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Performance Evaluation of Energy Harvesting Method on Intelligent Wearable Travel Aid Device for Blind Person

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***Abstract*—The intelligent wearable travel aid device has been developed for blind person usage for traveling purposes. The intelligent wearable travel aid device will be used along with the long cane that is usually used to detect any obstructions around the blind person. However, the problem on power supply to supply the electrical energy for the intelligent wearable travel aid device to work properly always been occurred. In order to fit the energy harvesting device on the intelligent wearable travel aid device, the comparison of the solar panel and photodiode is done. The performance evaluation to compare theenergy harvesting method on the developed intelligent wearable travel aid device for blind person has been conductedbased on the experiment result. The photodiode is proposed in this study due to small size and easy to arrange on top of developed wearable travel aid device compared to the solar panel which big size but commonly used as energy harvesting device. Consequently, the experimental result of the intelligent wearable travel aid device in terms of voltage, current and light intensity for the improved version with different type of configuration is proven respectively.**

***Keywords*—Energy harvesting, wearable device, travel aid, the blind person, smart system, assistive technology.**

I. Introduction

The World Health Organization (WHO) recently released statistics revealing that disabled persons make about 15% of the world population, or more than 1 billion people. According to statistics, there are 285 million visually impaired persons in the world, with 39 million fully blind and 246 million with inadequate vision [1]. As a result, a smart wearable device that is both useful and pleasant for the user is essential.

In a previous study, a variety of travel aid gadgets were developed. The wearable device may detect obstructions at the higher level of the physical body, such as in front, on the left side, and on the right side. The white cane, which was widely used by sight-impaired persons, encircled the lower half of the human body [1].The wearable gadget was utilised to discern between different types of obstacle [2]. A smaller and lightweight rechargeable battery is also an important characteristic that must be altered to fit inside the mainframe of the wearable gadget. The wireless power charging system was proposed utilising the wireless docking system to eliminate the need of normal batteries, which must be replaced every time they run out. As a result, the user found it difficult and inconvenient to operate the wearable gadget.

Visual impairment is a frequent disability that affects people's autonomy significantly [3]. According to the World Health Organization, there were around 285 million visually impaired persons in the United States, with 39 million being blind and 246 million having poor vision. Approximately 90% of the visually impaired individuals on the planet live in poverty. Around 82 percent of people who are blind and still are over the age of 50 [4]. This tough endeavour is viewed as a potential research because of the growth in the number of people with vision impairments. Several technologies have been employed for decades to solve the essential problem of improving the productivity and mobility of visually impaired persons, but no acceptable solution has yet been discovered. [5]-[7]

As a result, developing energy-saving technology to extend battery life and lower replacement costs has become critical for the industry's long-term profitability.

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By allowing energy-constrained instruments to work in a more regulated manner, wireless power charging technology has enhanced the long-term viability and longevity of wearable electronics. [8] In addition to powering medical sensors, embed devices, recharging detectors implanted in solid walls, and empowering an unmanned aerial vehicle's ground sensor, wireless power charging is currently being used in a variety of applications. Providing appropriate power density for charging a standard-sized portable electronic device, on the other hand, is difficult, posing a design problem [9].

Solar energy is one of the renewable energy sources that can help us move away from our dependency on fossil fuels and toward a more sustainable future. As a result, the installed capacity of photovoltaic cells (PV) has expanded considerably in recent years, cutting the cost per Watt. However, as the use of solar electricity grew, concerns about relatively high PV penetration rates began to surface [10]. Because of their high power density, solar energy collecting devices have gotten a lot of interest for outdoor Structural Health Monitoring (SHM) applications like highways and bridges [11].

Figure1: Solar panel

The PN junction is used to make the photodiode. Silicon, germanium, indium gallium arsenide, and lead sulphide were widely used in the manufacture of photodiodes for a wide range of applications.

Photodiodes include the PN photodiode, PIN photodiode, Avalanche photodiode, and Schottky photodiode [12]. The flow of electrons and holes from the N-side to the P-side creates the depletion area. The local detachment was lost in this region in order to react to the dispersal and achieve asymmetry and an internal intrinsic was developed.

