KENYATTA UNIVERSITY

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

BSc Biomedical Engineering

Final Year Project Report

DESIGN AND CONSTRUCTION OF A PORTABLE DUAL USB CHARGER

NAME: **NAMBALE BRIAN WATAI**

REG NO: **J23/4198/2016**

SUPERVISOR: **ENG. ARTHUR OGWAYO**

Final Year Project Report submitted to the Department of Electrical and Electronic Engineering, Kenyatta University, in partial fulfillment of the requirements for the award of Bachelor of Science degree in Biomedical Engineering.

2022

DECLARATION

I hereby declare that the project entitled "Design and Construction of a Portable Dual USB Charger" submitted to the Electrical and Electronics Department, Kenyatta University is a record of my original work towards the partial fulfillment of the degree of Bachelor of Science Biomedical Engineering under the supervision of Eng. Arthur Ogwayo and has not been submitted anywhere else. The contents embodied in this report have not formed the basis of any degree associate ships, fellowships or any other similar tittles.

SIGNATURE………………………………. DATE………………………………………….

NAME: BRIAN WATAI NAMBALE

REG NO: J23/4198/2016

TITLE OF PROPOSAL: PROJECT ON DESIGN AND CONSTRUCTION OF A PORTABLE USB CHARGER

SUPERVISOR CONFIRMATION:

This project report has been submitted to the Department of Electrical and Electronic Engineering, Kenyatta University, with my approval as the University supervisor:

SIGNATURE…………………………………………DATE……………………………………

NAME: ENG. ARTHUR OGWAYO

DEDICATION

I dedicate this report to the Almighty God who gave me the life, strength, endurance and the resources required for this course. I also dedicate it to my brothers and sisters for being there for me. Finally, I equally dedicate it to my parents who have really toiled to ensure that I get educated not forgetting their encouragement that has made me to be what I am today.

ACKNOWLEDGEMENT

I would like to express my sincere gratitude to everyone who helped me in the completion of this project. Along the process I faced challenges but am glad because they helped me get over the challenges to construct the Portable Dual USB Charger.

I sincerely thank Eng. Martin Nzomo for his coaching and guidance which enabled me to learn the minute aspects of proposal and project work. Without forgetting, I really appreciate the staff of the Electrical and Electronic Department for their great support throughout my study at the university. Am also thankful to my classmates who challenged me and made me believe it can be done.

I would also like to extend gratitude to my project supervisor Eng. Arthur Agwayo for his continued monitoring and help during the project work.

Last and most importantly am very thankful to my parents, brothers and sisters who have really inspired me to face the challenges and always have a winning mentality in life.

Table of Contents

LIST OF FIGURES

LIST OF TABLES

ABBREVIATIONS

AC	Alternating Current
USB	Universal Serial Bus
DC	Direct Current
LED	Light-Emitting Diode
CMOS	Complementary metal–oxide–semiconductor
DCR	DC Resistance
ESR	Equivalent Series Resistance
BATT	Battery
VCC	Common Collector Voltage
GND	Ground
TP	Testing Point
IC	Integrated Circuit
D	Diode
R	Resistor
L	Inductor
PMOS	Positive Channel Metal Oxide Semiconductor

NOMENCLATURE

V	Voltage, [V]
f	Frequency, [MHz]
A	Amperes, [A]
°C	Degrees Celsius [°C]
W	Watts [W]
%	Percentage, [%]
mA	Milli Amperes, [mA]
Ω	ohms, [Ω]
AA	50.5mm x 14.5mm

ABSTRACT

The consumer electronic devices operation relies on mobile power to remain operational when plugged out of the source of AC outlet. Most of these mobile devices utilize rechargeable batteries for supply of portable power. The aim of this project was to design and fabricate a Dual USB Charger for charging USB-powered devices (devices that are chargeable by USB cable), such as smartwatches, blood pressure monitors, glucometers, heart monitors, brain-sensing headbands, pain relief devices, thermoguns, mobile phones, cameras, among many others. The system was found to play a vital role especially in mobile charging cases during travelling. Two AA 1.5V dry cells connected in series and a single lithium battery were the ultimate source of power. AA dry cells are cheap, possess lots of power, have low internal resistance and are easily available everywhere. The 3V DC voltage produced by the AA dry cells (also rechargeable batteries) and lithium battery was suitably converted to 5V then fed to the device. Therefore, we can consider AA dry cells as a substitute for the conventional AC power from the mains. The capacities of the DC voltage supplied by the AA batteries can be upgraded. The power pack also consists of TP4056 chip for protection of single-cell lithium-ion battery against overcharging and undercharging. This circuit has a unique advantage in that it enables charging of our gadgets more efficiently with an expended compatibility range. Furthermore, the final circuit is relatively small, making it suitable to be used as a portable emergency battery charger.

CHAPTER ONE: INTRODUCTION

1.0 INTRODUCTION

Battery-powered devices are ubiquitous in our daily lives, and we are constantly plagued by low-charge issues that leave us stranded in the midst of the day affecting operation of Phones, diagnostic/health monitoring devices, and other electronic devices. Sometimes we can't find a power outlet to plug in an AC adapter. The Portable Dual USB charger comes in handy in these situations. It may run on two or three AA batteries, which are easy to come by or carry with you when on the go.

A battery generates electrical power by converting chemical energy contained in the battery. When the battery's electrolyte is depleted, it must be recharged. A battery charger is a device that delivers Direct Current (DC) to the battery in order to replenish the electrolyte that has been depleted.

A battery is a device made up of one or more electrochemical cells that transform chemical energy into electrical energy when they are charged. Dry cells are one of many varieties of electrochemical cells available for consumer usage in today's power-savvy world which was a remarkable innovation when they were introduced.

Batteries have become ingrained in our daily routines. The use of batteries is common, whether it is in a mobile phone, an emergency light, a smart watch, heart monitor, or any other electronic equipment. They make devices more portable, which makes them more convenient for consumers. The performance of a battery is determined by how it is used and charged. As a result, investing in a decent battery charger is critical. By sending an electric current through the battery, a battery charger or recharger provides it with the necessary power to continue running.

1.1 BACKGROUND OF THE STUDY

In the current society, the majority of the population boast of at least owning a smartphone or other diagnostic or health monitoring device. Today's technological advancements have allowed manufacture of complex components which are cheaper and affordable permitting most people to be able to improve their lifestyle. However, speed and battery life are the most sought-after specifications when someone wants to purchase a device. Consequently, there is great demand of portable battery charger packs for charging these devices.

If someone went for a trip to a place where there are no charging points, it is almost sure that the electronic devices would run out of charge after sometime. They would enjoy a lot but they could not record any memories because the cameras would run out of charge. Similarly, medical practitioners out in the field to conduct some research and record health parameters of the patients would be forced to halt the research if their recording devices ran out of charge. In addition, patient health monitoring devices might run out of charge while the patient is on the go yet the doctor need to continuously monitor the state of the patient through the data collected and sent to him by the monitoring devices.

