Design and Development of Portable Hand-Crank Generator

By

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16917

Dissertation submitted in partial fulfilment of
the requirements for the
Bachelor of Engineering (Hons)
(Mechanical)
May 2015

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CERTIFICATION OF APPROVAL

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(MECHANICAL)

Approved by,

____

(DR HILMI BIN HUSSIN)

UNIVERSITI TEKNOLOGI PETRONAS

BANDAR SERI ISKANDAR, PERAK

MAY 2015

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

(KU MUHAMMAD FAEZ BIN KU ARIFFIN)

ABSTRACT

During natural disaster there is a need to have good accessibility to electrical supply for telecommunication purpose. One of the possible solutions is utilize a green power generator which does not depend on electricity. Hence, the objective of this project is to design a portable hand-crank generator for generation of electricity required for communication devices. The design concept has been developed using morphological charts in which has identified the components to be selected in the final design of the portable generator, which is the standard crank, DC motor, spur gear system, and USB interface. Next, the target requirement and specification of design were established based on the calculation. The design was later drawn and finalized in CATIA software. The design is then fabricated by using rapid prototyping method in which tested and analysed in terms of output and efficiency. The output of the generator is 5V, with a maximum current output of 1.2A with a hand-crank rotation of 120–200RPM. The main advantages of the design and product are portable, effective, smart and convenient.

ACKNOWLEDGEMENTS

First and foremost, I would like to express my greatest and deepest gratitude to my dedicated and respected supervisor, Dr Hilmi Bin Hussin for his endless kind of support, knowledge, guidance and patience throughout the entire period of this project throughout this two semesters. A special thanks goes to laboratory technicians, Mr Musa Yusuf, Mr Hafiz Safian, Mr Zamil Khairuddin, Mr Jani, and Mr Asyraf for their ceaseless assistance, support and guidance in the project's electronic circuit building, and components testing in completion of this project. A special thanks to Dr Kurram Altaf, for providing me a fabrication solution of this project, together with suggestions and modifications required; to my beloved parents for their support, motivation and optimistic advices, and not to forget my fellow coursemates and friends, for their time and effort in sharing information with me and for their generosity and helpfulness; and last but not least, to all people who involved whether it is intentionally or unintentionally throughout the entire project. Above all, thank God for all His blessings and miracles that helped me to made it all the way to complete this final year project of May 2015.

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CHAPTER 1
INTRODUCTION

1.1 Background

Electricity is one of the major source needed by people nowadays. The form of energy can be used to power up many devices, home appliances and also machines to serve the needs of the people, community and also the country. Generally, electricity is generated by using fossil fuels, in which is generated either by using gas turbine or steam turbine. Nowadays, our electricity demand are increasing and consequently fossil fuel resource in which is finite and will be used up one day. Thus, alternative energy sources is currently being looked up for its utilization to replace the current fossil fuel resources such as wind, water, nuclear and many more.

Lately, natural disasters are one of the major issues raised in Malaysia. Natural disaster like flood that happened almost every year affected many people and destroyed many things around the affected area. In addition, the main necessities like electricity, clean water and also food are also badly affected, especially for those who cannot reach the safe area due to the pathways that has been blocked by the water thus they are waiting for the help from the rescuer in which took some time, even days.

During this situation, analyst has found that the communication method is essential in order to inform the victim's current situation and updates to their relatives, friends and also the rescuer. However, the limitation of the electricity source, and also the electrical storage stored in the battery or other energy storage method should be considered as the energy cannot be generated during the critical time. Thus, the device that generate small amount of electricity for communication devices should be introduced in order to increase their chance in survivability during natural disasters and also emergency situation in which requires electricity to communicate.

Thus, a solution is required in which to create a small power generator that is portable and can be used during critical situation mentioned. By using a motor generator concept as a reference, and also some other patented product, the solution will have some add-ons through it in which will suites the problem statement. The focus of this project is towards the solution for natural disasters or personal usage in which the electricity generated is sufficient for personal communication device and also small power backup purposes.

1.2 Problem Statement

Natural disasters is one of the biggest problem in Malaysia in which it affects large population of people. Recently, at the end of 2014 the worst flood happened across Malaysia's northeast, in which killed 21 people, 8 people were missing and more than 200 000 people are affected (AFP 2014). The worst flooding in decades also affected the major human needs such as foods, clean water, shelter and also electricity. There are also some cases reported in which the flood aid cannot be reach to certain areas due to the high magnitude of the flood and also the route is not safe to be reach. Thus, the affected group of people are having difficulties in getting basic necessities, especially in communication to contact other people due to the limited electrical resource to recharge the device (Jo-Lyn 2015).

The main concern of the situation stated above is how is the affected people can survive and communicate with other people in a limited source of electricity? Will the new invention is able to help the affected people without too much of energy needed in order to carry its weight, size and also its efficiency in generating electricity?

1.3 Objectives

The objectives of this project are listed below:

i. To design a portable hand-crank generator for generation of small electricity for emergency and natural disaster purposes.

ii. To develop a model of the portable hand-crank generator system based on CATIA software.

1.4 Scope of Study

In order to complete this project, the scope of studies listed need to be achieved. The list of the scope of studies are listed below:

i. Understanding the fundamentals of the crank generators and its applications
   - This includes the research on the type of generator selected, ratio of the moving shaft to generate electricity and also the electricity circuit design for electricity storage.

ii. Structural and Modelling Design by using CATIA Software
   - The software is needed for the developing of the model, design specification and also stress analysis in a computer.
   - The model is develop into 2D and also 3D, including the details of the parts involved in the design stage.

iii. Provide the Detailed Specification of the Final Prototype Designed
   - The specifications required may include the power generated per time of the rotating generator, minimum and maximum speed required, installation manual, power output produced and also the overall dimensions of the model.
   - The specifications listed are necessary to avoid any damage caused due to the improper handling and also the condition applied during the usage.

CHAPTER 2
LITERATURE REVIEW

2.1 Electrical Generator Concepts

Electrical generator is a system is which a machine that converts a mechanical energy into electrical energy. The principal of the change of energy is by using a magnetic induction. Magnetic induction concept works in which a conductor is cut across the magnetic field or flux, the current is induced and the voltage is generated at the same time (Bartelt 2009).

In the basic of electrical generator, the amount of voltage generated basically depends on several factors (Bartelt 2009):

- Strength of the magnetic field
- Angle of the conductor cuts the magnetic flux line
- Speed of the conductor cuts the magnetic flux line
- Length of the conductor in the magnetic field.

In determining the direction of the current flow through a wire, the left-hand rule is applied in which consist of the motion of the conductor across the magnetic flux, and also the direction of the magnetic flux, which is from the North Pole to South pole (Bartelt 2009).

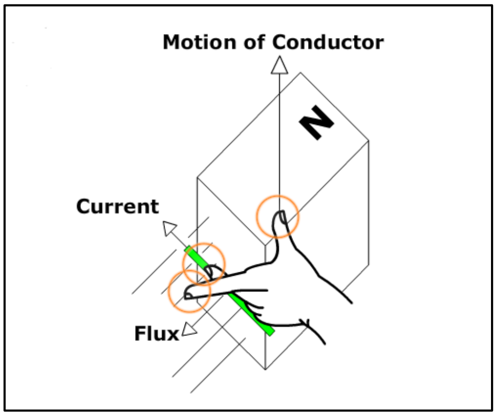


Figure 2.1: Left-hand Rule for Induced Current across the Magnetic Field

In the basic alternating current (AC) generator, the magnetic field is fixed and the current is flows around the loop. The rotating coil loop, rotated by hand crank, is then connected to a fixed wires known as brushes or slip rings. The output of the AC generator is in a form of sine wave (Moyer & Chicago 2010).

$$I(t) = I_{max} \,.\sin \omega t$$

In which ω is the angular frequency of the $\omega = 2\pi f$ and f is the natural frequency.

