

UNIVERSITY OF EDUCATION, WINNEBA
COLLEGE OF TECHNOLOGY EDUCATION, KUMASI

DESIGN AND CONSTRUCTION OF SELF- RUNNING PULSE BATTERY
CHARGER USING SOLID- STATE DEVICES

KUPPAH KINGSFORD KWAKU

DECEMBER, 2016

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**A Dissertation in the Department of ELECTRICAL/ELECTRONICS
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to the School of Graduate Studies, University of Education, Winneba in partial
fulfillment of the requirements for the award of Master of Technology Education
(Electrical/Electronic Technology) degree.**

DECEMBER, 2016

DECLARATION

STUDENT’S DECLARATION

I, **Kuppah Kingsford Kwaku**, declare that this dissertation, with the exception of quotations and references contained in published works which have all been identified and duly acknowledged, is entirely my own original work, and it has not been submitted, either in part or whole, for another degree elsewhere.

SIGNATURE:

DATE:

SUPERVISOR’S DECLARATION

I hereby declare that the preparation and presentation of this work was supervised in accordance with the guidelines for supervision of Dissertation as laid down by the University of Education, Winneba.

NAME OF SUPERVISOR: **MR. FRANCOISE SEKYERE**

SIGNATURE:

DATE:

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May God richly bless you all.

DEDICATION

This dissertation is dedicated to the Almighty God and to my lovely son, King Darius Sam.

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ABBREVIATIONS

Alternating Current	AC
Ampere-Hour	AHr
Battery one	B1
Battery two	B2
Capacitor one	C1
Capacitor two	C2
Cathode ray oscilloscope	CRO
Circuit Board	CB
Collector Current	IC
Direct Current	DC
Digital Video Disc	DVD
Diode one	D1
Diode two	D2
Diode three	D3
Diode four	D4
Electromotive force	e.m.f.
Forward Current	IF
Ghana cedi	GH¢
Greenhouse gases	GHG
International Energy Agency	IEA
Information Communication Technology	ICT
Integrated Circuit	IC

Light Emitting Diode	LED
Main Coil	MC
Neon	N
Peak Inverse Voltage	PIV
Printed Circuit Board	PCB
Reverse Current	IR
Resistor one	R1
Resistor two	R2
Resistor three	R3
Resistor four	R4
Resistor five	R5
Rural Electrification	RE
Switch	S
Transistor	T
Televisions	TVs
Vero Board	VB
Volts	V

ABSTRACT

The self-running pulse charger was designed and constructed using solid-state devices to produce pulse current for charging lead acid batteries. The aim of this research is to reduce the use of kerosene lanterns by rural dwellers and aid pupils to study at night in off-grid communities which do not have electricity. A coil of 200 turns, MJ11016 FET, NE555 IC and various values of resistors, capacitors and diodes were soldered on a printed circuit board (PCB) to ensure proper electrical connection. Digital voltmeter, capacitor and a 12V battery were used to record the pulses. The design was tested by various transistor/coil pair with different battery ratings to determine the output pulse strength of the device. The final results showed that the pulse charger with a coil of large number of turns had strongest output pulses. This will allow for fast charging of the battery there by increasing its efficiency. It is therefore recommended that a coil of 200 or more turns could be paired with MJ11016FET to design the pulse charger.

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

The modern world majority depends on electricity. Most gadgets (for example electric light, radio sets, computers, phones) in this era rely on electricity for their operation. Electricity has become an essential component of life. Currently, most citizens of developed countries take electricity for granted while third world or developing nations suffer from insufficient power generation and supply. There are many rural communities in these developing countries that do not have electricity connection. They are cut off from the national electricity grid due to their location. Ghana, for example, has approximately 2000 of these remote communities while it is estimated that there are up to 40,000 of such communities globally (World Bank Report, The Welfare Impact of Rural Electrification 2008).

However, over the past two decades, World Bank investment projects and other programs have made impressive gains in improving electricity accessibility to electricity in developing countries. Yet, nearly 1.6 billion people across developing nations do not have access to electricity –out of this number, more than 300 million homes, in both urban and rural areas remain without electricity (IEA 2006).