From experience, it is proven that AA batteries are great. The batteries have a lot of power, low internal resistance, cheap and available everywhere. Therefore, combining the use of AA batteries with the conventional use of lithium battery power banks and other principles of electronics, it was possible to construct a portable battery pack.

1.2 PROBLEM STATEMENT

Technology advancement has allowed for electronic devices circuitry to become increasingly smaller while at the same time, the today's user demands for a longer lasting battery. The design engineers have been challenged to increase the efficiency while decreasing the device's power consumption without compromising their performance and cost. However, consumers value speed of the electronic devices trading off the battery life.

1.3 JUSTIFICATION

With technological advances progression, electronic gadgets are increasingly becoming smaller but at the same time becoming more powerful. The demand by the consumer for long lasting yet cheaper battery is a major challenge for engineers to develop increasingly efficient batteries without compromising performance.

Therefore, development of an efficient, affordable external battery pack is a viable market solution. The underlying question has been whether the existing external battery packs meet the consumer desires or not. My project gives the answer to this question however, the current solution is not ideal but efficiency as well as speed has been increased as well as the cost and size have decreased making it affordable to huge user market.

1.4.1 MAIN OBJECTIVE

To construct a Portable Dual USB charger for charging all USB-powered devices.

1.4.2 SPECIFIC OBJECTIVE

To construct a portable Dual USB charger for mobile charging cases during travelling.

1.5 SCOPE AND LIMITATION OF STUDY

To design a portable dual power bank. As a result, this project primarily focused on the design to use both dry cells and a rechargeable lithium battery as the primary energy sources, the appropriate energy conversion techniques as well as output circuit configuration to enable charging USB powered devices. The increased demand for portable energy due to technological growth and innovation called for alternative chargers that are efficient, affordable and available everywhere. The charger needed to be designed in a simple way but with increased efficiency and performance. Even though the charger in this project could step up the battery voltage to the level of the USB voltage (DC 5V), the system efficiency was limited due to small power and voltage. Therefore, the acquired energy from the batteries was limited to small sized portable devices that could be charged by a USB cable.

CHAPTER TWO: LITERATURE REVIEW

2.1 INTRODUCTION

The performance of electronic devices is greatly influenced by the availability of energy. Fast growing population of the world and increased prosperity has led to an increase in the need for energy. To address the problem of charging portable devices in a cheap and easy way, AA batteries and a single rechargeable lithium battery were used as the energy sources. The energy provided from the AA batteries/lithium battery was applied to a step-up DC/DC converter to boost the input battery voltage to sufficient USB output voltage. The USB output port could be utilized for any type of mobile devices to charge their batteries. Battery chargers ensure that the mobile application is active by provision of constant supply of power.

2.2 MICRO USB 3V TO 5V BOOST CONVERTER:

Because the lithium battery (dry cells) only provides 3.7 volts (3 volts) and we need 5 volts to charge the phone, a 3 volt to 5-volt boost converter module was utilized. This boost converter module has a high efficiency of up to 92 percent with overcurrent protection built in. The internal topology is a non-isolated step-up converter with a switch frequency of 1MHz. This module can produce a total power output of 5W. By altering a resistor in the module, the output voltage can be changed to 12V, but the maximum current is limited to 400mA. However, this module comes with a 5V/1A rating by default. The output ripple is 20mV pk-pk under this grade. The module also contains a universal USB type-A female receptacle. As an interface, any USB power cord can be used. The module's operating temperature ranges from -40°C to +85°C. It also contains an LED that indicates the presence of a power supply from the battery. The existence of a power supply across the terminals is indicated by the red color LED.

2.2.1 VOLTAGE CONVERSION

In electronic circuitry, voltage conversion is inevitable whether it is decreasing or increasing voltage because components have different operating voltages. Various ways can be used to convert one voltage to another, particularly stepping down and stepping up. The conversion can be achieved by simple ways such as use of resistors and can also be as complex as using a potential divider designed featuring an internal potentiometer for adjusting desired output.

The latter, which is a liner regulator, has its resistance fluctuating depending with the load of the circuit which results into an output voltage capable keep constant with varying load. However, this technique has poor efficiency because it has huge power losses due to the generated heat. Therefore, the switching regulator idea provides the solution.

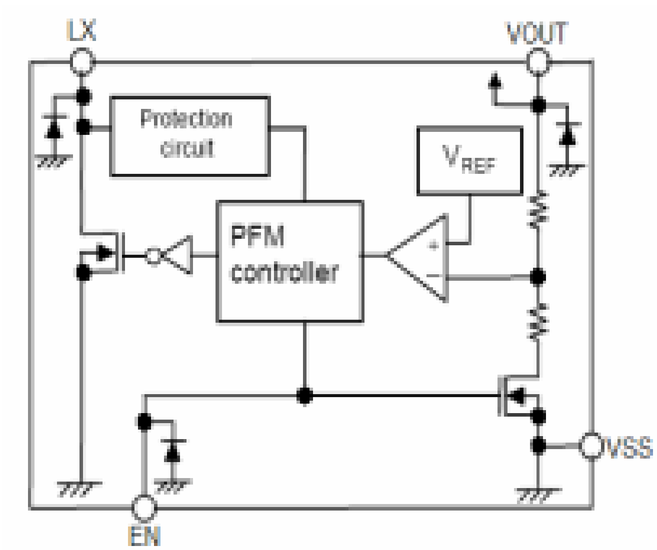
2.2.2 CE8301 CONVERTER CONCEPTS

CE8301 is a step-up CMOS PFM control switching DC/DC converter consisting mainly of a reference source of voltage, a comparator and an oscillator. A switching regulator is a device that repeatedly switches ON and OFF hence utilization of the average output voltage value. The driving factor of the CE8301 is its switching characteristic that makes it highly efficient. The CE8301 is used when the output voltage needs to be greater than the input voltage. The voltage is stepped up while the current is decreased in order to maintain identical power and increase time of charging.

2.2.3 CE8301 OPERATION PRINCIPLES

The PFM controller permits automatic switching of the duty ratio in accordance with the load (high current output: 75%, light load: 50%). This enables a low ripple product over high frequency, wide range and high current output. With CE8301, configuring a switching step up DC/DC converter can be achieved by the use of a capacitor, external coil and a capacitor. A protection circuit is used to turn ON the in-built MOSFET when the LX pin voltage exceeds the limit preventing it from damage. This feature alongside the low current consumption and mini package makes the CE8301 ideal in applications like the power supply unit for portable devices.

figure 2. 1 CE8301 INTERNAL CIRCUIT



2.2.5 CE8301 OPERATION

The CE8301 which is DC/DC step up converter is the engine of the circuit of the battery charger. A minimum of 0.9V is allowed as the input supply. In our case, an input supply of 3V (2 AA batteries or a single lithium battery) is stepped up to 5V and 1000mA.

