Design and Development of Mobile Charging System Using Thermoelectricity

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Nasser Alasmari[1], Mesfer Alwadai[2], Yousef Alqahtani[3]

Electrical Engineering Department, College of Engineering, Najran University, Saudi Arabia
eng.elc.nasser@gmail.com1 , Engmmmaw@gmail.com2 , tota-sh-2009@hotmail.com3

Abstract: Energy sources differ throughout the world-, as do the costs of acquiring those sources. Electric energy has become an important element in our daily lives, especially for those devices that cannot be eliminated due to necessity. The usage of mobile phones has become an important element of our lives and their battery consumption is increasing due to the installation of a variety of Android applications. Electricity is required to charge the battery of the mobile phone; however, and at times, while travelling in a remote area there might not be access to electricity. Thus, the mobile would not be able to recharged. This paper presents the idea to design a mobile charging system using thermoelectricity. The thermal energy from the human body has been utilized to generate the electric power needed for the mobile charging process. To do this, a Peltier circuit device is connected to the human body. The difference in temperature between the human body and the atmosphere generates the voltage at the output of the Peltier circuit. The output from the Peltier circuit is then given to the boost converter and amplified to generate 5 volts which in turn are used to charge the mobil.

Keyword: Thermoelectricity, Peltier, Mobile Charging

1. Introduction

In recent days, we have been witnessing a noticeable increase in the prices of electricity. Oftentimes, people cannot cover the cost of electricity produced entirely from conventional resources of energy, like oil and gas. These conventional energy resources also cause severe damage on the environment. The universe holds a vast amount of wasted energy, whether in solar energy, thermal energy, kinetic energy or other type. For this reason, there is an increase in the demand for clean energy produced by renewable energy resources, especially to fulfil the electricity demand for small electronic devices like the mobile battery.

When we use every day electronic devices, an energy source may be needed in order to either operate the device or to charge the device's battery. Due to the increasing demand for electricity, researchers are focusing on alternative sources of energy (like renewable energy) rather than depending upon conventional resources (i.e., hydro energy, fuel energy).

One such type of renewable energy source is the human body. This type of energy source is much more important in a country like Saudi Arabia, where most of the population live in remote locations. People living in parts of the world like this usually travel in the desert where the electric supply is limited. Consequently, people need a cost-effective renewable energy source to charge their mobile.

We can take advantage of the human body to generate energy more easily and economically via the principle of thermoelectricity. In thermoelectricity, the voltages will be induced in the circuit if the temperature difference occurs at the junction of the device. The key advantages of thermoelectric power generation are: it is maintenance-free, offers noise-free operation, and has simple components and circuit.

2. Literature Review

There have been several studies published on the subject of thermal generation. Two thermoelectric modules were used by Killander [1] to develop a stove-top generator. The maximum power generated by this system was 10 Watt. A similar approach was used by Rahman [2] to generate power for portable electronic equipment. Their circuit was capable of producing a maximum of 13.5 Watt.

Later on, a hybrid system was proposed by Roth [3] which combined the use of thermoelectric modules and a photovoltaic system. They used this hybrid system to give electric supply to the mobile telephone repeater. The power produced by this hybrid system was 50 Watt.

It has been observed that the above researchers did not use a maximum power point tracking system. The idea to convert the rotational mechanical energy produced by a bicycle into electrical energy was introduced by [4]. In [5] a new technique to charge a mobile phone was presented based on the research that used the power generated through the motion of a bicycle wheel.

The charging circuit developed in their study consisted of a microcontroller-based energy management system that controlled the amount of voltage and current required for the charging of the mobile phone. The main components of this system were a protection circuit, microcontroller, power supply and a battery. It was confirmed through experiments that a bicycle speed in the range of 7 mph (miles per hour) to 55 mph can produce sufficient power to charge the mobile phone. In a recent study [6], a research was conducted to determine a way to protect the battery from overheating during use in renewable energy applications. Their findings provided a base for developing a battery which can store renewable energy produced by the thermoelectric system. The analysis of the usefulness of the Peltier cells for renewable energy applications is provided in [7].

