May – June 2020
ISSN: 0193-4120 Page No. 7259 - 7269

Android-controlled, Peltier-based Thermoelectric Charging Station with Arduino

John Anjelo P. Torres[1, 2], Alfie I. Reototar[1, 2], and, Josiah Buhayan, M. Min. IT[1, 2, 3]
[1]College of Computer Studies
[2]First City Providential College
[3]Research Adviser
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***Abstract*:**
World's dependence on renewable energy continues to rise. Today, people commonly use the hydroelectric and geothermal forms of electricity generation which is good for industrial purposes. In this modern age there still exists communities with less power. Thus the researchers checked the feasibility of developing a simple and practical electricity-generating device using Peltier modules. Consulting the related literature and studies in electricity generation, they found the utilization of a thermoelectric device for generating electricity. This was accomplished through following the principle of waterfall model in the development of the device. The overall design is to produce power and enable monitoring and control using the Bluetooth device. From the data gathered—execution of the developed hardware and survey data the researchers have observed that it is possible to achieve with a practical potential. In light of these they recommend developing a thinner device with more elaborate circuitry in controlling stabilizing the electricity produced by the device—producing a more effective everyday charging device.

1.0 Introduction

Electricity is a marvelous, mesmerizing, almost magical thing, but we've become so accustomed to it, we don't often stop to think about how it works and where it came from. Electricity is generated by converting from various forms of energy. The common source of electricity the world uses today is coal and fuel. In Asia Pacific, where the Philippines is situated, mostly uses coal as energy source, though globally, it is still oil that has the largest share in the energy market, with more than 30% global share[1]. However, burning fossil fuels is bad for the environment. Coal, for example, emits mercury, sulfur dioxide, and carbon dioxide, which are harmful to both human health and the health of our planet. Luckily, there are other sources of electricity that are safer, more sustainable, and environmentally-friendly. These include wind energy, solar energy, geothermal energy, and biomass. These are variations of industrial solutions and the common household of the Philippines are yet to discover the practical way of generating even minimal amounts of electricity necessary for running devices such as chargers for smart mobile devices.

Philippines has relied 31% of its power in renewable energy[2], in the forms of geothermal, hydroelectric, biomass, solar, and wind; with the hydroelectric being the highest contributor. Using renewable energy has a growing popularity among the developed countries, and Philippines has still a long way to go in utilizing consumer-level products that generate renewable energy; positively the country has a forecast of a higher compound annual growth rate (13.4%) considering the 2019-2024 projection by MordorIntelligence[3].

May – June 2020
ISSN: 0193-4120 Page No. 7259 - 7269

The study aims to develop and evaluate a device that can generate enough electricity (5v) to power small devices, and following the waterfall method is the best way to go in developing such miniscule projects.

This study has the following limitations: The device can produce electricity using heat from the candle flame, this device will automatically store the produced electricity to the device`s electric storage. This device can charge small devices. Using the researcher`s developed android application, it can monitor the percentage of the device`s electric storage. The Bluetooth connection can connect up to 15 meters. The device is designed for exposure of no more than 130°C to 140°C hot side. The device cannot produce electricity without the heat of gas lamp. The device cannot handle bigger flame than the flame from the gas lamp. The device cannot charge greater than one small device and a small device that didn't use a usb charger cable. The device cannot charge the electric storage device and the small device simultaneously. The device needs ice or water to stabilize the output voltage of the Peltier.

2.0 Related Literature and Studies

This study is how maximum output power can be obtained from a thermoelectric generator (TEG) with non-ideal heat exchanges. Mr. Karrie demonstrated an anlytic approch based on a force-flux formalism that the sole improvement of the intrinsic characteristics of thermoelectric modules including the enhancement of the figure of merit is of limited interest: the constrains imposed by the working conditions of the TEG must be considered on the same footing. Introducing an effective thermal conductance we derive the conditions which permit maximization of both efficiency and power production of the TEG dissipative coupled to heat reservoirs. Thermal impedance matching must be accounted for as well as electrical impedance matching in order to maximize the output power. Our calculations also show that the thermal impedance does not only depend on the thermal conductivity at zero electrical and thermal conditions permitting optimal use of a thermoeclectric generator.

