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DESIGN AND CONSTRUCTION OF A MOBILE WEARABLE SOLAR CHARGER

[1]ISA M. SANI, [2] AHMAD M. RIJIYA, [3]Y.M SAGAGI and [4]ABDULHAKIM A.A
[1]Lecturer II, [2]Graduate Student, [3]Lecturer I and [4]lecturer II
[1] Department of Electrical and Electronics Engineering, Faculty of Engineering University of Maiduguri,
[2]Department of electrical and electronics engineering university of Maiduguri, [3]Federal University Birnin Kebbi and [4]Kebbi State Polytechnic Dakingari
[1]University of Maiduguri, Maiduguri, Nigeria

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Abstract
The goal of this study is to find solutions for the power shortage and unavailability of power in remote areas. One type of renewable energy that is abundant and inexpensive is solar energy, which is used in this research to power electronic devices such as cameras, iPads, mobile phones, and power banks. Wearable and mobile solar chargers make it simple to charge such devices. This project creates a mobile wearable charger, which is essentially a solar panel-based charging system for mobile devices. The flexible, light solar panel can be attached to wearables like school bags, jackets, and headgear. to harness the abundant solar energy that arises from walking in a field, participating in sports, going on an excursion, and living in remote rural areas. The energy produced is stored in a battery and supplied to the USB port attached to a Vero board. A cable is then connected to the solar panel and the device that needs to be charged. Both at night and during the day, it draws on the battery's energy reserved.

1.0 Introduction

Solar energy is among the most important, plentiful, non-polluting, and cost-free energy sources. It is a sustainable and clean energy source. Photovoltaic (PV) cells were created to convert solar energy—the sun's rays—directly into electrical energy. A solar cap is a cap that runs on solar energy. Wearable technology and solar panels can be used to make a solar charger that powers an electrical gadget. The wearables have the panels mounted on them. The energy produced can power a variety of devices, including fans, flashlights, mobile phones, and other electronics. Over time, the significance of appropriately utilizing renewable energy has grown more apparent. In this thesis, energy is utilized to power a cell phone, hand fan and power Banks.

Solar-powered clothing is a cutting-edge item that is still in its infancy within the field of wearable technology (McGuire, 2011). Wearable technology is the general term for electronics that may be worn on the body as a piece of apparel or as an accessory. The concept of smart garments originated with the idea of the wearable computer, which was actually a portable device rather than a wearable one, back in the 1980s. In the late 1990s, cooperation with professionals in the domains of textiles, clothing, and electronic engineering advanced dramatically. Consumer-oriented design was the focus of prototypes made by Ramtane, Alf than, Impious, Karinsalo, Malmivaara, Matala, & Vanhala (2000), and smart apparel is currently being developed for everyday usage (G. Cho & Cho, 2007). Alessandro Volta, an electrical engineer and wearable technology researcher, is currently called after the idea of electricity (Cho, 2010, p. 250). Solar-powered apparel uses solar cells as a backup energy source to generate electricity. Thus, the incorporation of photovoltaic materials into clothing can provide power for portable electronic devices and open up a world of possibilities for technologydriven fashion. Researchers and industry have shown interest in the solar-powered cap because of its practicality and environmental benefits (it generates electricity using a solar cell as an alternative energy source). Solar energy is regarded by modern scientists as "the first long-term energy source for human beings" and one of the most potentially important energy sources (Jeon & Cho, 2010, p. 251). The main problem with wearable electronics is that they require conventional power sources; nevertheless, wearers can wear lightweight, flexible solar-powered energy sources inside their garments without gaining extra weight. As a result, most solar-powered apparel incorporates a universal connector that can accommodate portable electrical devices like mp3 players and cell phones, offering a long-term fix to the persistent problem of suffering low battery life. Specifically, for clients of all ages, utilizing a mobile phone has become an essential component of digital activity. Customers have long bemoaned the short battery life of mobile devices, and the number of mobile subscribers climbed from 5.4 billion in 2010 to 6.8 billion in 2012 (International Telecommunication Union, 2013). To better serve consumers, interdisciplinary researchers have been actively working on textile creation, product development, and commercialization potential (Jeon & Cho, 2010; Schubert & Werner, 2006; Zou, Wang, Chu, Lv & Fan, 2010). These academics are employed in computer science, engineering, and design. Essentially, the focus of this study was on the wearable solar charger's design and assembly. This is a popular and easy-to-use commercial energy source that can power flashlights, fans, and cell phones. The three primary components needed for the device's construction, design, and powering are the voltage regulator, wearable, and solar panel. The goal of this project is to provide an alternative approach to using solar energy to produce power for electrical needs. There will be two types of solar caps: one for powering a fan and the other for charging phones. The device that powers the fan is made up of a cap, a solar panel, a fan, and a rechargeable battery. When the weather is hot, the person will wear.

