JSMT

http://publisher.uthm.edu.my/ojs/index.php/jsmt

e-ISSN : 2821-2835

Journal of Sustainable and Manufacturing in Transportation

Initial Study of Converting Sound Energy into Electrical Energy

Hamizah Muhammad Salleh[1], Musli Nizam Yahya[1*]

[1]Structural Integrity and Monitoring Research Group (SIMReG),
Faculty of Mechanical and Manufacturing Engineering,
Universiti Tun Hussein Onn Malaysia, Batu Pahat, 86400, MALAYSIA

*Corresponding Author

DOI: https://doi.org/ 10.30880/jsmt.2022.02.01.001
Received 7 December 2021; Accepted 8 September 2022; Available online 30 September 2022

Abstract: This study concerns on finding alternative source of energy by finding out the method of converting available and unused sound energy into electrical energy. The environmental issue including noise from the devices, factory etc has been increasing from year-to years. The purpose of this study includes to investigate the possibility of converting sound wave in a range between 70 dB to 80 dB into electrical energy by determining the effectiveness of the method to transform sound wave into electrical energy and study the percentage error between the theoretical and experimental output voltage produced. An electronic circuit-based experiment was conducted to fulfil the objectives of the study. Sound energy was converted into electrical energy by using microphone transducer, then the brightness of bulb and the voltage reading was observed and tabulated. Theoretical and experimental voltage value were compared and being represented in percentage error value. The data shows that there is potential of converting sound into electricity through the suitable electrical circuit and the output voltage increase linearly with the sound pressure levels (SPL) of the sound sources. Further research should include the study of relationship between distance of sound sources and the transducer, and the output voltage produced

Keywords: Alternative energy, transducer, sound pressure level, output voltage

1. Introduction

A well-developed city is never free of sound and noise, whether from industry or the outside world [1]. Alternative energy sources are in short supply, and the world is now reliant solely on non-renewable energy sources. Most of the fuel combustion process produces pollutants that may harm the environment. As the effects of global warming become more apparent, the search for alternate energy sources is becoming increasingly popular [2]. Sound is one of the most neglected energies in the renewable energy field, yet it can be used as a source of electrical energy if it is converted effectively. Sound is one of the most underappreciated energies that, when efficiently turned into electrical energy, can be regarded a source of electrical energy. Because of its abundance and purity, sound might be regarded an energy source. The ability to convert sound into unwanted and desired sounds is dependent on the situation and the sound's availability. The technological advancement of tomorrow and the future would benefit greatly from the generation of electrical energy from sound energy.

This approach of converting sound into electrical energy will handle numerous problems at once, including the need for an alternative source of electricity, the control of pollution, and the wasting of potential sound energy. It is critical to learn about and research the possibilities of sound becoming a new source of power in the future.

The purpose of this research is to find the most effective way for transforming sound wave in a range between 70 dB to 80 dB into electrical energy, as well as study the effectiveness of the method to transform the output voltage

Corresponding author: musli@uthm.edu.my

generated when sound propagation is converted into electrical energy. Output voltage depends on the sound level pressure of the sound source and will be produced when sound is converted into electrical energy by using the transducer. The percentage error between the theoretical and experimental output voltage is studied.

2. Methods

2.1 Circuit Design

An electronic circuit was designed to achieve and fulfil the objectives of the study as shown in Fig. 1. Electrical components are primarily purchased from a nearby business that offers electronic components. In addition, the laboratory decibel metre is costly and only usable in the laboratory, it is replaced with digital decibel meter apps from devices.

