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Development of Wearable Embedded Hybrid Powered Energy Sources for Mobile Phone Charging System

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Abstract: Mobile phones are an essential part of our day to day living. The increased reliance on mobile phone devices for communication, information sharing, connectivity and entertainment calls for a greater need to keep this device in a functional condition at all times. The epileptic nature of utility power supply, non-accessibility to power in remote locations and affordability of power due to high tariffs calls for a relative option to maintain connectivity of mobile phones. This research proposes to develop wearable embedded powered energy sources for charging mobile phones as a backup for instant and seamless charging of the phone battery once it drains. Our research addresses the inability of mobile phone users to charge their flatten phone batteries conveniently and seamlessly anytime and anywhere they find themselves. The hybrid powered charging system has the ability to harvest dissipated heat within the body of the phone and heat sources from the environment using an energy harvester, alongside the second energy source provided by the solar panel. The energy harvester will serve as a cooling measure to the device to maintain a stable temperature. The entire embedded device not only serves as an alternative power supply but also a protective covering to the mobile phone.

Keywords: Mobile Phone, Solar System, Energy Harvesting, Charger

1. Introduction

Communication devices can be wired or wireless in nature. However, mobile phones which come in wireless form are prevalent and imperative as a communication tool in our day to day life. Over 7 billion people today around the world make use of mobile phones for different purposes and the number is growing very fast since the world is now a global village. Nigeria with population of over 160 million people, with palpable epileptic power supply, lack of alternative power supply, absence of National grid in most rural areas (where chunk of these people live), high cost of fossil fuel for generator usage (which causes air pollution) coupled with very hash economy are issues of great concern to mobile phone users and telecommunication industries in Nigeria. Mobile phone users find it difficult to charge their phone batteries any time anywhere it drains due to the aforementioned factors which tremendously affects its use. This by extension has a negative impact on the telecommunication industries, whose lose returns are affected when the mobile devices are not in constant use, thereby limiting their ability to collect data that will be of assistance in making informed decisions. The benefits of developing and deploying a renewable energy harvester embedded in a phone casing for charging the phone battery before it completely drains flat cannot be overemphasized. The instant and seamless charging opportunity provided by this device for real time operation anytime and anywhere is enormous to the phone users, telecommunication industries and to the Nigerian economy at large. Mobile phone charging system based on energy harvesting was implemented as stated in Abhimanyu Ssowntharrajan [1]. In his report, two sources of renewable energy were considered; solar and wind harvesters. A major limitation of this device is the bulkiness of the system which cannot be deployed for mobile activity since massive devices such as wind turbines, motors and drives were essential components used. In the work of Anwarul & Alauddin [2], a solar powered mobile phone for farmers was designed and implemented. The system was basically for those farmers who stay outdoors for a long time under the sun and find it difficult charging their phones at work. Small solar panels (polycrystalline silicon) were placed on the cap worn by farmers to capture energy from the sun; the energy is converted and used to charge the phone. The charger was able to charge a phone from 7% to 67% in 105 minutes. However, only one supply of power was considered as input to the system, which is sunlight. A portable solar mobile charger was designed and implemented as stated in Bang T. et al [3] using modular design. Their system consists of two 3.7 lithium ion batteries connected in series as the backup batteries. The device was able to charge all mobile phones with a voltage requirement not greater than 5V. The solar module uses two 5.5V operating voltages. In the work of Gladwin A [4], a solar rechargeable mobile phone charger integrated on the phone casing was designed. The casing served as a protective covering as well as a backup power supply for the phone. The shortfall on the design is that only one source of power (solar) supply was considered without an alternate source when there is no sunlight or poor weather conditions. A solar powered public phone station was implemented using the Radio Frequency Identification (RFID) module as stated in Kadam P. et al [5]. The RFID card would be inserted into the card reader, which reads the RFID and sends signals to trigger the microcontroller to control the charging process powered by solar energy. A major limitation of this work lies in the handling of the RFID card. Once the card is missing, access to charging the device is denied. In the work of Rahil I. et al [6], a solar powered wireless phone charger using electromagnetic induction was implemented. Its merit lies in the fact that wires are not deployed in the charging process. Its demerit stems from the fact that it's not an efficient process (11% efficiency) because the power that can be transferred wirelessly is very small. The efficiency of the system deteriorates as the distance between the transmitter and receiver increases. In the work of Raj A. et al [7], a wearable device in the form of a phone casing for charging mobile phones was proposed. The device is compact but only one source of energy was considered to charge the lithium battery without considering situations when there is no sunlight. Secondly, the lithium ion battery discharges speedily due to background activities at the back end of the phone even when in idle mode. Design and implementation of a solar powered charging backpack using mono-crystalline solar cells was done by Taverne et al. [8]. Tests carried out under varying conditions clearly showed that the system managed to charge the phone with acceptable efficient ratings of 45.5%. However, there was excessive power dissipation that caused significant heat generation. Another disadvantage is that sunlight was the only source of power input. In the work of Tran B. et al [9], a solar powered convenient charging station for mobile devices with wireless charging capability was designed and implemented where users drop their mobile devices for charging. A prototype was built, tested and results showed that the station works properly. However, the disadvantage is that it is a station. Mobile devices have to be left at the station just to get charged. Another disadvantage is that sunlight is the only input source of energy to the system. A solar mobile phone charging station was implemented in Udayalakhmi & Sheik [10] as a public utility to power phones of individuals who are out of battery. Although a universal charging port was used to charge all types of phones, its major limitation lies in the fact that; individuals must locate such a station before accessing an external power source.

