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# Development of Portable Power Generator by Using Thermoelectric Generator for Hiking Purpose

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**Abstract**: The development of this project is to generate electricity from heat using the thermoelectric generator. This project is made for hikers. The power generator works as a tool that generate electricity and can be recharged using heat from a fire. This power generator comes with a sensor, which works to produce electricity when there is a different temperature detected. It can be used to charge a phone, power bank and others. The problem is while hiking when hikers running out of battery for their essential electronic devices. Thermoelectric generators will be used as a primary source to convert heat energy into electrical energy and become an input to the direct current (DC) buck converter. The DC buck converter will step down the voltage and boosts the current from the input to the load output. The universal serial bus (USB) module is used for charging electronic devices. The capability of this device to charge the electronic devices has been tested and it can charge about 10 percent in 30 minutes.

**Keywords**: Thermoelectric Generator, Heat, Power Generator

## 1. Introduction

Hiking is one of the most popular outdoor activities and hobbies for people in Malaysia. Here are some of the reasons why Malaysians like to go hiking, to enjoy nature, to get peace of mind, and physically the accommodation provides encourage the activity. But now, when hikers are trying to escape from all modern life traps, they stuck with various electronic charging activities devices. Most of the devices require frequent to keep them powered.

The designed purpose of this power generator is to assist the hikers in whatever circumstances. In some cases, when people get lost in the forest, they cannot use their devices due to running out of battery. The power generator is specially designed for charging a phone, power bank and others. This power generator works as a tool that generate electricity. It can be recharged using heat from fire and comes with a sensor, which works to produce electricity when there is a different temperature. Two separate electrical conductors forming electrical connections at different temperatures are composed of

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the sensor and the electrical unit. The sensor detects the temperature differences and interpreted them into temperature-dependent voltage. The sensor used for this project is a temperature sensor.

This project used a thermoelectric generator to generate the different temperature from heat and convert it to electricity that will be used to charge the battery. Heat is chosen because in the forest is easily provided wood twigs that can be used as a source of biomass. Besides that, hikers have mini stoves and butane gas to cook food while in a specific area. Mini stove basically can be used for indoors and outdoors because of its powerful burning mechanism and that design is simple and safe. In addition, it is also equipped with a spark starter and easy to adjust the gas tap to control the size of the fire as desired. From the mini stoves, it will help charge the power generator using fire.

## 2. Methodology

### 2.1 Project Overview

First, the primary source used is the source of biomass energy, such as tree limbs found in the forest during hiking. From this source, it must be lit with fire to provide the best possible heat. Next, the system is constructed using the thermoelectric generator as the power generator who changed difference temperatures to the power of electronic sources detect from the heat. The temperature should be below the maximum of 150 degrees Celcius. To find out the heat ness, this project added a digital temperature meter to display the measured. In addition, the temperature range from the flame is measured to analyze how much each voltage and current can be emitted at each distance.

To overcome this problem, methods that need to be used according to the surrounding conditions such as when in the forests we need to use the available resources. Firstly, we can use biomass resources that can be found in forests such as wood and twigs. These resources are readily available in forest areas and can assist in production using the Portable Power Generator. Next, the method of using a mini stove and butane gas can also be used as a tool on a portable power generator because the hikers will always carry this stuff for cooking purposes. This method can be help in solving this problem.

Thermoelectric generator connected to the buck converter. The DC buck converter can be step down the output voltage to the desired value. The buck converter is high ampere direct current. The value of the input range is 5 Volt until 40 Volt and the value of output is 5 Volt. The current can up to 3 Ampere. After that, the output DC buck converter has connected to the battery charger module and connected to rechargeable batteries which to store the output voltage from the buck converter. This project used a parallel battery voltage is 3.7V. Then, from the battery connected to the dual USB battery charger module for users to charge the electronic devices. The output USB module has two, one for a direct charge from output DC buck converter and one charged from rechargeable batteries. Type of USB output is a DC buck step down charger module. Figure 2.1 shows the block diagram for this project.