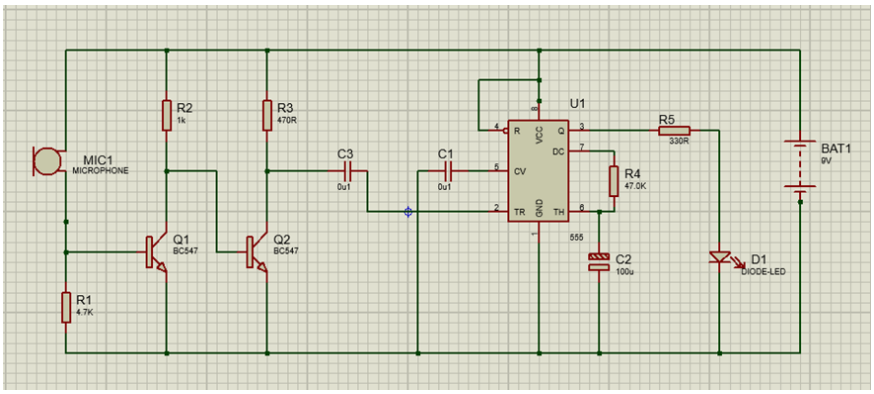

Fig. 1 - The circuit diagram that has been drawn using the Proteus software

The electrical components that were include in the circuit are electric condenser as the transducer, resistor, transistor, capacitor, IC 555 timer and battery 9V. The transducer used to convert sound to electric is the electric condenser microphone. Microphone is required to capture sound signals from the environment and convert them into electrical energy and the energy would not be needed to be re-converted to its original form of electrical signal [3]. For the equipment that are needed were digital application of decibel meter and multimeter. Decibel meter is a device of measuring instrument which will be used to detect sound levels by measuring the sound pressure. The digital sound pressure level that has been used is Sound Meter App have been tested and it could be sufficient for some occupational noise assessments [4]. The multimeter is used to measure the output voltage from the circuit. Diagram in Fig. 1 for the electronic circuit is drawn by using Proteus Design Suite Software. The components used and presented in the prototype and its specifications are listed in the Table 1. The circuit can be represented as in Fig. 2.

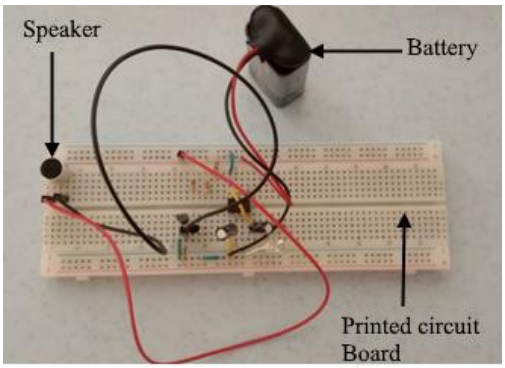

Fig. 2 - The circuit prototype that has been set up

Table 1 - Specifications of the components in the circuit

Component	Specification	Quality
Electric condenser microphone	Operating Voltage: 1-10V DC Operating Temperature: -20 to +70 degree C Unidirectional S/N Ratio: 56DB	1
Resistor	47K Ohm	1
	470 Ohm	1
	330 Ohm	1
	1k Ohm	1
Transistor	BC547	2
Capacitor	0.1	2
IC 555 timer	Number of pins: 8 DIP	1
LED	White Color	1
Battery	9V	1
Breadboard	165(L)x10mm(W)x55mm(H) contains 830 holes Standard 2.54mm (0.1") spacing between two holes	1

2.2 Methods

The procedures and overall view of the experiment are detailed as in the Fig. 3. Inputs must be prepared before the experiment is carried out. The processes are done to accomplish the objectives of the study. The sound sources are mostly common machines at home that produces sound, which are handphones, motorcycle engine, vacuum cleaner, speaker, and blender which having sound pressure level range from 70 dB to 80 dB. The output of the experiment is basically along with the objectives of the research. The results will be analysed and investigated further in the results section.

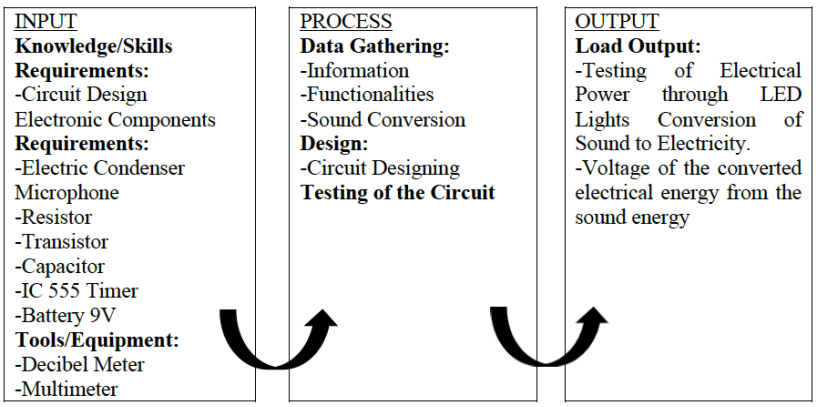

Fig. 3 - Input process output block diagram

2.3 Equations

The equations related to the study includes equation of converting Sound Pressure Level (dB) into voltage (V) to obtain the theoretical value of the voltage [2].

$$V = \frac{10_{10g(db)}}{2} \quad (1)$$

To compare the voltage obtained from the conversion of sound into voltage formula with the experimental value of sound being converted into voltage from the voltage value that has been measured directly from the circuit. We need

to compare theoretical and experimental value to figure out the efficiency of the prototype and how many percent does the sound energy can be converted into electrical energy. Eq. 2 is the percentage error formula.