In the opposite direction of the diffusion current, a current was formed. A built-in potential emerges when the equilibrium is attained. [13] When enough light contacts the photodiode's surface, an electron discharge forms within the junction, where the photoelectric effect occurs. A photon with a higher energy than the breach energy of 1.1eV is absorbed by silicon, which converts it to a semiconductor and produces a pair of electrons and holes. A photocurrent was created asa result of this occurrence. [14]

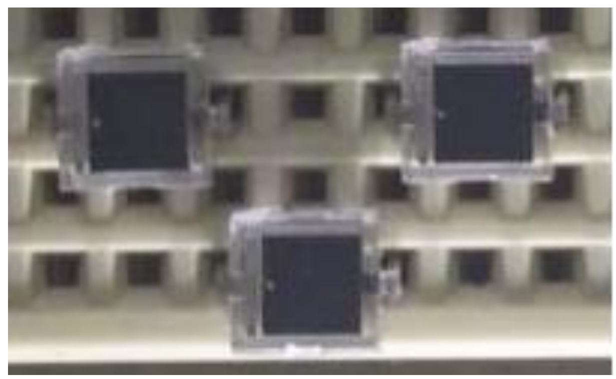

Figure2: BPW Photodiode

On the other hand, if a device requires a longer life span, energy harvesters may be a better option than battery technologies, albeit the form factor and value of the item should be carefully considered when assessing the operational life. Researchers have focused on approaches to generate energy for low-power applications that are both efficient and suitable for wearable travel aid devices. [15]-[16]

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TABLE I
COMPARISON BETWEEN SOLAR AND PHOTODIODE

Characteristic	**Solar**	**Photodiode**
Source of energy harvester	Light energy	Light energy
Mode operation	Photovoltaic mode	Photovoltaic and Photoconductive mode
Wavelength range	Broad wavelength	Narrow wavelength only at the center of optical
Output voltage	High	Low
Sensitivity to light	High	Low
Size(mm)	Large	Small
Weight (g)	Heavy	Light
Cost (RM)	Expensive	Low cost
Pros	Produce high output voltage	Smaller in size
Cons	Need voltage controller	Needs booster circuit to amplify output

On the other hand, radio frequency(RF) energy and harvesting topologies has gaining popularity as a way to power low-power devices. The selection of an acceptable RF source is the foundation of any RF energy harvesting model, followed by the other three primary steps of receiving antenna, converting to DC output, and using that output in any low-power applications. [17] There are billions of sources that generate radio frequencies all around the world. Small appliances like cell phones and hand-held devices, as well as massive setups like a radio base station and a mobile base station are examples of these sources. [18]

The majority of the RF energy delivered by these sources is omni-directional, regardless of the receiver's coordinate position. As a result, a significant amount of RF energy is wasted due to non-reception by any device. This proposes a method of gathering extra RF energy from the environment for use in low-power wireless charging devices, potentially improving the device's usability and durability. Due to the enormous number of radio frequency band energy transmitters, one of the key advantages is that RF energy is received continually. Mobile phones are just one example of a huge range of devices that might be considered.

When compared to the quantity of solar energy, ambient RF energy sources have a very low power densityo, but their main benefit is the continuous availability of radiations around the clock and their availability in both indoors and outdoors. [19]

RF energy harvesting is a cost-effective and environmentally friendly technology that not only removes hazardous RF energy from the atmosphere but also allows it to be used in low-power electronics applications. [20]-[21] Two alternative operating principles can be used to exploit radio frequency (RF) energy such as Wi-Fi, digital TV, and cellular transmissions. [22]-[23] Radiofrequency (RF) energy is another type of radiant energy. RF energy harvesting device scavenging the energy from the signal broadcast by a dedicated RF transmitter such as base station antenna, radio and TV signals, WiFi , and mobile devices. [24]

II. RELATED WORKS

Conventionally, the visually impaired person is dependedon white canes or guide dogs in order to help them to travelto the destination correctly and safe. Furthermore, the whitecane only could detect the obstacles by directly touch andthis situation are too dangerous for them since the obstaclesare too close. Thus, there are some researches which havebeen conducted in regards to support the visually impairedpeople. The devices which have been previously studied such as Guide cane [25], Robotic-cane [26], NavBelt [27], BLi-NAV[28]and My Second Eye [29]. In addition, there are some basic skillswhich required for visually impaired person to travel independently. Bousbia et al. mentioned that obstacle detectionand avoidance is very important skill for visually impairedperson to avoid the obstacles including the static and movingobstacles [30].