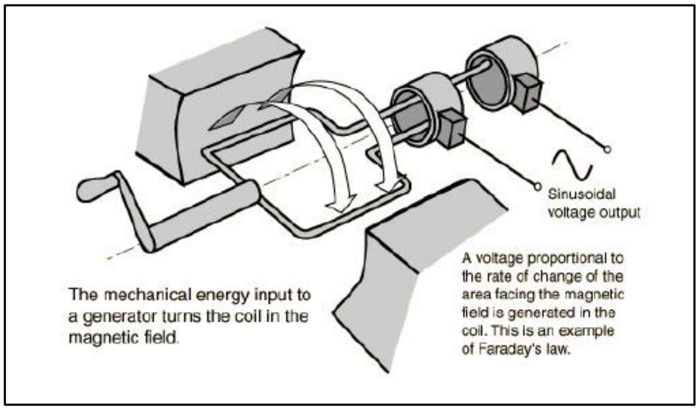


Figure 2.2: Simple AC generator with Rotating Loop

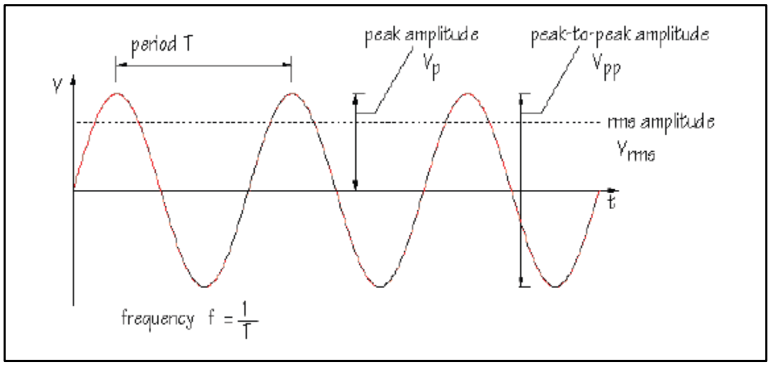


Figure 2.3: Sine Wave Terminology for AC Generator

In the basic model of the direct current (DC) generator, it is a way simpler than AC generator in which the current loop is turned due to the magnetic field produced by the fixed magnet (Moyer & Chicago 2010). The split ring commutator is used to reverse the direction of the current thus only one direction of current is produced. However, the current produced is not constant and this will affect the power produced. To reduce the problem, the wire coils is arranged at different angles so that the power output produced is totalled from the rectified sine waves (Moyer & Chicago 2010).

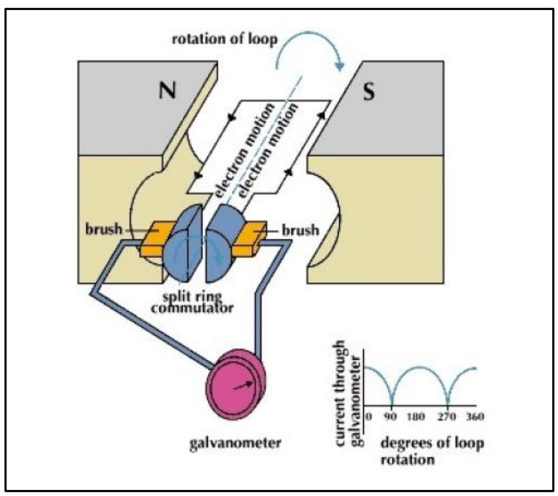


Figure 2.4: Simple DC generator with Split Ring Commutator

2.2 Example of Existing Small Generator

An example of the small generator available globally is the Ginlong 500-A PMG, one of the products produced by the Ginlong Technologies, located at Zhejiang, China (Technologies 2006). The model is a gearless, direct drive with a low RPM generator features. With a rated power output of 500W, a design lifetime up to 20 years together with the high quality material assembled, it is more than enough to generate electricity for a small electrical devices. It is perfectly designed for small wind turbines. However, the main disadvantages is that it has a low start up speed. This is due to the low cogging and its design in which has resistive torque features.

Electrical Specification	
Rated Output Power(W):	500
Rated Rotation Speed (RPM):	450
Recified DC Current at Rated Output (A):	20
Requied Torque at Rated Power(NM):	14.8
Phase Resistance (Ohms):	0.66
Output Wire Square Section (mm^2):	4
Output Wire Length (mm):	600
Insultation:	H Class
Generator configuration:	3 Phase star connected AC output
Design Lifetime:	>20 years

Mechanical Specification	
Weight (Kgs):	14.4
Starting Torque (NM):	≤0.45
Rotor Inertia (Kg.m^2):	0.006
Bearing Type:	High standard NSK 6207DDUC3 (Front) NSK 6207VVC3 (Rear)

Material Specification	
Shaft Material:	High standard Stainless Steel
Shaft Bearing:	High standard SKF or NSK bearing
Outer Frame Material:	High standard Aluminium alloy with TF/T6 heat treatment
(TF/T6 full heat treatment for increasing the performance of aluminium alloy as follows. Heat 4-12 hours at 525-545 degrees Celsius, quench with hot water, and precipitation heat treatment for 8-12 hours at 155-175 degrees Celsius.)	
Fasteners (nuts and bolts):	High standard Stainless Steel
Windings Temperature Rating:	180 degrees Celsius
Magnet Material:	NdFeB (Neodymium Iron Boron)
Magnets Temperature Rating:	150 degrees Celsius
Lamination Stack:	High specification cold-rolled Steel

Figure 2.5: Ginlong 500-A PMG Generator and Technical Specifications

The main features of the generator is that the 16 permanent magnets that attached to the rotor to ensure the efficiency of the induced current produced. For a simple and portable setup of a wind turbine, Ginlong 500-A PMG is an overkill generator to be chose due to its low start up speed in which is crucial for a minimal power generation.

2.3 Example of Hand Crank Generator

Another example of the available product to be include in the project is the hand electric generator. The concept used is that the human energy is required to rotate the rotor, and the current is induced in the generator at the same time. There are various types of hand electric generator available, mostly for military usage, emergency purposes and many more.

In this example, of the China product, called as Sunshine FSD-30W is a military-type hand electric generator(Unknown 2012). By using high-tech magnetic conversion technology and also a high strength aluminium composite alloy material at the outer case makes the generator is a water and shock resistant. The generator is also capable in handling a wide temperature range and also at high altitude. The generator is capable in producing a maximum power output of 30W thus it might be a good portable generator for a small electric usage.

Figure 2.6: Sunshine FSD-30W Military Hand Generator

Operating Specifications:

1. This hand crank generator uses high-tech magnetic conversion technology and the outer case is high- strength aluminum composite alloy material.

2. Operating conditions:

1) Temperature: -40°C — 60°C

2) Relative humidity: 80% — 90%(40 ± 2°C)

3) Altitude:≤5000m

3. Water - resistant.

4. Shock - resistant.

5. Current overload and overheating protection.

6. 12 months warranty.

Technical Parameters:

Output Power

Output

Voltage

Output

Current

Net Weight

Head size with handle(mm)

30W

15.5V±0.5V

1-2.8A

6.8kg

205×180×120

Figure 2.7: Sunshine FSD-30W Military Hand Generator Features and Specifications

2.4 Fundamentals of Electrical Energy

Electrical equation is generally in the form of Ohm's Law of equation, in which the voltage, V is directly proportional to the current, I flow through it (Chaplin 2009);

$$V = I R$$

R is the electrical resistance in which affects the value of voltage in the Ohm's Law of equation. In the same equation, the power produced by the flow of the current is determined as;

$$P = V I$$

From the equation as well, the power produced also can be obtained from the substitution of the voltage equation of the basic Ohm's Law of equation (Chaplin 2009).

$$P = I^2 R$$

The equation is equally important in determining the power required and also the selection of the motor in the design phase of the project. The equation is also important to determine the power loss in various circuits, in which will be applied in the design phase (Chaplin 2009).

In the communication devices, for example a smartphones, the battery is rated in mAh (milliamp hours) which is the measurement unit for battery. A typical smartphones only consumes about 5 Watts of electricity while charging (Herrman, 2012) and also required 5 Volts of power input. The similar range of wattage and voltage is also applies to other devices such as tablets, camera, MP3 player and also a camcorder. Thus, the selection of the generator is varies, depending on the usage, analysis and also the durability of the generator itself.

CHAPTER 3
METHODOLOGY

This project consist of few stages in the constructing the portable hand-crank generator, including the designing, constructing, testing, evaluating, and also final prototyping.

