Faculty of Electrical Engineering

ENERGY HARVESTING FOR CHARGING SYSTEM IN WEARABLE TRAVEL AID DEVICE FOR VISUALLY IMPAIRED PERSON

Nurul Nadia binti Ayub

Master of Science in Electrical Engineering

2022

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NURUL NADIA BINTI AYUB

A thesis submitted in fulfillment of the requirements for the degree of Master of Science in Electrical Engineering

Faculty of Electrical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2022

DECLARATION

I declare that this report entitled "Energy Harvesting for Charging System in Wearable Travel Aid Device for Visually Impaired Person" is the result of my own work except for quotes as cited in the references.

Signature : ……………………………………

Author : Nurul Nadia Binti Ayub

Date : …………..9/9/2022…..………

APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Master of Science in Electrical Engineering.

Signature : ....

Supervisor Name : Ir. Dr. Anuar Bin Mohamed Kassim

Date : …………..9/9/2022…..………

DEDICATION

To my most beloved father and mother, I would like to dedicate this thesis for you. My family members, brother and sister and to all my friends who always supported me in any situations.

ABSTRACT

Intelligent spectacle is one of electronic travel aid device that was used by visually impaired person to assist them in their daily life. It was used to detect obstacle in their path such as signboard, hanging pots and others that may cause injuries. This study aims to design a power charging system that can be used by visually impaired person easy and efficiently. The main objective is to evaluate the performances of power consumption, design energy harvesting circuit and analyzed power charging system on wearable device. It features experiment using solar, photodiode, thermoelectric generator and radio frequency in different configurations. The performance of power charging system was measured in terms of voltage,current and power. This research stated that the higher the intensity of light strike the surface of the harvester, the higher amount of energy produced. Radio frequency shows that the closer transmitter to receiver the higher energy can produced. The data was collected using the equipment of energy harvester and analyzed using graph analytics. The intelligent spectacle can be used up to 38 hours using a powerbank with a capacity of 2600mAH while a 130mAH Li-po battery can be used approximately 3 hours and 45 minutes. Solar produced the highest output energy at 4.33V, 0.34A and 1.47W while TEG produced the lowest output at 0.015V, 27mA and 0.4mW. This is due to its large in size of photovoltaic cell and higher efficiency in energy conversion. Series configuration shows maximum energy produced for photodiode at 1.47V, 3.47mA and 5.17mW. In order to give the comfortability and increase the quality of life for the visually impaired person, photodiode was chosen as it able to produce ample energy and it comes in smaller size. Thermoelectric generator was found as the least energy produced among other harvester. The validity was obstructed by a limited amount of light intensity during cloudy day and closeness of transmitter to receiver. In conclusion, photodiode was suitable to be used in wearable device as energy harvester but it needs to design with circuit booster.

PENUAIAN TENAGA UNTUK SISTEM PENGECASAN DALAM PERANTI BANTUAN BOLEH PAKAI UNTUK PENGGUNA CACAT PENGLIHATAN

ABSTRAK

Cermin mata pintar adalah salah satu alat bantuan perjalanan elektronik yang digunakan oleh orang cacat penglihatan untuk membantu mereka dalam kehidupan seharian. Ia digunakan untuk mengesan halangan di laluan mereka seperti papan tanda, pasu gantung dan lain-lain yang boleh menyebabkan kecederaan. Kajian ini bertujuan untuk mereka bentuk sistem pengecasan kuasa yang boleh digunakan oleh orang cacat penglihatan dengan mudah dan cekap. Objektif utama adalah untuk menilai prestasi penggunaan kuasa, mereka bentuk litar penuaian tenaga dan sistem pengecasan kuasa yang dianalisis pada peranti boleh pakai. Ia menampilkan eksperimen menggunakan suria, fotodiod, penjana termoelektrik dan frekuensi radio dalam konfigurasi yang berbeza. Prestasi sistem pengecasan kuasa diukur dari segi voltan, arus dan kuasa. Penyelidikan ini menyatakan bahawa semakin tinggi keamatan cahaya yang melanda permukaan penuai, semakin tinggi jumlah tenaga yang dihasilkan. Frekuensi radio menunjukkan bahawa lebih dekat pemancar dengan penerima tenaga, lebih tinggi tenaga boleh dihasilkan. Data dikumpul menggunakan peralatan penuai tenaga dan dianalisis menggunakan analisis graf. Cermin mata pintar itu boleh digunakan sehingga 38 jam menggunakan powerbank berkapasiti 2600mAH manakala bateri Li-po 130mAH boleh digunakan lebih kurang 3 jam dan 45 minit Solar menghasilkan tenaga keluaran tertinggi pada 4.33V, 0.34A dan 1.47W manakala TEG menghasilkan tenaga terendah pada 0.015V, 27mA dan 0.4mW. Ini disebabkan oleh saiz sel fotovoltaiknya yang besar dan kecekapan yang lebih tinggi dalam penukaran tenaga. Konfigurasi siri menunjukkan tenaga maksimum yang dihasilkan untuk fotodiod pada 1.47V, 3.47mA dan 5.17mW. Bagi memberi keselesaan dan meningkatkan kualiti hidup bagi orang cacat penglihatan, fotodiod dipilih kerana ia mampu menghasilkan tenaga yang mencukupi dan ia datang dalam saiz yang lebih kecil. Penjana termoelektrik didapati sebagai tenaga paling sedikit dihasilkan di kalangan penuai lain. Kesahihan telah dihalang oleh jumlah keamatan cahaya yang terhad semasa hari mendung dan kedekatan pemancar dengan penerima. Kesimpulannya, fotodiod sesuai digunakan dalam peranti boleh pakai sebagai penuai tenaga tetapi ia perlu direka bentuk dengan penggalak litar.