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. 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. [31]

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Figure 3: Developed My Second Eye

As a consequence, modifications to the bulky spectacle have been made, such as the kind of ultrasonic sensor used, the type of battery used and the type of electrical circuit used, to reduce the wearable device's weight. The improved version of a blind spectacle version 2 that has many types of sensors as well as a power bank that can be recharged. The current solution is to use a power bank instead of a battery, however this is still inconvenient for blind people. Despite its improvised pattern, the power bank cannot be charged by a visually impaired person since it connects to the power adapter via a connection.The attachment on the power bank was difficult to discover for blind people and the battery had to be replaced when it ran out.

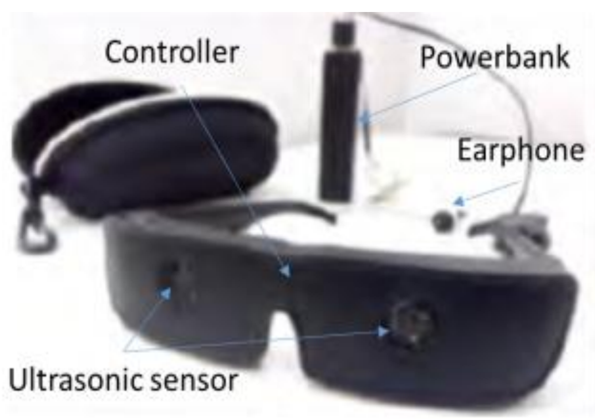

Figure 4: Improved Wearable Travel Aid Device

To solve the problem, a wireless power charging system was proposed to collect energy from the environment in order to construct wireless 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. [32]

III. EXPERIMENTAL SETUP

This section describes the experimental setup used to assess the efficacy of energy harvesting on an intelligent wearable travel help gadget. Electronic components such as an AVR microcontroller, ultrasonic sensor, Li-ion powerbank as a rechargeable battery, single earphone, LEDs as warning devices and a vibrator were used to create an enhanced version of a blind spectacle. A wearable device evaluation equipment was developed for this study to evaluate the effectiveness of a wireless power charging system on a portable device for visually impaired people.To begin with, the experiment was conducted in a single component.

The photodiode was connected via channel A, while the solar panel was connected via channel B. Luminance devices were placed above the equipment to determine the value of light. The equipment was left for 12 hours, from 7 a.m. until 7 p.m. The arrangement was put in a location with the most sunlight. The information was then compiled and shown in Excel. After that, the energy harvester was modified to three parts and relocated to the same place. The gadget then stored the data to an SD card. To collect data, the following step was to increase the number of sources from one to three.After that, the design was changed to a parallel pattern, and data was collected. Finally, each source's performance was assessed in single component, series, and parallel modes.

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Figure 5: Developed evaluation equipment