$$V = 1\ x\ R \tag{2}$$

3. Results and Discussion

3.1 Results

In the beginning of the experiment, when the circuit is operating with sound as the source of energy, the led brightness was observed. An assumption can be made from the observation of the brightness of the LED, from the brightness of LED, expectations can be made on the voltage throughout the circuit to be high or low. According to Ohm's law, the current flowing through a conductor between two points is proportional to the voltage across the conductor and can be represented in the Eq. 3.

$$V = I \times R \tag{3}$$

From this equation, as the current of the circuit increases when the brightness of the LED increases, the voltage also increases along the circuit When LED lights up brightly for a second and dimly for another moment, the voltage and current of the circuit is expected to be increase and decrease throughout the time and does not constant. The results indicates that the LED brightness depends on the voltage flows throughout the circuit. The brighter the LED brightness, the higher the current and voltage of the circuit. This proves that the circuit has successfully converted sound into electrical energy as the output of the LED lights up.

Table 2 - Result of LED brightness for respective sources

Source	LED brightness
iPhone X handphone speaker	According to song
Vinnifier Speaker	Does not light up
Blender	Lights up brightly
Vacuum Cleaner	Light up
Motor Engine	According to Engine

3.2 Measuring Output Voltage (mV) of the Circuit

Furthermore, the output voltage produced in the circuit was measure. The output voltage is driven by the current that has been converted by the microphone and flows throughout the circuit to lights up the LED. As the LED is the indicator of the current and voltage, the output voltage is measured from the leg of the LED. This output voltage is important as it could prove the presence of electricity in the circuit. Three data of the highest range of the voltage from the multimeter reading is taken for accuracy of the data. Average of the data is then taken as the voltage for the sound source.

Table 3 - Result of Voltage (mV) of respective sources

Source	Average (mV)			
	Reading 1	Reading 2	Reading 3	Reading 4
iPhone X handphone speaker	126.3	126.5	123.5	125.43
Vinnifier Speaker	3.5	3.5	3.2	3.4
Blender	1190	1112,6	1193	1165
Vacuum Cleaner	157.4	129.9	123	136.76
Motor Engine	854	874	866	864.67

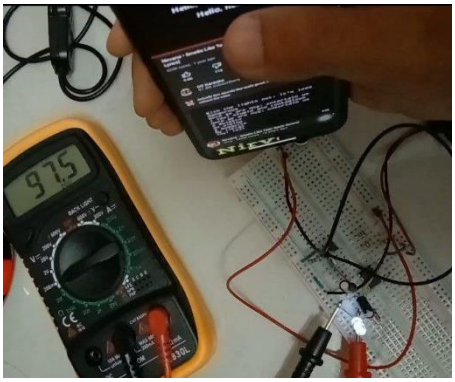

Fig. 4 - Measuring the output voltage for iPhone speaker as the source of sound energy

3.3 Measuring the Sound Level Pressure (dB) of the sound source and Calculate Theoretical Value for Conversion of dB to Voltage

Sound level pressure is the pressure level of a sound that is measured in decibels (dB) and can be called as the volume of something that produces sound. Decibels are the unit of measurement for SPL (dB) and sound pressure level metre is used to measure it. Based on the sound level (dB) that has been measured by using the smart phone applications, an average of 70 dB to 80 dB is the sound pressure level for the sound produced by the iPhone X handphone speaker, Vinnifier speaker, Blender, Vacuum Cleaner and Motorcycle Engine. From the decibels measured in, the sound pressure level is converted into voltage by using Eq.1.

Table 4 - Result of Sound Level (dB) of respective sources and value of the theoretical voltage

Source	Average (dB)	Theoretical Voltage (mV)
Iphone X handphone Speaker	74.47	15710
Winnifier speaker	74.80	15729
Blender	78.13	15918
Vacuum cleaner	74	15682
Motorcycle engine	77.63	15890

3.4 Calculation of Percentage Error of the Circuit

Moreover, we need to compare the voltage obtained from the conversion of sound into voltage formula with the experimental value of sound being converted into voltage from the voltage value that has been measured directly from the circuit. We need to compare theoretical and experimental value to figure out the efficiency of the prototype and how many percent does the sound energy can be converted into electrical energy. Table 4 shows the tabulation of data.

Table 5 - Percentage error of the experiment

Source	Average (dB)	Voltage (formula)	Voltage (experiment)	Percentage error (%)
Iphone X handphone Speaker	74.47	15710 mV	125.43 mV	99.2
Winnifier speaker	74.80	15729 mV	3.4 mV	99.97
Blender	78.13	15918 mV	1165 mV	99.2
Vacuum cleaner	74	15682 mV	126.76 mV	99.83
Motorcycle engine	77.63	15890 mV	864.67 mV	92.56

The percentage difference for all the sound sources shows higher than 90% but lower than 100%. From the percentage difference, we could analyze the loss of the sound energy that is not converted to the electrical energy. The highest percentage difference shows that lowest sound energy has been converted into electrical energy and lights up the LED.