They developed a renewable energy system using Peltier's in order to provide energy to the remote sensors that were being used for monitoring applications. A thermoelectric based energy producing system was developed in [8]. The developed system uses several thermal energy converting modules to convert environmental heat into electricity, which is then used to charge the battery. A DC-DC converter was used to control the amount of energy supplied to the battery and a microcontroller based system was used to track the maximum power point.

The concept of conversion of thermal energy into electric energy to power the electric stove was proposed by [9]. Recently, a step up converter was designed by [10] to boost the voltages from solar cells. A control circuit was developed to monitor the maximum power point and to decide when to store extra energy into the battery. In a similar work, an efficient battery system has been developed using the programmable logic controllers [11]. However, none of these studies have used thermoelectric effect to utilize the thermal energy of the human body for mobile charging application.

3. Experimental Design

Thermoelectric generation was performed using a simple circuit consisting of a Peltier and a boost converter. The block diagram of the circuit interface has been shown in Figure 1. The flow chart showing the operation of the thermoelectric generation circuit has been presented in Figure 2.

The operation of the device starts by first placing it on the hand of the user and then finding the difference of heat between the hot and cold plates of the Peltier. The power is generated and emitted to the boost converter circuit. After the amplification, the generated power is given to the mobile charger. If the generated power is less than the power required to charge the mobile device, the temperature difference between the two plates will be increased by providing the cold substance on the cold plates of the Peltier. The operation of the Peltier circuit has been given below:

The Peltier is a square-shaped device that has two directions, a cold sensor and a heat sensor as shown in Figure 3. The voltage is produced by placing the hot direction of the Peltier on the body with the cold direction exposed to the outside atmosphere. If necessary, the output voltage could be increased by increasing the temperature difference between the hot and cold side of the Peltier.

The four parts of the Peltier component have been connected in a series to allow the production of 500 mV, as each piece of Peltier produces approximately 150 mV in the thermal conditions we have provided. The series connection of the Peltier has been shown in Figure 4.