Samanvita N. et al [11] developed Automatic Coin-Based Solar Tracking System Cell Phone Charger. In their work, coin sensor module was combined with solar tracking technique to achieve phone charging. When a coin is dropped on the sensor module, the system adjusts the solar panel to face the sun to receive the required energy to charge the phone. In the work of Prajval K. et al [12], an efficient public phone charger was developed. They used RFID technology solar panel and rechargeable battery to achieve the system. The system can be deployed in various locations to encourage phone users to get their phones charged anywhere. Jabber & Jeong [13] deployed ambient light energy harvesting on photovoltaic to charge low powered smartphones and wearable devices. They demonstrated experimentally solar concentrator designed to improve on light energy harvesting. The throughput of the solar concentrators showed an improved light intensity of approximately 1.85 and 1.43 times at an angle of 90◦ and 71◦, which harvested ambient light energy at 2500 lx light intensity within an office environment. Hao C. et al [14] proposed hybrid wind energy harvesting system (WEHS), to power low-power sensors on canyon bridges. Piezoelectric and electromagnetic mechanisms were integrated to improve on the output power at low wind speeds. Initially, the S-rotor which features a one-way bearing, transforms wind energy into rotational mechanical energy. The piezoelectric cantilever beam and coils work in unison to convert mechanical energy into electricity, with the help of the rotational magnet array. To enhance the performance of the piezoelectric transducer, the arrangement of symmetrical poles in the tip magnet is designed to lower the starting wind speed and resistance torque during energy harvesting. The experimental outcomes reveal that the symmetrical poles arrangement in the tip magnet can effectively reduce the starting resistance torque and improve the output power at low wind speeds. Xinqing et al [15] developed food storage temperature monitoring system with solar energy harvesting and wireless charging. The wireless charging, energy consumption, solar energy harvesting and wireless temperature monitoring performances were analyzed in real time.

2. Materials and Method

The proposed system shown in Figure 1 is the circuit diagram of the embedded hybrid powered energy sources for mobile phone charging systems. The hybrid source consists of solar panel and energy harvester. The solar panel outputs voltage which is sampled through voltage divider resistors (R3 and R4) and sent to the Analog to Digital Converter (ADC) input of the control unit. The energy harvester converts heat from its environment and generates a voltage of 4V from its output terminals when a temperature difference is applied across its hot and cold surfaces. The magnitude of this output voltage from the energy harvester module is first sampled through voltage divider resistors (R1 and R2) and sent to the ADC input of the controller which processes it to determine the level of power available. When there is sufficient power available from a heat energy harvester or solar panel as processed through instructions provided to the control unit, the control unit then reads the battery voltage to determine if the internal battery is full or in need of charging. If the battery is full, the controller keeps the charge control transistors in the OFF state. If the battery is in need of charging, both transistors Q1 and Q2 are switched ON using an internally generated pulse width modulation (PWM) signal through (Resistor R6, Diode D1 and Resistor R5, Diode D2) which varies the duty cycle of switching. When either or both transistors (Q1 and Q2) are switched ON, power flows from the energy harvester input sources (TEGpro) to the output load through Diodes D3 and D5 or through Diodes D4 and D6 (solar panel) respectively to the internal proposed graphene battery while storing some energy in the parallel connection of inductors and capacitors (L1, C1 for heat harvester module and L2, C2 for solar panel module). When transistors Q1 and Q2 are switched OFF by the control unit through gate driver circuitry of R6 and D1 for Q1 and R5 and D2 for Q2, energy from the inductor and capacitor are released through D5 and D6 to the internal battery while the battery temperature is constantly being monitored by the control unit. If the battery temperature is detected to have increased by the controller, the PWM signals at 5 the gates of MOSFETS Q1 and Q2 are reduced in the same proportion to reduce the charging current and hence stop further rise of battery temperature. In the same vein, the charging current will be stepped up if the temperature is reduced. This cycle will continue until the battery is fully recharged after which both transistors Q1 and Q2 are switched OFF. When the charge micro button is depressed, the controller switches ON the transistor Q3 circuitry which is configured to boost or step up the battery voltage from 3.7V to 5V using PWM to recharge the in-built battery of the phone through the USB port.