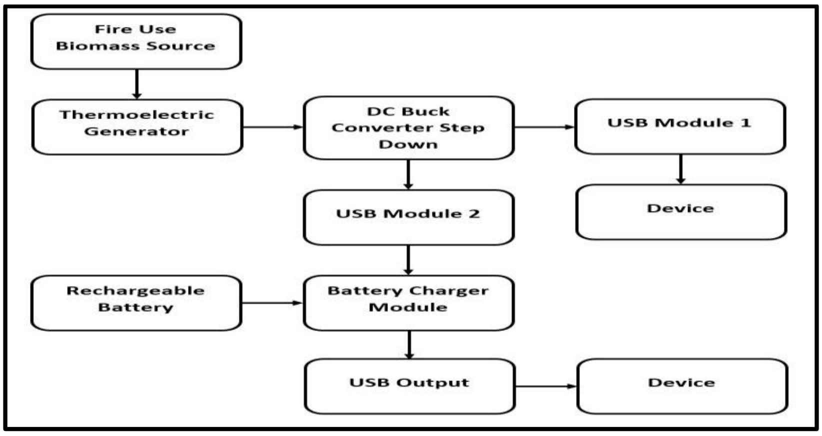


**Figure 1: Block Diagram Process**

### 2.2 Hardware Development

This project contains of main hardware components which is Thermoelectric Generator, DC Buck Converter Step Down, Battery Charger Module, Rechargeable Battery, and USB Output Module. The hardware design has focus on detection and monitoring part. Then, the other part is functioning as output.

## 3. Results and Discussion

This section is about the result obtained throughout this project from the beginning till the end of this project. This chapter also explain about the hardware implementation and includes problems occurred upon completing this project.

### 3.1 Results and Discussion

The project was analysis and data measured throughout the completion of the project in detail. To ensure that the measured data is successful this project has been carried out by making various tests to differentiate the data between the sources used. All results is about the component testing, to analyze different temperatures input of relation with voltage output using biomass source, analyze the buck converter circuit, component testing and the part of discussion have some testing to get the result by using hot water and fire using the stove. The data measure depends on the project objectives. In addition, the measured data only focuses on the temperature level as well as the output voltage and some of the data measured is data that has been set on the project to support the function of a circuit.

This project uses biomass sources to be burned to generate electricity. The heat from the fire will be detected by the thermoelectric generator circuit that connected to the DC buck converter circuit. The regulated voltage from DC buck converter is used to charge electronic devices through a USB port. The project has been tested and data have been measured to ensure this hardware can be used as desired. Figure 3.1 shows the hardware circuit connection from the thermoelectric generator to DC buck converter. The DC buck converter output connects to a USB output module to charge the electronic device and battery charger module using a USB cable. The temperature sensor not connected to the circuit it acts as a temperature detector on aluminium mess tin only.

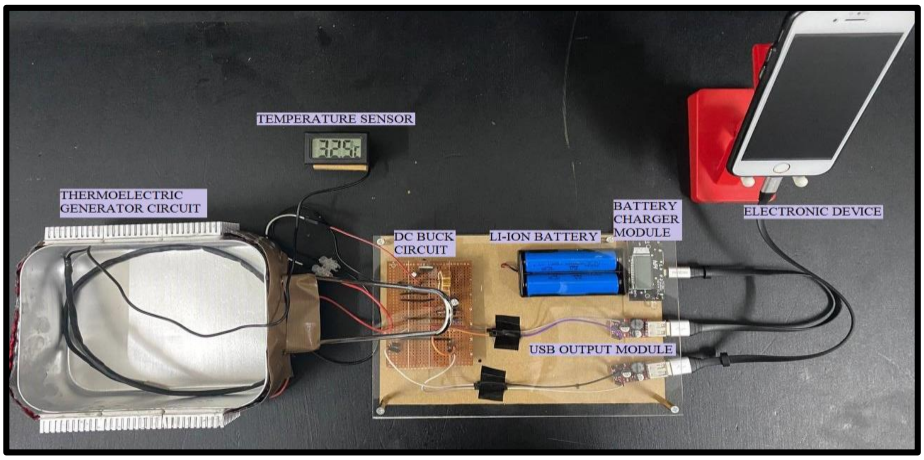


**Figure 2: Hardware Circuit Connection of The Project**

Figure 3.2 show an overview of the hardware of this project. Aluminium mess tin is used as hardware for thermoelectric generators because this aluminium is a good heat conductor and can easily detect heat from the fire and heats up quickly. If it is too hot it can cause damage to the thermoelectric generator, but the heat sink has been placed on each thermoelectric to increase the heat flow from the heating device. Lastly, the acrylic sheet was used as a protector for the circuits.