Furthermore, nearly 260 billion rural households are without electricity, many of these households are in isolated communities located too far away from the national grid. These ‘off-grid’ communities are generally small and scattered all over the country. They

consist of low-income households which are economically unattractive to government electrification programs that must prioritize the allocation of scarce resources. Consequently, alternative sources of energy such as solar, wind and self-running battery charger must be utilized to provide electricity to such off-grid communities.

In this vain, the government of Ghana is committed to increasing the country's rural electricity supply. Following independence in 1957, the pace of rural electrification (RE) had been slow owing to the fact that government had to focus on the industrial sector. As a result by 1970, the number of rural areas with electricity had grown by only (1%). However, the World Bank in its structural adjustment in the early 1980's prompted the government to shift its focus to rural electrification. In order to accomplish this, in 1989 the self-help electrification program was set up where the rural communities acquired the electric poles by themselves and the government then funded the rest of the project. (Barfour, 2013).

Yet, despite the rapid urbanization of parts of the nation, about three quarters of Ghana's population still reside in rural areas. Most rural inhabitants continue to rely predominantly on traditional biomass fuels to meet most of their energy needs. For cooking, most rural households use firewood, crop residue while some use kerosene. Kerosene is the primary energy source for households without electricity source as it is to power lanterns or lamps. Thus even among households with electricity, kerosene is an important backup lighting source. Additionally, kerosene serves as backup source for households with electricity. Hence it is not surprising that kerosene is used by the vast majority of rural households.

The goal of RE programs in developing countries goes beyond providing rural households affordable modern energy at a cheaper price than inferior alternatives over the long run. RE is expected to improve rural people's quality of life and spur growth on a range of socioeconomic fronts. As a replacement for kerosene, base lighting sources, electric lighting substantially reduces indoor air pollution and carbon emission. In addition, it allows school-going children to read during evening hours, thus encouraging more hour of study. Furthermore, it benefits income generating activities through business operations being able to stay open longer and promoting productive uses (Martins, 2005).

The benefits of RE, are well known and have been extensively studied. For individual households, the advantage is the shift from traditional to modern lighting systems, typically from kerosene lamps to superior quality electric lighting. Poorer community members benefit indirectly from the power provided to schools, health centers, water-supply systems and communication facilities. Off-grid electrification also stimulates the aeration of micro enterprises which increases overall economic benefits.

Additionally, the benefits of replacing kerosene with electricity extend beyond a higher-quality lighting source. Switching to electric lighting also serves as a medium to eliminate indoor air pollution (IAP) caused by the smoke emitted from kerosene lamp, which in Africa accounts for about half a million premature deaths annually. (Smith, 2000)

Rural electrification (RE) greatly improves the quality of life for rural inhabitants. Electricity bring benefits such as increased study time and improved study environment for school children, extended hours for small businesses, and provides greater security. Furthermore, electrification brings both entertainment and information as television sets are powered. (Gustavsson, (2007).

As result of the immense advantages of electricity, many rural dwellers are willing to pay for it. According to a World Bank report, willingness to pay for electricity is high, exceeding the long-run managerial cost of supply, hence, in principle, (RE) investments can have good rates of return and be financially sustainable.

Lighting and television account for at least 80 percent of rural electricity consumption and therefore constitutes the bulk of the benefits delivered by (RE). Fans and irons are also used by a minority of consumers. Another potential benefit to be gained from RE is that, it can put a stop to the use of firewood and kerosene stoves.

Electricity is also used in community health facilities – notable for the cold chain for vaccines. The positive impact of RE on service provision is augmented by the great willingness of health and education workers to stay in communities which have electricity. RE can provide a fresh impetus to small scale home run businesses, even though few households use electricity for productive purposes. There is significant growth in the number of enterprises in communities as a result of electrification and these enterprises are able to operate for more hours. This, therefore, positively impacts household income.

However, in spite of the numerous benefits of RE outlined above; there are many rural communities in Ghana which are not connected to the national grid. These typically small and isolated communities generate much or all of their electricity using diesel generators. While diesel generators may have a relatively favorable capital cost, they have exceptionally high operating cost due to their low efficiency, in addition to the high cost of transporting diesel fuel to remote communities which have very bad and sometimes immotorable roads. Also diesel prices are expected to increase in the coming years. (Davidson, & Mwakasonda (2004)).