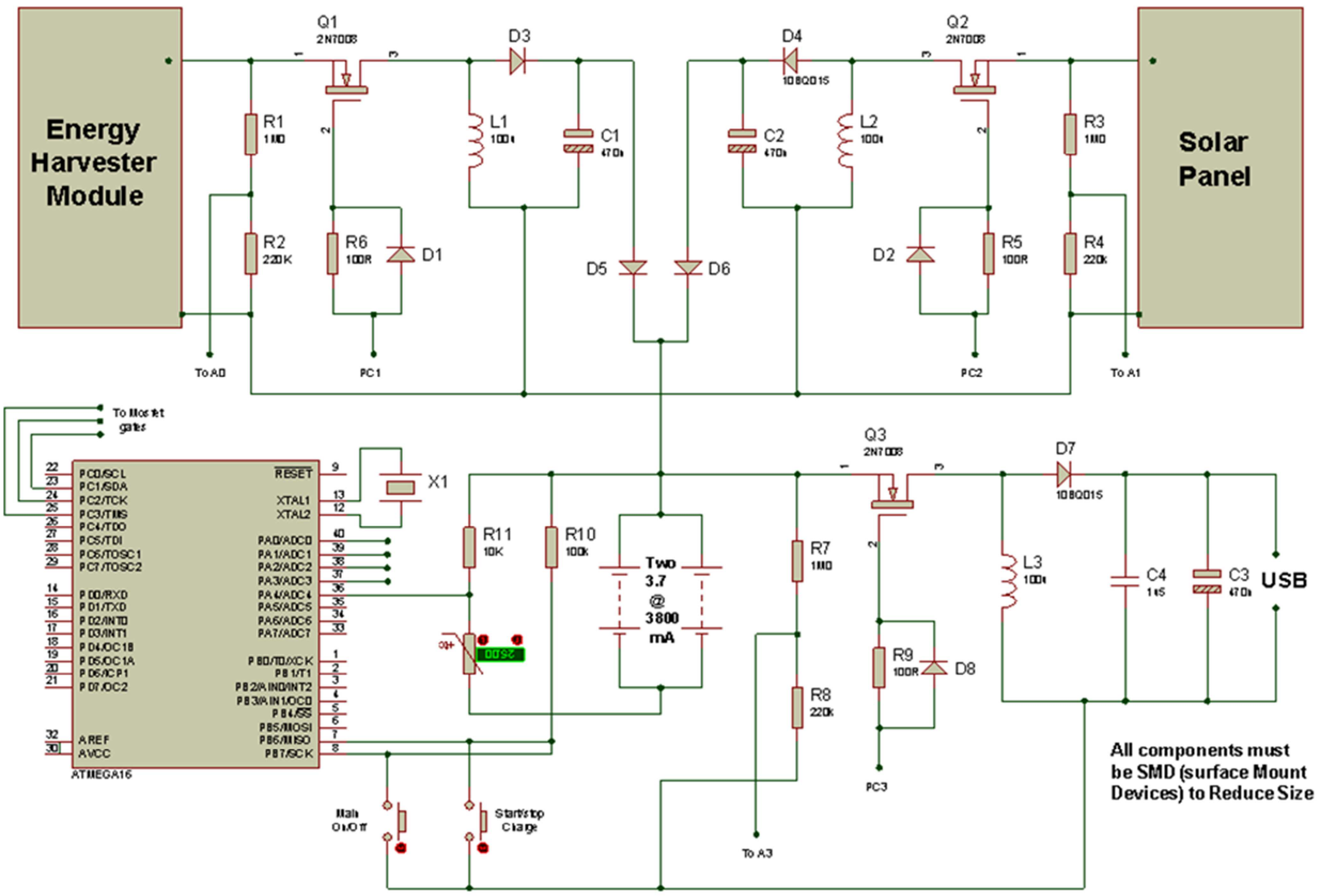

Figure 1. *Circuit Diagram of the embedded hybrid powered energy charging system.*

The hardware design methodology approach deployed to achieve the proposed system is Top- down approach. The system is broken down into various modules as shown in figure 2. The following components would be sourced for in developing the prototype:

1) Solar panel (70mm x 50mm)

2) Energy harvester (30mm x 27mm)
3) Controller (15mm x 15mm)
4) PCB Board (25mm x 50mm)
5) Battery (35mm x 50mm)
6) Resistors, Inductors, Capacitors, Diodes, Transistors, Microsoft buttons, USB Port, Jumper Wire, soldering iron, soldering lead.

Based on the size of the PCB, spaces are created for phone camera, touch and finger reader. The solar panel is placed at the lower end of the circuit board based on its size. The controller is placed next to the solar panel while the harvester is mounted close to the microcontroller to enable it harvest the energy emitted. This hybrid combination in the energy sources constitutes the novelty of the work. The battery is connected such that it can be charged by solar panel and energy harvester in a smart approach to sustain the life cycle of the battery. For the microcontroller, instructions are developed using an object-oriented design approach.

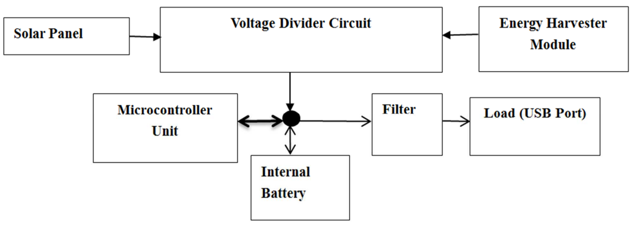

Figure 2. *Block Diagram of the proposed system.*