ACKNOWLEDGEMENTS

First and foremost, I would like to take this opportunity to express my sincere acknowledgement to my supervisor Ir. Dr. Anuar Bin Mohamed Kassim from Faculty of Electrical Engineering Universiti Teknikal Malaysia Melaka (UTeM) for his essential supervision, support and encouragement towards the completion of this thesis.

I would also like to express my greatest gratitude to Associate Professor Dr. Ahmad Zaki Bin Shukor from Faculty of Electrical Engineering, co-supervisor of this research for his advice and suggestion in evaluation performances of power consumption in wearable travel aid device. Special thanks to UTeM short term grant funding for the financial support throughout this project. Particularly, I would also like to express my deepest gratitude to Mr. Awang, the technician from Awang's company for their assistance and efforts in all the lab and circuit design works.

Special thanks to all my colleagues, my beloved mother,father and siblings for their moral support in completing this degree. Lastly, thank you to everyone who had been associated to the crucial parts of realization of this project.

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LIST OF ABBREVIATIONS

PD	-	Photodiode
PV	-	Photovoltaic
RF	-	Radio Frequency
LED	-	Light Emitting Diode
Ni-Cd	-	Nickel Cadmium
Ni-MH	-	Nickel Metal Hydrate
Li-Ion	-	Lithium Ion
TEG	-	Thermoelectric Generator
TEC	-	Thermoelectric Cooler
PED	-	Portable Electronic Device
ETA	-	Electronic Travel Aid

LIST OF SYMBOLS

I	-	Current
V	-	Voltage
P	-	Power
V_T	-	Total Voltage
I_T	-	Total Current
R_T	-	Total Resistance

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1. M. Kassim, N. N. Ayub, A. Z. Shukor, M. A. A Abid, A. K. R. A. Jaya, T. Yasuno, Performance Evaluation of Energy Harvesting Method on Intelligent Wearable Travel Aid Device for Blind Person, Volume 12, Issue 07, July 2022

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1. A. M. Kassim1, N. N. Ayub, A. Z. Shukor, M. R. Yaacob, W. M. Bukhari,M. A. A. Abid, A. H. Azahar, D. A. Prasetya, T. Yasuno, and A. K. R. A. Jaya, Performance Evaluation of Energy Harvesting Method for Wireless Charging System in Wearable Travel Aid Device for Visually Impaired Person, Lecture Notes in Mechanical Engineering, Springer, pp. 222–235, 2022
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Copyright:

1. Integrated Circuit Layout for Intelligent Spectacle LY2021M03984

CHAPTER 1

INTRODUCTION

1.1 Background

The World Health Organization (WHO) recently revealed figures showing that handicapped individuals account for 15% of the global population or more than 1 billion people. According to the statistics, there were 285 million visually impaired people with 39 million being completely blind and 246 million having limited vision (Avila and Zeng, 2017). As a result, an intelligent wearable gadget that was both helpful and comfortable for the user is critical. A number of travel help gadgets were produced in the prior study. The wearable gadget can identify impediment at the upper level of physical body such as in front, on the left side and right. The below of human body was enclosed by the white cane, which was frequently used by sight challenged people. The wearable device was used to distinguish the impediment in different directions (Shadakshari and Shashidhara, 2020). Furthermore, a compact and lighter rechargeable battery is a crucial feature that must be adjusted to fit inside the wearable device's mainframe. The power charging system was proposed to abolish the utilization of the standard battery, which needs to be replace entire time it depletes. Correspondingly, the user felt discomfort and troublesome to utilize the wearable device.