2.2.6 INDUCTOR SELECTION

For an inductor to be used with CE8301, it must fulfill the following two requirements: Firstly, the inductor should have the capacity to handle a current of 2.5A to 3A minus runaway saturation. Secondly, the inductor should have a DCR lower than 0.5 ohms to maintain low copper loss. Duty cycle of a boost converter can be calculated as;

$$DC = \left(\frac{V_{IN}}{V_{OUt}}\right)$$

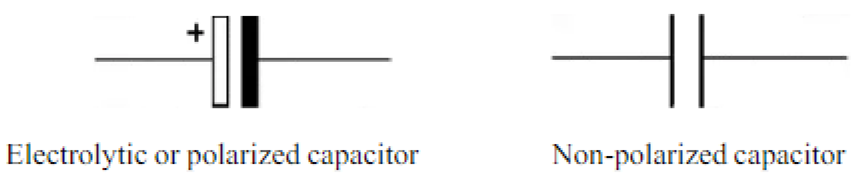
Inductor value is defined by the formula;

$$L \leq \frac{(V_{IN} - V_{SW}) \times t_{ON}}{2A}$$

2.2.7 CAPACITOR

Electrolytic and polarized are the two types. A capacitor is a device that stores electric charge and must be connected in the proper order. In a timing circuit, a capacitor is combined with a resistor. It can also be used as a filter to block AC signals while allowing DC signals to pass through.

figure 2. 2 Capacitor types



2.2.8 CAPACITOR SELECTION

The output capacitor must possess low ESR to ensure proper performance. This is because a high ESR capacitor can cause mode hopping between burst and current modes at high current due to increase in output current by $I_{SW} \times ESR$ when inductor current flows to the diode. Maximum allowable output ESR can be calculated by;

$$ESR_{MAX} = \frac{V_{OS} \times V_{OUT}}{V_{REF} \times 1A}$$

Where;

$$V_{OS} = 15mV$$

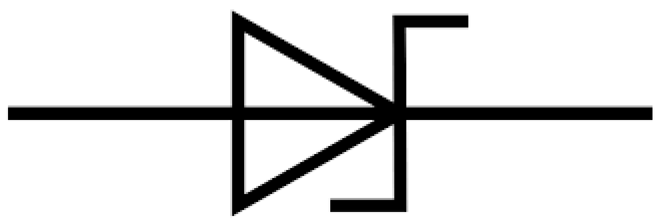
$$V_{REF} = 1.24V$$

A good electrolytic capacitor close to CE8301 must be decoupled with the input capacitor for provision of stable input supply. Long leads from the source of power to the switcher can have significant impedances at the switching frequency of CE8301. At high frequencies input capacitor facilitates low impedances.

2.2.9 SCHOTTKY DIODE

With a low voltage drop of 0.5V and a high forward current of 1A, the SS14 is a surface mount High Power Schottky Rectifier. The diode has a high efficiency and can handle a 30A surge current. It's typically seen in high-frequency inverters and Polarity Protection systems.

figure 2. 3 Schottky diode



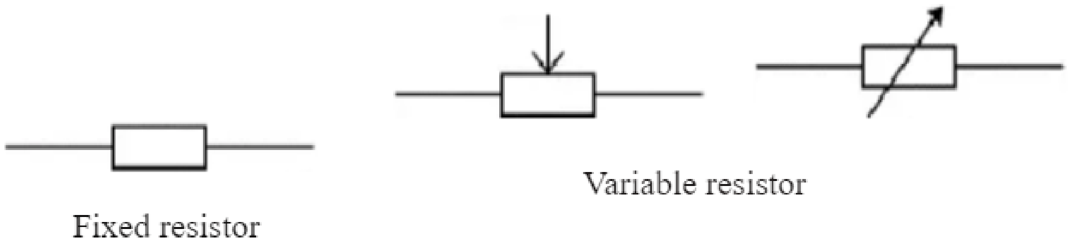
2.2.10 DIODE SELECTION

A Schottky diode is used because of its high switching speeds. General purpose diodes should not be used because they are very slow to be used in switching regulator applications.

2.2.11 RESISTOR

There are two types of resistors: fixed and variable. They are used to prevent current from flowing to other components or devices.

figure 2. 4 Resistor types



2.2.12 TRANSISTOR

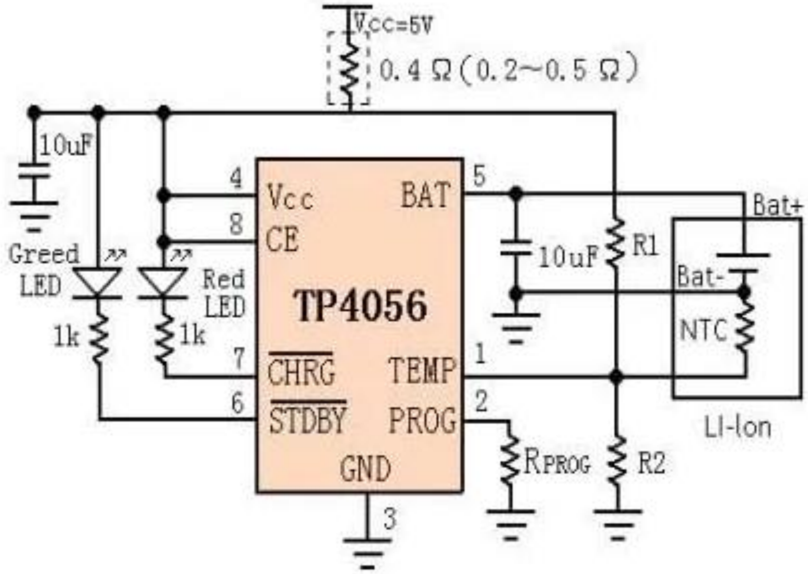
A transistor is a device that amplifies current. It can be used with other components to create a switching or amplifier circuit. NPN and PNP are the two types.

figure 2. 5 Transistor types

2.3. TP4056

This is a low-cost charging system for single lithium-ion batteries of any sort. Mobile batteries, 18650 NMC cells, Lithium pouch batteries, and other types of lithium batteries are available. The micro-B receptacle and easy-to-adjust 1A output current regulation make it a solid option for charging low-capacity batteries. It works with any mobile charger that plugs into a wall outlet, as well as any USB to micro-B cable. It has an integrated PMOS load switch architecture, which means it has less additional components overall.