1. *Design Stage*

   The portable hand-crank generator is designed according to the specifications required in the project objectives, by using CATIA provided. The design includes the base model, the generator box, pre-designed motor and aftermarket shafts, and also the exploded model of the design. Due to its portability features included, the design should be user-friendly in assembly and disassembly feature, and also smaller in size.

2. *Product Fabricating and Prototype Build*

   The final designed selected in the first stage is then fabricated and built accordingly. Some minor changes will be expecting to occur at this stage, depending on the fabrication and material capability. The design is fabricated from scratch, by using the materials provided in the laboratory.

3. *Product Testing, Analysis and also Finalizing*

   The prototype built is tested, and the details of the performances, specifications, capabilities are recorded accordingly. The efficiency of the prototype is calculated and the prototype is finalised together with the report and its details.

3.1 Process Flow

Process flow is one of the indicator on how the process of the developing the portable hand-crank generator is build. The process flow for the developing of this project is shown as below:

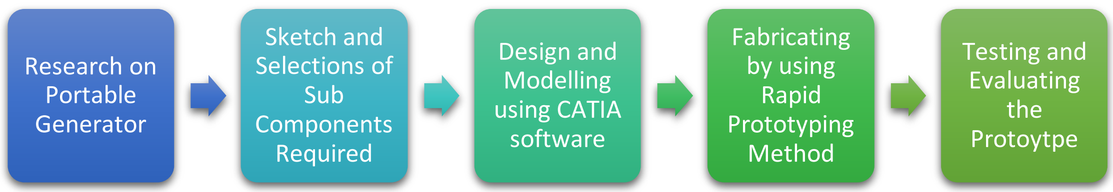


Figure 3.1: Process Flow of the Developing of Portable Hand-crank Generator.

From this process flow, the project is developed based on several stages required to ensure that the project will achieve its objectives and purposes stated earlier.

3.2 Gantt Chart

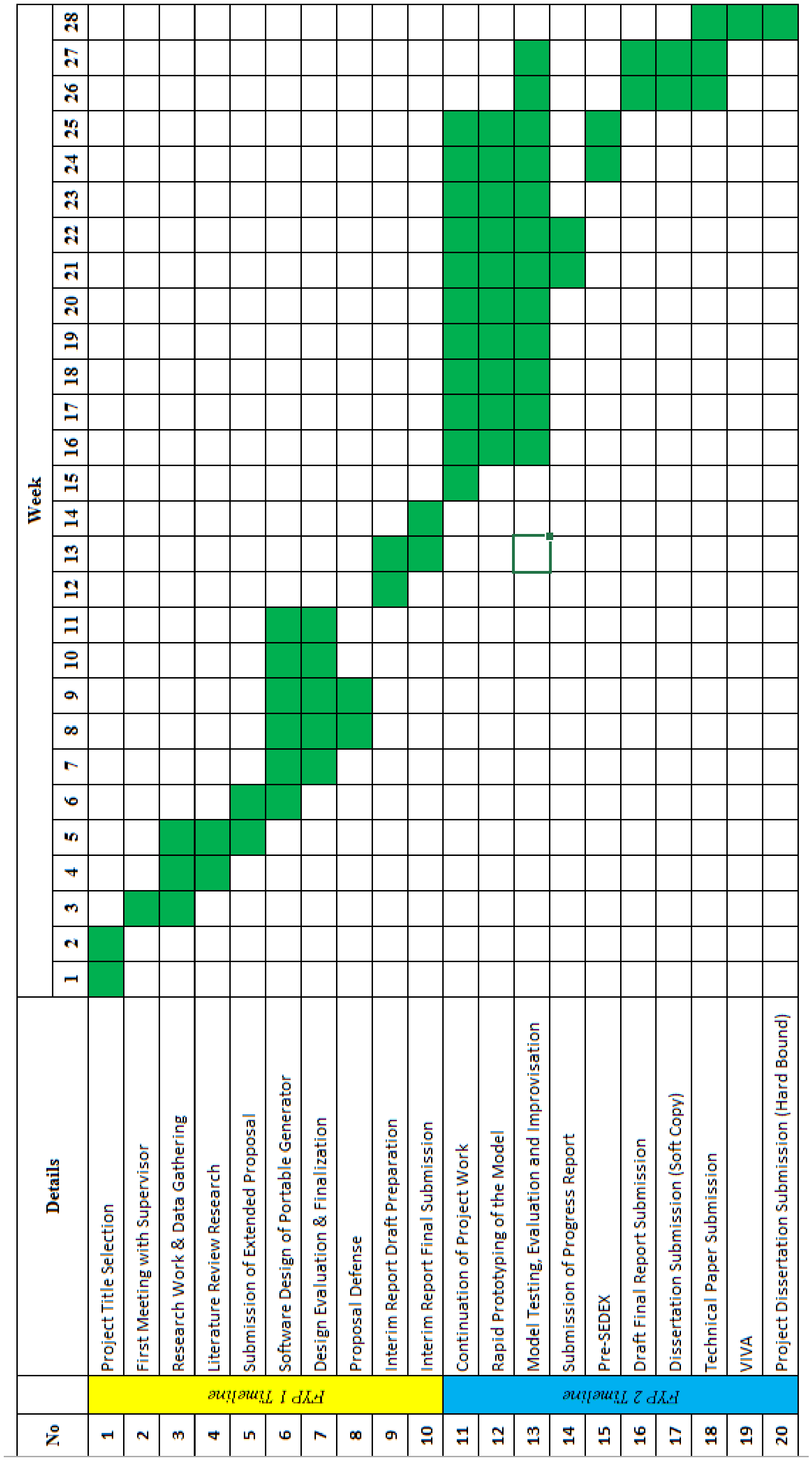


Figure 3.2: Gantt Chart for the Portable Hand-Crank Generator Project

3.3 Key Milestones

Table 3.1 below shows the key milestones of the project together with its description. The target completion date is also included to ensure that the project is not behind the schedule planned.

Table 3.1: Completion Target Date for each Subtopic

Item	Description	Target Completion Date
1	FYP 1 Starts	2 February 2015
2	Literature Review Regarding the Project Assigned	23 February 2015
3	Modelling Sketches of the Design	27 March 2015
4	Finalizing of the Design, Mechanisms and Specifications required	17 April 2015
5	Developing of the Prototype based on the Final Design	27 July 2015
6	Testing. Analysis and Prototype Outcomes	17 August 2015
7	Conclusion and Report Submission	24 August 2015

3.4 Physical Decomposition of Portable Hand-Crank Generator

Based on the information gathered from the whole working system of reference product available in the market and also from the requirement needs for this project, decomposition of the prototype was done. This decomposition will only include main components of the device in which will be the concentrated throughout this design project. Figure 3.3 and Figure 3.4 show the physical and functional decomposition of the portable hand-crank generator device.

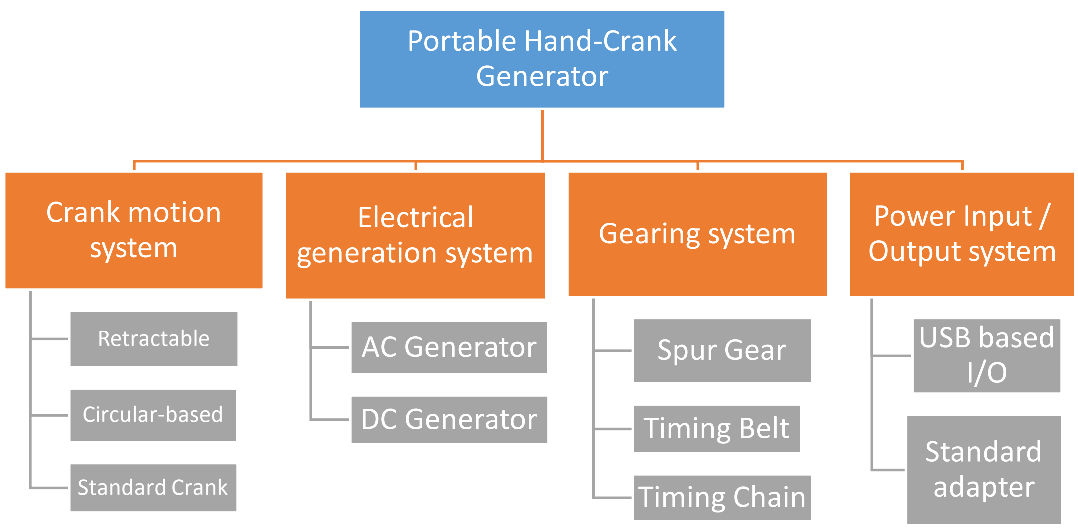


Figure 3.3: Physical Decomposition of the Portable Hand-Crank Generator

3.5 Functional Decomposition of Portable Hand-Crank Generator

Figure 3.4 below shows the functional decomposition of the portable hand crank generator. The diagram show the change of energy that goes through different sets of components in the whole system.