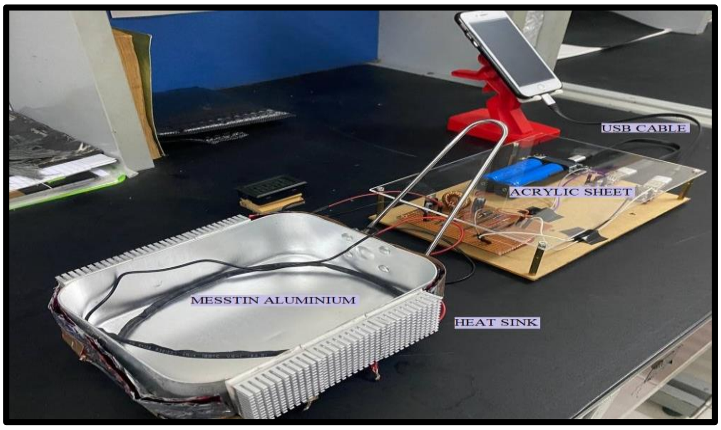


**Figure 3: Overview of the Hardware Connection**

Table 3.1 shows the differences temperature and output voltage from the DC buck converter that used biomass as a source to generate fire. This project was successful because it obtained an input voltage of more than 5 Volts. The temperature is not too high due to the small fire, but it is concentrated on the mess tin and it is easy to get the voltage output needed for the circuit. The temperature reached 5 Volts at 52.1 degrees Celcius.

**Table 1: Data of Differences Temperature and Output Voltage using Biomass Energy**

| Temperature | Voltage |
|---|---|
| 36.2°C | 2.7V |
| 39.1°C | 3.5V |
| 40.8°C | 3.8V |
| 43.3°C | 4.2V |
| 50.9°C | 4.92V |
| 53.1°C | 5.1V |
| 56.4°C | 5.34V |
| 59.6°C | 5.68V |

Differences temperature is important because the output voltage depends on the level of heat detected. The higher the temperature level can get the higher output voltage value. To keep the fire more stable it is necessary to carefully add the biomass source to maintain heat temperature. Figure 3.3 shows the final testing that proves biomass energy power supply can charge the electronic device using heat from the fire. This testing proves that this project has achieved the desired objectives.

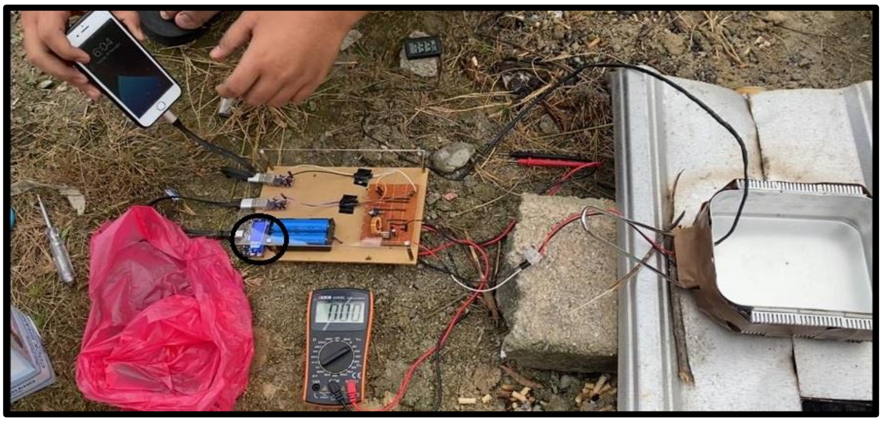

**Figure 4: Charging Electronic Devices using Biomass Energy Power Supply**

#### 3.1.1 Charging Capability Test

Charging capability test is measured based on the time taken for the circuit to charge the electronic devices. Table 3.2 shows the data of the time taken and the percentage of charging capability. The percentage of charging increase 1% to 2% for every 5 minutes of charging time. Total time for this testing is 30 minutes. The percentage increase for 30 minutes charging time is 10% for the phone and 9% for the power bank. The time to charge the power bank is lower than the USB port because depends on how much capacity of the power bank battery.

**Table 2: Data of Differences Time and Increase Percentage using Biomass**

| **Time** | **Increase Percentage** | |
|---|---|---|
| | **Handphone** | **Power Bank** |
| 0 – 5 Minutes | 2% | 2% |
| 5 – 10 Minutes | 2% | 1% |
| 10 – 15 Minutes | 2% | 1% |
| 15 – 20 Minutes | 1% | 1% |
| 20 – 25 Minutes | 2% | 2% |
| 25 – 30 Minutes | 1% | 2% |
| **Total** | **10%** | **9%** |

Next, a comparison was made using direct USB laptop to test charging stability. Table 3.3 shows the time taken and the percentage of charging capability using a USB laptop. From the table, the difference using the USB laptop compare to charging using the project circuit almost the same because the increasing percentage around 1% to 2%t every 5 minutes. The total charging percentage increase 9 % for 30 minutes of charging time.