1.1 NEED OR THE STUDY

Power shortage and unavailability of power in remote areas, the flexibility associated with solar energy, light solar panel can be attached to wearables like school bags, jackets, and headgear. to harness the abundant solar energy that arises from walking in a field, participating in sports, going on an excursion, and living in remote rural areas.

2.0 MATERIALS AND METHODS

2.1 Forecast for The Adoption of Wearable Technology

Clothes and accessories that have been enhanced or created using electronics are referred to as "wearable technology" (WT) (King, 2011). They can be used to more effectively monitor data about a user or their environment because of their near closeness to the body. By providing people with entertainment or information, they serve them (Buena flor et al., 2013). Wearable technology differs from other portable devices like mobile phones in that it is designed to be seamlessly integrated into everyday life (Casson et al., 2010). This permits it to remain undetected. There are two main categories of wearable technology in general. "Wearable computers" (WC) are the earliest of these; they are electronics-encased jewellery pieces, such as bracelets.

2.1.2 Solar Power Devices

Currently, wearable technology researchers are mostly focused on solar-powered clothes that can generate wearable energy sources from solar cells (Suh, et al., 2010). One of the desired characteristics is to be "small, lightweight, and rechargeable with high capacity". The sun has the most potential since, in contrast to other energy sources like wind and waves, it can directly produce electrical energy through the use of solar cells. Additionally, there is growing concern about dependence on coal and oil (Mather & Wilson, 2006). Since a solar cell uses sunlight to produce energy directly, it is sometimes referred to as a photovoltaic cell or "light electricity;" The terms "photo" and "voltaic," which are derived from the moniker of an electrical specialist represents "light" and "electricity," respectively. According to Alessandro Volta Cho (2010) on page 250,
Method

2.2 RESEARCH METHODOLOGY

The block diagram below gives a pictorial understanding of wearable charger work and shows in schematic form the general arrangement of the parts or components of a system or process. The block diagram of the entire system is shown in figure 3.1, followed by the components description. The project design was built from several units which include the sun energy, photovoltaic unit, reservoir unit, filtering unit, regulating unit, switching unit and the DC output supply unit.

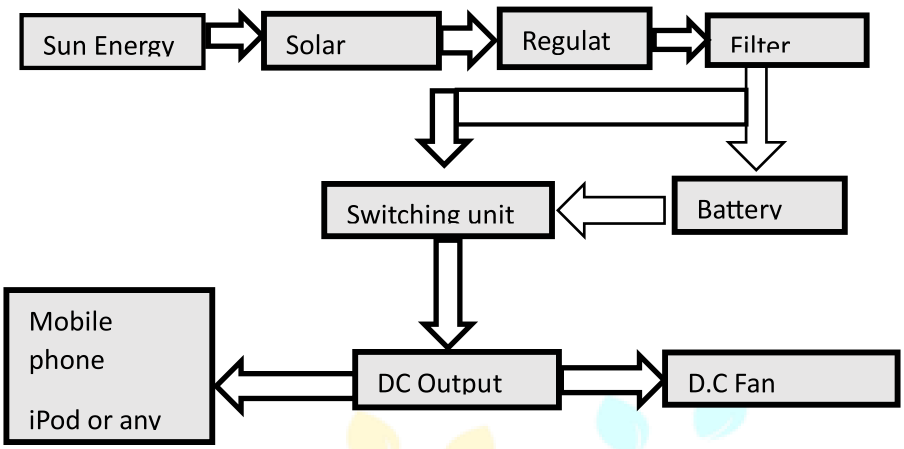

Fig 2.1; the block diagram of the system

The entire work was conducted in two main stages that is:

1. Design, and
2. Construction stage

2.2 This stage details the assumption for design, design of component, description of the design system, circuit diagram, analysis and calculations of all the units that make up the system.

2.2.1 Assumptions for Design

• Solar panel should be capable of supplying 5-6volts.
• The cap should be easily carried.
• Reservoir should store charge properly and supply it when require.

2.2.2 Design of Components

Different components needed for this system are designed. When designing above assumptions are taken under consideration

2.2.2 Solar panel

Solar panels generate free power from the sun by converting sunlight to electricity with no moving parts, zero emissions, and no maintenance. The solar panel, the first component of an electric solar energy system, is a collection of individual silicon cells that generate electricity from sunlight. There were various types of solar panel. In this construction TYN355-366 type solar panel was used. The capacity of this type of solar panel was 5V (volt) and 5W (watt).It could able to supply 800-1000 mA current which was required for charging a battery (mobile, camera etc.). It was required to place the solar panel perfectly on the head .

Fig 2.2 Solar Panel

2.2.2.1 Reservoir (Battery)

They use chemical energy to store the electrical power. We wouldn't have electricity if we didn't have storage. So, we require the storage batteries for use at night or during utility interruptions. Reservoir's storage capacity was charged. When needed, it may provide the batteries with power.

2.2.2.2 Charging system

A solar panel was linked to a PCB board. The PCB board measures 14 cm in length and 6.5 cm in width. The PCB board has an LED bulb and a USB port attached. Ultimately, a cable was used to link the USB port to the battery cell. The cable's length was utilized as required.

2.2.2.3 Filter

The filtering unit which makes use of filters as a circuit which is frequency selective, this unit minimizes the ripple content of the rectified voltage to the nearest value. This ripple is as result of sun energy component associated with the direct current DC value. This is made up of capacitor connected across the output to smoothen the voltage to have the minimum ripple factor. It is preferable to choose a filtering capacitor that will hold the peak-to-peak ripples at approximately 10% of the peak voltage. Therefore;

$$V_{peak} = \sqrt{2} \times V_{rms} = \sqrt{2} \times 6 \qquad 1$$

$= 8.49$

$$V_{ripple} = 0.1 \times V_{peak}$$

$V_{ripple} = 0.1 \times 8.49$

$V_{ripple} = 0.849V$

But also

$$V_{ripple} = I / 2fc \qquad 2$$

Where; I = current taken by the load

f = frequency of supply

C = filtering capacitor

$$C = I / 2fV_{ripple} \qquad 3$$

$= 0.085 / (2 \times 50 \times 0.849)$

$C = 1001.7\mu F$

From this calculation, a standard capacitor of 1000µF was chosen.

2.2.2.4 Regulator

The regulator is a single chip that regulates the ripple free rectified voltage to give a constant output voltage. Since the circuit needs a supply voltage of 5V, a 5V regulator was used. The LM 7805 voltage regulator is a fixed linear voltage regulator integrated circuit. It belongs to the family of the 78xx. The LM 7805 voltage regulator has built in protection against overheating and short circuits, making them quite robust in most applications. The LM7805 is used in this project to produce stable regulated 5v supply to the universal serial bus female port.