figure 2. 6 TP4056 Internal Circuit

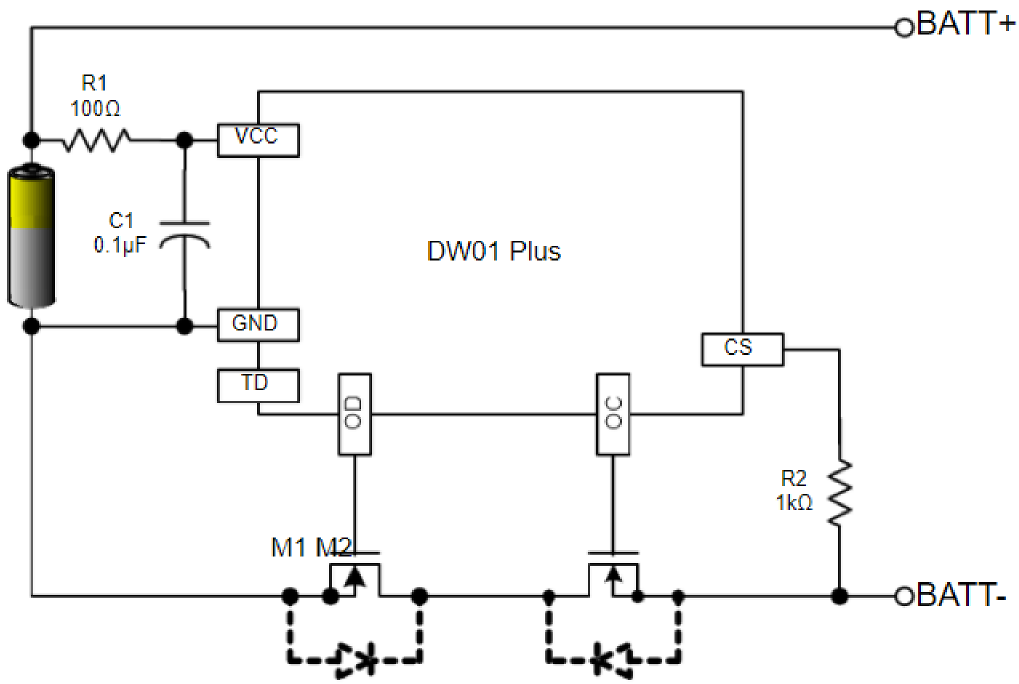


The module also contains two indicators: a red color LED that indicates the charging status, and the completion of charging is indicated by a green color LED. Because the charge current is regulated by thermal feedback, this module may work at high ambient temperatures. The charge voltage is 4.2V, and the current can be modified in the module by adjusting a resistor. When purchased, however, the default current will be 1A.

The protective circuit includes the following components:

i. **DW01x** - Dual MOSFET control single cell lithium-ion battery protection IC. The datasheet includes an application test circuit, which is shown below.

figure 2. 7 TP4056 Protection circuit



ii. **FS8205A-** Dual N-Channel enhancement MOSFET with a shared drain. The resistance between the drain and the source is also low. The DW01A IC is used to control the MOSFET's gate.

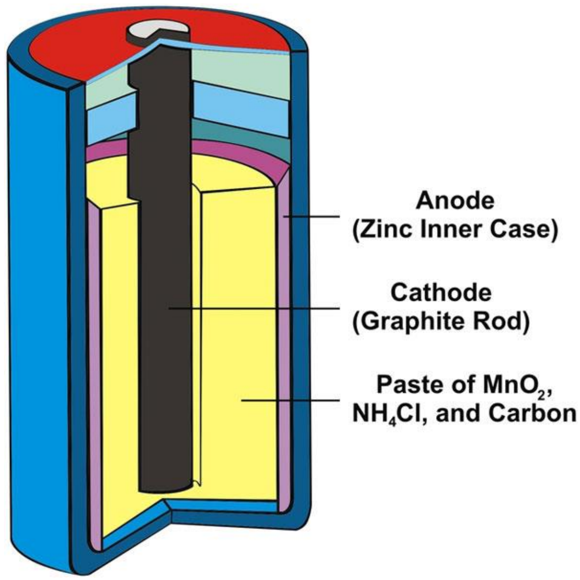
By managing the MOSFET through the circuit, the DW01A provides Overcharge, Over discharge, and Overcurrent control.

2.4 AA BATTERIES

A battery is a device made up of one or more electrochemical cells that transform chemical energy into electrical energy when they are charged. Dry cells are one of many varieties of electrochemical cells available for consumer usage in today's power-savvy world, but they were a remarkable innovation when they were introduced. The original wet-cell batteries were usually delicate glass carriers with lead bars swinging from an open top. They necessitated extra caution to minimize leakage. The invention of the dry-cell battery was prompted by this amount of risk, as well as a variety of other factors.

A dry cell is made out of an immobilized electrolyte paste with just enough moisture to allow the current to flow smoothly. A dry cell, unlike a wet cell battery, can work without leaking since it does not contain free fluid. As a result, dry cell batteries are the greatest choice for practically every portable device.

figure 2. 8 Dry Cell Battery



The zinc-carbon battery is a typical dry-cell battery that is an adaption of the Leclanché cell, a wet cell. The cell is built up of a zinc compartment that serves as the anode, as seen in the figure above. The cathode is a carbon bar completely encased in a carbon, ammonium chloride (NH4Cl), and manganese oxide paste (MnO2).

2.4.1 Dry Cell Battery Types and Applications

An AA battery is a dry cell battery used in a variety of electrical devices. Dry cell batteries are made up of a variety of metals and other compounds and are available all over the world.

Examples include; R6 (carbon-zinc), Lr6 (basic), Kr157/51 (nickel-cadmium), Fr6 (lithium-iron-disulphide), and Hr6 (nickel-metal-hydride).

The standard non-rechargeable AA batteries are the Lr6 (antacid), Fr6 (lithium-iron-disulphide), and R6 (carbon-zinc). Rechargeable AA batteries are the Hr6 (nickel-metal-hydride) and Kr157/51 (nickel-cadmium). Standard non-rechargeable AA batteries have an operating voltage of 1.5 volts, while rechargeable batteries have a voltage of 1.2 volts.

AA batteries are used in a variety of ways. A single AA battery powers the popular Stompers (four-wheel-drive toy automobiles). Another application is as part of a penlight, which is a small-sized pen flash-light that is powered by two AA or AAA batteries. In addition to digital cameras, dry batteries are used in them. Because digital cameras require a lot of energy, users are advised to use AA rechargeable batteries rather than AA non-rechargeable batteries because the cost of using non-rechargeable batteries would be a financial strain.

2.4.2 Handling and Disposal in a Responsible Manner

Batteries frequently include substances that are hazardous if released into the environment. Batteries are accepted at a number of local recycling facilities; however, modern alkaline batteries can usually be dumped with regular trash. Buyers should also consider using rechargeable batteries, which may be reused and then recycled, reducing the amount of waste going to landfills.

2.5 EXISTING SOLUTIONS

Among the existing solutions are power banks of which they contain in-built lithium-ion batteries and supply power via a USB port The power banks can as well be charged through the same USB port hence they are re-usable and can charge multiple devices when they run out of battery. Even though the existing power banks can be used on several devices and have large capacities of power storage, they need to be charged from time to time when they run out energy. The lithium batteries in the power banks are also uncontrolled during their recharging which possess a high risk. The battery charger proposed in this project can be used to charge the existing power banks once they run out charge. One battery charger can be used to charge several power banks in case multiple power supply is needed. The proposed battery charger also provides option for use of rechargeable lithium batteries but in this case the lithium battery recharging is controlled by use of TP4056.