A significant amount of energy they consumed each year is rejected as waste heat to the ambient. Conservative estimates place the quantity of energy wasted at about 70%. Converting the waste heat into electrical power would beconvenient and effective for a number of primary and secondary applications. A viable solution for converting waste heat into electrical energy is to use thermoelectric power conversion. Thermoelectric power generation is based on solid state technology with no moving parts and works on the principle of Seebeck effect. In this work a thermoelectric generator (TEG) system simulator was developed to perform various parametric and system optimization studies. Optimization studies were performed to determine the effect of system size, exhaust and coolant flow conditions, and thermoelectric material on the net gains producesd by the TEG system and on the optimum TEG system design a sports utility vehicle was used as a case study for the application of TEG in mobile systems. (Karri, 2012).

Smart home is not a new term for science society however, it is still far more away from people’s vision and audition. As electronic technologies are converging, the field of home automation is expanding. Various smart systems have been proposed where the control is via Bluetooth, internet, short message service (SMS) based, etc. Bluetooth capabilities are good and most of current laptop/notebook, tablets and cell phones have built-in adaptor that will indirectly reduce the cost of the system. However it limits the control to within the Bluetooth range of the environment while most other systems are not too feasible to be implemented as low cost solution. Wi-Fi based home automation system is

May – June 2020
ISSN: 0193-4120 Page No. 7259 - 7269

presented. It uses a PC (with built in Wi-Fi card) based web server that manages the connected home devices. The users can manage and control the system locally (LAN) or remotely (internet). The system supports a wide range of home automation devices like power management components and security components. A similar architecture is proposed where the actions are coordinated by the home agent running on a PC. Other papers also presented internet controlled systems consisting of a dedicated web server, database and a web page for interconnecting and managing the devices. These systems utilize a PC which leads to a direct increase in cost and power consumption. On the other hand, the development and hosting of the web page will also result in additional costs. The design and implementation of a microcontroller based voice activated wireless automation system is presented. The user speaks the voice commands through a microphone, which is processed and sent wirelessly via radio frequency (RF) link to the main control receiver unit. Voice recognition module is used to extract the features of the voice command. This extracted signal is than processed by the microcontroller to perform the desired action. The drawback is that the system can only be controlled from within the RF range. The reference also presents a voice activated smart home automation system. This system provides graphical user interface (GUI) using Microsoft Visual Basic software hosted by a PC, and uses Microsoft Speech Recognition engine. The signal is than transmitted via RF link to the microcontroller to which the home appliances are interfaced. Again a PC is used that account for an increased cost and power consumption. International Journal of Computer Networks & Communications (IJCNC) Vol.6, No.1, January 2014 35 A significant contribution to smart home system has been made by the above mentioned systems. However, a PC is used as a server that increases the cost and power consumption while others require web page hosting that adds up the extra cost. The voice activation systems either use PC software or separate voice recognition module for speech recognition.

3.0 Methodology

3.1 System Design

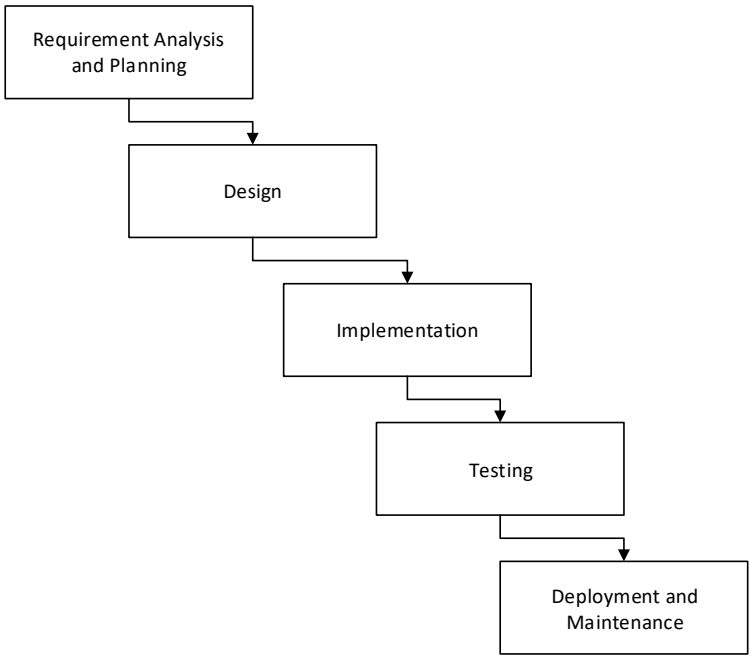

Figure 1: Visual representation of the System Development Life Cycle.

The proponents applied the Waterfall Model to develop the study. The waterfall model is a classical model used in system development life cycle to create a system with a linear and sequential approach. It is termed as waterfall because the model develops systematically from one phase to another in a downward fashion. This model is divided into different phases and the output of one phase is used as the input of the next phase. Every phase has to be completed before the next phase starts and there is no overlapping of the phases.