7805 IC Rating:

- Input voltage range 5V- 35V
- Current rating $I_c = 1A$
- Output voltage range $V_{max}=5.2V$, $V_{min} = 4.8V$

The percentage regulation or simply regulator of a power supply is given by

Percentage (%) regulation =

$$\frac{V_{max} - V_{min}}{V_{max}} \times 100 \qquad (4)$$

$$\frac{12-5}{12} \times 100 = 58.33\% \qquad (5)$$

2.2.2.5 Switch

A switch is an electrical device used for switching ON and OFF of an electrical current in a circuit. When the circuit is closed, current passes though the circuit, and OFF shows that the circuit is open and no current passes through the circuit.

2.2.3 Description of The Designed System

There are two different ways to charge: 1) Directly; 2) By the use of a reservoir. One end of the cable is connected to the USB port on the solar panel and the other end is attached to the battery cell in the "direct charging" approach. The only way that the "charging by reservoir" method differs from the earlier one is that it makes use of a reservoir to store charge. The mobile phone's battery cell is then supplied with current by the reservoir's stored charge.

2.2.4 Circuit diagram

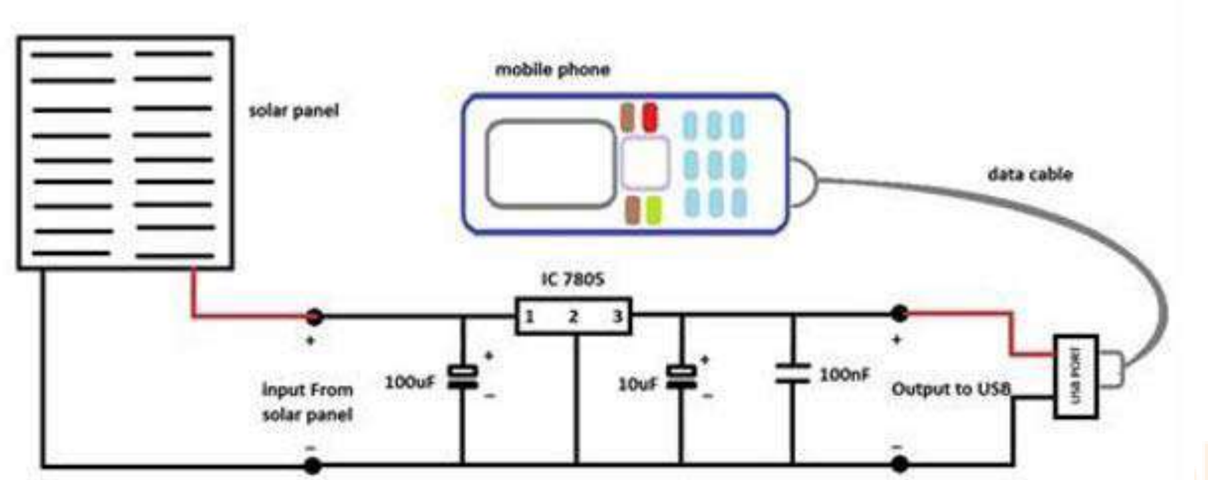

Fig 2.3: Circuit diagram (mobile phone connected with solar)

Fig.2.3 shows that, a solar panel is connected with lm7805. This integrated circuit (IC) is divided with 3 section and amount of current flow is 1000µF. Now, IC is connected with the output of USB. A data cable is connected with USB port. Finally, current flows through the data cable and charge the battery of mobile.

2.3.1 Components Required; -

i. Solar Panel
ii. wearables (jacket, cap etc.)
iii. PCB board
iv. USB port
v. Reservoir
vi. Wire
vii. LED lamp
viii. Battery (mobile phone battery)
ix. Multi-meter
x. switch

2.3.2 Description of Construction

- A PCB board is connected with solar panel. Solar panel consists of Semiconductor material silicon (Si). There are two types of silicon i) p-type silicon ii) n-type silicon. These two types of silicon produce PNP junction or NPN junction.