3. Expected Results

The expected output is an intelligent hybrid battery mobile phone charger integrated into the phone casing for instant phone charging and protective covering to the mobile phone. The proposed wearable device capable of harvesting energy in two sources is shown in figure 3. The combination of the solar panel and energy harvester will add green to the system and make it more reliable and efficient. The portability of the system will enhance the processing capability of the phones and keep the users ready for communications any day and anywhere.

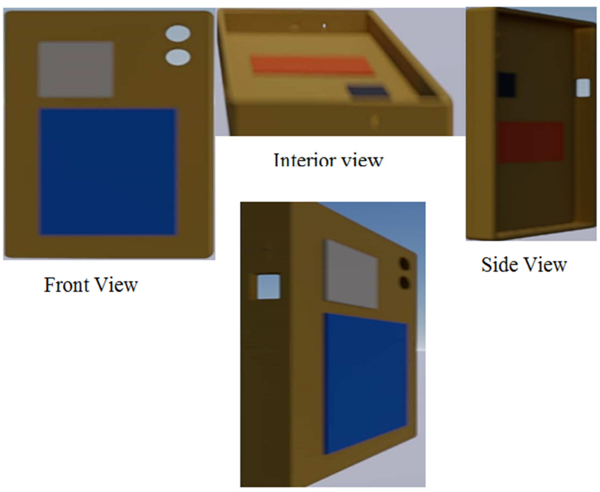

Figure 3. *Various view of the proposed system.*

4. Conclusion

The proposed wearable embedded hybrid powered energy sources for phone charging system will tremendously alleviate the sufferings phone users go through to keep their phones active for communication. The wearable device would expand the phone technologies and deliver job opportunities when deployed. This article has the design phase of the research work. The second phase of this research work is on implementation and testing, which would be the next part to be published. The second phase is in progress and there discussions on the system and limitations would be treated. For future work, we recommend the use of latest nanotechnologies in order to reduce the size of the proposed integrated smart phone cover.