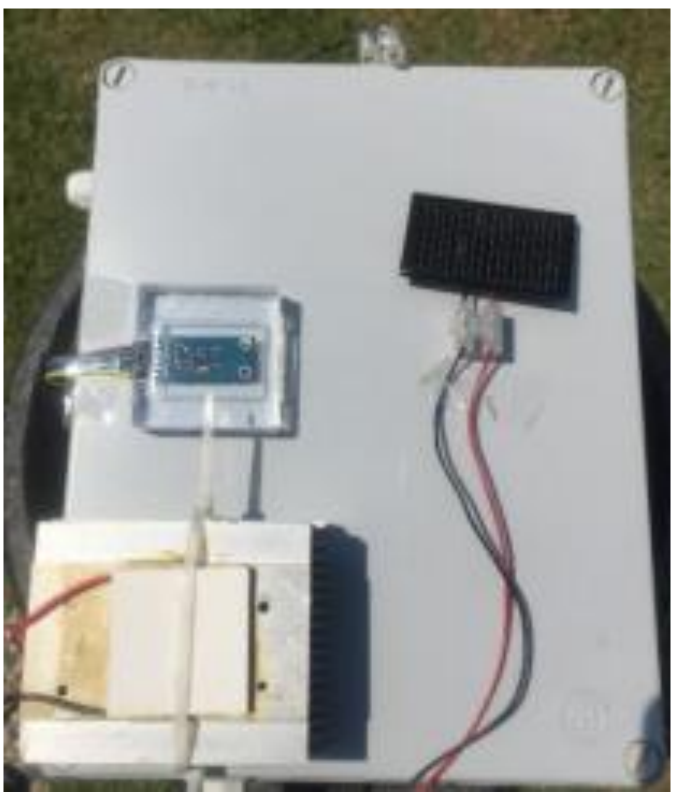

Figure 6: Experiment using solar panel and photodiode

Figure 7 depicts an analogue input circuit for an energy harvesting device that was used in this experiment. Pin 1, pin 2, and pin 3 are the three input terminals of the circuit.

The load pin on the Arduino MEGA 2560 R3 was linked to a 100k ohm to 220 ohm resistor with a 0.1 ohm shunt resistor, and the Voltage1, Voltage2, and Voltage3 pins on the Arduino MEGA 2560 R3 were connected to AD0, AD1 and AD2. In the HX711 ADC, V_{cc} was linked to 5V for each ADC converter. The HX711 ADC's SCK and DT pins are linked to the Arduino's digital pins 23, 27, 41, and 43.

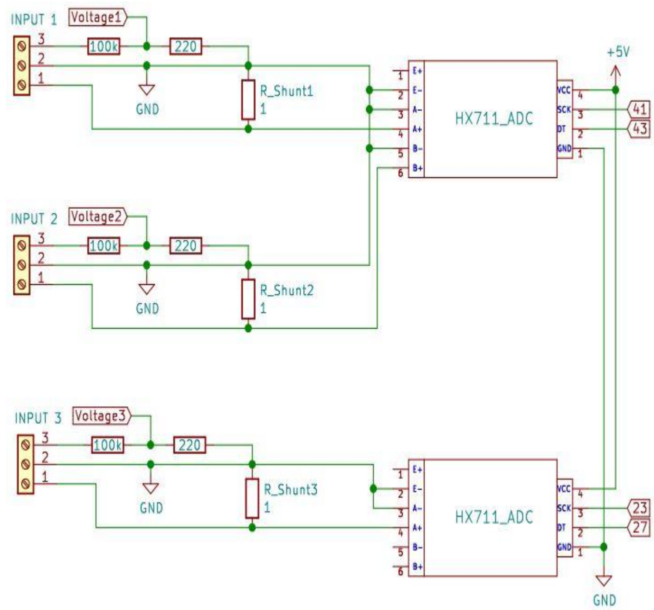

Figure 7: Design for energy harvesting device

IV. Experimental Results

The graph below demonstrates how light intensity affects the voltage and current results for each circuit setup. Because of their properties as light energy suppliers, the experiment was limited to solar and photodiode. Light energy was employed to generate electrical energy in both solar and photodiode systems. Figure 8 reveals that at 11.43 a.m., solar produced the greatest output voltage of 3.71 V, with the highest light intensity produced by the digital light intensity sensor being 26000 lux. The study demonstrates that the higher the light intensity, the more energy an energy harvester can create. Photodiode, on the other hand, produces less energy than a solar panel.The photodiode produced the majority of its energy below 0.5 V, which is lower than solar energy, as seen in the graph. It can only create maximum energy at 0.5V, even at the highest peak value of light intensity.