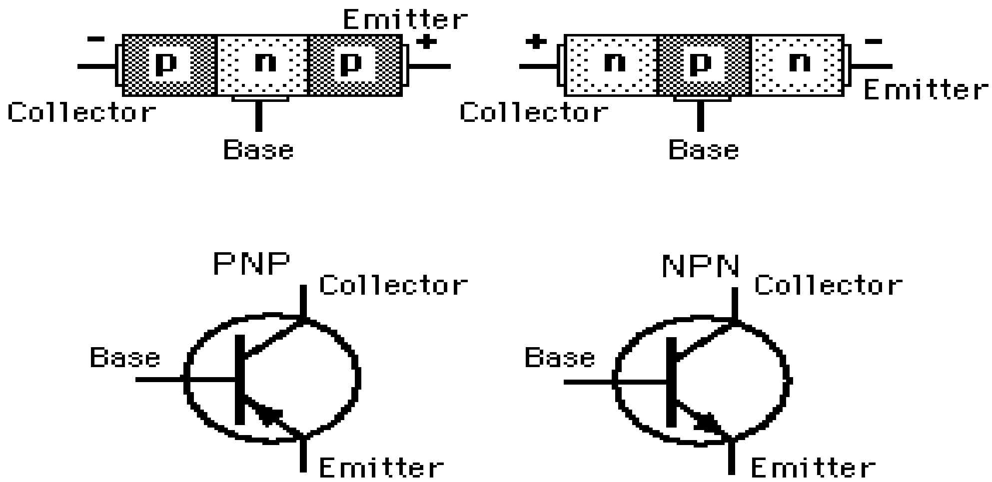

Fig 2.4; PNP junction and NPN junction

- Solder the positive output wire of the voltage regulator to the USB's positive. Similarly, connect the negative output of regulator to the negative of USB. The USB port must be fixed properly to the PCB. Next, connect the solar panel to the input of the voltage regulator (positive of solar panel to positive input of voltage regulator and negative of solar panel to negative input).
- The regulator circuit consists of the following components.
  1) IC7805
  2) 1000uF
  3) 100uF
- USB port and LED lamp is attached with PCB board. When sun light strikes on the panel photon release and electron start to flow.
- A cable is connected with USB port. Once everything is connected, measure the output voltage in open sun light. It should be around 5V. Now, connect batteries of mobile phone and it starts charging.

3.0 Results and Discussion

The intended circuit for charging the smartphone was used for the circuit's initial testing. For a significant amount of time, the original battery % was noted and verified every five minutes. Records were kept of the current flowing to the load, the input and output voltages, and both. To obtain a clear comparison of the circuit's operation, the test was conducted on both clear and foggy days. The cells were positioned as near to 90° to the sun as feasible, free of any obstacles, under both test circumstances.