Moreover, when fossil fuels such as diesel are burned they raise the level of carbon dioxide in the atmosphere which affects the ozone layer.

Another effect of burning fossil fuel is emission of greenhouse gases (GHG) which contributes to greenhouse effect consequently increasing factors for global warming. Scientists agree that even a small increase in the global temperature would lead to significant climate and weather changes, affecting cloud cover, precipitation, wind patterns, the frequency and severity of storms.

Rise temperatures would also cause a rise sea levels as well as reduce the supply of fresh water worldwide as flooding occur along coastlines, salt water is transported inland. Millions of people would be effected, especially poor people who live in insecure locations like cocoa growing communities. To lessen those long-term effects, many nations, communities and individuals are taking actions to reduce greenhouse gas emission in order to slow down global warming by reducing dependence on fossil fuels and increasing the use of renewable energy.

Renewable energy such as wind, solar and fuel cell are particularly attractive for rural communities since they offer a clean source of power. However, these issues of GHG emission, high cost of diesel and the costly nature of renewable energy can be addressed by designing a simple and cost effective self-running pulse battery charger. This charger can be used to power homes in rural communities. The pulse battery charger is capable of running a battery for a longer period of time when compared to other means of battery charging such as trickle charging.

The large body of literature on the benefits of rural electrification shows that rural electrification greatly contributes to the welfare and growth of rural households (ADB 2010; Barnes, et al 2003; Cockburn 2005; Khandker 1996; Martins 2005).

A number of studies conducted by the World Bank indicate that rural communities are willing to adapt modern ways of generating electricity for their socio-economic well-being and also reduce their dependence on firewood and kerosene.

However, no concerted effort has been made to design a cost effective and efficient device to serve as alternative source of electricity in remote communities in Ghana especially in cocoa growing areas. It is in view of this that this research seeks to design and construct simple device for pulse charging of a battery or a bank of batteries.

1.2 Statement of the Problem

The amount of electrical current a battery can produce is limited by the amount of chemical reaction which can take place within it. When chemical reaction in a battery has ended through defect or long use, the battery is discharged and can no longer produce a

flow of electrical current. A battery charger is device used to put energy into a secondary cell or rechargeable battery by forcing an electric current through it (Francis 1981, Deere 1984).

There are many methods of charging cells and batteries such as constant-current, trickle, floating, constant-voltage, etc. However, these methods of charging batteries are not efficient and cannot be used in rural areas without electricity. Due to these problems, most of the rural dwellers in the off-grid communities resort to the use of generator sets to charge batteries or send them to the cities for charging. With the high cost of the generator sets and the increasing cost of fuel makes it expensive to charge batteries in these communities.

One way of minimizing the high cost of charging batteries is to design a simple self-running pulse charger with electronic components which can be used to charge batteries in rural areas. The benefit of using this charger is in two folds; firstly, it will allow for fast charging and increase the efficiency of the battery and secondly, reduce the cost of charging batteries in the rural communities. Thus designing the self-running pulse battery charger is appropriate.

1.3 Objectives of the Study

1. To design and construct a self-running battery charger to pulse charge lead acid batteries using electronic devices.
2. To increase the charging efficiency of lead acid batteries
3. To reduce the cost charging battery using pulse charger.

1.4 Significance of the Study

The study is to explore the use of solid state-devices to produce pulses to charge battery in off-grid communities to reduce their dependence on kerosene lantern. It will also increase the efficiency and the charging rate of the battery which are of prime importance in the battery charging industry.

1.5 Hypothesis

1. Pulse charging battery may be better than floating/trickle charging in terms of efficiency
2. There will be significance difference between pulse charging and floating/trickle charging in terms of charging period.
3. Pulse charger will improve the life cycle of lead acid battery

1.6 The Scope of the Design

This project should have been designed to pulse charge batteries rated at 24V, 48V and above. However, due to unavailability of certain components on the local market, the project was limited to batteries rated at 12V and below.

1.7 Limitations

The major limitations during the construction of this project were unavailability of some of the components such as IC and Transistor on the local market and financial constraints for importing them to Ghana. Changes in environmental conditions also affected the component value thereby giving different values than recorded on the data sheet. These affected the design process and the performance components.