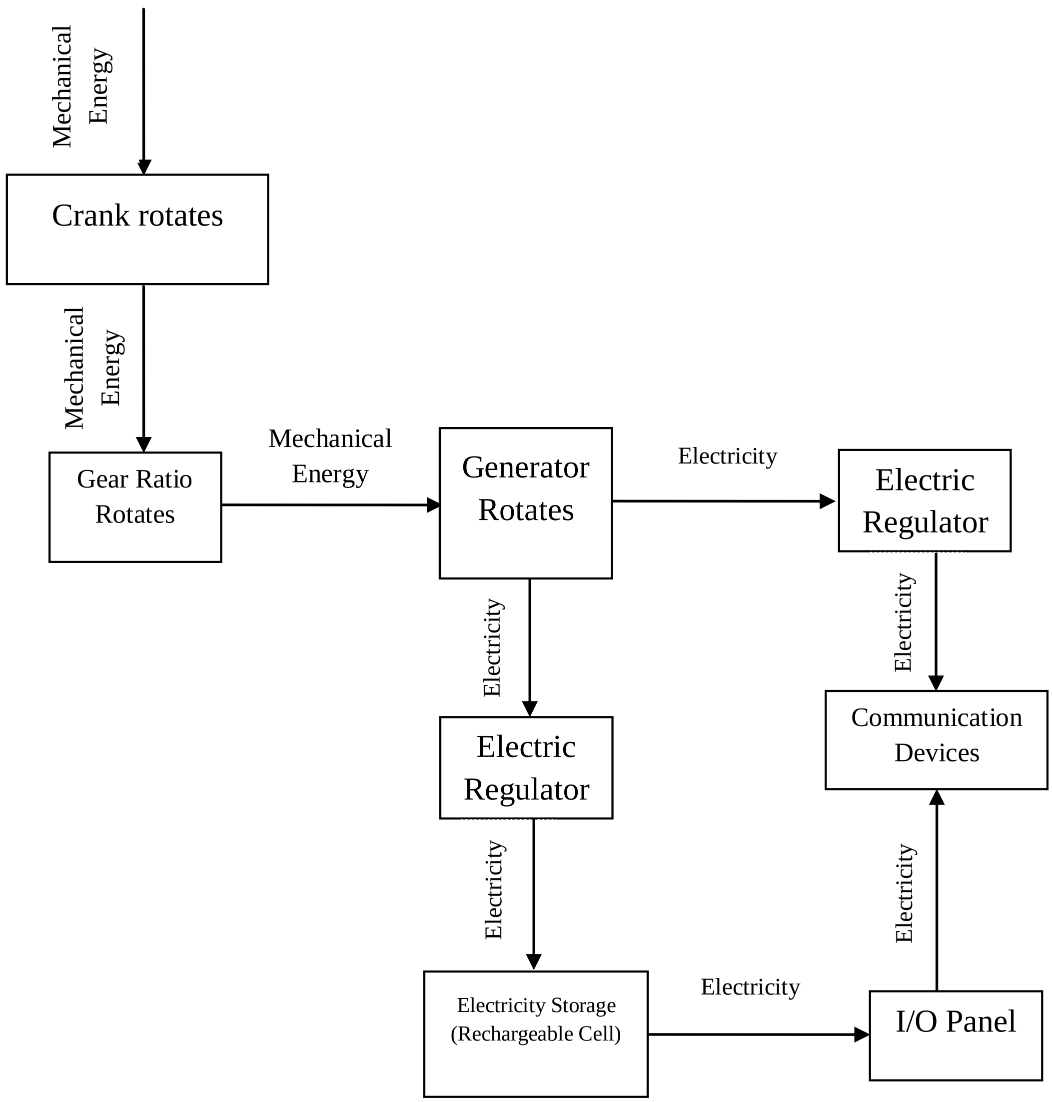


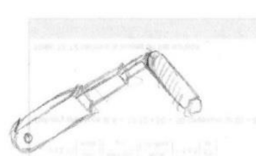
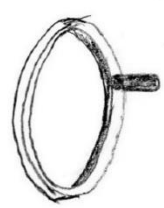
Figure 3.4: Functional Decomposition of the Portable Hand-Crank Generator

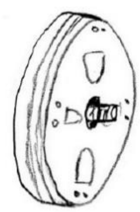
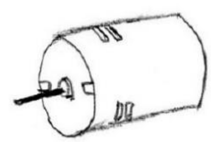
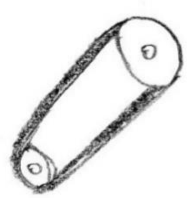
3.6 Morphology Chart

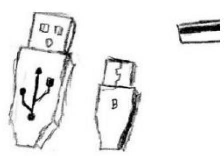
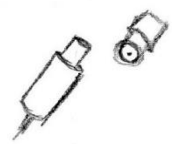
Based on the functional decomposition sketched earlier, a morphology analysis is performed. A comprehensive morphology chart is needed in order to perform a thorough analysis. The chart consist of 4 critical sub-components from the functional decomposition chart shown and the means of performing them.

The subsystems selected in the morphology chart is crucial for the prototype design of the device. Any non-essential subsystem is neglected and considered as an optional system. The chart is shown at table 3.2 below:

Table 3.2: Morphology Chart and Sample of Mean

Sub-components	**Components & Equipment - Means/How**		
	1	2	3
<u>Crank-motion system</u> Earlier stage in which the human energy is converted into mechanical energy. The rotation of the crank occurs at this stage.	**Retractable Crank** The crank has the capability in retracting when needed, in which saves space but requires tedious mechanism to make it work. 	**Circular-based crank** A simple and basic crank based, has better strength but requires more space in terms of storage. 	**Standard crank** A basic crank that is mostly used in simple applications (eg. pencil sharpener). A proper crank length is required for maximising the rotation towards the generator as it is fixed in length. 

<u>Electrical generation system</u> The important stage in which the mechanical energy is converted into electrical energy. Certain factors are needed in order to achieve desired power output of the generator	**AC Generator** Commonly knowing as alternator, the alternating current is produced for various usage together with huge power output that is capable to produce. 	**DC Generator** Commonly known as dynamo or mini generator, the basic electricity generator that uses the current induction principle in order to produce electricity. However, the power produce is not as big as AC generator. 	
<u>Gearing / Transmission system</u> The system in which affected the power produced by the generator. The gear ratio is the main factor in this system as it will determine the ratio of crank rotation to power output produced.	**Timing Belt** By using the concept of belting, this is the smoothest and the most convenient way of transmission system. The only drawback is that it is lack of efficiency. 	**Timing Chain** Compare to the timing belt, the belting is replaced by a series of chains, in which has higher efficiency in transmitting the power, but lack in specifications required in the market. 	**Spur Gears** The cheapest way of transmitting the power from one source to another. Requires proper calculation in order to get maximum power transmission, and also the availability is quite limited. 

<u>Power Input / Output Interface system</u> The system in which the electricity produced is either stored to temporary storage or transferred to the device.	**USB Interface** The most commonly method used for transmission of data and electricity. Cheaper, vast in availability and easy to handle. 	**Standard Adapter** The alternative way of transferring current and data. Limited in availability, but quite reliable and last longer. 	

3.7 Concept Generation

From the morphological chart constructed previously, the final concept is generated in a form of table. The selection of the sub-components shown in Table 3.3 is then explained with its justification in Table 3.4.