CHAPTER THRE: METHODOLOGY

3.1 DESIGN

There are many alternative solutions including use of linear regulators however, linear regulation has a very low efficiency and cannot be used to turn 3V to 5V. Therefore, switching regulation by use of a booster converter is chosen for the design and implementation of this project. The circuit makes use of a booster converter to amplify the given DC voltage.

The designing process begins with analysis of the CE8301 datasheet. The 3-pin structure of CE8301 should be provided with correct levels of voltage for the converter to perform as desired. Using CE8301 pin information, schematic and the test jig is presented by LTSpice software, the purpose and analysis of each component is performed.

figure 3. 1 SCHEMATIC REPRESENTATION

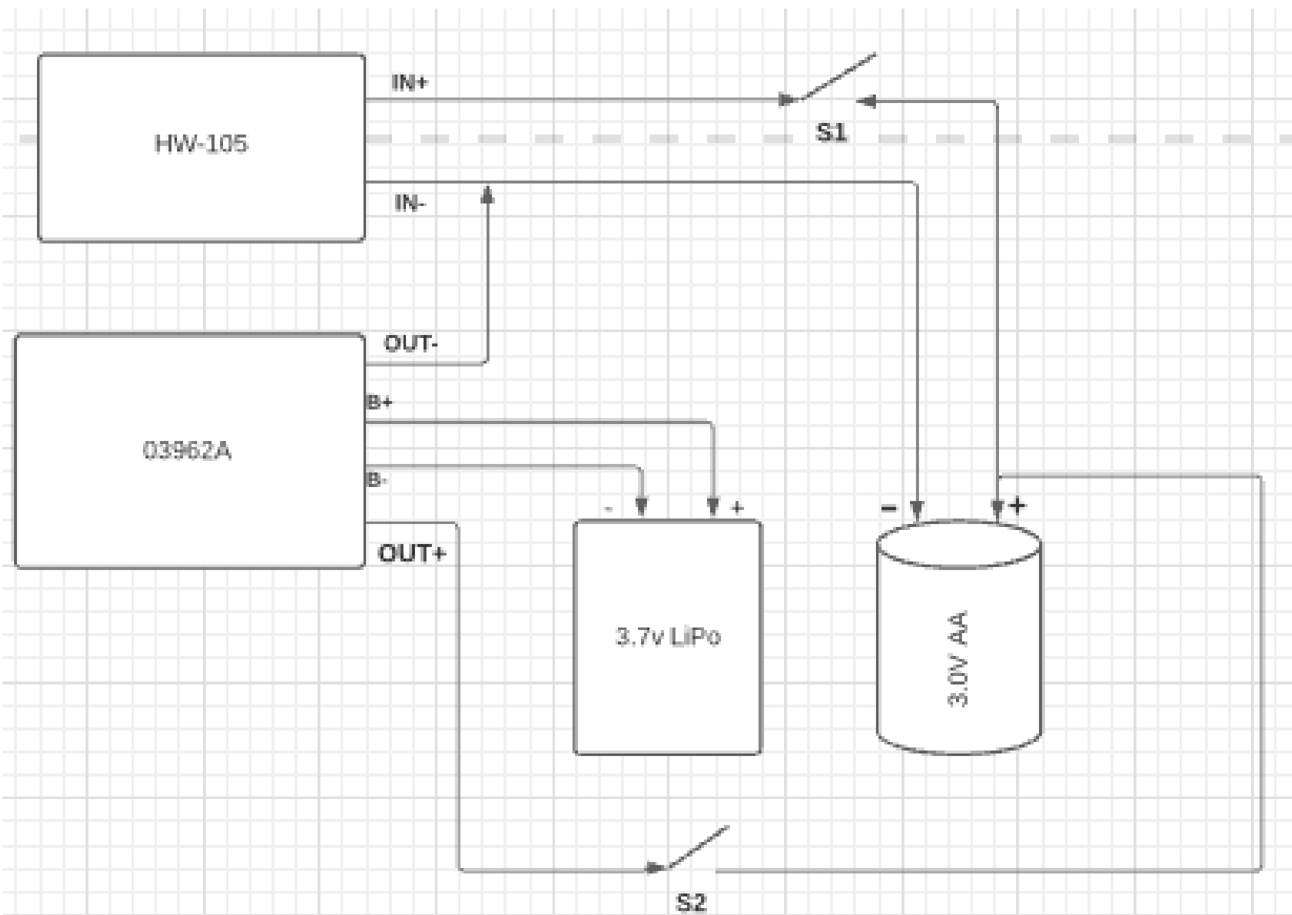
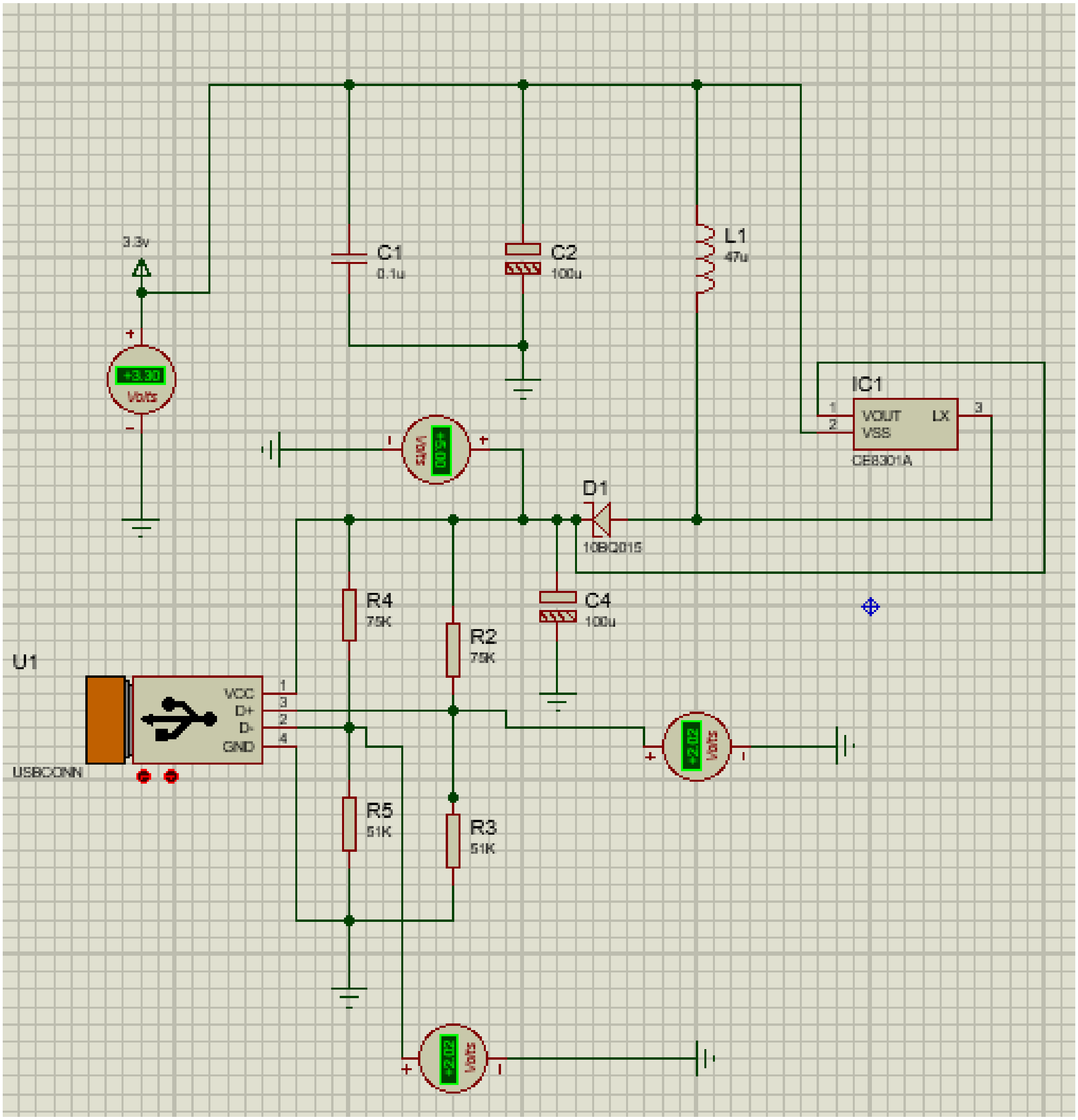


