UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DESIGN AND MODELLING OF PORTABLE USB CHARGER USING DC MOTOR

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Engineering Technology (JTKE) (Hons.)

by

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Date	:	……………………………………………

APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Electrical Engineering Technology (Industrial Power) with Honours. The member of the supervisory is as follow:

....

(Project Supervisor)

ABSTRAK

Tujuan kajian ini adalah untuk membangunkan pengecas USB mudah alih yang menggunakan DC Motor. Dengan menggunakan pengecas ini, mana-mana peranti elektronik yang menggunakan USB sebagai sumber kuasa boleh dicas bila-bila masa dan di mana sahaja. DC Motor adalah komponen utama dalam reka bentuk. Ia menghasilkan elektrik apabila pemotongan medan magnet berlaku di dalamnya. Motor ini akan diputar menggunakan engkol tangan. Tenaga yang menghasilkan akan dikawal selia oleh pengatur voltan pada aras 5V. Tenaga yang dihasilkan akan digunakan untuk memberi kuasa kepada port USB dan boleh digunakan sebagai pengecas yang mudah alih. Tenaga yang dihasilkan juga boleh digunakan untuk mengecas bateri boleh dicas semula di dalam peranti ini. Projek ini adalah sangat berkesan dan boleh digunakan pada bila-bila masa, di mana sahaja termasuk keadaan kecemasan seperti banjir.

ABSTRACT

The purpose of the study is to develop a portable USB charger which using DC Motor. By using this charger, any electronic device that use USB as power supply can be charged anytime and anywhere. The DC Motor is the main components in the design. It produces electricity when the cutting of magnetic flux occurs inside it. The motor will be rotated using hand crank. The energy produces will be regulated by the voltage regulator at 5V. The energy produced then will be used to power up the USB port and can be use as portable charger. The energy produced also can be used to charge the rechargeable battery inside the device. The project is very effective and capable of being used at anytime, anywhere including emergency situation such as flood.

DEDICATION

To my beloved parents, my family, my teachers and my fellow friends, thank you for the support and help given to me on completing this thesis.

ACKNOWLEDGEMENT

Firstly, most thanks to Allah S.W.T for giving me the opportunity to complete this report "Projek Sarjana Muda" with a success after I went through a lot of obstacle with patience. I would also like to thanks my parent and my family for encouraging me throughout all the difficulties I had faced and keep supporting on my financial. Without their permission and blessing, I would not be able to further my study in this university and not able to do my degree project.

Not to forget, I would like to thank my supervisor, Puan Nurbahirah binti Norddin for guiding me in completing this project and report. She has taught me a lot of useful things and knowledges not only in theoretical but also practical. Furthermore, thanks to all lecturers and technicians that have guided me to get a good knowledge and experiences either in the class or in the lab session.

Besides, I would also like to thanks all my fellow friends including my friends under the same supervisor, Ida, Azni, and Nurul for sharing and comparing opinion on the report

Finally, I would like to thank anyone that has contributed either directly or indirectly, for giving me the support and help in order to make this project successful.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

AC	-	Alternating Current
DC	-	Direct Current
V	-	Volts
A	-	Ampere
Li-ion	-	Lithium Ion
mAh	-	milliampere-hours
USB	-	Universal Serial Bus
PSM	-	Project Sarjana Muda

CHAPTER 1

INTRODUCTION

1.0 Introduction

In this section, it basically explains the background of this project and explaining the objective, the scope, problem statement and project significant.

1.1 Project Background

In this modern era, electricity is one of the very important thing in our daily life. Electricity can be definite as the presence and flow of electric charge. It is use as energy to power up nearly everything around us. To use electricity, it need to be generated. Electricity can be produced by various way such as solar, nuclear, coal, fossil fuel. One of the most used concept to generate electric is cutting of magnetic flux. Such as dynamo and actuator.

Electric motor is an electrical machine that converts electrical energy to mechanical energy, while the conversion of mechanical energy to electrical energy is done by electric generator. The source of the mechanical energy and varies from hand crank to internal combustion engine. The generator is divided in to two types, producing dc voltage, and ac voltage. But the research will be focused on motor that produced dc voltage.

Nowadays, there are lots of electronics devices around us. All of this device are created to our lives easier. Electronic device are varies from telecommunication system, entertainment, calculation and even the cigarettes are available in electronics. But all these electronics devices have one common thing; all of it require electricity to work. Hence, most of these electronics devices are equipped with battery. But, as the device being used, the energy stored inside the battery will run out. In the event of emergency where electric source are limited, the electronic device can hardly operate.

Mainly, all of this electronic device are using electric supply from home such as electric socket. Nowadays, all the electric socket at home use 230V to supply electricity for the household. But when there are no electricity available at house, these electronic simply cannot functioning. Therefore, alternative power source is needed.

1.2 Problem Statement

The creation of electronic device such as mobile phone makes our life easier, but its battery will run out of its charge and need to be recharge. In the event of emergency such as natural disaster where electrical source is limited, it can play role in live or death situation. It also can make the situation worse without electricity. For example, when smartphone are out of battery, the user lost connection and cannot call for help. Therefore, we need something to recharge these devices without the source of electricity. This charger also need to be small, portable, and can be use in any condition.

Cikgu 'unsung hero' di SK Manek Urai Lama

RAZIATUL HANUM A. RAJAK
23 JANUARI 2015

Like 4 Share Tweet

SHAH ALAM - Tindakan seorang guru di Sekolah Kebangsaan Manek Urai Lama di Kuala Krai yang menghantar pesanan ringkas kepada pasukan penyelamat kemudian menutup telefon bimbitnya bagi menjimatkan bateri mampu menyelamatkan nyawa ratusan mangsa banjir yang terperangkap di sekolah itu.

Ketua Penerangan Umno Kelantan, Datuk Md Alwi Che Ahmad berkongsi cerita tersebut ketika menjadi panel pada Wacana Sinar Harian siri ke-34, Kelantan Pasca Banjir: Bicara Hati ke Hati Pas, Umno Bangunkan Semula Kelantan yang berlangsung di Auditorium Kompleks Kumpulan Media Karangkraf, semalam.

Ketika kejadian pada 25 Disember lalu, pelbagai maklumat tersebar di aplikasi WhatsApp dan laman sosial mengaitkan sekolah berkenaan.

Namun, kata Md Alwi, bantuan yang dihantar pihak berkuasa tidak dapat sampai ke lokasi pada malam kejadian tersebut.

"Misalnya SK Manek Urai Lama yang tersebar WhatsAapp kata 200 orang mati...runtuh. Sebenarnya pada malam 25 Disember itu, Datuk Mustafa (Pengerusi Jawatankuasa Bencana Banjir Kelantan, Datuk Seri Mustapa Mohamed) ketika itu masih di Mekah dan saya menghubungi Panglima Angkatan Tentera sebab ramai wakil rakyat dah minta tolong.

"(Selepas) Itulah helikopter pergi (ke sekolah). Untuk makluman di sekolah itu, mereka berpindah dari tingkat satu ke tingkat empat. Bayangkan mereka di sana dari 24 Disember hingga 26 Disember. Kita hantar helikopter dan bot tapi tak boleh masuk," ceritanya.

Mengimbas kembali situasi itu, beliau menyebut tentang seorang guru yang tidak diceritakan jasanya.

"Ada seorang cikgu...dia memang 'unsung hero'. Telefon bimbitnya masih mempunyai bateri jadi, dia SMS kemudian dia tutup telefon untuk jimat bateri. SMS dia lah sebenarnya yang datang meminta tolong.

"Nasib baik bomba ada kenderaan amfibia bomba, pada malamnya, kenderaan ini sampai ke sekolah tapi bukan SK Manek Urai Lama, sekolah yang sebelah lagi. Sebab elektrik dah putus dan tak dapat nak beri 'signal', dia hanya dengar bunyi enjin bot.

"Kemudian dia hubungi kita balik. Alhamdulillah pagi esoknya, barulah helikopter dapat masuk dan Tan Sri Panglima Tentera Darat sendiri turun dengan tali bawa makanan dan air kepada mereka," katanya.

25 Disember lalu, Sinar Harian melaporkan lebih 400 mangsa banjir yang terpaksa mendiami tingkat tiga SK Manek Urai Lama berikutan air menenggelamkan sehingga tingkat dua bangunan berkenaan, dilaporkan selamat.

Figure 1.1: Sinar Harian Newapaper article 23 January 2015

From Figure 1.1 which show Sinar Harian Newspaper article on 23 January 2015, it states that a teacher able to save more than 400 lives of flood victim that had occupied the third floor to take cover. All he did was constantly turn on and off his phones to save battery. If his phones are out of battery, he cannot call for help, thus all the 400 lives at that place are in danger. Hence, in order to prevent this from happen again, a device need to be designed to be able to charge phones at anywhere and anytime.

1.3 Objectives

The aim of the project is to design and modelling the portable USB charger using DC Motor. This general objective can be broken down into two more specific objectives that would together achieve the overall aim of this project as follows:

a) To design the electrical circuit for generating and transferring of energy from DC Motor to USB device including power bank.

b) To modelling portable Universal-Serial Bus(USB) Charger casing based of certain criteria.

1.4 Scope

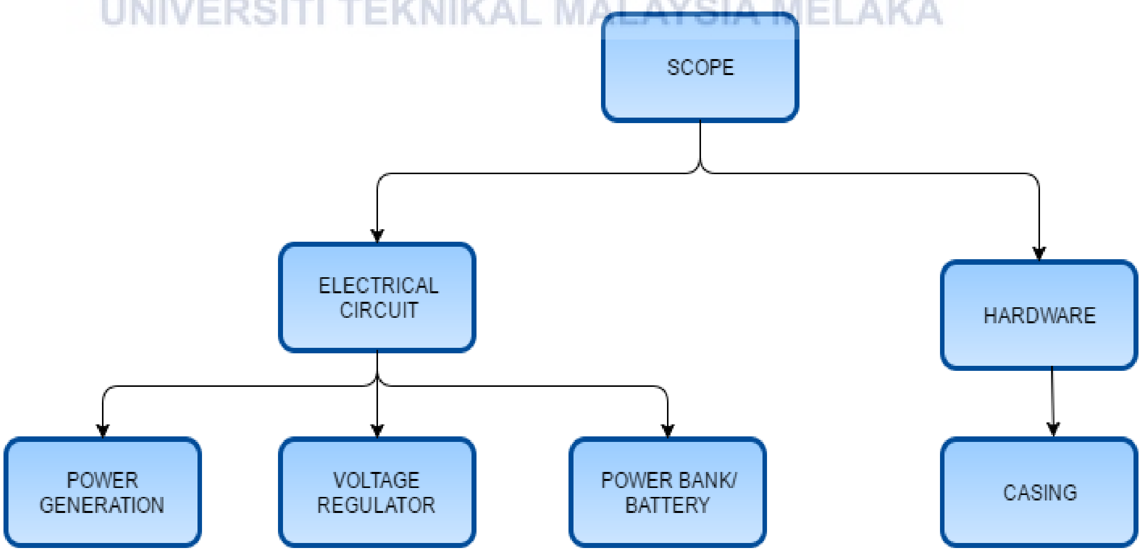


Figure 1.2: Scope flowchart

From the Figure 1.2, the scope will be divided into 2 main item which is electrical circuit and the hardware of portable USB charger. For the electrical circuit, it is broken down to three main components which is the power generation which is using DC motor, voltage regulator, and power bank which consist of battery inside. For the hardware part, is focused to the casing. The shape of the casing is designed in such way all component can be fitted inside.

1.5 Project Significant

In the end of the project, the portable USB charger using DC Motor is successfully constructed and demonstrated. From the project testing and demonstration, the portable USB charger is able to generate electricity and able to provide energy to electronic devices by using USB port.

1.6 Thesis Outline

This thesis consists of five chapter. Chapter 1 are the introduction that consist of the element necessary to get to know to this project such as problem statement, objectives and scope. Chapter 2 are literature review, which contain previous research and the material used in this thesis. Chapter 3 is methodology, which explain the method used in this thesis. Chapter 4 is result and analysis. All the data and result obtained during experiment and testing will be presented and analyzed. Last chapter is chapter 5 whish is the conclusion. This chapter will conclude the thesis and contain problem faced during research and suggestion for future research.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

In this literature review section, it comprises from the journal on the internet, paper proceedings and research, books and lectures. The literature review includes the cases investigation of the project that may be arise to overcome the problem and also gives a powerful knowledge on the fundamentals of the project.

2.1 Electrical Machine

Electrical machine can be classified into two types which is electrical motor and electrical generator. Electrical motor is a machine that convert electrical energy into mechanical energy. In this machine, a force is induced in a conductor that has a current going through it and placed in a magnetic field. The other one is electrical generator that converts mechanical energy into electrical energy. For the generator, an EMF(voltage) is induced in a conductor if it moves through a magnetic field. This machine can be classified further into two types which is AC machine and DC machine. In this project, we are focusing on the DC machine. Hence, it also can be called as DC motor or DC generator.