Table 3.3: Selected Sub-components for Final Concept

Sub-components	**Alternatives**		
	1	**2**	**3**
Crank-motion system	Retractable Crank	Circular-based crank	Standard Crank
Electrical generation system	AC Generator	DC Generator	
Gearing / Transmission system	Timing Belt	Timing Chain	Spur Gears
Power Input / Output Interface system	USB Interface	Standard Adapter	

3.8 Process Flow of the Chosen System

Figure 3.5 below shows the process flow of the whole system, starting from the crank motion to the output of the electricity generated.

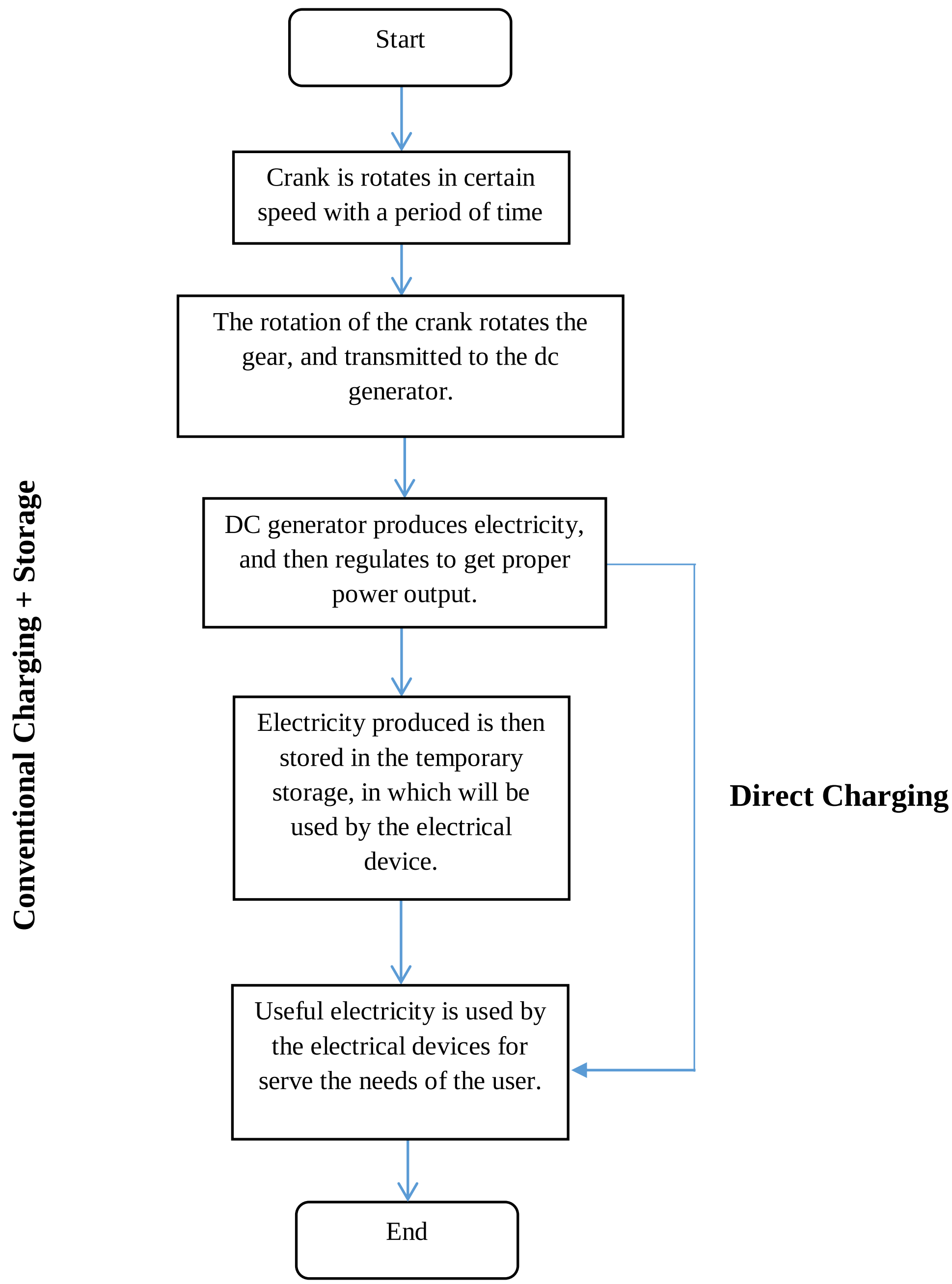


Figure 3.5: Process Flow of the Portable Hand-Crank Generator

3.9 Final Concept Justification

Table 3.4 below explains the selection of the subsystem identified as referred to the justification section. The justification is important in order to make a proper selection of each subsystem.

Table 3.4: Final Concept Justification on Selected Alternatives

Sub-components	Alternatives	Justification
Crank-motion system	Retractable Crank	- Saves space when required to dismantle - The length can be adjusted, depending on user preferences.
Electrical generation system	DC Generator	- Only small power required for the charging electrical devices. - Relatively cheap, and the replacement unit is hugely available in the market.
Gearing / Transmission system	Simple Gears	- Simplest concept, with minimal assembly required. - High efficiency of power transmission from the crank to the generator - Low in maintenance, only small lubricating required.
Power Input / Output Interface system	USB Interface	- Available globally, replacement parts is not an issue. - Can be used with many electrical devices in which uses USB ports compare to other interfaces.

3.10 Specifications Draft for Final Design

Based on the selections that has been made for the design, the specifications of the dimensions, and selected parts is listed to be focused on in the next stage of building the prototype.

Specifications Target;

Base Dimension : (300 x 200 x 200) mm

I/O Interface : USB Based (USB 2.0 and mini USB)

Generator Used : 12V DC Motor (Dynamo) with 12:1 Gear Reducer

Minimum Input : 100RPM at 5V (approx.)

Efficiency : 83% (DC Motor), 95%(DC Booster)

Electrical Circuit : L7805CV 5V Regulator with 5V DC Booster (Max 1.2A output)

Permanent Storage : Yes (5000 mAh Cell)

Removable Storage Option : Yes (Range up to 20000 mAh)

Materials : Acrylonitrile Butadiene Styrene Plastic (ABS)

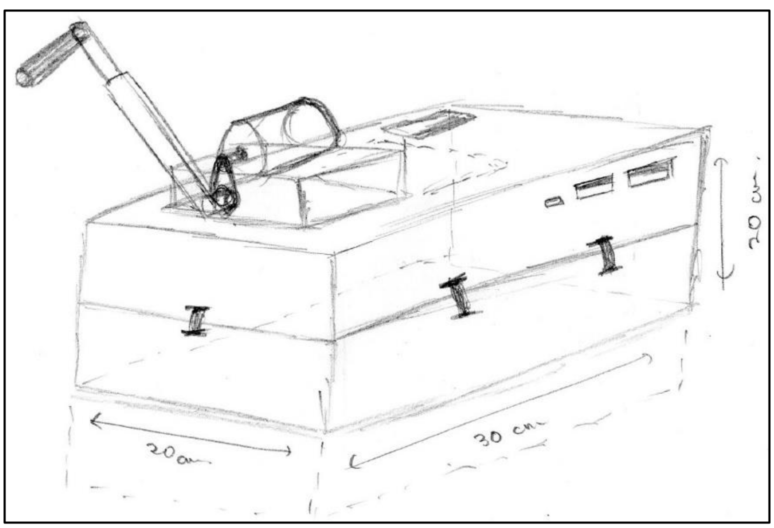


Figure 3.6: Conceptual Sketch of the Portable Hand-Crank Generator

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Product Specification and Dimensions

The final design of the product has been identified, analysed and finalized as shown below:

Specifications;

Base Dimension : (150 x 100 x 100) mm

I/O Interface : USB Based (USB 2.0)

Generator Used : 12V DC Motor with 12:1 Gear Reducer

Minimum Input : 100RPM at 5V (approx.)