figure 3. 2 SIMULATION



3.3 CIRCUIT DESCRIPTION

The main circuit ends at capacitor C4 and this is the point where the output voltage is tapped. Voltage test at TP1 ought to range between 4.8V and 5.2V. At TP1, the voltage must be greater than 3V. The circuitry connected to output voltage at C4 configures the USB port. The USB type A female jack has four points of connections; D+, D-, VCC and GND. The GND and VCC pins are the power rails while D- and D+ are data rails. Vbus connects to the output of the circuit ≈ 5V. Since the USB is for charging, the data rails need to be connected to a potential higher than 0V but lower than VCC. Therefore, a potential divider network is necessary and is created by R2, R3 (at D+) while R4, R5 (at D-). TP2 and TP3 points are used to check the voltages at the divider outputs. The voltage should be approximately 2V.

3.4 LIST OF MATERIALS USED

3.4.1 EQUIPMENT USED

Soldering iron	Veroboard
Lead	USB connector
Breadboard	Battery casing
Plier	Terminal connector
Wire stripper	Component Used
Cutter	Schottky diode
Earthing clip	Capacitor
De-soldering pump	Inductor
Electrician knife	LED
Battery	ON/OFF switch

Table 3. 1 CIRCUIT ELEMENTS

Element	**Description**
IC1	CE8301
U1	USB Type A female jack
R2, R4	75K
R3, R5	51K
C1	0.1 μ F
C2, c4	100 μ F
L1	4R7
D1	SS14
Battery Holder	2 × AA Battery Holder
Prototype case	Custom case
IC2	TP4056

3.5 CIRCUIT ELEMENTS DESCRIPTION

3.5.1 CE8301

The CE8301 integrated circuit is a micropower DC/DC step up converter. Minimum allowed input supply voltage is 0.9V and maximum output current is 1A.

3.5.2 USB FEMALE JACK

This is a type A jack and can fit on any kind of PCB. Type A USB to microUSB cable connects to external devices.

3.5.3 SCHOTTKY DIODE

Schottky diode (SS14) was used due to the switching regulator type application. Schottky diodes have high switching speeds as well as negligible forward voltage drop. The normal diodes such as IN4001 are non-suitable.

3.5.4 L1

Inductor L1 holds current and releases it into the output capacitor. The inductor must be capable of holding at least 1A current. 4R7 inductor was used.

3.5.5 C4 and C2

C2 and C3 electrolytic capacitors eliminate any AC ripples

3.5.6 C1

C1 is a bypass capacitor. C1 stabilizes the output as well as shorting to ground any Ac signal i.e., filters noise signals.

3.5.7 Batteries

The AA batteries supply the power used. 2 batteries each 1.5V connected in series to give 3V which is used as the input supply.

3.5.8 TP4056

The TP4056 chip is a single-cell lithium-ion battery charger that protects the cell against overcharging and undercharging.

3.6 SIMULATION

The LTSpice software is used to simulate the converter. Simulating the converter is significant because it provides evidence and theoretical values proving that the mobile charger will remain within the outlined technical specifications

The charger circuit is to be simulated in the proteus software. The proteus software illustrates how the circuit will function in real life and also allows to check for the voltages and current at the test points to the expected outcomes and validate the performance of the designed circuit.

3.7 BREADBOARD TEST

The individual components are connected to create an equivalent circuit on the breadboard. The breadboard test is used to eliminate doubts and inconsistencies simulation prior to actual fabrication. The output from the AA batteries connected in series is used. The operating voltage from the converter is 1.5v and the operating current is 600mA. The output current is tapped from female USB jack and passed to the device to be charged for example a smart watch.

3.8 CONSTRUCTION TEST

After assurance level of simulation in proteus and breadboard test from preliminary trials is attained, the individual elements are soldered to construct the device.

The components to be used in the proposed design and the copper board are needed for the construction test. The first step involves figuring out how the required components are to be integrated onto the copper board made specifically for the LT1302 IC chip. The location of the elements to be connected to the IC pins are also determined since the chip has a predetermined set location. A soldering wire and iron are used to connect the components in the specified manner. The USB voltage divider should also be created. The divider enables for the connection of data pins to different levels of voltage.

3.9 PACKAGING OF THE DEVICE

Packaging the mobile charger is very important. An electronic package is required to provide a case for the charger. A drill gun will be used to make holes in the packaging case for the female

USB outputs, the inputs and holes to stabilize the board and make it secure in the case. The case allows for the leads to be connected without exposing the inner device circuitry.