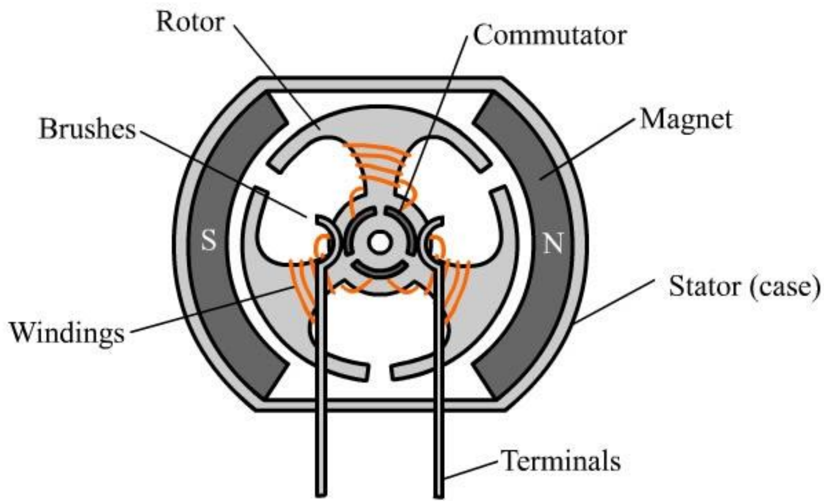


Figure 2.1: Cross section of DC Motor

Figure 2.1 shows important parts inside the DC Motor. There are several important components inside the motor. The components are rotor, stator, winding, air gap, brushes, and commutator.

2.1.1 Rotor

Figure 2.2: Rotor

Figure 2.2 shows a rotor inside electrical motor. Rotor is the moving part inside electric motor which will turn shaft to convey the mechanical power. The rotor generally has conductors laid into it which convey currents that interface with the magnetic field of the stator to produce the force that will turn the shaft. Notwithstanding, a few rotors convey permanent magnets, while the stator holds the conductors.

2.1.2 Stator

Figure 2.3: Stator

Figure 2.3 shows stator inside electrical motor. A stator is a stationary component of the motor's electromagnetic circuit and ordinarily comprises of either permanent magnets or windings. The stator core are comprised of numerous thin metal sheets, also known as lamination. The lamination are utilized to lessen energy losses that would come about if a solid core were utilized.

2.1.3 Winding

Windings are wires that are laid in coils, which is generally wrapped around a laminated soft iron magnetic core so that it will form magnetic poles when it is energized with current. Electric machines divided into two basic magnet field pole setups which is salient-pole machine and the nonsalient-pole machine. In the salient-pole machine, the pole's magnetic field are delivered by a winding wound around the pole underneath the pole face. Meanwhile in the nonsalient-pole, the winding is circulated in pole face slots. A shaded-pole motor has a winding around part of the pole which setback the phase of the magnetic field for stated pole. Meanwhile, some motors have conductor which comprise of thicker metal, for example, bars or sheets of metal, normally copper, albeit once in a while aluminum is utilized. These are normally powered by electromagnetic induction

2.1.4 Air Gap

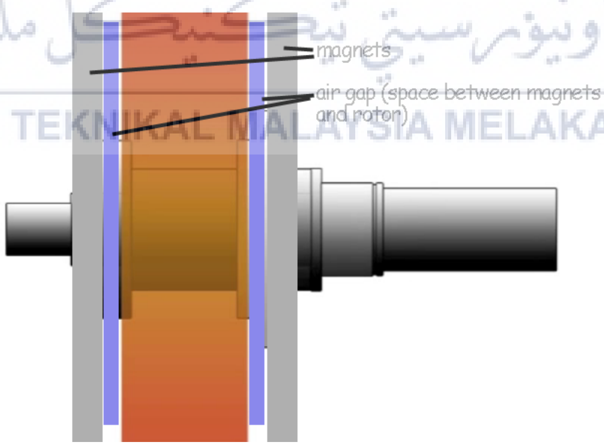


Figure 2.4: Air gap between rotor and stator

Figure 2.4 shows air gap inside an electrical motor. Air gap in shown in purple colour. Generally, air gap inside electrical motor is the distance between the rotor and stator. The air gap has imperative impacts, and usually it is as small as it could. Large gap has strong negative impact to the performance of and electrical motor. It is the fundamental source of the low power factor at which motors operate. The air gap increments magnetizing current. Therefore, the air gap should be as minimum but not too small gap as it may posture mechanical issue in addition to noise and losses.

2.1.5 Commutator and Brushes

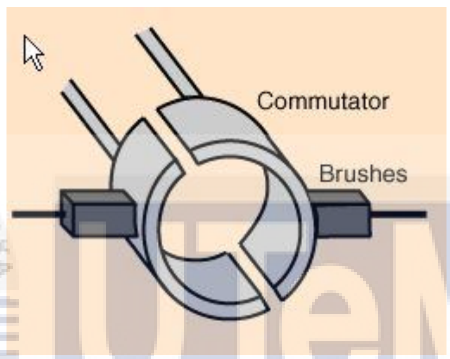


Figure 2.5: Commutator and brushes

Figure 2.5 shows a pair or commutator and brushes inside electrical motor. A commutator is a component used to switch the input of most DC machines and some AC machines comprising of slip ring segments insulated from each other and from the electric motor's shaft. The motor's armature current is supplied through the stationary brushes in contact with the spinning commutator, which causes required current reversal and applies power to the machine in an ideal way as the rotor rotates from pole to pole. Without such current inversion, the motor would brake to a stop. Meanwhile, a brush is a device that conducts current between stationary wires and moving parts, most generally in a rotating shaft. Regular applications include electric motors, alternators and electric generators.

2.1.6 Fundamental of Faraday’s Law

The DC generator produce electrical power based on fundamental principle of Faraday's law of electromagnetic induction. As per these law, when a conductor moves in a magnetic field it cuts magnetic lines force, due to which an EMF is induced in the conductor. The magnitude of this induced EMF relies on the rate of change of flux linkage with the conductor. This EMF will bring about a current to flow if the conductor circuit is closed. Therefore, there are 2 essential part of the generator which is magnetic field and the conductor that move inside the magnetic field to cut the flux.

2.2 Voltage Regulator

Every electronic circuit is intended to work off of some supply voltage, which is normally thought to be consistent. A voltage regulator provides this consistent DC output voltage and contains circuitry that constantly holds the output voltage at the design value regardless of changes in input voltage or load current. In this project, the input voltage from the dc motor are varies regarding to the speed the motor is rotated using hand crank. Therefore, voltage regulator is needed to regulate the voltage to a constant value. Generally, there are two types of voltage regulator, which is linear voltage regulator and switching voltage regulator.

2.2.1 Linear Voltage Regulator

According to Simpson, C. (2011), a linear voltage regulator works by utilizing a voltage-controlled current source to drive a constant voltage to appear at the regulator output terminal.

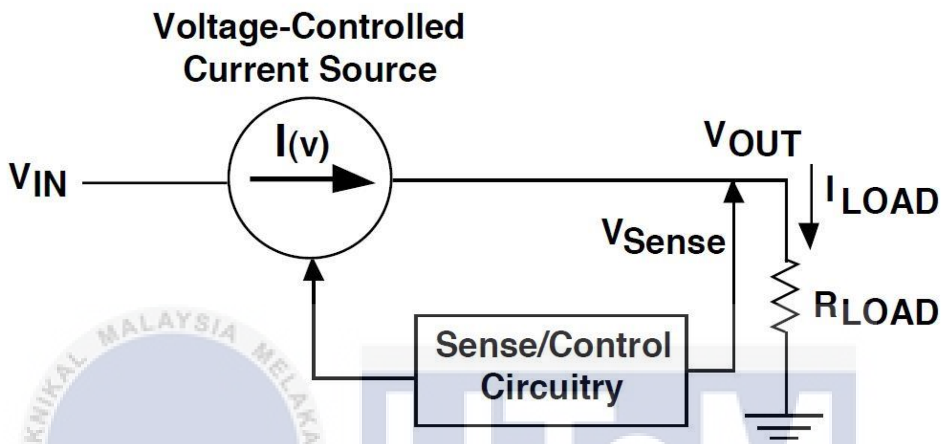


Figure 2.6: Linear regulator functional diagram (Simpson, C. (2011))

Figure 2.6 show the functional diagram of linear regulator. Based on the circuit, the control circuitry will monitor and sense the output voltage and modify the current source to hold the output voltage at the desired value. The design limit of the current source defines the maximum load current the regulator can source and still maintain regulation.

The output voltage is controlled by utilizing a feedback loop, which requires some sort of compensation to guarantee the stability of loop. Most linear regulators have built-in compensation, and are totally steady without external components. A few regulators such as Low-Dropout types do require some external capacitance connected from the output lead to ground to ensure the stability of regulator.

Another characteristic the linear regulator is that it requires a limited amount of time to “correct” the output voltage after an adjustment in load current demand. This "time lag" defines the characteristic called transient response, which is a measure of how quick the regulator comes back to steady-state conditions after any change of load.

Generally, the linear voltage regulator works by providing path from supply voltage to the load through a variable resistor. When the process occur, energy is release in form of heat. The amount of heat energy released is equal as following formula;

*(Input voltage - Output voltage) * Current drawn by load*

Therefore, the bigger the differences in output voltage and input voltage, the higher the amount of heat energy released. This cause the linear voltage regulator have very low efficiency compared to the switching voltage regulator. But the advantage of linear regulator is that it is lot more cheaper compared to the switching regulator.

2.2.2 Switching Voltage Regulator

The switching regulator is expanding in popularity since it offers the advantages of higher power conversion efficiency and increased design flexibility where various output voltages of different polarities can be created from a single input voltage. A switching regulator works by taking little lumps of energy, tiny bit at a time, from the input voltage source, and moving them to the output. This is accomplished with the assistance of an electrical switch and a controller which regulates the rate at which energy is transferred to the output. That is why it is called with the term “switching regulator”

There are 4 most commonly used switching converter in the switching regulator. The first one is Buck and it is used to decrease a DC Voltage ta a lower value. Next one is Boost and it is the opposite of Buck. Oppositely, it is used to increase a DC Voltage to higher value. The third is Buck-Boost, where an output voltage generated opposite in polarity to the input. The last is Flyback, where an output voltage that is greater than or less than the input can be generated, as well as multiple outputs.

In our project, we will be focusing on Buck converter, since we need to reduce the voltage produced by the DC Motor to constant 5V. Figure 2.7 below show how buck converter works and the current flow path when the switch is on and off.

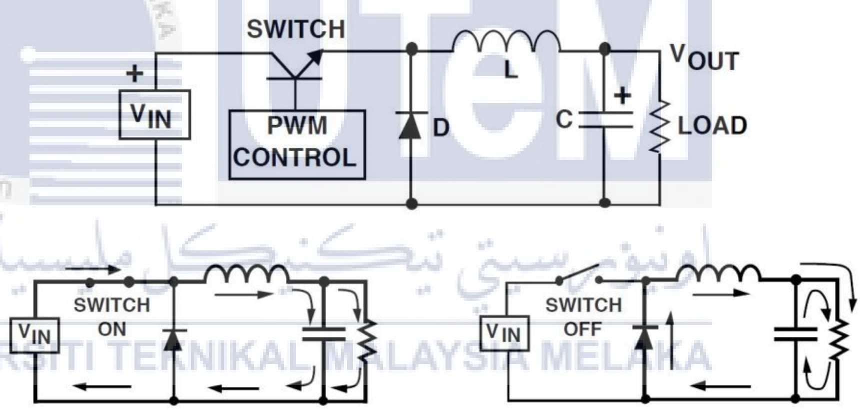


Figure 2.7: Buck Regulator (Simpson, C. (2012))

At the point when the switch turns on, the input voltage is connected to the inductor. The contrast between the input and output voltages is then constrained over the inductor, causing current through the inductor to become higher. Amid the on time, the inductor current flows into both the load and the output capacitor and charge the capacitor.

At the point when the switch is turned off, the input voltage connected to the inductor is removed. Nonetheless, since the current in an inductor cannot change in a split second, the voltage across the inductor will acclimate to hold the current constant. The input end of the inductor is forced negative in voltage by the declining current, eventually reaching the point where the diode is turned on. The inductor current is then flows through the load and back through the diode. The capacitor discharges into the load during the off time, adding to the total current being supplied to the load.

The shape of current flowing in the inductor is shown in Figure 2.8 below.