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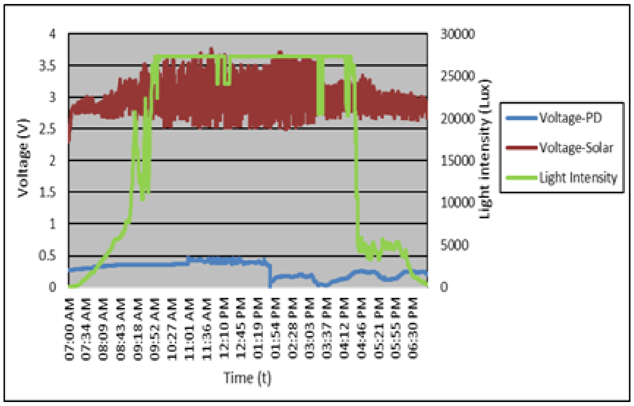

Figure 8: Graph Voltage and Light Intensity vs Time in single configuration

Figure 9 illustrates the current produced by solar and photodiode, with solar producing 0.17 A and photodiode producing 0.03 A at peak light intensity of 26000 lux. The result showed that the photodiode's current value was very low, and that while it could be used for charging, it would take a long time to fully charge. Due to poor light coverage at 3:09 pm, solar current dropped dramatically from 0.12 A to 0.02 A, and then progressively decreased until it reached zero. At 4:26 p.m., the photodiode increased the current value from 0.01V to 0.02V.

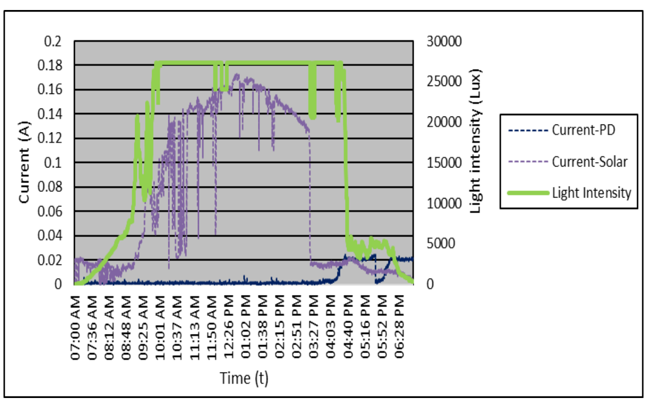

Figure 9: Graph Current and Light Intensity vs Time in single configuration

According to figure 10, the greatest energy provided by the solar was 4.33V, while the photodiode was 1.5V, and the peak value of light intensity was 26000 lux between 10 a.m. and 4 p.m. Even when the solar panel is multiplied, the amps value tends to stay the same in a series system, but the voltage value increases.

According to figure 11 the solar amps may reach a maximum of 0.35A at 10:30 a.m., while the photodiode's greatest amps value is 3.47mA. The result reveals that the photodiode's amps value was very low, with an output of less than 0.05A.In order to increase the value of current, the energy harvester needs to arrange in parallel order where the value of voltage will remained the same while the value of amps will increase.