CHAPTER FOUR: RESULTS AND DISCUSSION

Following the construction and testing of the various modules (charging module, power storage, and mobile charging module), they were enclosed in a plastic casing as shown below.

figure 4. 1 Enclose plastic case with switch

Figure 4. 2 picture of different modules

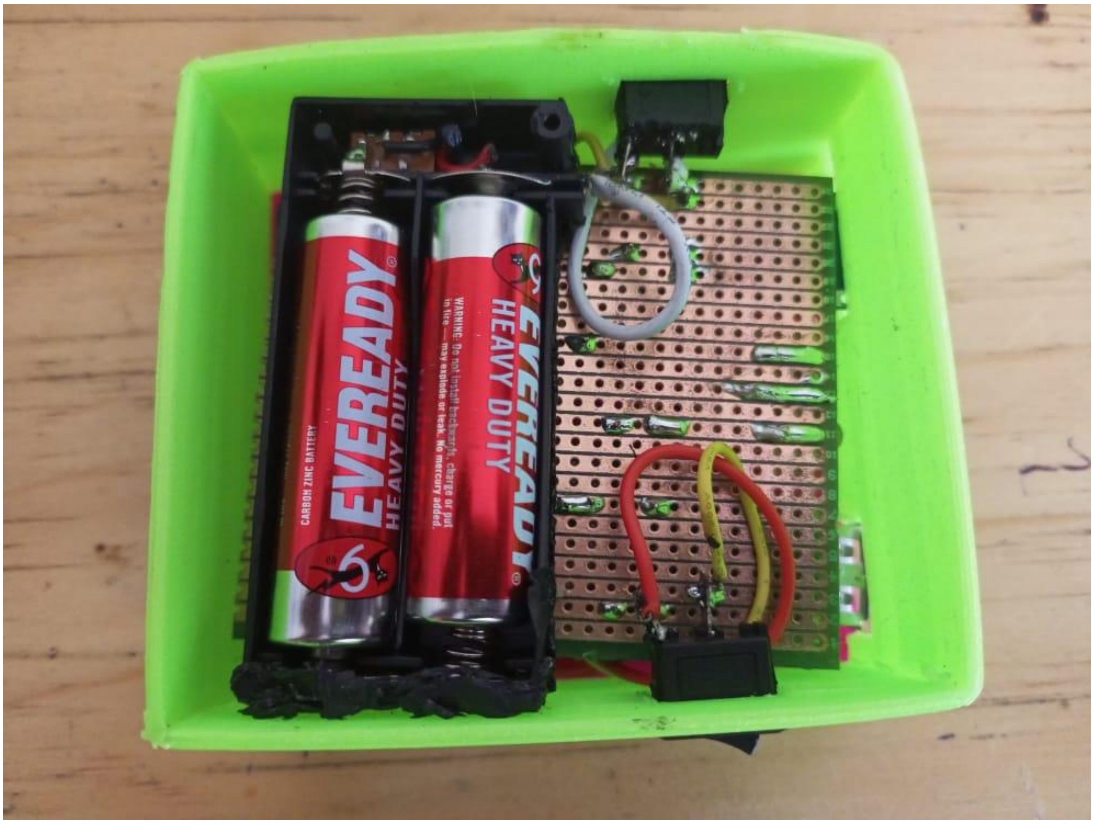


figure 4. 3 Back side showing position of the dry cells

figure 4. 4 side view showing I/O ports

When the charging module is turned on, the power bank has a USB connector interface through which the module device can be connected for charging.

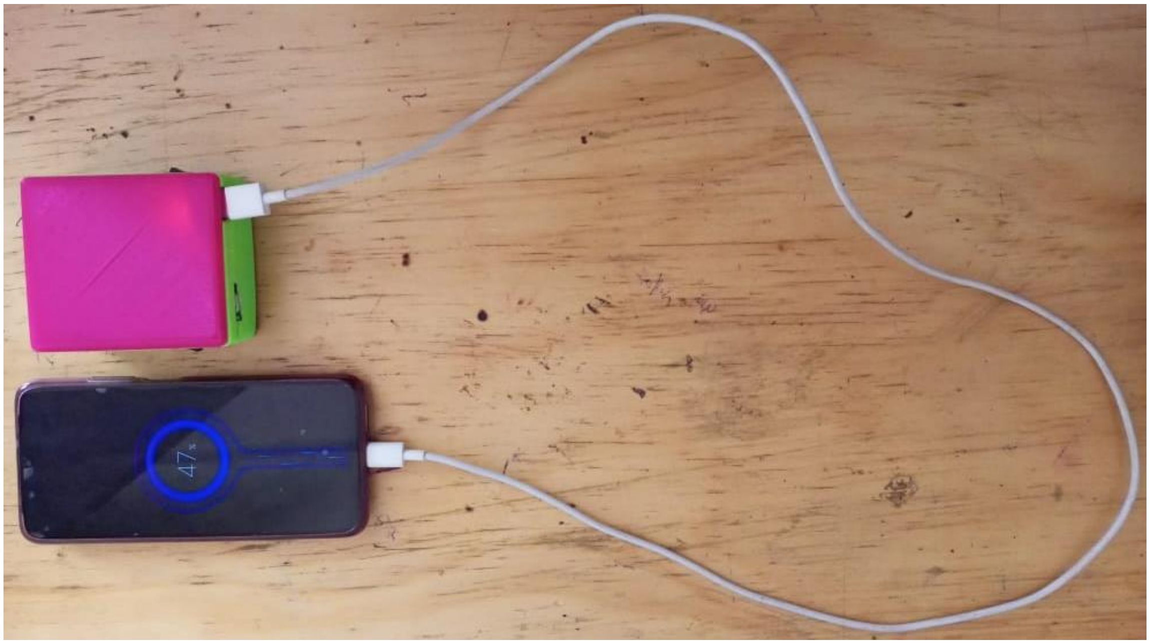


figure 4. 5 The constructed power bank charging a smartphone

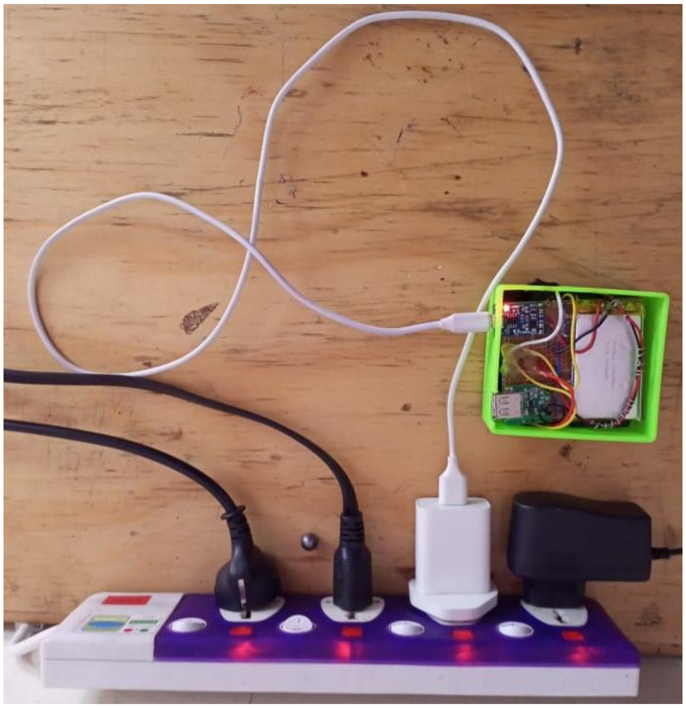
For a variety of gadgets, this charger delivers lightweight, high energy density power sources. Some examples of such gadgets are:

Smartwatches, blood pressure monitors, glucometers, heart monitors, brain-sensing headbands, pain treatment devices, thermoguns, mobile phones, cameras, and other portable equipment.