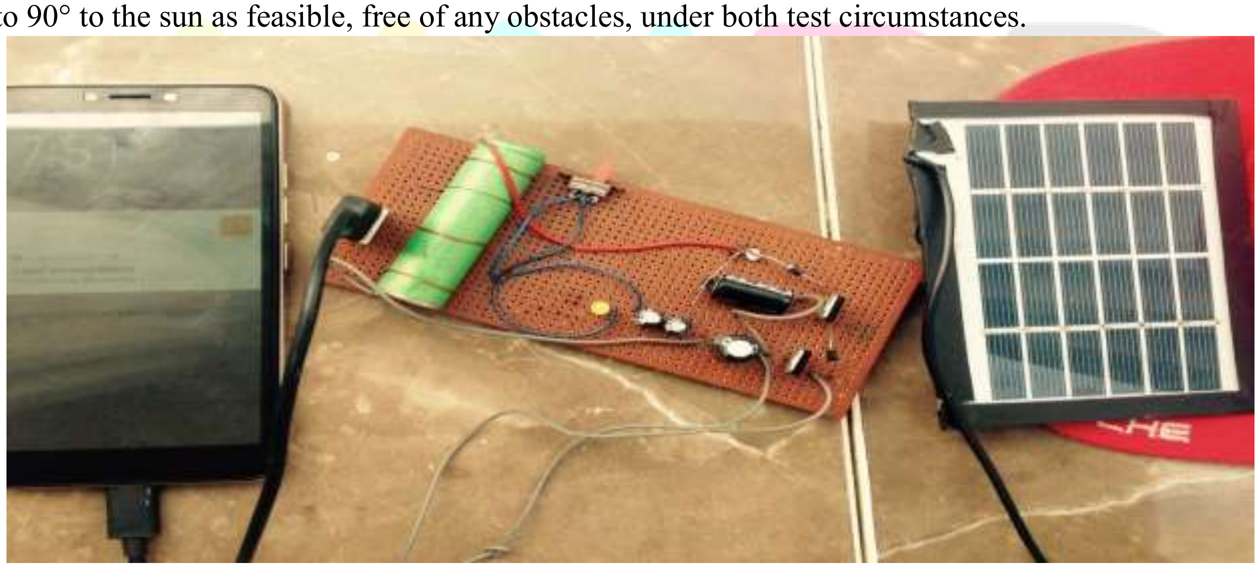

Figure 3.1; Charge test setup

Figure 3.1 the test setup is displayed. The tests were conducted over several days. The test that was conducted in Maiduguri, Borno state, Nigeria, on November 10, 2022, during overcast weather, is listed below. The panel was installed in an open area without any building shade, with the assumption that it will remain static.

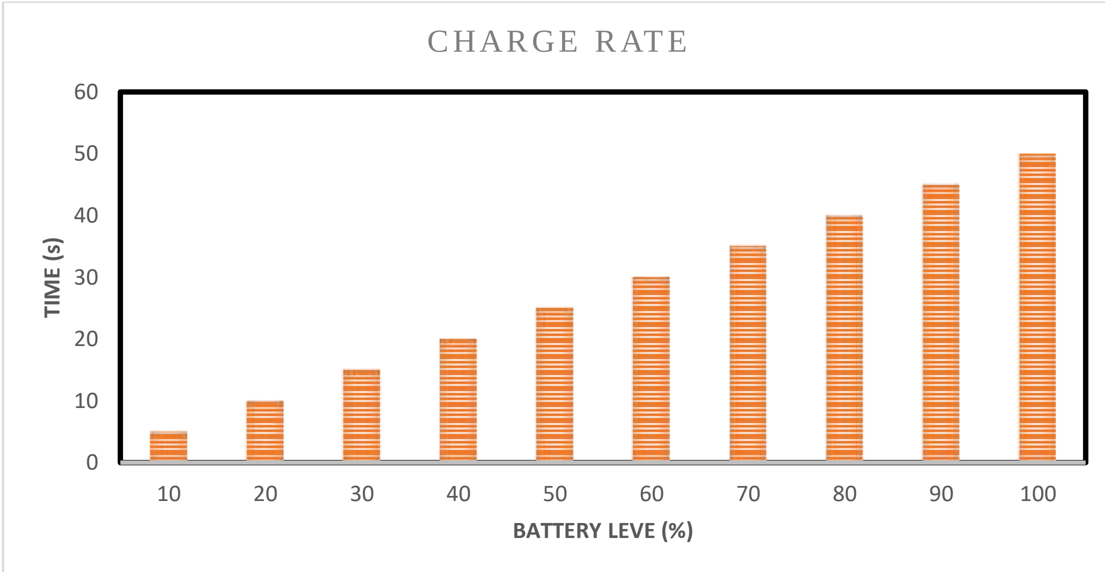

Figure 3.2: Increasing charge of battery over test time.

The battery's rising charge over the test period is seen in Figure 3.2. The battery had a 0% starting charge. Similar to earlier, there is just a slight gain in battery capacity—it rises to 10% in the first five (5) minutes of charging. The battery's capacity increases significantly throughout the course of the next thirty minutes of charging. As the battery capacity increases, the growth becomes directly proportionate to the rise in time starting at 16:05 in a ratio of 1:2.