Wearable device is an important component of Internet of Things (IoT)-based smart applications. They were tiny, affordable gadgets that can identify a variable of interest and communicate the findings on a regular basis to a collecting location. The major part of the time, batteries were used to power them. Wearable device was frequently powered by batteries. However, the expense of restore or sustained depleted batteries was prohibitively expensive and these batteries were especially burdensome to replace in remote locations owing to geographic limits (Grossi, 2021).

Consequently, creating energy saving technologies to increase battery life period and reduce substitution charge has turned into vital for the everlasting profitability of the industry. Power charging technology has improved the long term viability and durability of wearable gadgets by allowing energy restrained tools to operate in a more controlled way. Power charging has now being employed in a range of applications, as well as powering medical sensors, embed devices, recharging detectors installed in solid walls and empower an unmanned aerial vehicle's ground sensor. However, providing adequate power density for charging a standard sized portable electronic item is challenging, creating a design issue (Grossi, 2021).

The procedure of converting the surrounding energy into useable electrical energy was known as energy harvesting. As a consequence of recent technical breakthroughs, energy harvesting models have grown increasingly structured at transforming trace quantities of energy from the surrounding into electricity. Low power gadgets may be charged continually using ambient resources, potentially removing the demand for a battery. In either cases, these devices might be devoid of connections, cables and battery control panels. Providing them with a great deal of movement while charging and utilising (Yue et al., 2017).

The quantity of experiment dedicated using energy scavenging method has been quickly rising in the latest because of remarkable enlarge in creating portable devices in the absence of batteries as the energy resources is endless without wire applications. New autonomous sensor powering options as well as enhanced technical awareness and adoption, were required to eliminate battery changing as a key operational and environmental concern (Yue et al., 2017).

Energy harvesters, on the contrary, can offer a recommended answer than battery technologies if a device demands a longer life span, albeit the form element and value of the device should be meticulously study when considering the operating life. Researchers have concentrated on ways for creating energy for low-power applications that are both efficient in providing output voltage and suited for wearable travel aid devices (Yue et al., 2017).

1.2 Problem statement

In a prior research, certain wearable gadgets were built for visually impaired persons. The design was comparable to the spectacles that visually challenged people often wear to cover their eyes. In the previous research, the produced wearable device version 1 was big and heavy, weighing around 590g without the typical battery, as illustrated in figure 1.1. When the user wears the previously created My Second Eye, it cannot be fitted as a spectacle and was prone to tumble. When a visually challenged person uses it, they feel uneasy. In an effort to give convenience to the user, the ergonomic design of the spectacles must also be addressed.

Figure 1.1: Developed wearable device version 1 in the previous study

As a result, changes to the bulky spectacle such as the kind of ultrasonic sensor used, the sort of battery used and the type of electrical circuit utilised have been developed to minimize the load of the wearable device. Figure 1.2 shows an enhanced version of a blind spectacle version 2 that incorporates several types of sensors as well as a power bank that serves as a rechargeable battery. The existing answer is to use a power bank instead of a battery, although this was still not an ideal for blind persons to utilise. Despite it improvise pattern, the power bank incapable to be charged simply by a visually impaired person because it used a connector to attach with the power adapter. It was tough for blind persons to locate the attachment on the power bank and the battery must be replaced when it runs out.

To solve the problem, a power charging system was proposed to collect energy from the environment in order to construct docking systems that does not require the usage of a standard battery. The suggested technology will make it easier for blind individuals to charge their spectacles with energy from the environment.

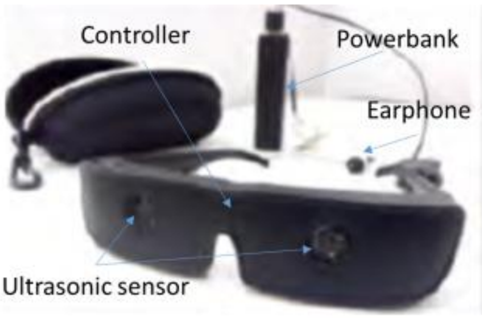

Figure 1.2: Developed wearable device version 2 in the previous study

1.3 Objectives

The primary goal of this project is to look at the feasibility of using a power charging system on a wearable gadget for people who are visually impaired. The following sub-objectives must be achieved:

a) To evaluate the performances of power consumption on wearable device for visually impaired person at maximum load test.

b) To design the energy harvesting circuit on wearable device for visually impaired person.

c) To analyze the performance of energy harvesting method on power charging system for wearable device in terms of voltage, current and power generated.

1.4 Research scopes

The following scopes and limits is taken into consideration in order to accomplish this research and meet the objectives:

a) Based on objective 1 on evaluation of power consumption on a wearable device using rechargeable battery.