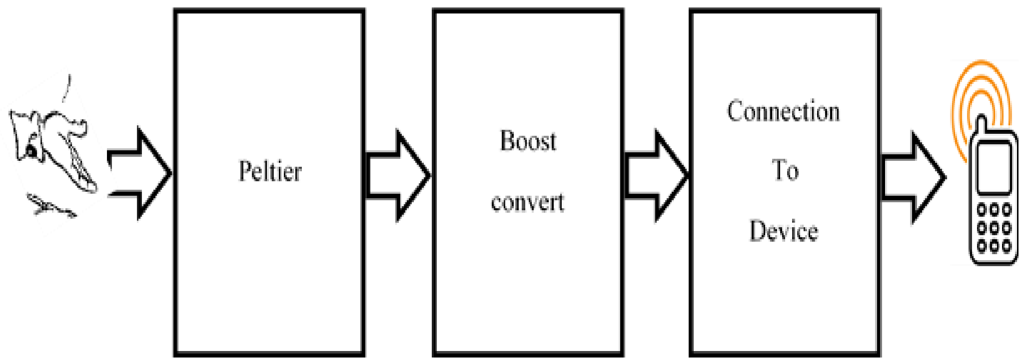

Figure 1. Block diagram of the thermoelectric generation

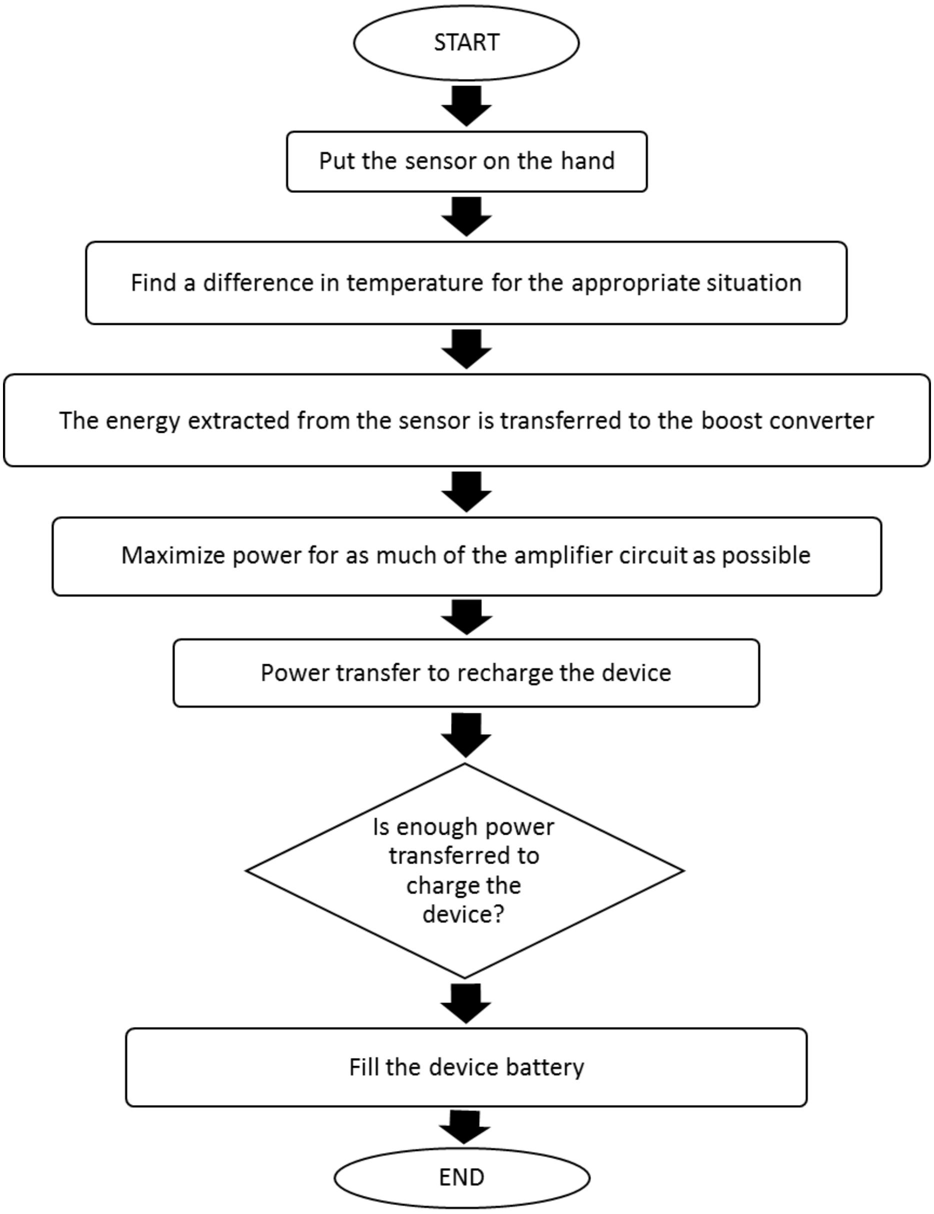

Figure 2. Flow chart of thermoelectric generation

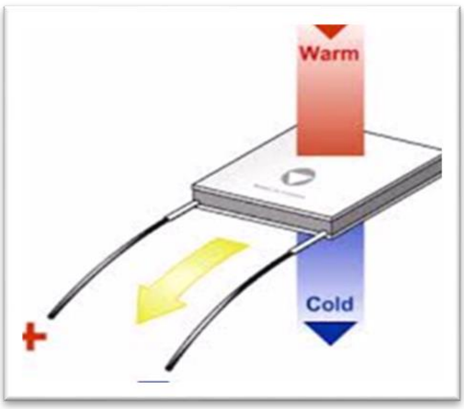

Figure 3. The process of the Peltier generating the voltages

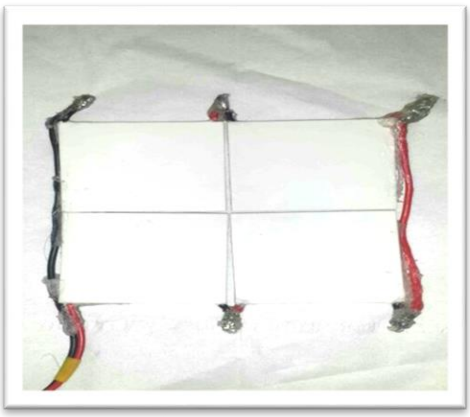

Figure **Error! No text of specified style in document.**. Four pieces of Peltier serially connected