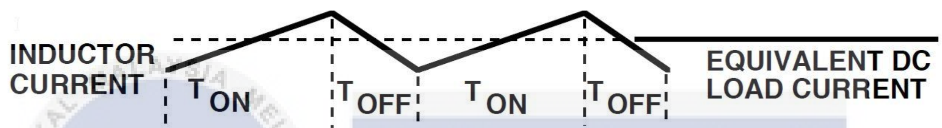


Figure 2.8: Buck regulator inductor current

As clarified, the current through the inductor slopes up when the switch is on, and inclines down when the switch is off. The DC load current from the regulated output is the average value of the inductor current. The peak-to-peak difference in the inductor current waveform is alluded to as the inductor ripple current, and the inductor is regularly chosen sufficiently substantial to keep this ripple current under 20% to 30% of the rated DC current.

Overall, the switching voltage regulator have higher efficiency compared to the linear voltage regulator. Switching regulator have higher output current and produce lesser heat. But on the downside, the circuit of switching regulator are complex to design, and cost a lot more compare to the linear voltage regulator.

2.3 Battery

A battery is a device that is created to store electrical energy inside it. It is made up of one or more electrochemical cells to give power to other electrical devices. A battery have two terminal which is positive (anode) and negative terminal (cathode). There are two types of battery which is primary and secondary. Primary batteries are intended for one-time use only and when it is used, it is discarded. This occur because the electrode materials are irreversibly changed during discharge. The example of primary battery is alkaline battery. Meanwhile, secondary battery battery also knows as rechargeable battery, can be discharge and recharge again. In this battery, the original composition of the electrodes can be renewed by reverse current. Famous example of secondary batteries are lead-acid batteries which is commonly used in vehicle, and lithium-ion batteries which are widely used in electronic devices. For this project, we will be focusing in secondary batteries as it is rechargeable. Furthermore, we will be focusing on lithium-ion batteries as it is widely used inside portable electronics.

2.3.1 Comparison of Rechargeable Battery

Among the various rechargeable batteries previously stated, Rechargeable Li-ion batteries have increased extensive enthusiasm for recent years as far as most astounding specific energy, cell voltage, good capacity retention and negligibly small self-discharge. Table 2.1 analyzes the attributes and performance of the four most important battery technologies.

Table 2.1: Characteristics and performance of commonly used rechargeable batteries

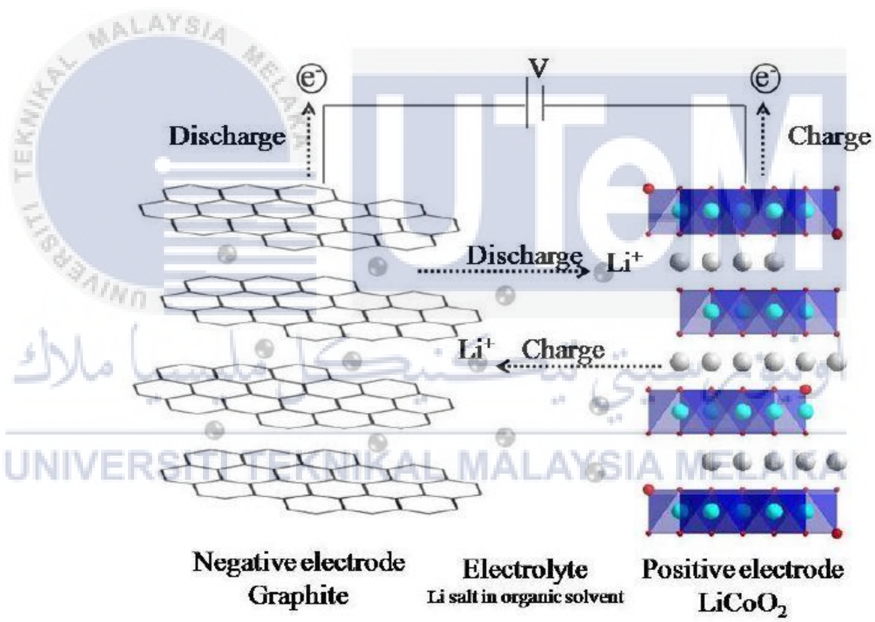
Battery type	**Lead-Acid**	**Ni-Cd**	**Ni-MH**	**Li-ion**
Commercialization	1970	1956	1990	1992
Voltage (V)	2.1	1.2	1.2	3.6-3.7
Energy Density	60-75 Wh/L 30- 50Wh/kg	50-150Wh/L 40-60Wh/Kg	140-300Wh/L 60-120Wh/Kg	250-620Wh/L 100-250Wh/Kg
Power Density (W/kg)	180	150	250-1000	250-340
Cycles	500-800	2000	500-1000	400-1200
Memory Effect	No	Yes	No	No
Monthly self discharge rate	3-20%	10%	30% (Temperature dependent)	5% at 21°C (Temperature dependent)

It is desirable that the energy delivered by a battery during its discharge should be as high as could be expected under the circumstances. The energy output of a battery is reliant on the proportional weight of active material present in it.

From the table above, Lithium metal being the third lightest component. Lithium based materials with low molecular weight can adequately produce batteries with high capacity. Furthermore, lithium ion batteries utilize non aqueous electrolyte that offer high operating voltage which is more than 4V, Meanwhile, other batteries with aqueous electrolyte normally produce 1-2V only. In this way, little weight, compact lithium ion batteries built up a strong market place for portable electronic devices.

2.3.2 Lithium Ion Battery

Lithium ion battery are made up of three primary components, positive and negative terminal are isolated by a separator plunged in electrolyte. Negative terminal is normally an electron donor group which is electropositive in nature like lithium metal. Positive terminal is normally an electron acceptor which is strongly electronegative. In the discharge process, the negative terminal electrochemically oxidized and discharges electron. This electron travels through outer circuit to the positive anode which receive electron. In Figure 2.9, the schematic of lithium ion battery operation is clarified using LiCoO2 as positive terminal and carbon as negative cathode.



Positive electrode: $LiCo^{3+}O_2 \underset{Discharge}{\overset{Charge}{\rightleftharpoons}} x\,Li^+ + Li_{1-x}Co^{4+}{}_xCo^{3+}{}_{1-x}O_2 + e^-$

Negative electrode: $C + xLi^+ + e^- \underset{Discharge}{\overset{Charge}{\rightleftharpoons}} Li_xC$

Overall: $LiCoO_2 + C \underset{Discharge}{\overset{Charge}{\rightleftharpoons}} Li_{1-x}CoO_2 + Li_xC$

Figure 2.9: Schematics of Li-ion battery using LiCoO2 as cathode and graphite as anode

During charging, Li^+ travel from $LiCoO_2$ to carbon through the electrolyte which causes oxidation of Co^{3+} to Co^{4+} and the opposite thing happens during discharging where Li^+ travel from carbon to $LiCoO_2$. Function of electrolyte is to act as medium for the exchange of ion between the two electrodes. Generally, lithium salt broke down in organic solvent is utilized as electrolyte in lithium ion batteries. There are several main requirements for the electrolytes are;

1) it ought to be a decent Li-ion conductor and electronic insulator,
2) steadiness over the working voltage window,
3) chemical compatibility with cell components and electrodes,
4) thermal stability and
5) there ought not be any charge gathering and concentration polarization.

Nowadays, lithium-ion batteries are widely used in home electronics. They are a standout amongst the most prevalent sorts of rechargeable batteries for portable electronics with a small memory effect, higher energy density, and lower self-discharge rate.

Figure 2.10: Various shape of lithium ion battery

2.4 USB Port

Nowadays, USB it is commonly used in connection, communication, and power transfer. USB was intended to standardize the connection of computer peripherals such as pointing devices, keyboards, printers, digital cameras, and network adapters towards computers, both to convey and to supply electric energy.

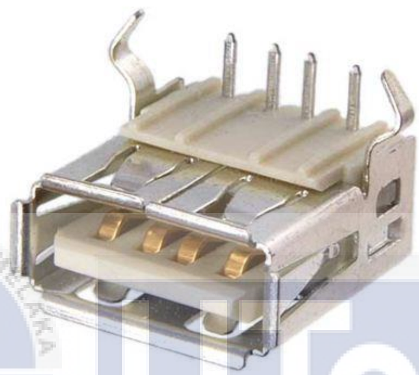


Figure 2.11: Commonly used USB Port

CHAPTER 3

METHODOLOGY

3.0 Introduction

This chapter provides the detail explanation of methodology that is used along this project. The purpose is to ensure the project is working according to the plan. This chapter includes a design system and selection component that is required in this project. The DC Motor is used as the primary power source in this system. Voltage regulator, battery and USB port is used to handle the energy produced by the DC Motor.

3.1 The Project Planning

Project planning is important to ensure the project are in order

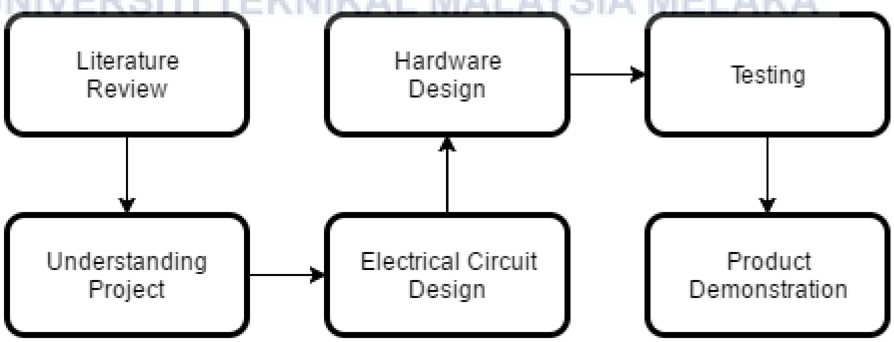


Figure 3.1: The project planning

The methodology for this project is constructed according to the plan. This project is constructed by combining the 12V DC Motor, voltage regulator, battery and USB port. The generating of energy is started when the 12V DC Motor is rotated using mechanical energy by the user. The cutting of magnetic flux is occurring and electrical energy is produced. The voltage is varying according to the speed of the motor rotated. The energy is then regulated to 5V by using voltage regulator since USB only need 5V. The electrical energy is the transmitted to the battery or the USB Port.