References

[1] Abhimanyu Ssowntharrajan (2020). Design and implementation of a mobile phone charging system based on solar energy harvesting.

[2] Md. Anwarul Abedin. & Md. Alauddin (2019). Solar Powered Mobile Phone Charger for Farmers. *Duet Journal* (2). http://103.133.35.64:8080/jspui/bitstream/123456789/417/1/3.pdf

[3] Bang Tran, Joshua Ovalle., Karl Molina., Ruben Molina. & Ha Thu Le (2021). Solar-Powered Convenient Charging Station for Mobile Devices with Wireless Charging Capability. *WSEAS Transactions on Systems.* doi: 10.37394/23202.2021.20.29.

[4] Gladwin Antony., Hanharan S., Hari Haran. & Clement Raj. (2021). Design of solar charging case for mobile phones. *International conference on physics and energy,* 1-6. *Journal of Physics conference series.* doi: 10.1088/1742-6596/2040/1/01203.

[5] Kadam P., Sontakke M., Narate Agrawal R. & Sorte S. (*2022).* Design of mobile solar powered public station using RFID.. *International conference on Electronics and Renewable systems*, 186-191. doi: 10.1109/ICEARS5357952364.

[6] Rahil Imtiyaz., Aman Kumar. & Gutanjail Mmehta. (2021). Design and implementation of solar powered wireless mobile phone battery charger using electromagnetic induction. *International journal of innovative research in science, engineering and technology.*

[7] Raj A. S., Prabhavathy B. & Hawkinson S. J (2020). “Rehabitated solar powered consumed utilitarian charging device for mobile phone using ABD”. *International Journal of Psychosocial Rehabilitation.* 24 (8).

[8] Taverne, Jonas, Muhammad-Sukki, Firdaus, Ayub, Ahmad Syahir, Sellami, Nazmi, Abu-Bakar, Siti Hawa, Bani, Nurul Aini, Mas'ud, Abdullahi Abubakar & Iyi, Draco (2018). Design of solar powered charging backpack. *International journal of power electronics and drive systems*. (2) 848-858. https://doi.org/10.11591/ijpeds.v9n2.pp848-858

[9] Tran Bang, Ovalle Joshua, Molina Karl, Molina R., and Le H. T. Solar-Powered Convenient Charging Station for Mobile Devices with Wireless Charging Capability. *WSEAS Transactions on Systems*, *20*, 260-271.

[10] Udayalakhmi J. K. and Sheik Mohammed. S. Design and Implementation of solar powered mobile phone charging station for public places. *Proceedings of the 2018 IEEE International conference on current trends towards converging technologies*. 1-5.

[11] Samanvita N, Shruti Gatade, Singaravelan A, Shreeram Kulkarni (2022). Automatic Coin-Based Solar Tracking System Cell Phone Charger. *Published in: 2022 Fourth International Conference on Emerging Research in Electronics, Computer Science and Technology (ICERECT)*. Date of Conference: 26-27 December 2022. DOI: 10.1109/ICERECT56837.2022.10059595.

[12] Prajval Kadam, Mayur Sontakke, Aniket Narale, Rahul Agrawal, Swati Sorte (2022). Design of Mobile Solar Powered Public Station Using RFID. *Published in: 2022 International Conference on Electronics and Renewable Systems (ICEARS)*. Date of Conference: 16-18 March 2022. DOI: 10.1109/ICEARS53579.2022.9752364.

[13] Jabbar Hamid and Jeong Taikyeong (2022). Ambient Light Energy Harvesting and Numerical Modeling of Non-Linear Phenomena. *Appl. Sci.* 2022, 12, 2068. https://doi.org/10.3390/app12042068

[14] Hao Cao, Xiaoping Wu, Hao Wu, Yajia Pan, Dabing Luo, Ali Azam & Zutao Zhang (2022). A Hybrid Self-Powered System Based on Wind Energy Harvesting for Low-Power Sensors on Canyon Bridges. International Journal of Precision Engineering and Manufacturing-Green Technology https://doi.org/10.1007/s40684-022-00424-0

[15] Xinqing Xiao, Meng Wang, Guoqing Cao (2023). Solar energy harvesting and wireless charging based temperature monitoring system for food storage. *Sensors International.* Vol 4, 2023, 100208. https://doi.org/10.1016/j.sintl.2022.100208