A boost converter (step-up converter) has been used to amplify the voltages produced by the Peltier. The 400 mV - 500 mV output of the Peltier has been amplified to the 4.5 V - 5 V range. The block diagram of the developed boost converter has been shown in Figure 5.

The CE8301 boost converter as shown in Figure 6 has been used in these studies.

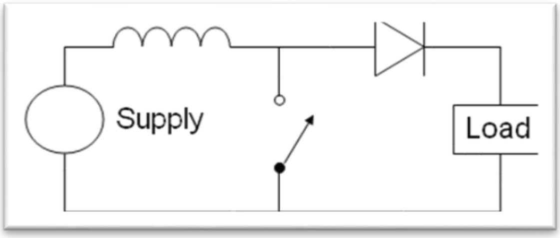

Figure 5. The basic schematic of a boost converter

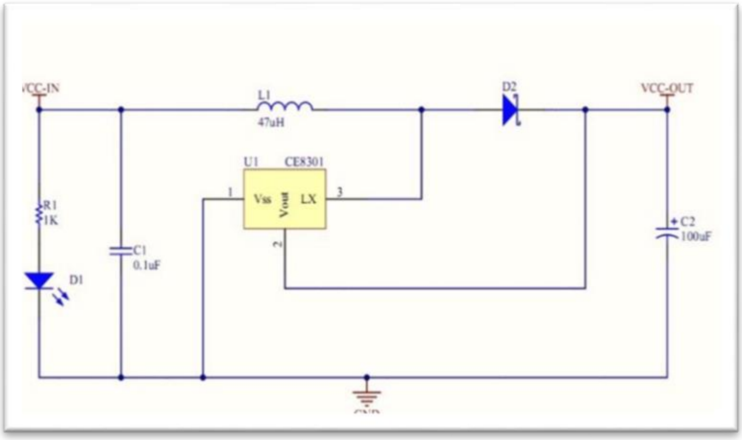

Figure 6. The developed boost converter circuit

The output of the boost converter circuit was connected to the mobile charger through a wire with a USB port. The operational diagram of the developed system has been shown in Figure 7.

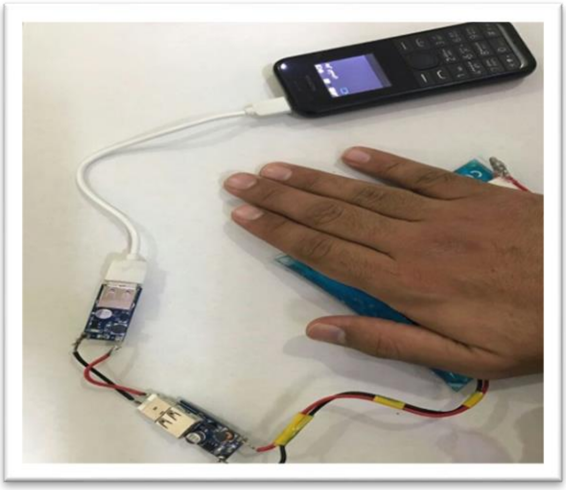

Figure 7. The operational diagram of the developed system

4. Results and Discussions

The results of the experiments performed on various conditions are shown in Table 1. There are three readings taken in three different circuit arrangements.