3.2 Flowchart for the project

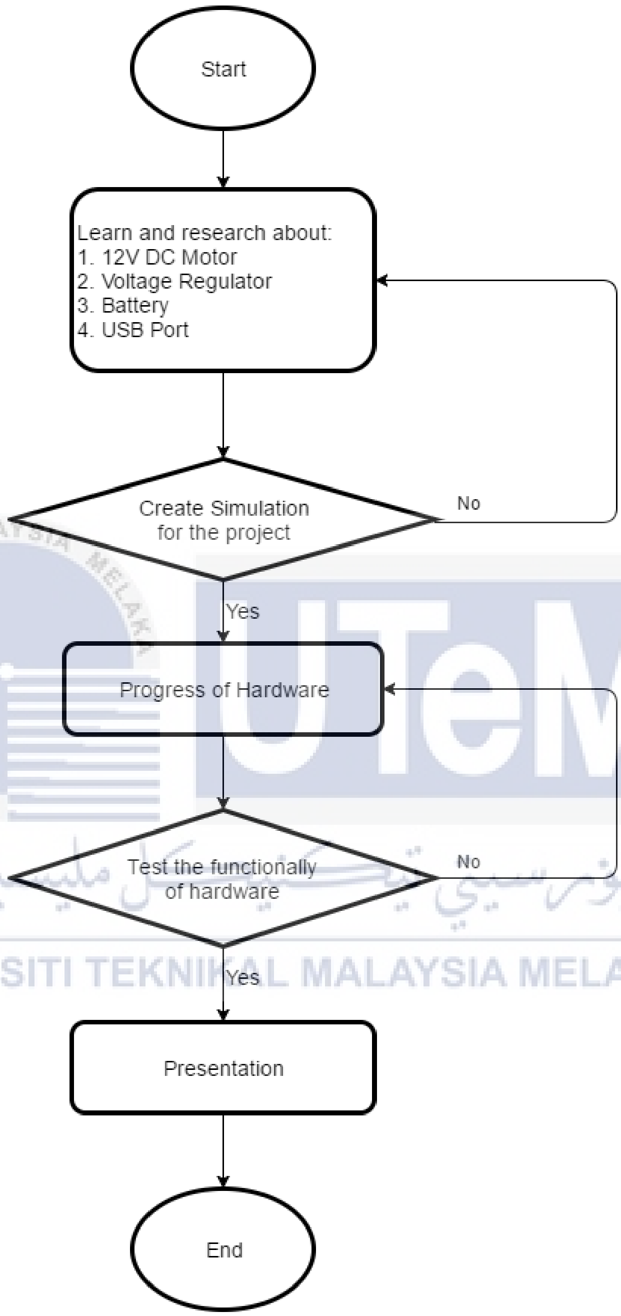


Figure 3.2: Flowchart for program

3.3 The Overview of the Project

Figure 3.3 shows the overall hardware design to develop the system

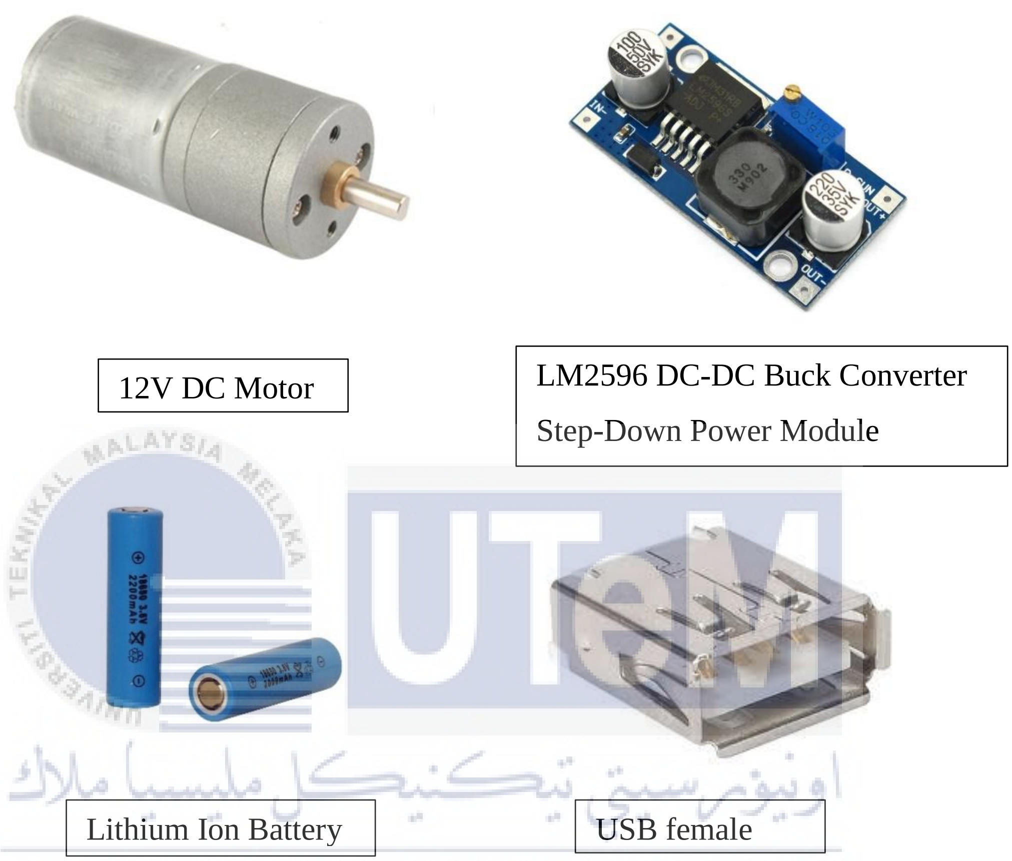


Figure 3.3: Overall hardware used

3.4 The Construction Model

The most important part of the project is the structural of the model. For this project, DC Motor is used to generate electricity. The electricity is then regulated to 5V by the voltage regulator. The energy is then stored inside the battery. Then the battery can supply the energy to the USB port.

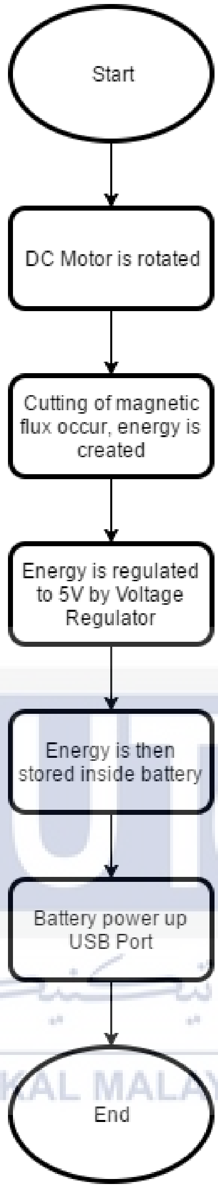


Figure 3.4: Construction model

3.5 Hardware Components

3.5.1 12V DC Motor

The DC Motor is the most important part of the project. When it is rotated, the cutting of magnetic flux is occurred and electricity is produced. Figure 3.5 shows the DC Motor as the main source of electricity in this project

Figure 3.5: DC Motor

Table 3.1: Specification of DC Motor

Model Type	0.8 W
Rated Voltage	12V DC
Reduction Ratio	1:270
Direction of Rotation	Clockwise
Reversibility	Reversible
At no load:	
Speed	10.8 ±10%rpm
Current	0.035A(max 0.43A)
At max efficiency	
Torque	2.4kg.cm
Speed	9.3 ±10%rpm
Current	0.068A (max 2.4A)

3.5.2 LM2596 DC-DC Buck Converter Step-Down Power Module

Figure 3.6: LM2596 DC-DC Buck Converter Step-Down Power Module

The LM2596 series of regulators are monolithic integrated circuits that provide all the active functions for a step-down (buck) switching regulator, capable of driving a 3-A load with excellent line and load regulation. These devices are available in fixed output voltages of 3.3 V, 5 V, 12 V, and an adjustable output version.

Table 3.2: Specification of LM2596 DC-DC Buck Converter Step-Down Power Module

Vin (Min) (V)	4.5	Vin (Max) (V)	40
Vout (Min) (V)	3.3	Vout (Max) (V)	37
Iout (Max) (A)	3	Regulated Outputs (#)	1
Switching Frequency (Min) (kHz)	110	Switching Frequency (Max) (kHz)	173
Iq (Typ) (mA)	5	Performance Features	Enable
Duty Cycle (Max) (%)	100	Operating Temperature Range (C)	-40 to 125

3.5.3 Lithium-Ion Battery

Figure 3.7: UltraFire 12500 1200mAh 3.7V Rechargeable Lithium-Ion Battery

Its high particular energy makes Li-cobalt the well-known decision for smartphones, power banks, digital camera. The battery comprises of a cobalt oxide cathode and a graphite carbon anode. The cathode has a layered structure and during discharging, lithium ions travel from the anode to the cathode. The flow are the opposite when it is charging. The disadvantage of Li-cobalt is a moderately short life range, low thermal stability and limited load capabilities.

Table 3.3: Specification of 18650 3.7v 2200mAh Lithium-Ion Battery

Cell Type	Lithium Ion	Built-in Protected Circuit	No
Battery Model	14500	Over Voltage Protection	No
Head Type	Button Top	Short-Circuit Protection	No
Mark Capacity	1200mAh	Over-Charging Protection	No
Actual Capacity	900mAh	Over-Discharging Protection	No
Voltage	3.7V	Mercury Free	Yes
Rechargeable	Yes		
Rechargeable Times	1000		

3.5.4 USB Female

Figure 3.8: Female USB Port

USB-A female is the standard “host” connector type. It is widely found in hubs, computer, laptop and mobile phone charger. It is commonly attached to USB-A male to do connection for power transfer, communication, or connection. It uses 5V to functioning.

CHAPTER 4

RESULT AND ANALYSIS

4.0 Introduction

In this chapter, the result and the analysis of the prototype performance which is the portable USB charger using DC motor. All the result from both simulation and the hardware testing will be recorded and discussed in detail in this chapter. From the result, the best type for component used in Portable USB Charger can be determined.

4.1 Prototype Development

In order to develop the prototype, each component will need to be determined. One of the most important component inside Portable USB Charger is voltage regulator. The function of voltage regulator is to regulate certain voltage level to desired value. In this case, the value desired is 5V, since USB only required 5V to be functional. Generally, there are two type of voltage regulator which is linear voltage regulator and switching voltage regulator.

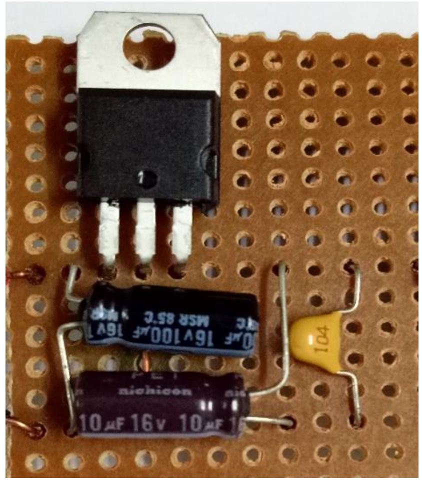
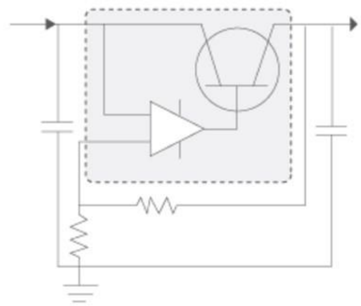
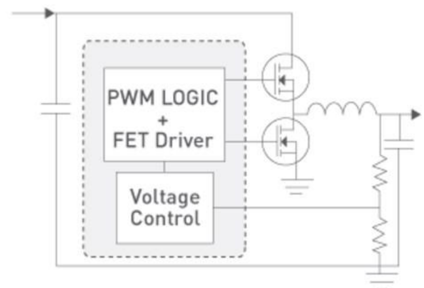


Figure 4.1: 5V linear voltage regulator

Figure 4.2: switching regulator

Table 4.1: General difference between linear regulator and switching regulator

Type	Linear Voltage Regulator	Switching Voltage Regulator
Control		
Design Flexibility	Buck	Buck, Boost, Buck-Boost
Efficiency	Usually low-medium for low differences between Vin and Vout	High
Complexity	Low	Medium to high
Size	Small to medium, may be larger at high power	Smaller at similar higher power (depending on the switching frequency)
Total Cost	Low	Medium to high as it may use external component
Ripple/Noise	Low	Medium to high
Vin Range	Small (Depend on power dissipation)	Wide
Advantages	Low cost, Simple	Efficient, High power
Disadvantages	Power released in heat	Noisy, Complicated, Expensive

4.2 Simulation Results

The simulation test is conducted to determine the performance of linear voltage regulator using Multisim software. The circuit was designed so that it represents the Portable USB Charger

4.2.1 Simulation Case 1

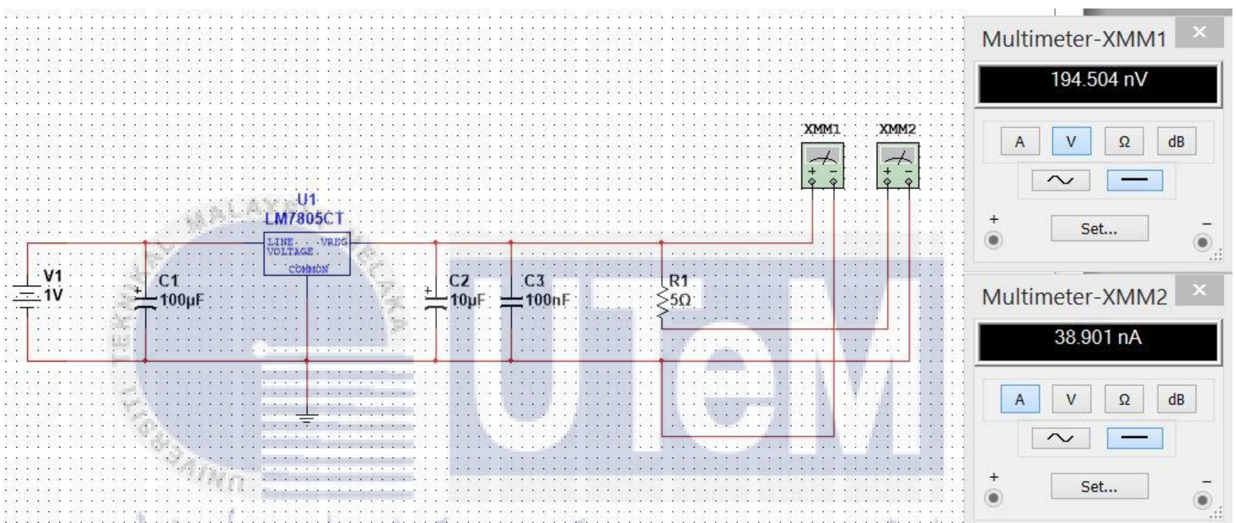


Figure 4.3: Simulation case 1 using Multisim

In this case simulation, the input voltage represent input from DC Motor, LM7805 as 5V Voltage regulator, the load represents the USB device. For the first experiment, the input voltage was changed in increasing manner to simulate that when the DC Motor is rotated faster, the voltage input also higher. However, the load resistance is fixed to 5 Ohm.