Maximum Output : 5V at 1.2A (min. 0.6A)

Efficiency : 83% (DC Motor), 95% (DC Booster)

Electrical Circuit : L7805CV 5V Regulator with 5V DC Booster (Max 1.2A output)

Permanent Storage : No

Removable Storage Option : Yes (Range up to 10000 mAh)

Materials : Polylactic Plastic (PLA)

Building Method : 3D Printer (3D CubePro Duo)

4.2 Electrical Circuit Layout

The electrical circuit layout has been design and constructed based on the schematic diagram shown below:

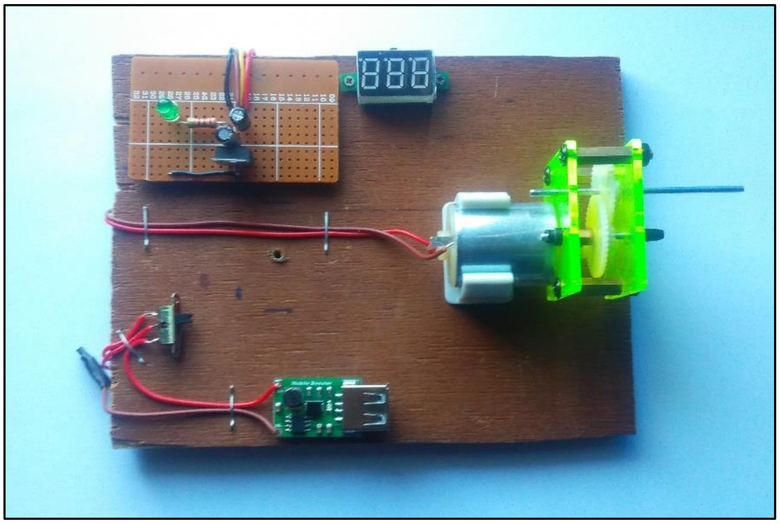


Figure 4.1: Electrical Circuit Layout in Portable Hand-crank Generator

In the Figure 6.2.1, the 12V DC motor is rotate and produces voltage, depending on the rotation of the motor in the hand crank motion. The voltage obtained from the DC motor is then go through either the 5V DC booster or voltage regulator, the high voltage obtained will be regulated to 5V, and the low voltage obtained will boost to 5V by using a reroute switch. The voltage is regulated to 5V as the USB devices mostly supported a maximum of 5V only. The voltage is then routed into a series of USB ports, for charging purposes.

Basically, the circuit layout consumes a small area in which can fit enough to the new dimension of the generator's box. The simple construction is enough to provide a power required by communication devices for emergency purposes.

4.3 How the Product Works?

During operation of this mode of power generation, the set of hand crank and gear box will be attached to the generator to produce electrical power. The suggested time for this mode is during the emergency situation where there is no power supply by grid and a few number of phone call is needed. For example at the disaster area, where the power grid usually need to be disconnected to certain area or disturbed, the usage of Portable Hand-Crank Generator will be useful to charge up a phone in order to make a one crucial phone call. As the generator is in small dimension, it is suitable and convenient for people to use at any place and time.

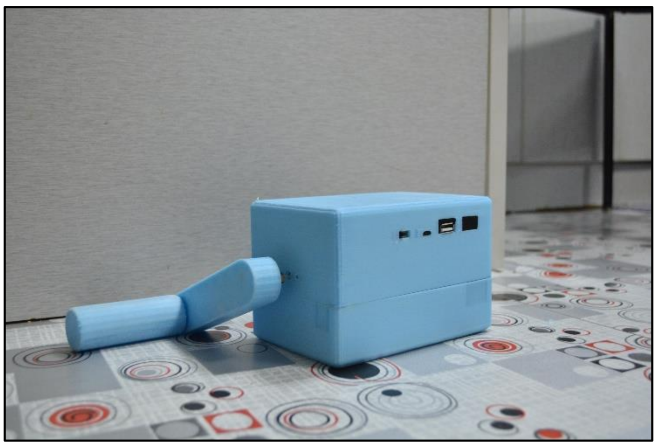


Figure 4.2: Prototype of Portable Hand-Crank Generator

4.4 Overall Prototype Overview

The product has been designed by using CATIA V5R18 Student Version. In this instance, there are several parts created and designed accordingly. The images below shows parts that has been designed, including with some templates required such as aftermarket DC Motor, USB Ports and also gearbox for better viewing perspective.

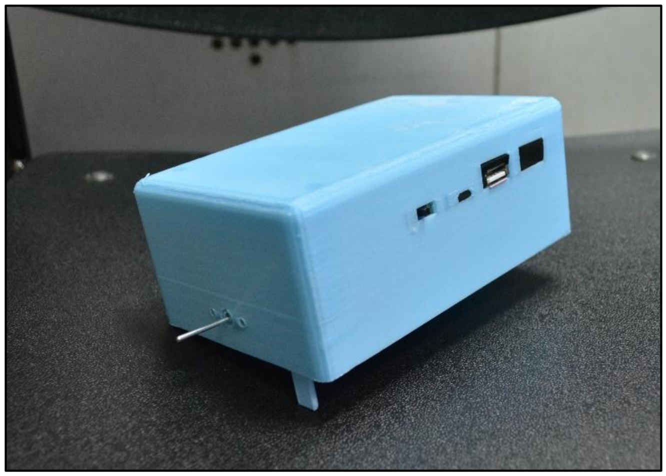


Figure 4.3: Top Cover

Figure 4.4: Bottom Cover

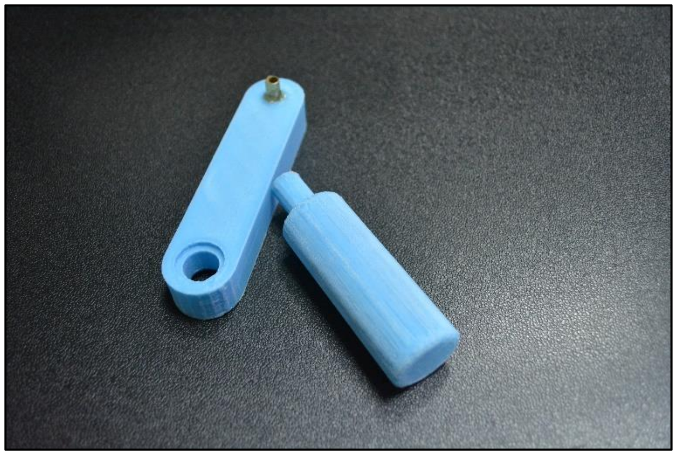


Figure 4.5: Hand Crank and Handle

Meanwhile, the circuit board sketched consists of several minor components such as USB Ports, DC Booster and Voltage Regulator as shown in Figure 4.6.

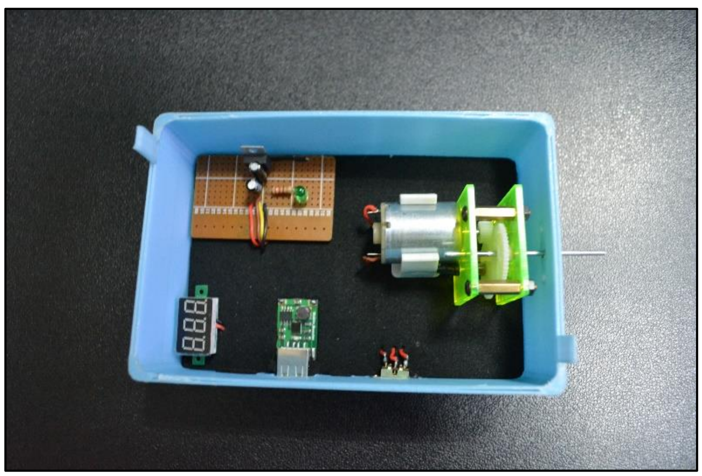


Figure 4.6: Electrical Circuit Board

4.5 Advantages of the Design

i. *Compact Design*

The main casing has been designed to compactly store direct current (DC) generator, electronic circuit board in which consist of voltage booster and current regulator, interface output (I/O) panels, permanent rechargeable battery and also a compartment to insert personal rechargeable device (powerbank) for extended charging storage.

ii. *Ergonomic and safe*

The top cover consists of several air vents for releasing heat produced in the generator and battery to ensure longer operating time. The bottom cover consists of series of rubber feet to prevent slipping during hand crank operation on the flat surface.

iii. *Minimal and Simple Interchangeable Modes*

The whole system is stored in the set of small briefcase for better portability and mobility during natural disaster, where all of them can be packaged as the whole in one case.