More advanced technology leads to more advanced people living their lives, which in turn leads to more advanced technology. People move more quickly as a result of this. People can move more with the support of a power bank because it is effective and efficient. It is essential for anybody who uses their gadgets, whether they be smartphones, smartwatches or other health monitoring device. Home based patients, for example, need to communicate with the physician at any time because information moves at a rapid pace, and the physician need that information to make critical prescriptions. If our device(s) has a low battery during such time, a power bank comes in handy.

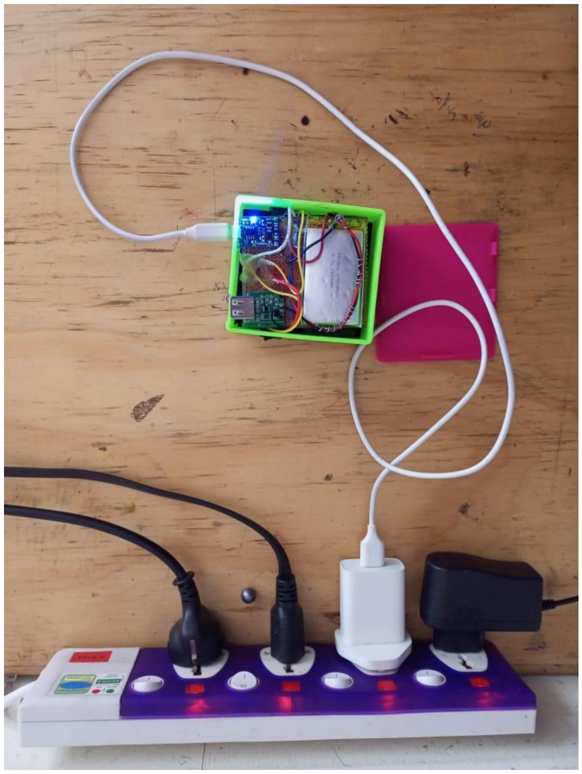
Another illustration of the utility of a power bank is witnessed during an emergency. An emergency is a situation that cannot be predicted ahead of time. However, if an emergency occurs, it is critical to communicate with authorities or family members. If our device(s) has low battery power at that moment, a power bank comes in handy.

figure 4. 6 Recharging the lithium battery (Red LED indicates charging)



When the power supply plug is plugged into a 240V AC outlet and the power switch is turned on, a red indicator illuminates, indicating that power has been given to the circuit and the battery charging module has begun charging the battery. The red LED turns off when the battery is fully charged, the blue LED turns on, and the relay turns off, preventing the battery from being overcharged.

figure 4. 7 Recharging the lithium battery (Blue LED indicates full charge)



CHAPTER FIVE: CONCLUSION AND RECOMMENDATION

The system was found to play a vital role especially in mobile charging cases during travelling. AA dry cells are cheap, possess lots of power, have low internal resistance and are easily available everywhere. Therefore, we can consider AA dry cells as a substitute for the conventional AC power from the mains. The capacities of the DC voltage supplied by the AA batteries can be upgraded. This circuit has a unique advantage in that it enables charging of our gadgets more efficiently with an expended compatibility range. Furthermore, the final circuit is relatively small in size, making it suitable to be used as a portable emergency battery charger.

Since batteries frequently include substances that are hazardous if released into the environment, it is my recommendation that buyers should consider taking the used-up batteries at local recycling facilities for recycling to reduce the amount of waste going to landfills. Future works can be done focusing on the use of clean energy such as solar energy in order to conserve the environment.

Table 5. 1 PROJECT TIME PLAN

Activity	Week																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Research																				
Overview																				
Parts list																				
Design																				
Simulation																				
Order parts																				
Fabrication																				
Test																				
Results																				
Analysis																				
Demo																				
Documentation																				
Presentation																				
Submission																				

Table 5. 2 BUDGET

Element	**Description**	**Price**	**Quantity**	**Total**
IC1	CE8301	$ 2.00	1	$ 2.00
IC2	Tp4056	$1.2	1	$1.2
U1	USB female jack	$ 0.50	1	$ 0.50
R2, R4	75K	$ 0.10	2	$ 0.20
R3, R5	51K	$ 0.10	2	$ 0.20
C1	0.1 μ F	$ 0.50	1	$ 0.50
C2	100 μ F	$ 0.50	1	$ 0.50
L1	47 μ H	$ 0.30	1	$ 0.30
D1	1N5818	$ 0.50	1	$ 0.50
Connectors	Connector wires	$ 2.00	1 pack	$ 2.00
Circuit Board	Custom PCB	$ 2.50	1	$ 2.50
Batteries	AA Battery	$ 0.50	2	$ 1.00
Casing	Acrylic protective case	$ 5.00	1	$ 5.00
Lithium Battery	3.7v 1200mAh	$7.00	1	$7.00
Switch	ON/OFF	$ 0.2	2	$ 0.4
Total				$ 24.0

REFERENCES

1. Wong, K. H., & bin Daud, M. Z. (2020, December). Thermoelectric Generator for Charging Mobile Devices. In *2020 IEEE International Conference on Power and Energy (PECon)* (pp. 29-34). IEEE.
2. Wong, K. H., & bin Daud, M. Z. (2020, September). Simulation Studies on Converter for Thermoelectric Generator Mobile Charger. In *2020 IEEE Student Conference on Research and Development (SCOReD)* (pp. 1-6). IEEE.
3. Ouremchi, M., El Alaoui, M., Farah, F., El Khadiri, K., Qiidaa, H., Lakhssassi, A., & Tahiri, A. (2018, December). Li-Ion Battery Charger Based on LDO Regulator for Portable Device Power Management. In *2018 6th International Renewable and Sustainable Energy Conference (IRSEC)* (pp. 1-4). IEEE.
4. Wu, S. T., Chen, J. Y., & Cheng, Y. T. (2020, September). A Lithium-Ion Battery Charger with Portable Monitoring Function. In *2020 IEEE International Conference on Consumer Electronics-Taiwan (ICCE-Taiwan)* (pp. 1-2). IEEE.
5. Kularatna, N. (2011). Rechargeable batteries and their management. *IEEE Instrumentation & Measurement Magazine*, *14*(2), 20-33.
6. Al-Mashhadany, Y. I., & Attia, H. A. (2015). High performance for real portable charger through low power PV system. *International Journal of Sustainable and Green Energy*, *4*(3-1), 14-18.
7. Ahmad, I., & Fernandes, B. G. (2020, October). Concept of Universal USB Charger. In *2020 IEEE Industry Applications Society Annual Meeting* (pp. 1-5). IEEE.
8. Kothari, A., & Rajashekar, J. S. (2016, February). Portable Solar Battery Charger for Backpacks. In *National Conference* (p. 160).

9. Attia, H. A., Getu, B. N., Ghadban, H., & Mustafa, A. K. A. (2014). Portable solar charger with controlled charging current for mobile phone devices. *Int. J. of Thermal & Environmental Engineering*, *7*(1), 17-24.

10. Addo, C. K. (2017). *Design and construction of a solar cell phone charger with battery bank* (Doctoral dissertation, University of Education, Winneba).