Table 4.2: Result for Simulation Case 1

Load Resistance (Ω)	Input Voltage (V)	Output Voltage (V)	Output Current (A)
5	1	194.504n	38.901n
5	2	591.043m	118.209m
5	3	1.559	311.74m
5	4	2.536	507.236m
5	5	3.513	702.674m
5	6	4.479	895.708m
5	7	4.994	998.724m
5	8	4.994	998.764m
5	9	4.994	998.804m
5	10	4.994	998.844m
5	15	4.995	999.044m
5	20	4.996	999.243m

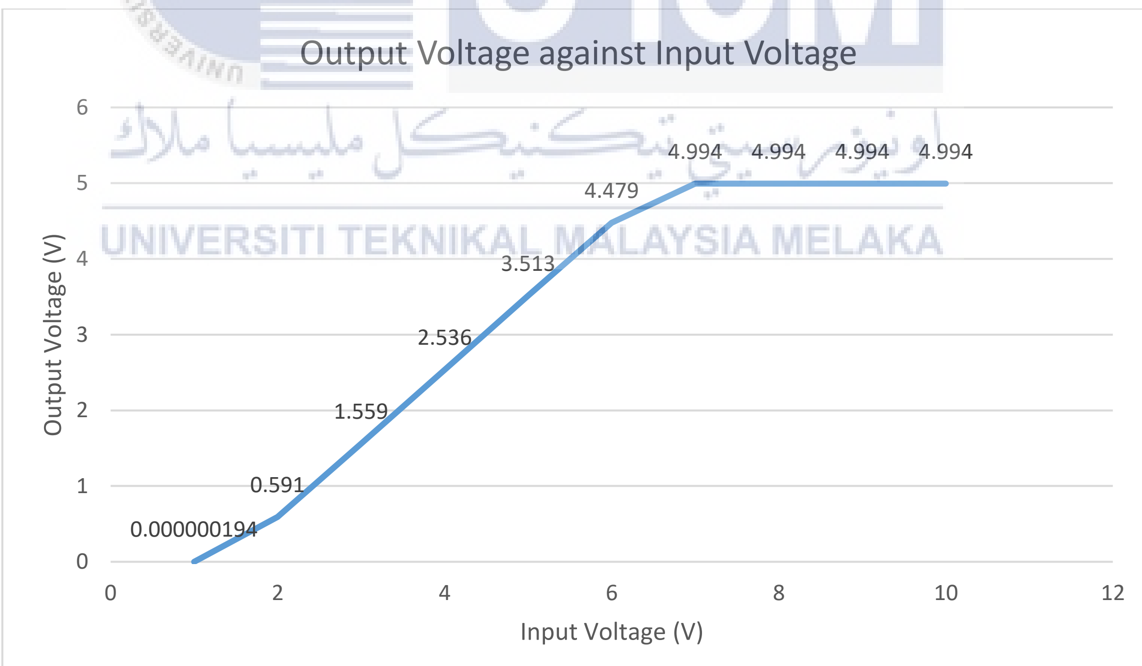


Figure 4.4: Graphical analysis of output voltage against input voltage for simulation case 1

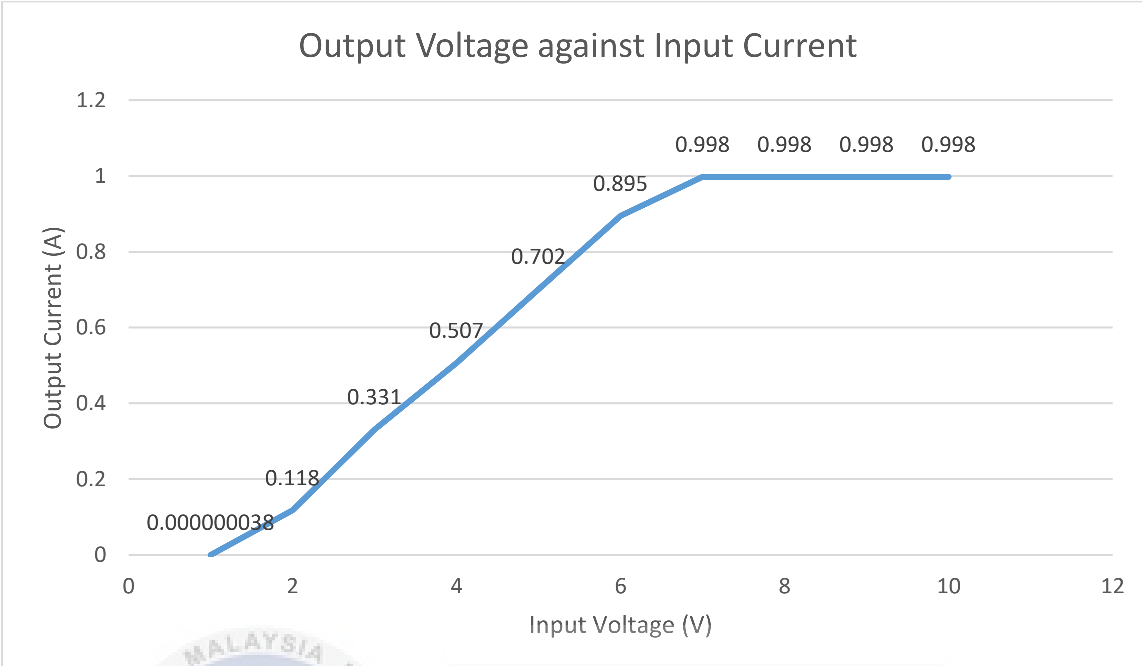


Figure 4.5: Graphical analysis for output voltage against input current for simulation case 1

For simulation case 1, when the input voltage increase, it will affect the output voltage. When the input voltage is below 3V, the output voltage is extremely small. Its require that the input voltage is more than 6V so that it will operate at optimum condition. The maximum output voltage achieved is only at 5V, since the voltage regulator will limit it to 5V only. For output current, when the input voltage increase, the output current also will increase, This is following Ohm's Law that the current are directly proportional to the increase of voltage (V=IR).

4.2.2 Simulation Case 2

For the simulation case 2, it is nearly identical to simulation case 1, but in this simulation, the input voltage which represent the Input from DC Motor will be fixed, while the load resistance is being varied to simulate different device that use the USB. The input voltage will be fixed to 10V while the load resistance is varied from 1 Ohm to 20 Ohm.

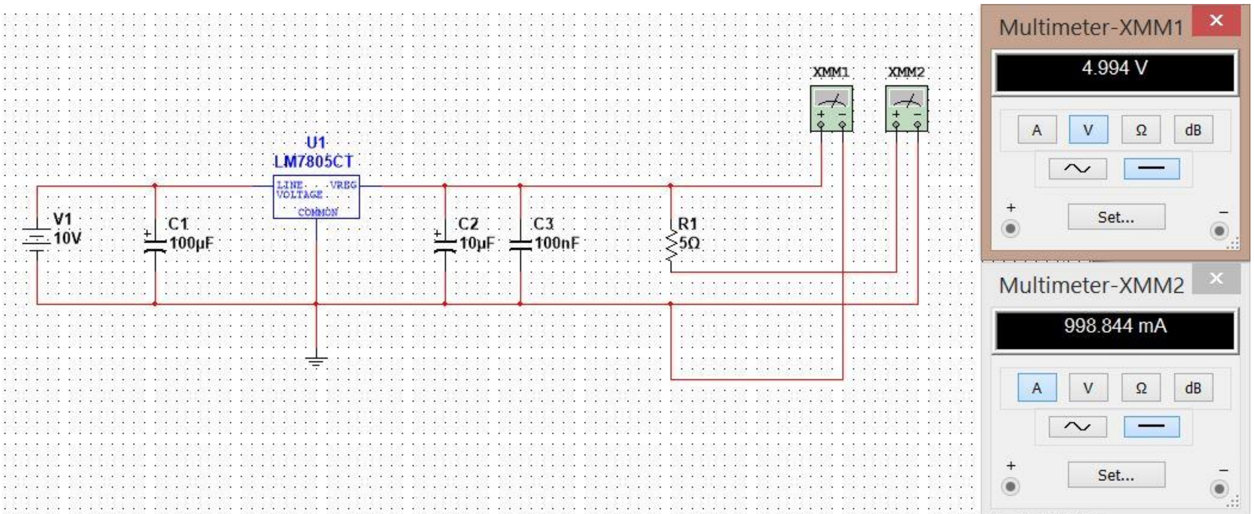


Figure 4.6: Simulation case 2 using Multisim

Table 4.3: Result for simulation case 2

Input Voltage (A)	**Load Resistance (Ω)**	**Output Voltage (V)**	**Output Current (A)**
10	1	2.402	2.402
10	2	4.762	2.381
10	3	4.989	1.663
10	4	4.992	1.248
10	5	4.994	0.998
10	6	4.995	0.832
10	7	4.996	0.713
10	8	4.997	0.624
10	9	4.998	0.555
10	10	4.998	0.499
10	15	4.999	0.333
10	20	5	0.249

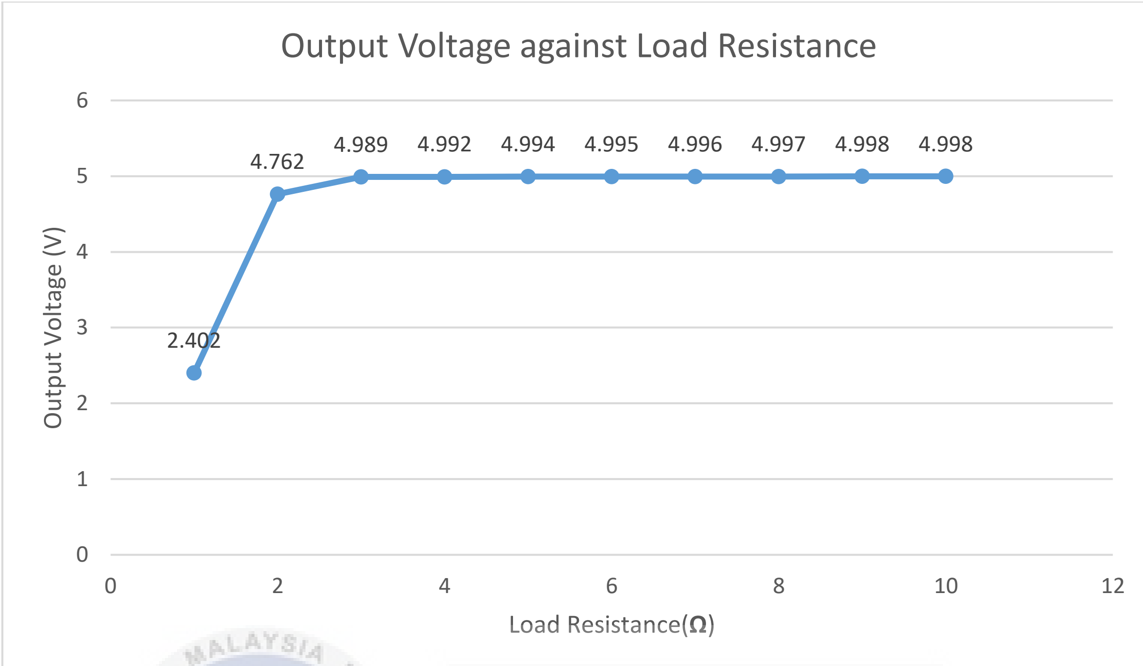


Figure 4.7: Graphical analysis of output voltage against load resistance for simulation case 2

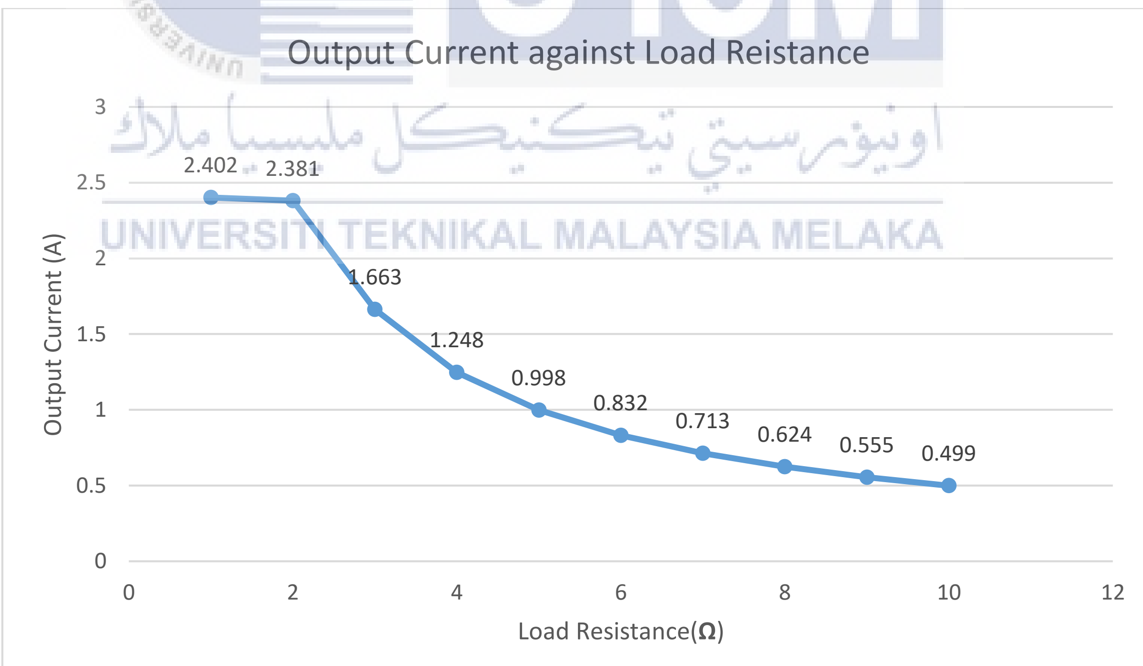


Figure 4.8: Graphical analysis of output current against load resistance for simulation case 2

For the simulation case 2, When the load resistance increase, the output voltage will increase to maximum of 5V. The output current will decrease as the load resistance increase. This follow the Ohm's Law that stated V=IR. When the resister/load increase, the current will decrease.