3.2 Planning

The system required the following hardware:

a.) An Arduino Uno
b.) Peltier Module
c.) Power Storage
d.) Candle
e.) USB Power Module
f.) HC-05 Bluetooth Module

The proponents used the following software; Arduino Software Development Kit for the programming of the hardware. The Android Studio was used to create the Android-based user interface of the power generation and monitoring.

3.3 Designing

Figure 2: Block Diagram of the system design.

The figure above shows the flow diagram from the heat coming from the candle and converted to electricity. Then transfer it to electric storage and if you want to monitor you need to connect to Bluetooth to get the percentage of the battery and display the battery percentage. If not, you can see the heat that converted into electricity.

3.4 Developing

3.4.1 Data Flow Diagram

The user will start up the heating element; wherein the peltier module will generate energy to be controlled.

May – June 2020
ISSN: 0193-4120 Page No. 7259 - 7269

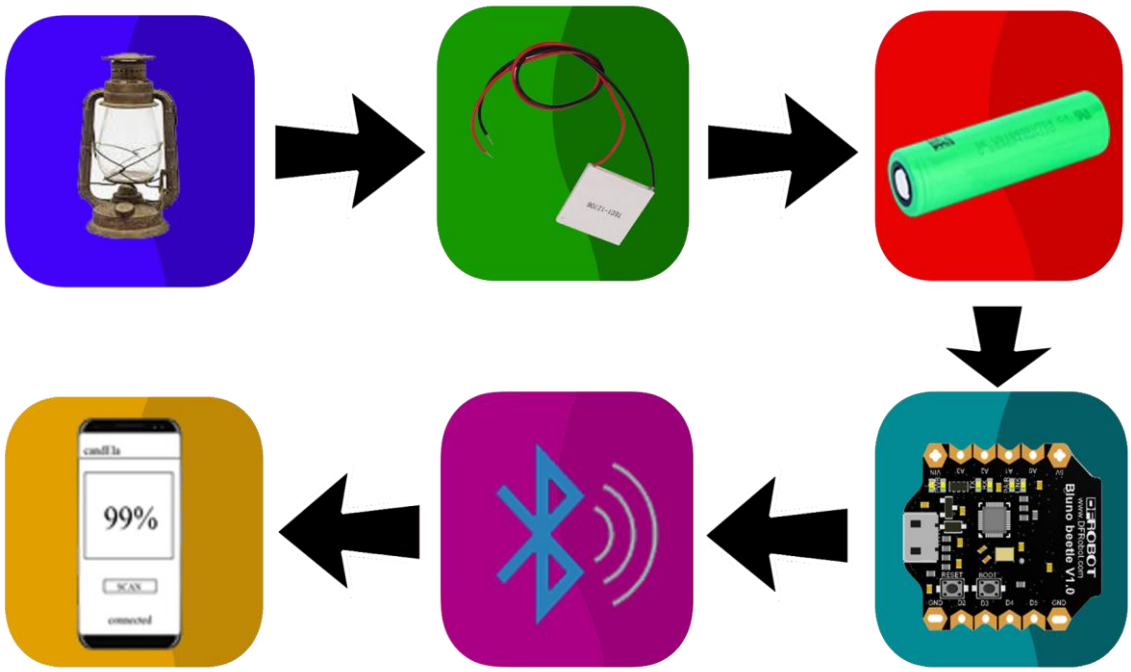

Figure 3: The Context Level Data Flow Diagram of the system.

3.4.2 Flowchart

The figure above shows the flow diagram from the heat coming from the candle and converted to electricity. Then transfer it to electric storage and if you want to monitor you need to connect to Bluetooth to get the percentage of the battery and display the battery percentage. If not, you can see the heat that converted into electricity.