3.5 Graph of Voltage Vs Sound Pressure Level

Based on the result of the experiment, the graph was plotted to find out the relationship between voltage and sound level. The y-axis of the experiment is Voltage(mV) the output of the experiment while the x-axis is the Sound Pressure Level (dB) which is the manipulated variable of the investigation.

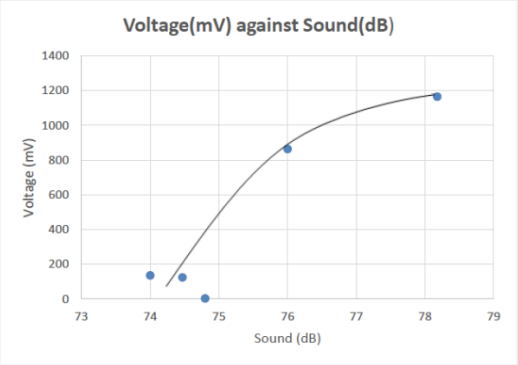

Fig. 5 - Graph voltage vs sound pressure level

From the graph, the trend can be seen as voltage(mV) is increasing linearly to the sound level pressure (dB). The results show that as the noise level increases, the corresponding voltage that was measured at the multimeter also increased. In real application, to produce more electrical energy, more sound energy is needed.

3.6 Implementation in Real Life

As the fuels are limited, we are looking for new source of energy. Because sound energy can be successfully converted to electric energy, it has the potential to help alleviate the worldwide electricity crisis. Electrical energy is a sort of green technology which might contribute with CO2 reduction. Noise pollution on the road might be transformed into electricity and utilized to power streetlights, traffic signals, and other electrical devices. Noise pollution from traffic can be converted to electricity and utilized to power traffic lights, so reducing the consumption of fossil fuels for energy. Microphone is a form of transducer, that changes the form of energy into electrical energy [5]. There are also a variety of additional transducers that can convert sound into electrical energy, which is advantageous to our lives in terms of saving energy, time, and fuels for future use.

4. Conclusion

From the research and the studies, it is confirmed that there is high potential of converting sound wave in a range between 70 dB to 80 dB to electric. The investigation has successfully proved that the transforming sound propagation into electrical energy for the harvesting objective is not impossible with the aid of microphone transducer. However, this study has shown and prove that microphone can be used to convert sound to electrical energy to light up an LED.

From the circuit, it can be concluded that the LED cannot be functioning if there is no sound energy as the source of energy. There were few times troubleshooting the circuit with other types of transducers and piezoelectric, nevertheless, the microphone is the best yet easier transducer that can be connected and handled in the circuit. Hence, this shows that the second objective of the project has been achieved successfully as the effectiveness of the circuit designed has been proven to be able to convert sound energy into electrical energy.

When the sound energy from the sources were successfully converted into electrical energy, the LED lights up and the output voltage produced has been measured and recorded. From the result and discussion, the output voltage is linearly increasing with the sound pressure level (SPL). This proves that the sound energy can become one source of energy when it is harvested through a suitable method. However, when the theoretical and experimental voltage value have been compared and being represented in the percentage error value, future research is needed for modification of the circuit design and experimental procedure to lower the percentage error and increase the efficiency of the energy harvesting process. In a conclusion, all the objectives and planning for the study have been managed to be accomplished effectively.

Acknowledgement

The authors wish to thank to the Acoustic, Noise and Vibration (NOVIA), Faculty of Mechanical and Manufacturing Engineering, Universiti Tun Hussein Onn Malaysia that has supported on the accomplishment of research activity.

References

Garg, M., Gera, D., Bansal, A., & Kumar, A. (2015). Generation of electrical energy from sound energy. 2015 International Conference on Signal Processing and Communication, ICSC 2015, 410-412.

Salvador, C. S., Abas, M. C. A., Teresa, J. A., Castillo, M., Dimaano, K., Velasco, C. L., & Sangalang, J. (2017). Development of a traffic noise energy harvesting standalone system using piezoelectric transducers and super-capacitor. Proceedings - 25th International Conference on Systems Engineering, ICSEng 2017, 2017-Janua, 370-376.

Ansari, R. A. (1997). Conversion of Electricity From the Sound Energy (Noise Pollution). Journal of the Indian Medical Association, 95(1), 1-2.

Hosier, F. (2014). Do smartphone apps provide accurate noise measurement? Safety News Alert.

Fueldner, M. (2020). Microphones. In Handbook of Silicon Based MEMS Materials and Technologies. INC.