4.3 Experimental Results

From the observation, the load resistance used in simulation cannot be used in laboratory testing. This is because when the value of resistor is too low, the current will be very high and the circuit are not suitable for high current value. Both resistor and regulator can be extremely hot and damaged. The regulator become hot because it regulates higher voltage to 5V by releasing the energy in form of heat. The resistor become hot the current that pass it are above the limit that the resistor can withstand. Hence, higher value of resistor as load are needed to replace the small value of resistor used is previous simulation. Beside other type of regulator which is switching regulator needed to be tested to see the performance. Then, both result of linear and switching regulator can be compared and analyzed to determine the best regulator.

In hardware testing, there are four elements that are being measured. The 4 elements are input voltage (V), load resistance (Ω), output voltage (V), and output current(A). The input voltage will represent the input from DC Motor. The load resistance represents the USB device. Each USB Device has their own rating and different load. Both Output Voltage and Output Current represent voltage and current in the USB. For the testing at lab, the value is changed so that it does not become too hot. In addition, the switching regulator also are being tested.

4.3.1 Experiment Case 1

In this experiment, the regulator used is linear regulator. The input voltage is increased exponentially while the load resistance is fixed to 50 Ohm.

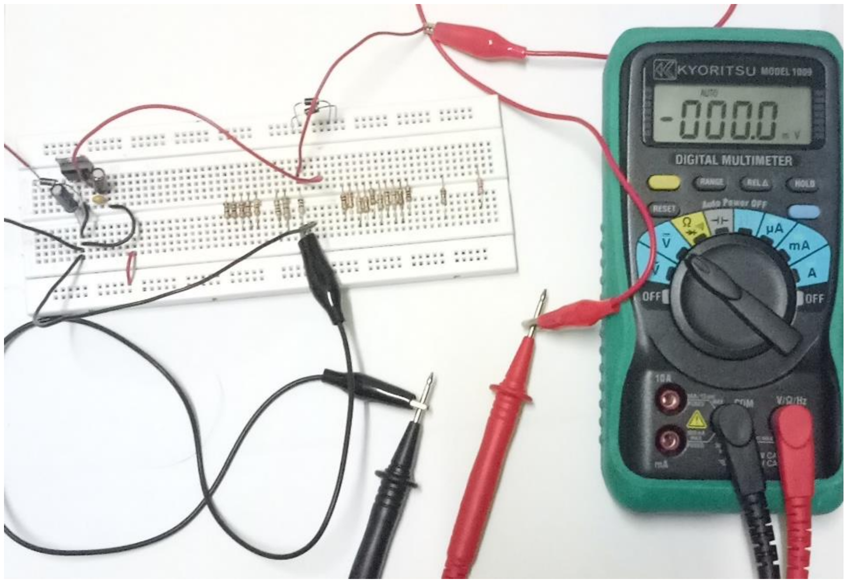


Figure 4.9: Setup for experiment case 1

Table 4.4: Result for experiment case 1

Load Resistance (Ω)	Input Voltage (V)	Output Voltage (V)	Output Current (mA)
50	1	0	0
50	2	0	0
50	3	0	0
50	4	3.5m	0.09
50	5	22.8m	0.35
50	6	0.746	11.54
50	7	4.40	76.4
50	8	4.78	90.9
50	9	4.79	91.3
50	10	4.79	91.3
50	15	4.80	91.3
50	20	4.80	91.3

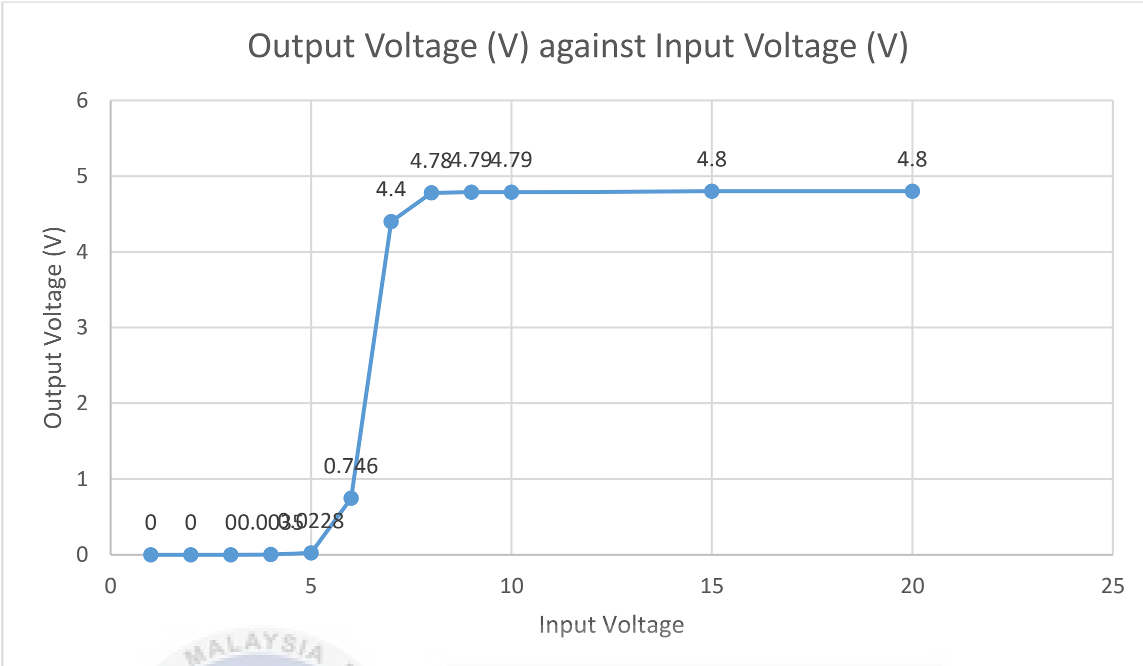


Figure 4.10: Graphical analysis of output voltage against input voltage for experiment case 1

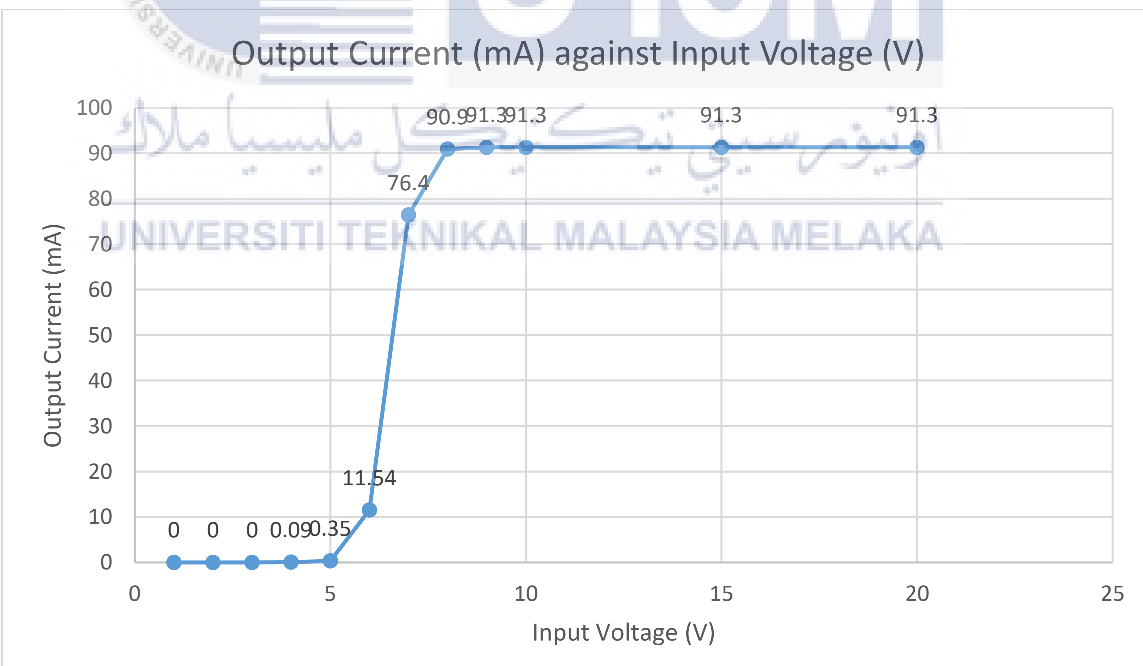


Figure 4.11: Graphical analysis of output current against input voltage for experiment case 1

4.3.2 Experiment Case 2

Experiment case 2 is nearly the same as Experiment case 1, but the linear regulator is replaced with switching regulator.

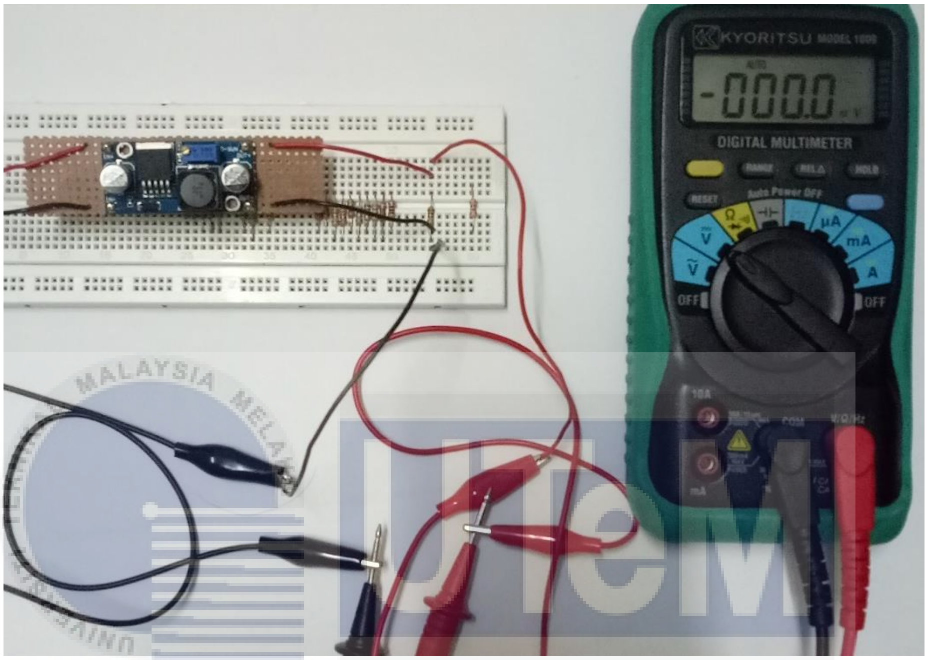


Figure 4.12: Setup for experiment case 2

Table 4.5: Result for experiment case 2

Load Resistance (Ω)	Input Voltage (V)	Output Voltage (V)	Output Current (mA)
50	1	0	0
50	2	0.779	15.35
50	3	2.397	35.00
50	4	3.362	48.2
50	5	4.12	67.2
50	6	4.78	78.0
50	7	4.88	79.8
50	8	4.88	81.2
50	9	4.88	82.3
50	10	4.89	82.9
50	15	4.89	81.5
50	20	4.89	81.5