Figure 4.7: Portable Hand-Crank Generator (All Parts)

4.6 Advantages of the Product

i. *Portability*

The design for portable hand-crank generator make it easy to be installed for operation and to be stored in a casing kit when not being used. All the components of this product can be easily stored when not in use and suitable to be carried to any places. This feature make it very suitable to be used in emergency situation.

ii. *Low cost power source solution during emergency*

This product provides a cheap alternative solution for supplying power source to electronics devices in the situation where normal power source is inaccessible or down. During a disaster time, such as the big flood that occurred in East coast of Malaysia in December 2014, the affected people faced a great difficulty to power up their phones and make an important call to update situations in disaster areas and relief centre. The solution back then was by asking for fully charged power bank to be distributed to the disaster relief centre. This can involve high amount of money as one unit of power bank can cost about RM 60 to RM 80. Furthermore, the power bank needs to be recharged when the capacity is fully discharge. It is also time consumption to send power bank back and forth for charging and distribution. With this product which is cost below than RM200, the problem of power demand for electronic devices can be solved effectively and efficiently.

iii. *Power source during travelling to remote area*

Other than its usage as the power supply for electronics devices during disaster time, this product can also be used by travellers who travel to remote areas where there is a limited or no access to electricity supply. The crank generator would provide an easy solution to obtain emergency power supply. It can also be used by fisherman during emergency case.

4.7 Discussions

During the process of the fabrication, there are several changes that has been done to the overall parts due to some inconvenience issue. Below is some of the changes that has been done throughout the fabrication process.

i. *Downsizing of the Overall Dimensions*

Initially, the design's dimension has been set to (300 x 200 x 200) mm. During the fabrication process is conducted, the printing base on the 3D printer are only allowed a design with a maximum cross section of (250 x 200 x 180) mm only. Thus, the initial design has been resized to accommodate the printing base area available.

Figure 4.8: Original Size of Top Cover before the Machine Broke Down

ii. *Design Features*

The design has been included with some features such as air ventilation for better temperature control in the generator box, bigger size in overall to support bigger removable powerbanks available in the market, to support external input such as wind turbine system and also critical dimensions to support the inner components. However, due to the limitation of the sensitivity of the 3D printing on this features, the new updated design has omitted the features with minimal appearances, so that the printing job can be done in time.

iii. Materials Stock Availability

In the final draft of the design, the material that has been decided in this fabrication is Acrylonitrile Butadiene Styrene (ABS) Plastic. This is due to the properties of the ABS plastics which is light and also strong. However, the first two attempts was a failure as the warping effects comes in during the first few layers of printing. Then it has been proposed that ABS material is change to Polylactic Plastic (PLA) as the warping does not occur by using this material. Other than that, the amount of materials available in the laboratory also contributes to the issue, thus only few parts are fabricated. PLA and ABS plastics will take some time to order and at the same time some to arrive and there was a possibility that the fabrication is cannot make it in time due to the time constraint.

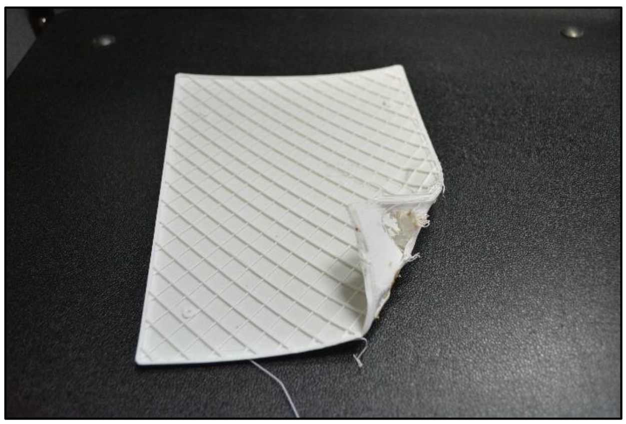


Figure 4.9: Warping of ABS Material due to Large Cross-sectioned Area

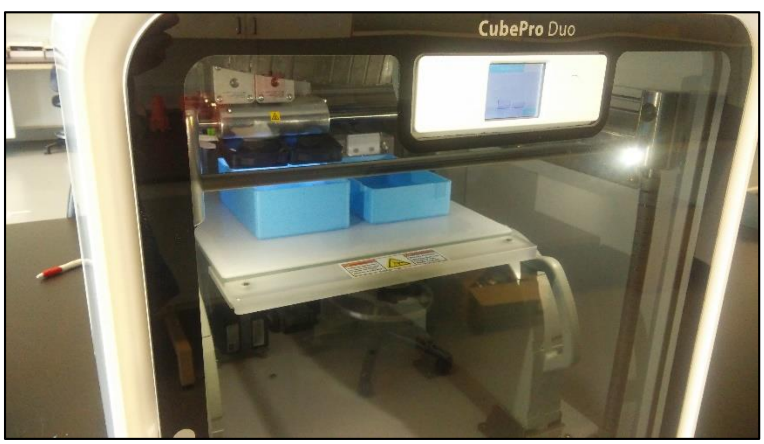


Figure 4.10: Downsizing and Replacing the Material to PLA

iv. *Electrical circuit*

The electrical circuit has a great change in overall. The circuit has two different modes; namely regulator mode and booster mode. The regulator mode (default) is the setting in which the voltage from the DC motor is generated from 5V to its maximum value achievable (12V) but yet it is regulated to 5V. Meanwhile, the booster mode requires a range of voltage from 2-5V only. If the voltage is exceeding the maximum voltage required, the booster will broke down. Thus, the booster mode is only applicable when the voltage obtained from the regulator is not enough (less than 5V) and it is indicated by the LED on the board.

Other than that, the permanent battery storage has to be removed due to the limits in the compartment of the new dimension. The route has been replaced to voltage meter to read to voltage value from the regulator.

4.8 Marketing/Business Plan

i. Marketability

As the product mainly aims for the location which regularly being hit by natural disasters, the product can be promoted globally, not only restricted to Malaysia region. The global map for natural disaster-prone places is shown in the figure below.

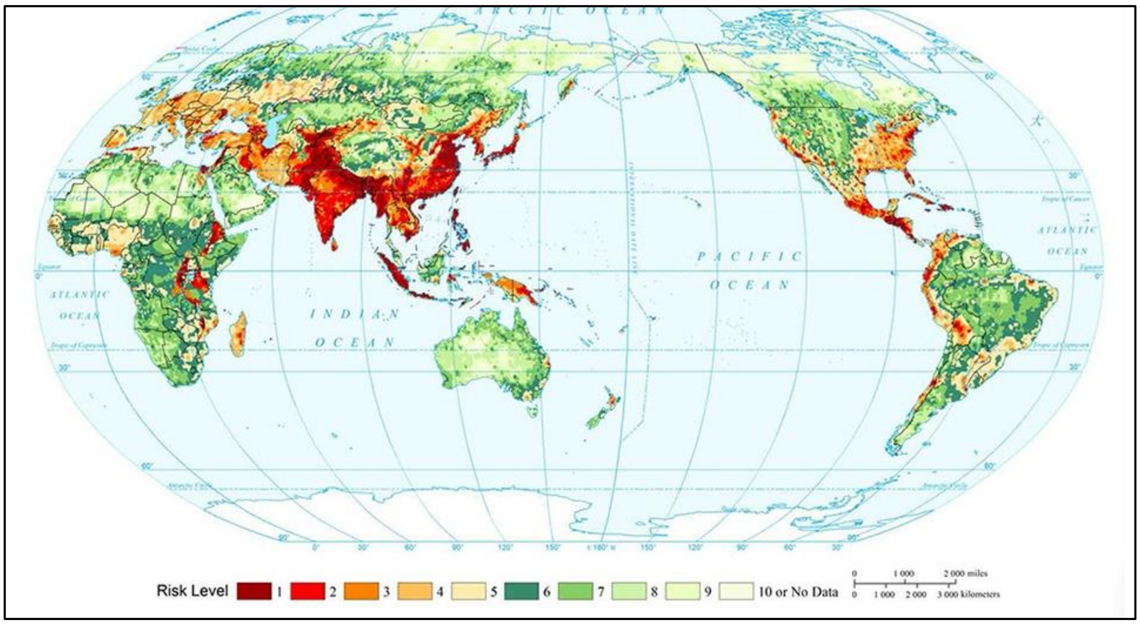


Figure 4.11: Global mapping of Annually Multi-hazard Risk level

From this map it can be seen that the most highly risked level areas are in Asian, Europe and Central America regions. Types of natural disasters include earthquakes, floods, wildfire, landslides and volcanoes. Taking into account that the targeted user for this product is roughly 1% from the total affected population with high risk level, it is estimated that the potential users for this product is about 10 million.

ii. Production

For the prototype cost, the product can be produced below RM200 as a single device. It will be much cheaper when it goes into the mass production later. Estimated costs of product's components include sets of plastic materials, motor, gearbox, simple electronic circuit board, and rechargeable battery.

