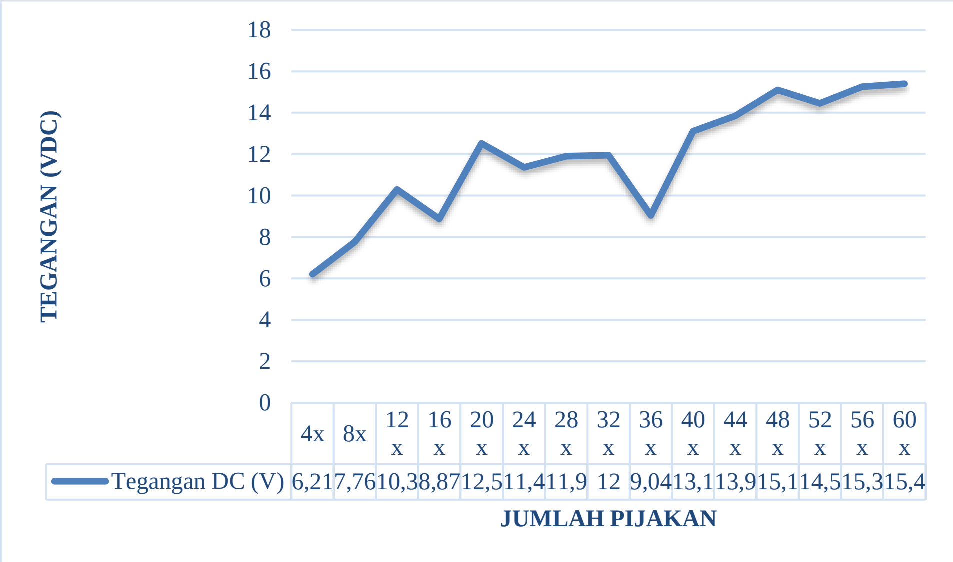

Figure 10. Graph 16 Piezoelectric Chip DC Voltage Not Connected to SSHI.

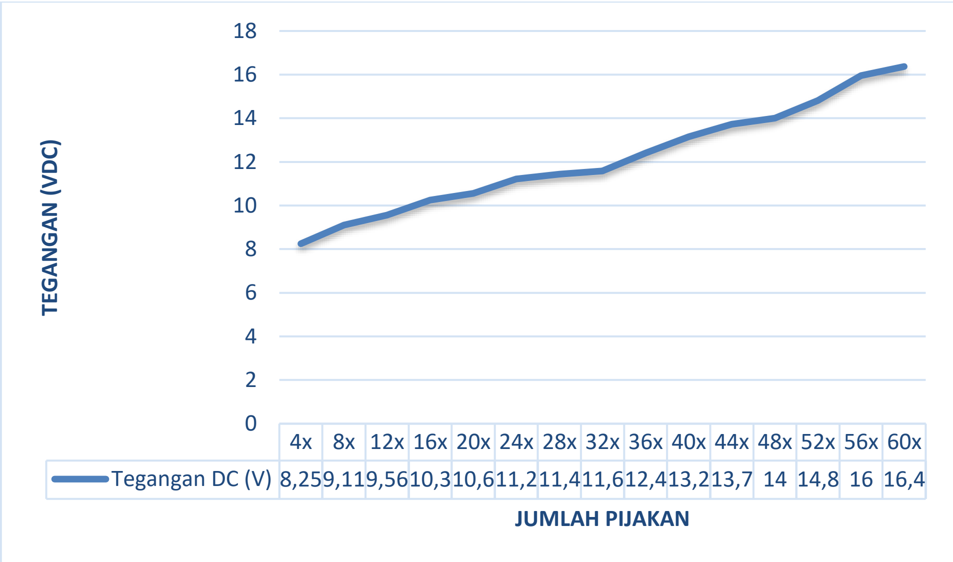

Figure 11. Graph 16 Piezoelectric Chip DC Voltage SSHI Connected.

4. Conclusion

The piezoelectric energy harvester floor is energy that produces low voltage, even though it has low voltage the piezoelectric energy harvester floor has the advantage of being free of air pollution and does not depend on weather changes, in this study it was concluded that the piezoelectric energy harvester floor produces electrical energy by providing mechanical energy in the form of pressure or vibration, the circuit on the floor of the piezoelectric energy harvester with the most optimal voltage output characteristics, namely a series-parallel circuit connected to SSHI by testing provides a number of footings, SSHI provides a more stable voltage compared to using a Boost Converter, by providing 16 piezoelectric chips on the harvesting floor connected to SSHI, the weight and the number of footings on the floor of the piezoelectric energy harvester produce different voltages, the voltage will continue to increase when the number of footings and weight increases. It is hoped that this research can further develop a series of piezoelectric energy harvesting floors that are connected to SSHI and Boost Converter, which is hoped to produce energy harvesting floors on a larger scale so that their utilization is maximized.

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