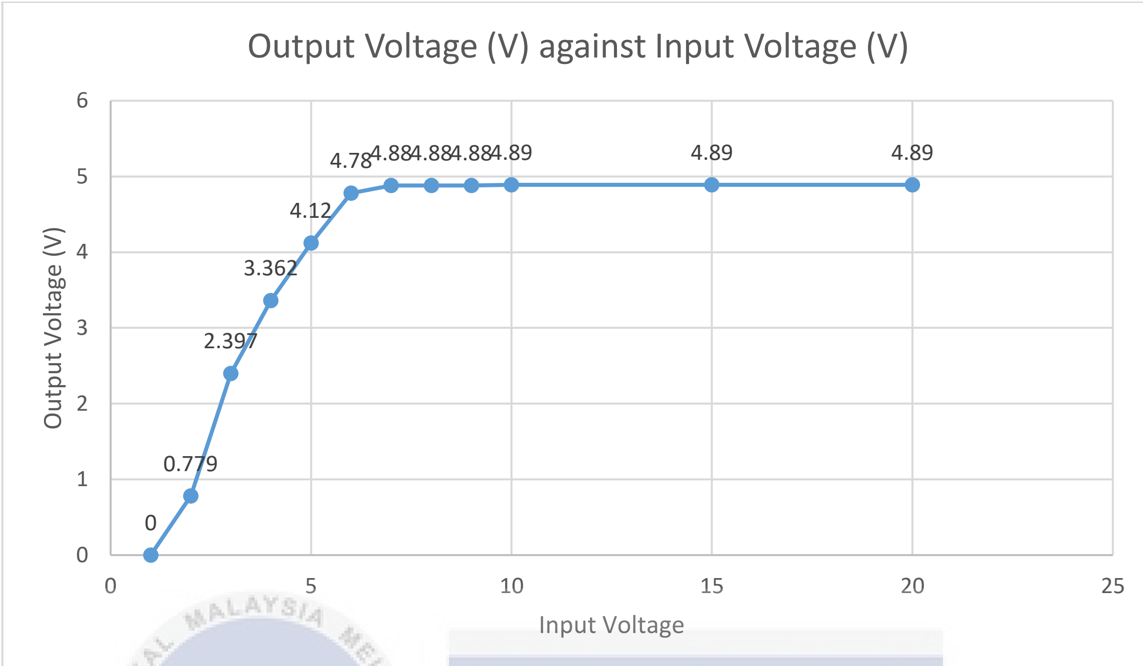


Figure 4.13: Graphical analysis of output voltage against input voltage for experiment case 2

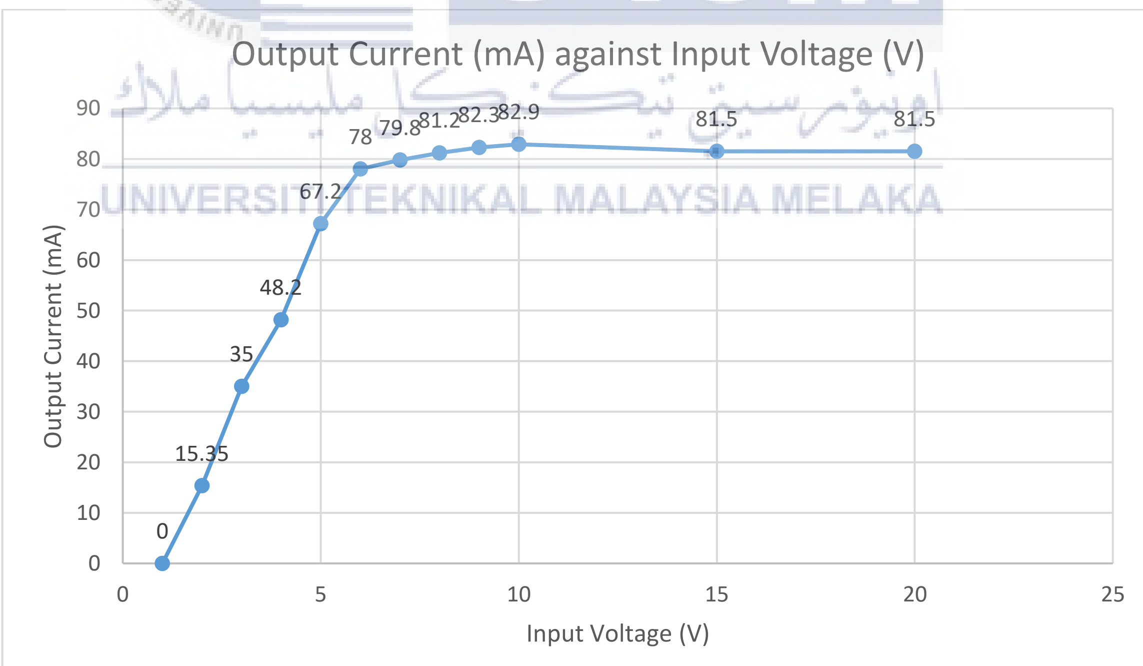


Figure 4.14: Graphical analysis of output current against input voltage for experiment case 2

Based on the result from both Experiment case 1 and Experiment case 2, switching regulator show steady increase of voltage when the input voltage is increased but linear regulator only show increase in voltage when the input voltage is more than 7V. This is because the linear voltage requires minimum of 7V to properly functional.

For the current, it shows similar trend with the output voltage. The output current show steady increase for switching regulator, but for linear regulator, the output only show significant increase when the input voltage is more than 7V. However, the maximum current achieved by the linear regulator is higher than switching regulator, where the maximum current for linear regulator is 91.3 mA, while for switching regulator is 82.9 mA.

4.3.3 Experiment Case 3

In this experiment, a linear regulator will be used. Different from Experiment case 1, this time the load resistance value which represent the USB device will be changed. Instead, the input voltage which represent input from DC Motor will be fixed to 10V.

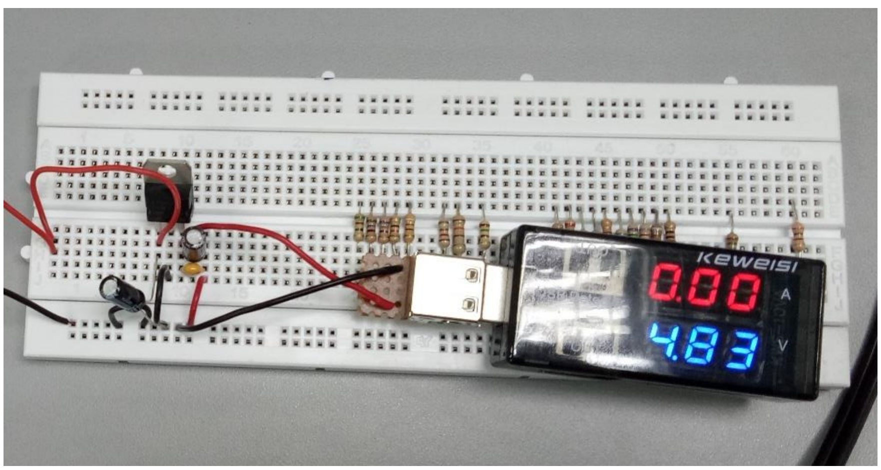


Figure 4.15: Setup for experiment case 3

Table 4.6: Result for experiment case 3

Input Voltage (V)	Load Resistance (Ω)	Output Voltage (V)	Output Current (mA)
10	50	4.21	89.0
10	55	4.23	81.0
10	66	4.33	67.8
10	80	4.35	57.0
10	90	4.49	51.5
10	120	4.64	39.6
10	130	4.51	37.5
10	150	4.70	32.0

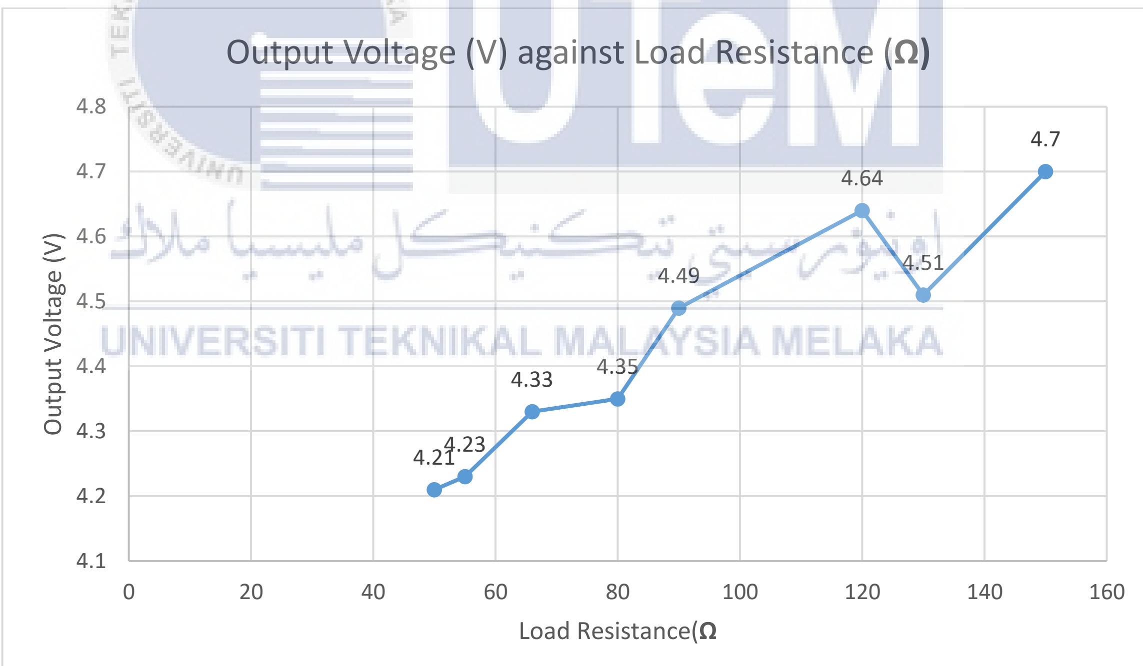


Figure 4.16: Graphical analysis of output voltage against load resistance for experiment case 3

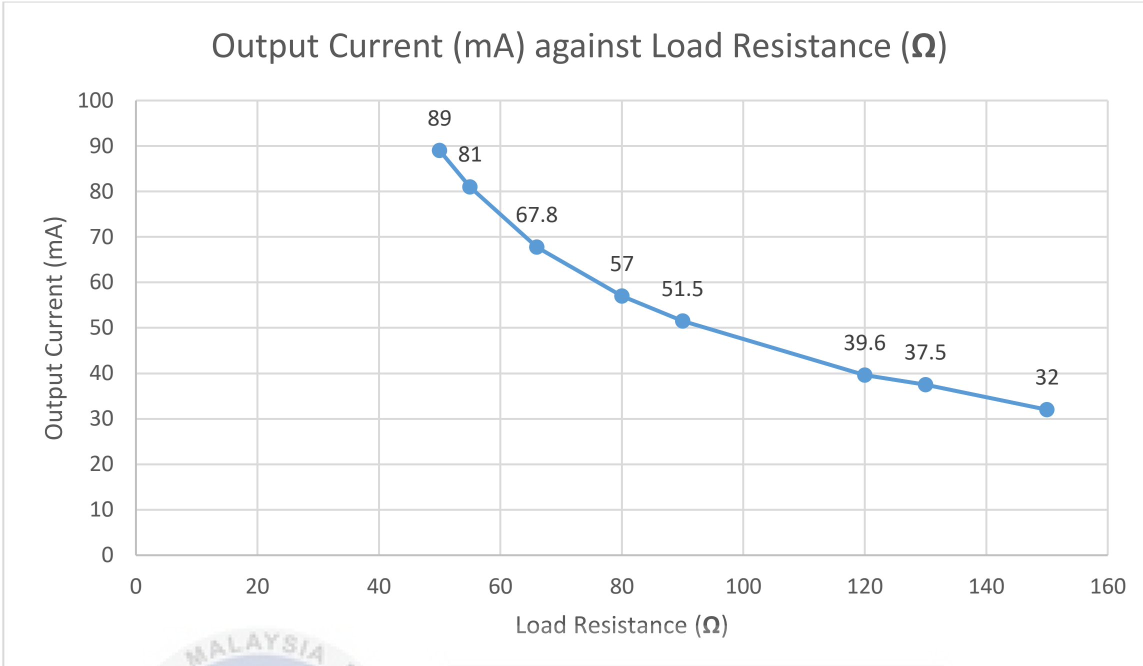


Figure 4.17: Graphical analysis of output current against load resistance for experiment case 3

4.3.4 Experiment Case 4

The Experiment case 4 is set up the same as Experiment case 3, but the linear regulator is replaced with switching regulator. The data obtained will be analyzed later.