- The first reading was taken when one side of the Peltier plate was connected with human body and other side of the Peltier was kept open to the environment temperature. The output voltage for this arrangement of the circuit was very low.
- The second reading was taken when one side of the Peltier plate was connected with human body and other side of the Peltier was connected to a cold substance. The output voltage for this arrangement of the circuit was recorded to be 0.5 volt.
- The third reading was taken when one side of the Peltier plate was connected with human body and other side was connected to a cold substance and the output was connected with amplification,

regulation circuit. This arrangement generates 5 volt at the output which is enough to charge a mobile device.

Table 1. The summary of the various circuit arrangements and output voltages

Reading Number	Circuit Arrangement	Output Voltage (V)	Output Current (mA)
1	One side of the Peltier plate with human body and other open to the environment temperature	0.2	0.10
2	One side of the Peltier plate with human body and other connected to a cold substance	0.5	0.16
3	One side of the Peltier plate with human body and other connected to a cold substance and the output connected with amplification, regulation circuit	5	2.16

It has been concluded from Table 1 that the designed circuit arrangement shown in reading 3 could be used for mobile charging applications. The developed circuit could be utilized to charge the electronic gadgets in remote areas where conventional energy source is not available.

The comparison with the already published research as presented in [8] indicated that this system has an advantage of utilizing the thermal energy of the human body. While the results presented in [8] are using an extra source of energy to heat the hot side of the plate up to 100 c^0.

5. Conclusion

The mobile charging system in this paper has been developed using the concept of thermoelectricity. The developed charging system is useful for those travelling in remote areas without access to conventional electricity. Additionally, the developed system is simple and consists of economical components like a Peltier and boost converter. Testing on various mobiles has shown successful charging. The system could be further improved for a wireless charging system.

References

[1] A. Killander, J. C. Bass, H. Technology, and S. Diego, "A stove-top generator for cold areas," in *IEEE 15th international conference on thermoelectrics*, 1996, no. 1996, pp. 390–393.

[2] Ataur Rahman and Y. Abdi, "A Novel Electro Conductive Graphene / Silicon- Dioxide Thermo-Electric Generator," in *The International Conference on Information Technology and Digital Applications*, 2017, pp. 1–12.

[3] A. Steinhuser, W. Schulz, H. Schmidt, and W. Roth, "Photovoltaic power supply for telecommunication network components in remote areas," in *TELESCON 2000. Third International Telecommunications Energy Special Conference (IEEE Cat. No.00EX424)*, 2000, pp. 221–225.

[4] C. Arntzen, "The bicycle-powered smartphone charger," Faculty of California Polytechnic State University, San Luis Obispo, 2013.

[5] A. N. Howell, "Bicycle powered charger," University of Wyomin, 2016.

[6] C. Zhang, K. Xu, L. Li, M. Yang, H. Gao, and S. Chen, "Study on a Battery Thermal Management System Based on a Thermoelectric Effect," 2018.

[7] R. Hájovský, M. Pieš, and L. Richtár, "Analysis of the Appropriateness of the Use of Peltier Cells as Energy Sources," pp. 1–13, 2016.

[8] J. Eakburanawat and I. Boonyaroonate, "Development of a thermoelectric battery-charger with microcontroller-based maximum power point tracking technique," *Appl. Energy*, vol. 83, pp. 687–704, 2006.

[9] S. M. O. Shaughnessy, M. J. Deasy, C. E. Kinsella, J. V Doyle, and A. J. Robinson, "Small scale electricity generation from a portable biomass cookstove : Prototype design and preliminary results," *Appl. Energy*, vol. 102, pp. 374–385, 2013.

[10] V. S. Nayagam and L. Premalatha, "Green Energy Based Coupled Inductor Interleaved Converter with MPPT Technique for BLDC Application," *Int. J. Power Electron. Drive Syst.*, vol. 9, no. 4, pp. 1725–1732, 2018.

[11] N. Mohammed, K. A. Danapalasingam, and A. Majed, "Design , Control and Monitoring of an Offline Mobile Battery Energy Storage System for a Typical Malaysian Household Load Using PLC," *Int. J. Power Electron. Drive Syst.*, vol. 9, no. 1, pp. 180–188, 2018.