As the product is mainly made in plastic, thus injection molding technology is preferred in order to produced small parts in which require precise measurements with detailed features. As the technology is widely available and much cheaper in mass production scale, thus it is possible to produce it in a large scale.

In a small scale, to reduce the production cost of the product, 3D printer is required to replace the injection molding technology. Even though it is still contributes to higher cost in total, but it is feasible in a small scale. The production time for small quantity also can be shortened as the parts can be printed instantly.

The table below shows the rough estimation on the production cost of the product:

Components	**Cost (MYR)**
Generator Box (Top Cover, Handle, Crank, Bottom Cover, Acrylic)	100
Electrical Components (DC Motor, DC Booster, Regulator, Wires, Gearbox, Switch)	60
TOTAL	**160**

Table 4.1: Rough Cost Estimation for Single Production

CHAPTER 5
CONCLUSION AND RECOMMENDATION

In conclusion, this product has successfully achieved its target from the objectives listed earlier. The generator is designed from scratch by using CATIA software before it is fabricated by using 3D printing method. Meanwhile, the electrical circuit is constructed and built properly according in order to achieve its output which is 5V and capable of charging the communication devices. The analysis of the specification has been carried out and listed as shown on the Chapter 4.

However, there are still some recommendations required. Some of the recommendations is that to have the proper fabrication solutions such as injection molding, using acrylic and also wood for prototyping purpose. The techniques used has already caused a few changes in the overall design, thus creating a simple and unappealing results. This unfortunate issue has consumes lots of time and the final product might not achieve as it was targeted earlier.

The output of the design has managed to achieve its target, in which producing a stable 5V of power to charge a standard communication devices available in the market. By using a normal hand-crank motion, an average speed of 130RPM is approximately can produce the desired output with a current of 1.2A (minimum 0.6A), due to the DC booster installed in the circuit. Thus, the generator concept has achieved its target in its power output targeted.

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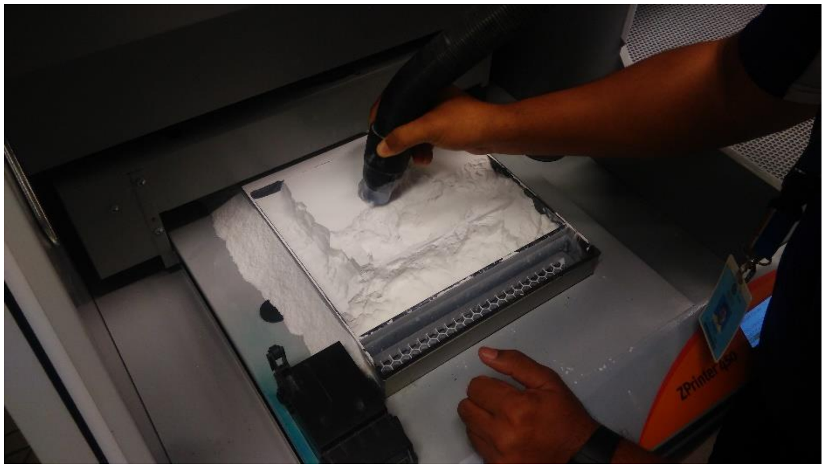
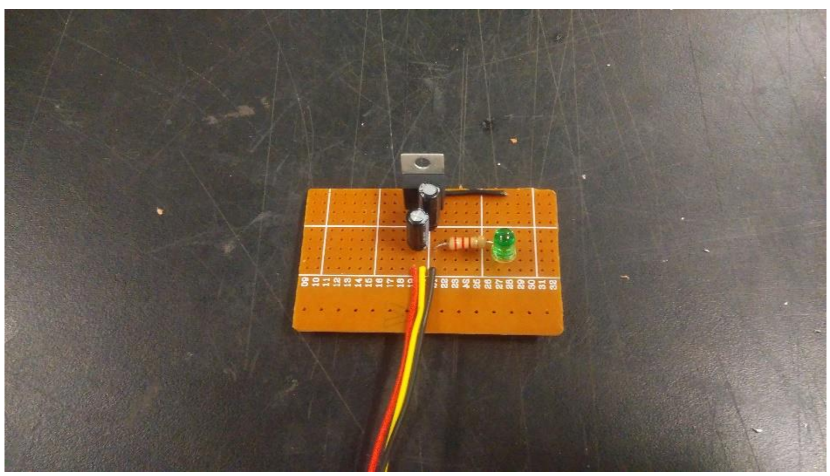
APPENDICES

Closer view of USB output

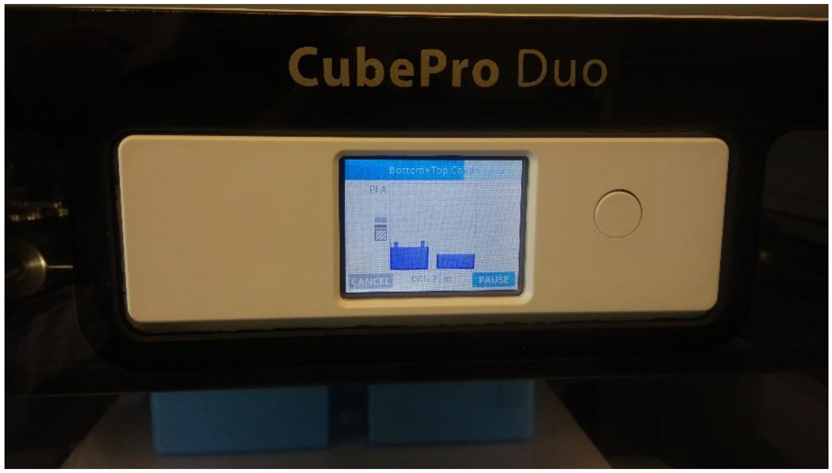
Bottom cover with removable powerbank option



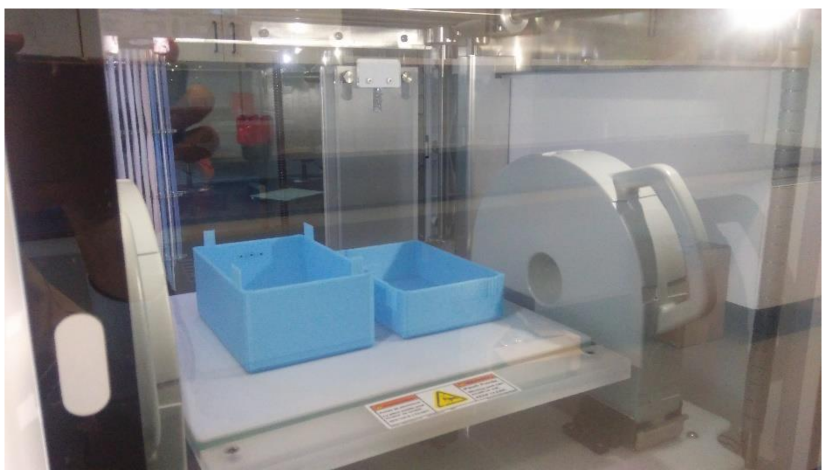
Initial fabrication process by using powder method



5V DC regulator circuit board



Printing of parts using PLA (3D Printer)



Completion of PLA printing process