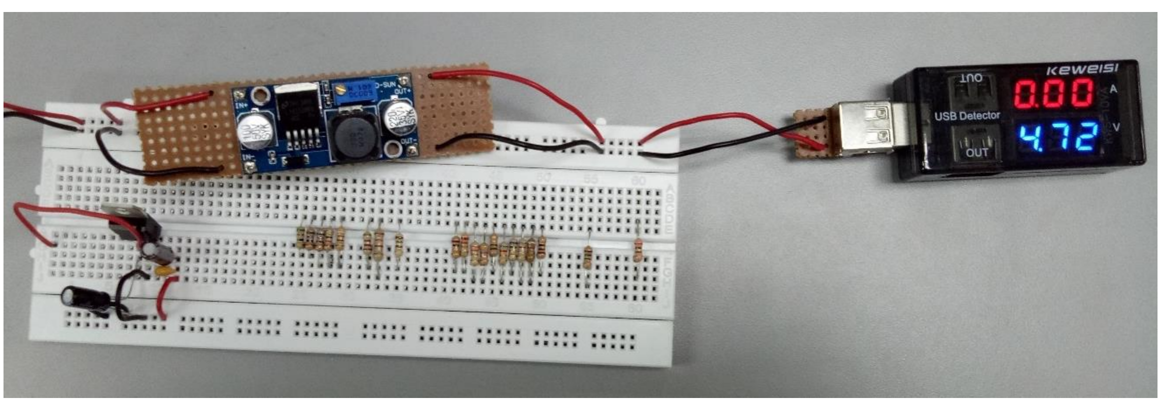


Figure 4.18: Setup for experiment case 4

Table 4.7: Result for experiment case 4

Input Voltage (V)	Load Resistance (Ω)	Output Voltage (V)	Output Current (mA)
10	50	4.64	87.4
10	55	4.85	80.0
10	66	4.86	66.7
10	80	4.92	54.4
10	90	4.90	47.1
10	120	4.91	39.9
10	130	4.92	37.4
10	150	4.83	31.3

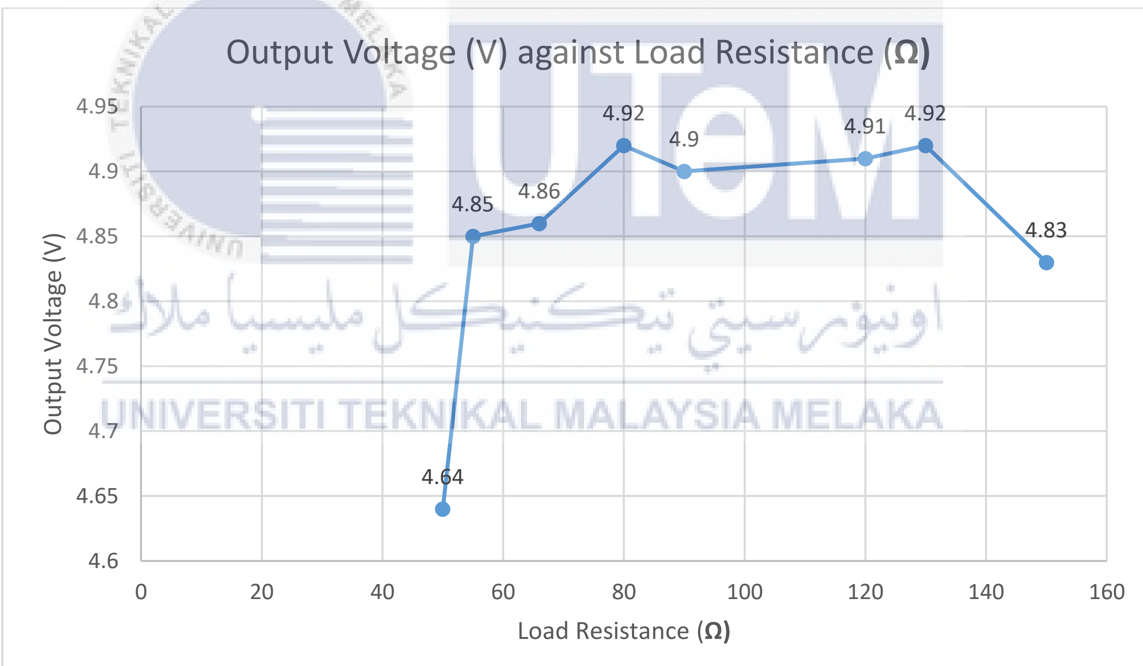


Figure 4.19: Graphical analysis of output voltage against load resistance for experiment case 4

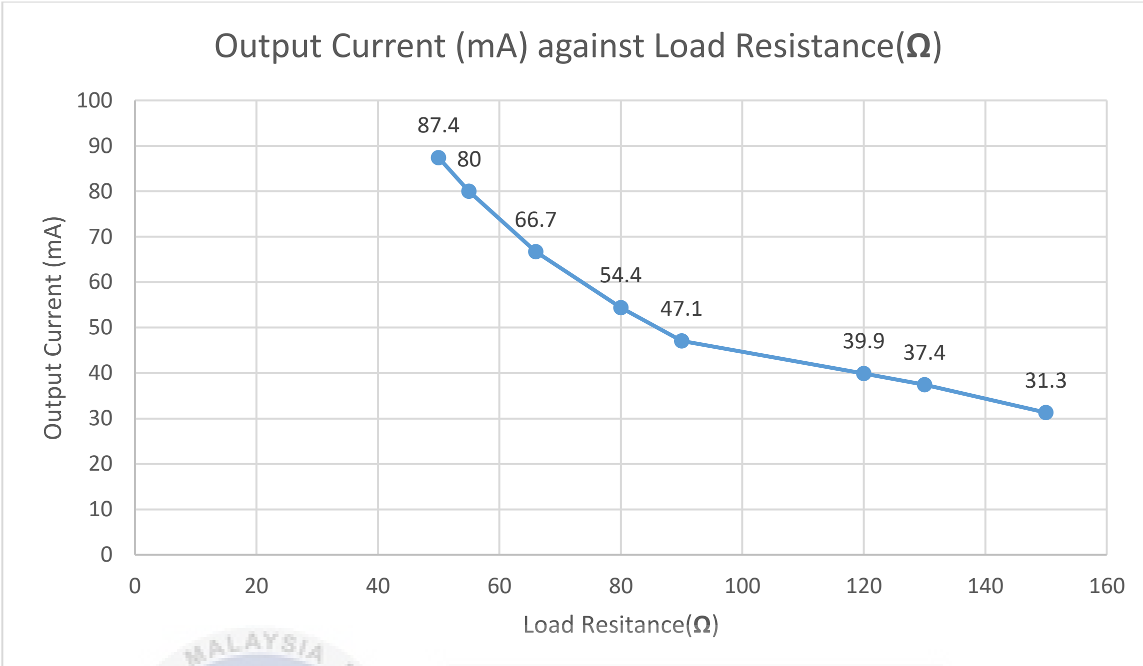


Figure 4.20: Graphical analysis of output current against load resistance for experiment case 3

From the Experiment case 3 and 4, when the load resistance is increased, the linear regulator show small increase in voltage towards 5V. For switching regulator, all the output voltage are close to 5V and stable. Overall, the load resistance does not have significant impact on the output voltage since all the output voltage are close to 5V.

For the output current, when the load resistance is increased, both output current value for linear regulator and switching regulator are decreased. This is following the principle of Ohm's Law, (V=IR) where when the load increase, the current decrease. However, all the output current value for linear regulator are higher than switching regulator.

4.4 Discussion

From observation, the most of output current for linear regulator is higher than switching regulator. However, most of output voltage for switching regulator is higher than linear regulator. Other observation, it is noted than the voltage regulator inside linear regulator can be hot due to releasing energy in form of heat, but the temperature for switching regulator are stable at room temperature. Other than that, the value of output voltage for switching regulator are not consistent. The voltage adjuster at switching regulator need to be tweak regularly to gain 5V. This may pose big problem in the future as the circuit need to be tweak regularly and make the usage difficult. But for linear regulator, the value are constant and does not need to be tweaked. However, the heat problem need to be overcome if it is going to be used.

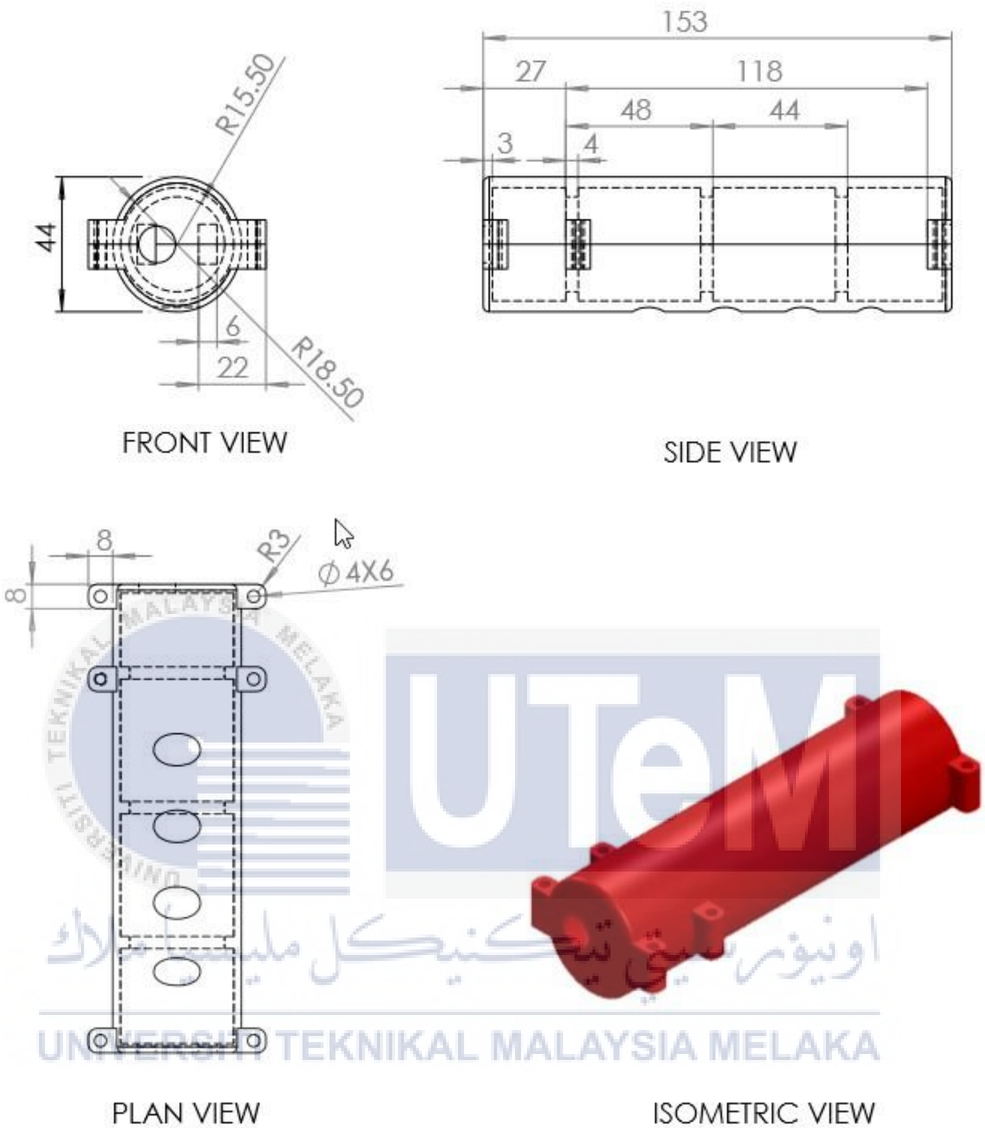
4.4.1 Suggestion

After completing the experiment and do the observation, linear regulator may be better than switching regulator. First, the cost to make linear regulator is a lot cheaper than switching regulator. Next, the output current of linear regulator is higher than switching regulator. However, the heat problem inside linear regulator must be overcome. For that, a heatsink for regulator can be used. Heatsink is a thermal conductor that carries away heat for regulator into fins to provide large area for heat to be released. Hence, the usage of heatsink can cool down the voltage regulator quickly and overcome the heat problem.

Figure 4.21: Heatsink for LM7805

Figure 4.22: LM7805 with heatsink

Other than regulator, the other important component is the casing. The casing for portable USB charger are modelled using Solidwork software. The casing is then printed out using 3D printing machine. The criteria needed is that the casing must be strong enough to hold all the component inside it and are comfortable to be held.



4.23: Design of portable usb charger casing

CHAPTER 5
CONCLUSION

5.0 Introduction

In this chapter, the conclusion and suggestion for future work to improve further study are discussed. This chapter highlight on summary of research, problem faced during research and suggestion for future research.

5.1 Summary of Research

In conclusion, the objective of the project is to design and develop a portable USB Charger using DC motor. In order to achieve that, each component is determined and being assembled into one complete system. The project is based on the concept that the energy can be generated easily anywhere and anytime using DC motor. The DC motor can be rotated using mechanical energy from human. For convenience, a crank is used to rotate the motor easily.

5.2 Problem Faced during Research

While doing this research, the problem faced is modelling and printing the casing for Portable USB Charger. A significant higher skill needed to design a suitable case. The 3D printing machine also need to be in optimum condition before start the printing process. Even small defect can cause the casing are not suitable to be used.

5.3 Suggestion for Future Research

In order to improve the further study, the overall circuit can be redesigned to make it smaller so that less space are needed. By doing that, the casing can be redesigned to make it smaller. Other than that, further research can be done in order to increase the current output from portable USB charger. Last but not least, further research can be done to determine the performance of portable USB charger in daily life in term of charging time to charge USB device, the life span of the device, and number of cycle of charge

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