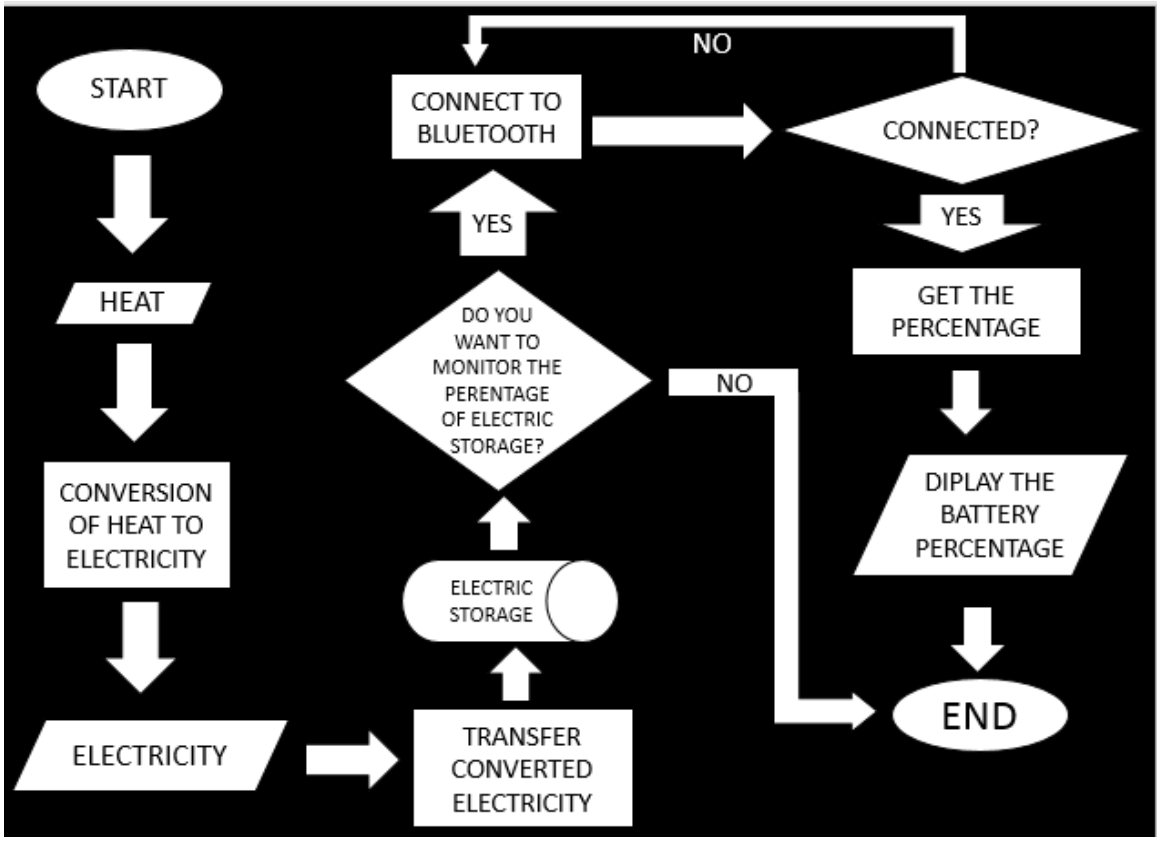

Figure 4: The proposed system flowchart of the study.

May – June 2020
ISSN: 0193-4120 Page No. 7259 - 7269

3.5 Testing and Debugging

For testing the device itself, the proponents let it undergo the stages of Functionality and Stability testing to ensure the system works and the data is gathered from the low-level up to high-level functions.

The proponents will use survey questionnaires to evaluate the overall functionality of the system. We gathered 30 community members, students, and teachers as respondents to test our research. After the demonstration of features, we gave them some questionnaires to answer.

3.6 Evaluating the System

3.7 Implementing the System

Figure 5: Representation of practical implementation of the system.

Figure 5 shows the practical implementation of the device. It graphically shows how the user will use the device in conducting the control and heat generation.

4.0 Results

This chapter presents the data gathered and its interpretation. Data gathered are placed in a table and is followed by its interpretation.

Functionality

Respondents
30 Percentage
%
Very Functional
18
60%
Well Functional
10
33%
Slightly Functional
2
7%
Functional
0
0

Not Functional
0
0

Table 1. Evaluation results of the respondents regarding the functionality of the system.

According to the results as expressed by Table 1, it shows that the majority (60%) agrees that the device satisfies the need as per the requirement discussed.

Reliability

Respondents
30 Percentage
%
Very Reliable
18
60%
Well Reliable
11
37%
Slightly Reliable
1
3%
Reliable
0
0%
Not Reliable
0
0%

Table 2. Assessment of the respondents regarding the reliability of the system.

According to the results as expressed by Table 2, it shows that the majority (60%) agrees that the operates reliably.

Satisfaction

Respondents
30 Percentage
%
Very Satisfied
18
60%
Satisfied
12
40%
Neutral
0

0%	
Unsatisfied	
0	
0%	
Very Unsatisfied	
0	
0%	

Table 3. Expression of satisfaction among respondents

According to the results as expressed by Table 3, it shows that the majority (60%) were satisfied with the stated operation of the device. Overall perspective shows that the device operates as satisfactory as it could.