Figure 3.3 shows that during the test, the current never varied from its maximum output of 450mA. As seen in Figure 3.4, this was caused by the input voltage continuing to be higher than the circuits permitted volt drops

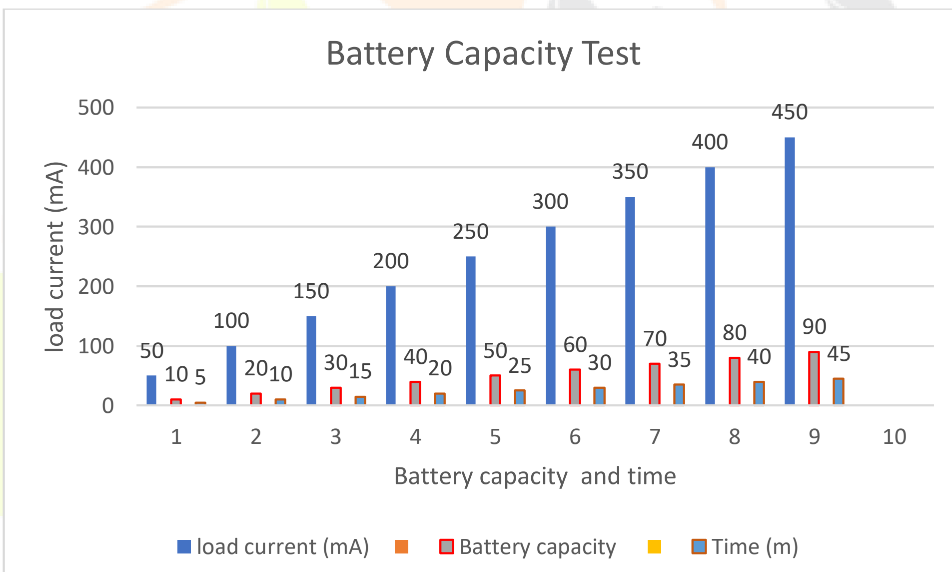

Figure 3.3: Battery capacity test

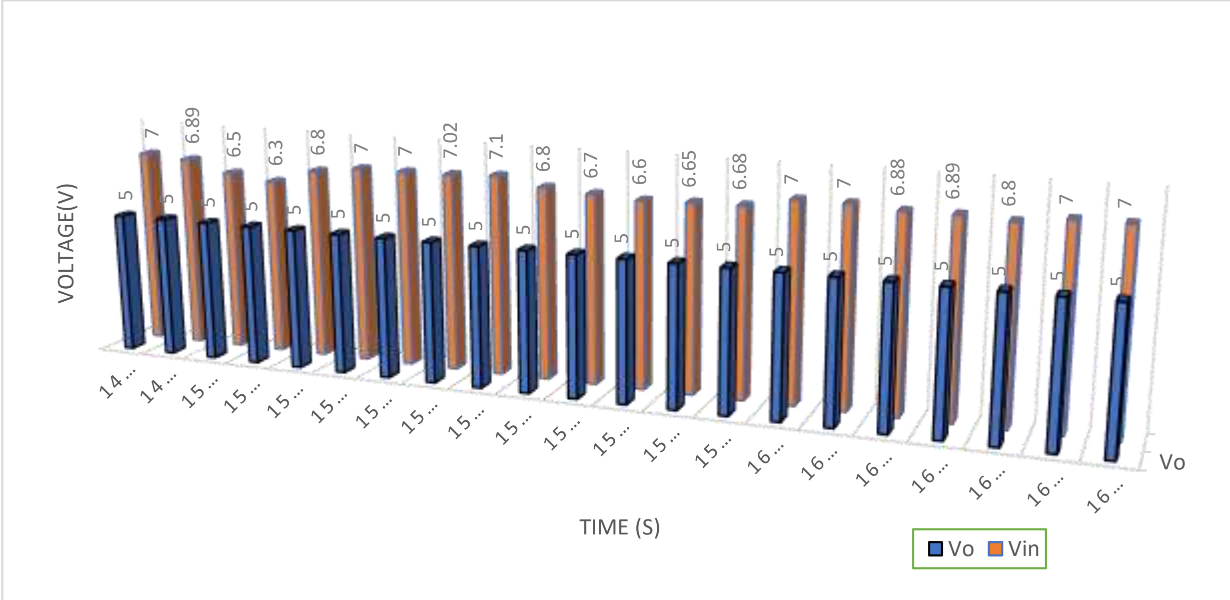

Figure 3.4: Input and output voltage comparison test

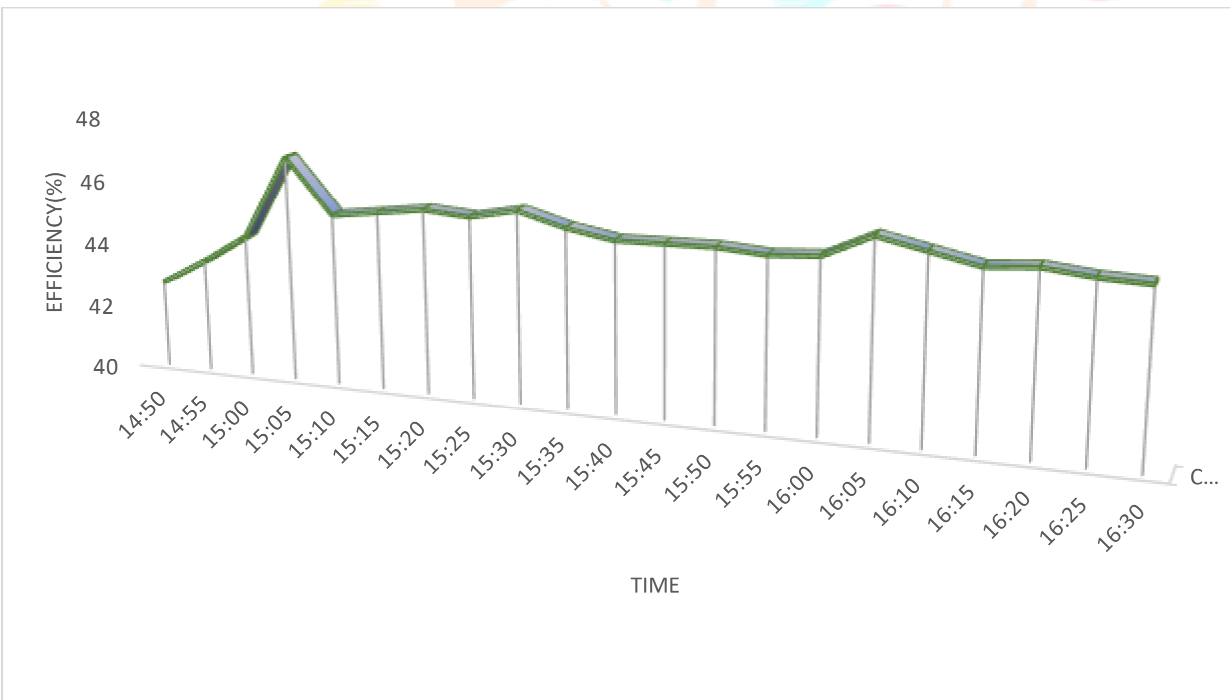

Fig. 3.5 Load Current Test

It is clear from Figure 3.5 that the circuit's efficiency is very nearly 45.5%. 42.73% and 46.96% were the lowest and highest efficiency percentages, respectively. As a result, a significant amount of power was wasted as heat, significantly raising the LM7805's temperature. The testing' findings show that the circuit was able to charge the phone. It is also simple to see how important it is to match the circuit's attributes with the appropriate cell rating. The cell test indicates that higher input voltages would cause more heating and reduced efficiency.

4.0 Conclusion

This project design and construction of a solar mobile wearable device was achieved, having carefully selected the entire components that were required for the construction the device was built according to the circuit diagram tested by using it to charge a cell phone and a battery bank, for accessories with higher voltage requirement improvement should be carried out in order to accommodate them.

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