**Table 3: Data of Differences Time and Increase Percentage using USB Laptop**

| **Time** | **Increase Percentage** |
|---|---|
| | **Handphone** |
| 0 – 5 Minutes | 1% |
| 5 – 10 Minutes | 2% |
| 10 – 15 Minutes | 1% |
| 15 – 20 Minutes | 2% |
| 20 – 25 Minutes | 1% |
| 25 – 30 Minutes | 2% |
| **Total** | **9%** |

### 3.2 Comparison using Different Heat Sources

In this section, the biomass energy power generator is compared with different types of sources to determine the ability and performance of which resources gives the best result.

#### 3.2.1 Hot Water as a Heat Source

The thermoelectric power generator consists of thermoelectric modules, hot water will be boiled first to reach a high temperature. Hot water will be placed inside the container and equipped with thermoelectric on the outside of the aluminum container. Next, the aluminum container will detect and carry the heat to all parts of the thermoelectric generator. It can produce high voltage if hot water exceeds 90 ° C.

Next, hot water has been boiled using a water heater and will be tested as soon as the water is heated into the container. This test is done to identify the difference in temperature and the value of the output voltage obtained. The data obtained will be shown in the Table 3.4. From the table, the water is less effectively used as heat to thermoelectric generators due to several factors such as environment. The data temperature was decrease when the water less hot, so the output voltage also decreases from the 6.64V to 1.6V in 3 minutes only.

**Table 4: Data of Differences Temperature and Output Voltage using Hot Water**

| Temperature | Voltage |
|---|---|
| 89.7°C | 6.64V |
| 86.9°C | 4.43V |
| 84.4°C | 3.86V |
| 83°C | 3.29V |
| 76.6°C | 1.6V |

The water temperature decreases so the output voltage also decreases from the 6.64V to 1.6V in 3 minutes. Based on the theory, if the hot water remains at a temperature of 90° C and above it may be effective to use as a heat source. Figure 3.4 shows the setup experiment used to shows it ability to support the charging of electronic devices.

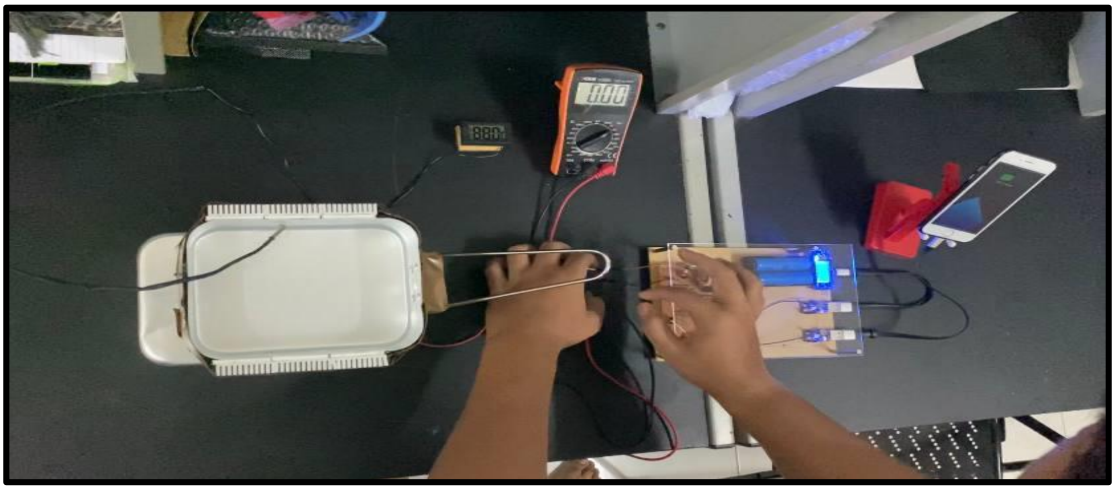

**Figure 5: Charging Electronic Devices using Hot Water**

As a conclusion, initially hot water was able to support charging when the temperature is around 90° C above and can produce a high output voltage. But if the water becomes warm and the temperature drops below 86° C it cannot produce the required output voltage.

3.2.2 Mini Stove as a Heat Source

This test is done to differentiate the heat level of the fire using the heat source by using biomass compare to heat from the mini stove. The mini stove used butane gas. The advantage of using a mini stove it is easy to light a fire.

The data obtained are shown in Table 3.5. The data shows that this mini stove is effective for use as the heat source to thermoelectric generators because it produces 5V output voltage when the temperature reached 70.5° C. Compare to using biomass source the output voltage 5V produce when the temperature reached 52.1° C. The difference is using a mini stove it can control the temperature of the fire from reaching high temperatures to prevent thermoelectric burning.