1. Does the research can be an alternative source of energy?

	Respondents	Percentage
Yes	30	100%
No	0	0%

Table 4 Opinion of the respondents according to the operation of the device.

As per discussion of the operation and testing, we have verified the operation of device and its capability to generate electricity enough to power small mobile devices.

2. Does the research satisfy your need?

Respondents	Percentage	
Yes	30	100%
No	0	0%

Table 5 response whether the device and research satisfies the problem area.

According to the response, all responses agreed that it could satisfy their need considering the problem area being discussed.

3. Does the research help to reduce the source and cost of our electricity bill?

	Respondents	Percentage
Yes	29	97%
No	1	3%

Table 6 shows that the system if helpful to reduce the electrical bills.

According to the response, all responses agreed that it may be helpful in reducing electric bills.

4. Do you think the research has a big impact in our community in terms of electricity source?

	Respondents	Percentage
Yes	30	100%
No	0	0%

Table 7 shows that the system is helpful to the respondents.

According to the opinion of the respondents, they think that it could provide a significant impact in the community in terms of electric source.

5. Do you think this research helps you?

May – June 2020
ISSN: 0193-4120 Page No. 7259 - 7269

	Respondents	Percentage
Yes	30	100%
No	0	0%

Table 8 show that the respondent convince that this system helps our society.

Discussion

4.1 *Effectiveness of the Device*

In utilizing the device, it is positive that it is capable of generating electricity, and may be effective for practical use.

5.0 Conclusion

As the findings suggest, the proponents came up with a conclusion. Planning what source of data to be used, software and hardware elements to be utilized, finding related studies and literature, and identifying the scopes and limitation of the study has been properly completed. From the data that has been gathered during the design, implementation, and operation, the researchers have concluded that it is possible to create such device that could power simple mobile devices through the use of heat energy. From the survey data the researchers could conclude that using Peltier modules can be a reliable source as it operated properly during the device operation and testing.

6.0 Recommendation

As for the practical application, the device is still far from being an everyday charging device. It requires more design concerning the effective heat dissipation while generating electricity since as the heat increases, there's the high possibility of damaging the heat-generating device. Hence the researchers strongly recommend a more careful circuit design in the future in heat passage and dissipation, as well as the stabilization of generated electricity since there is a large amount of fluctuation while heat is applied in the device.

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May – June 2020
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Definition of Terms

Accuracy – the quality or state of being correct or precise.

Android – a mobile operating system (OS) currently developed by Google, based on the Linux kernel and designed primarily for touchscreen mobile devices such as smartphones and tablets.

Android V4.0 (Jelly Bean) – a version of Android Operating System

Bluetooth – a wireless technology standard for exchanging data over short distances

Cardiac Attack – also known as cardiopulmonary arrest or circulatory arrest, is a sudden stop in effective blood circulation due to the failure of the heart to contract effectively or at all.

Circuit Board - a thin rigid board containing an electric circuit; a printed circuit..

Debug – refers to the act of identifying and removing errors from computer hardware or software.

Graphical User Interface – refers to a visual way of interacting with a computer using items such as windows, icons, and menus, used by most modern operating systems.

Hardware - the machines, wiring, and other physical components of a computer or other electronic system.

Heart Rate - the speed of the heartbeat measured by the number of contractions of the heart per unit of time, typically beats per minute (bpm)

Hypertension – a state of having an abnormally high blood pressure.

Input – data put into a computer system

Mobile App - a computer program designed to run on mobile devices such as smartphones and tablet computers.

Output - data produced by a computer

Power Supply - an electronic device that supplies electric energy to an electrical load

Processor - logic circuitry that responds to and processes the basic instructions that drive a computer

Reliability - an attribute of any computer-related component (software, or hardware, or a network, for

May – June 2020
ISSN: 0193-4120 Page No. 7259 - 7269

example) that consistently performs according to its specifications.

Smart Phone - a mobile phone with an advanced mobile operating system which combines features of a personal computer operating system with other features useful for mobile or handheld use

Software - the programs and other operating information used by a computer.

System Development Life Cycle - also referred to as the application development life-cycle, is a term used in systems engineering, information systems and software engineering to describe a process for planning, creating, testing, and deploying an information system.

Threshold - the point or level at which something begins, ends, or changes

Waterfall Model – a type of System Development Life Cycle