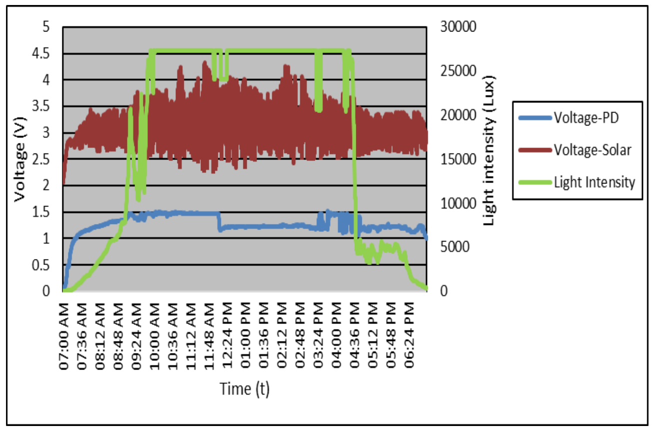

Figure 10: Graph Voltage and Light Intensity vs Time in series configuration

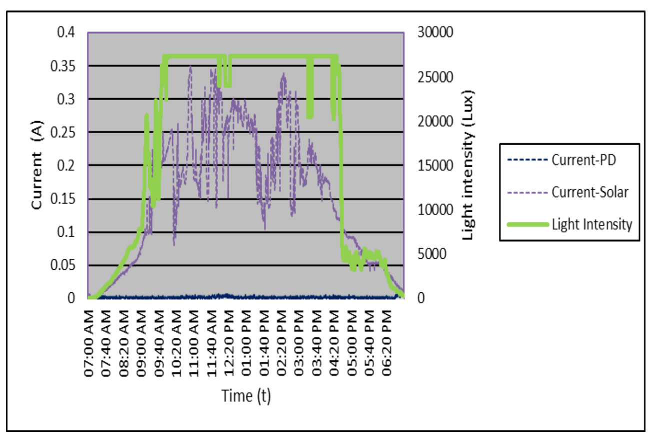

Figure 11: Graph Current and Light Intensity vs Time in series configuration

Figure 12 shows the maximum value of light intensity at 26000 lux, with solar producing the greatest voltage of 3.68V. Furthermore, the maximum voltage produced by photodiode was recorded at 0.44V. In parallel configuration, the voltage tends to remain the same but the value of amps increase as the energy harvester was multiplied.

Based on figure 13, the graph shows current produced by solar was at the highest with 0.14A while photodiode with 0.82mA.

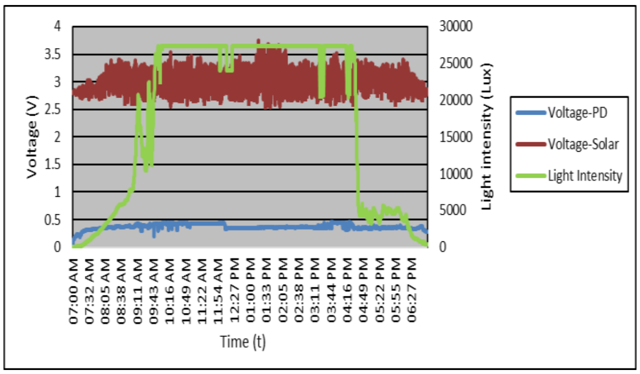

Figure 12: Graph Voltage and Light Intensity vs Time in parallel configuration

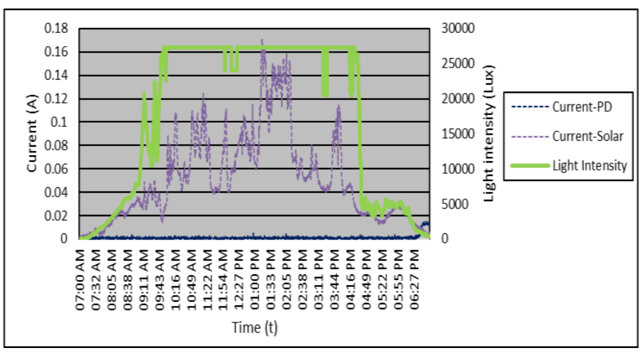

Figure 13: Graph Current and Light Intensity vs Time in parallel configuration

V. CONCLUSION

As the conclusion, the comparison of the performance for the solar panel and the photodiode has been conducted in this study. In terms of voltage, current and light intensity, the results for solar and photodiode reveal that the highest output recorded by light sensor results in higher output in both voltage and current. At 10:00 p.m., the light sensor recorded the greatest value of 2600 lux, which remained until 4:30 p.m., when the value began to progressively decline until zero. The quantity of voltage and current generated can be affected by the light intensity. This may be demonstrated by the fact that when light intensity was measured at a maximum of 2600 lux, both solar and photodiode voltage and current provided the highest values until light intensity began to diminish owing to low light sources.

Both solar and photodiode are equally in term of the performance and the proposed photodiode are able to provide energy resources as an alternative to replace the solar panel that can be used to recharge the battery inside the intelligent wearable travel aid device during travelling outside. As for further improvement on the travel aid device, the design of the battery system will be created in to produce more energy output order to give longer time usage and easy for blind person to use.

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