**Table 5: Data of Differences Temperature and Output Voltage using Mini Stove**

| Temperature | Voltage |
|---|---|
| 35.5°C | 0.12V |
| 40.5°C | 1.09V |
| 45.3°C | 2.06V |
| 55.9°C | 3.66V |
| 60.4°C | 4.35V |
| 65.3°C | 4.97V |
| 70.5°C | 5.07V |
| 75.5°C | 5.46V |
| 80.4°C | 5.97V |
| 85.5°C | 6.43V |

Figure 3.5 show the setup for charging electronic devices using mini stove. When it reaches output voltage 5 Volts and above it transfers heat energy to electrical energy can charge electronic devices.

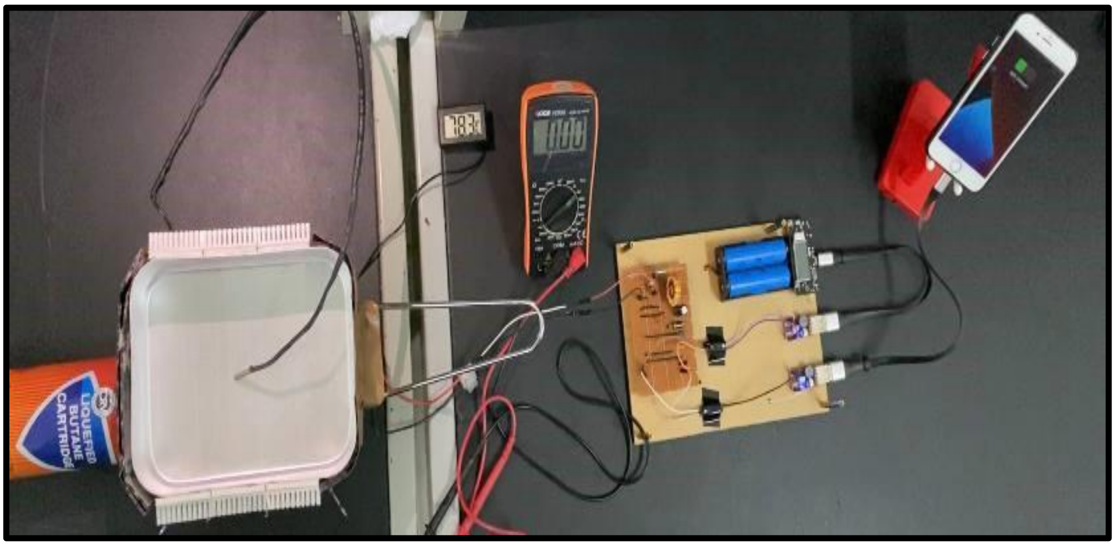


**Figure 6: Charging Electronic Devices using Mini Stove**

Lastly, as a conclusion, mini stove is effective for use as heat source to thermoelectric generator. The advantage of using this mini stove is the fire direct to mess tin and constant so it can generate high temperature that can cause thermoelectric burns. However, the disadvantage of it is using butane gas which is costly and flammable.

3.3 Summary

This chapter summarized all result obtained throughout the completion of this chapter. From the results it can be seen why the same temperature from differences sources produces differences output voltages. This is because, the heat level is unstable and in a short time it can change. The differences of temperature and output voltage used as testing in this project because of the temperature sensors detect a change in a physical parameter such as resistance or output voltage that corresponds to a temperature change so indirectly it involves a lot of testing in the project. Next, the biomass source can be used as a source of heat but the fire that burns should be controlled by constantly adding fuel to maintain the heat level and stability of the fire. In addition, the mini stove can also be used as fuel by using butane gas it is also very easy to use because it can control the fire but it has a relatively high cost and flammable butane gas if space ventilation is insufficient and dangerous. Finally, hot water is not recommended to be used as heat input for this project if it is in a forest area because hot water requires a high level of heat to produce high voltage.

## 4. Conclusion

In a nutshell, this project has been successfully development of a biomass energy power supply from fire for hiking purpose. This project can to some extent help hikers who have been in the forest for too long can charge electronic devices that have run out of battery. By simply using a thermoelectric generator it can detect heat with the next fire it can produce electrical energy and can charge your electronic device.

As conclusion, this project has completed all the objective needed. First, design a power supply circuit that can convert biomass energy into electrical energy. This energy exchange can be produced by using the fire burned as heat energy. Next, develop the power supply using heat by a thermoelectric generator. The thermoelectric generator has detected the heat from the fire through aluminum because aluminums is a good heat conductor and easy to detect the heat quickly. Lastly, to analyze relationship with the differences of temperature input and of voltage output. The higher the heat temperature detected on the fire the higher the output voltage value that can be generated from this project.

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