1.8 Project Organization

This project work will consist of five chapters. Chapter One consists of background to the study, problem statement, objectives, hypothesis, significance of the study, scope and the limitations. Chapter Two presents the literature review. Chapter Three on the other hand, discusses the methodology used for this study. Chapter Four then presents the results of the project and discusses them. Finally, Chapter Five presents the conclusion and recommendations for the study.

CHAPTER TWO

LITERATURE REVIEW

This chapter focuses on reviewing related literature the subject of this research. The benefits and advantages of using self- running pulse battery charger as an alternative source of power for rural communities are also discussed. It will also examine the existing methods of battery charging systems. These will guide the direction of this project and aid in exploring new methods of charging battery.

2.1 Historical Background

A battery, which is actually an electric cell, is a device that produces electricity from chemical reaction. People like Alessandro Volta (1745-1827) and Luigi Galvani (1737-1789) carried out the research that led to an electrochemical energy storage device. As a result their names live on as ‘volts and galvanic cell (Theraja and Theraja 2005). In 19th century, Volta worked in close collaboration with the French National Institute to further improve the battery. The first battery suitable for mass production was developed in 1802 by the chemist Dr. William Cruickshank. The various batteries developed at this time were all primary cells, and so could not be recharged. In 1859 the French physicist Gaston Plante used conductor plates in dilute sulfuric acid, which led to the first rechargeable battery.

During the industrial revolution the development of electro-chemical energy storage devices gathered pace. Large-scale production of rechargeable lead acid batteries as described by Theraja and Theraja 2005 started around 1880, when Emile Alphonse

Faure' developed a process in which the lead battery reach a high capacity after just a few number of charging cycles. In the following decades batteries and battery chargers underwent further developments.

It is possible to draw substantial amounts of energy from the local environment and use that energy to charge batteries. When this method of charging is used, the batteries gradually get conditioned to this form of non-convectonal energy and their capacity for work increases. Additionally, about 50% of vehicle batteries which have been abandoned for being incapable of holding their charge any longer, will respond to this type of charging and be revived (Kelly, 2010).

However, it is not practical to use power homes. Firstly, lead-acid batteries produce acid when they are repeatedly charged. This is harmful to home environment. Secondly, it is not recommended to discharge batteries for more than a twenty hour (20hr) period.

This means that a battery rated at a capacity of 80Amp-hours (AHr) should not be required to supply a current of more than 4amps. This restriction makes the operation of batteries for power generation impracticable, except for very minor loads like lights, TVs, DVD recorders and similar equipment with minimal power requirements. The development of the .current charging system provides a very good and simple charging method which uses 'cold electricity'. This addresses the constraints imposed by using batteries with regard to current drawn and charging time.

According to Patrick Kelly (2010) through extensive experiments with the Tesla switch circuit, it was discovered that when a battery was fully conditioned to use cold electricity, that could be disconnected, discharged independently to its fully capacity, and recharged fully in less than one minute. This style of operation as stated by Kelly completely deals with the objection to using battery banks to power household equipment of any power. Roger Andrew (2011) in his paper discusses a magnet-triggered boosting pulse for magnetic spinning tops to spin 9 shallow dishes.

Also according to Ronald Knight (2001) when batteries are conditioned by repeated cycles of charging and discharging the capacity of the batteries being charged increases. Ron Pugh (2004) also experiments with John Bedini's invention and design a pulse generator for pulse charging batteries by using solid state devices. Furthermore Alexkor in 2003 designed a battery charging system which was very effective, cheap and easy to build. It was constructed based on EMF in magnetic fields and pulsing in coils.

Also Howerd Haley (2003) stresses the major difference between 'conditioned' batteries and all other batteries which have not been conditioned. He notes that "to condition a battery, it needs to be repeatedly charged with 'cold' electricity and discharged again". He further stated that 'cold' electricity is either high frequency AC electricity or alternatively a pulsed DC at high voltage.

2.2 Battery Charging Methods

A battery can be discharged and recharged many times in each cycle, the charging process stores energy in the battery in the form of potentially reactive compounds of sulfuric acid, lead and oxide. Forcing a direct current (dc) into the plates during this charging process is essentially the reverse of the discharge. The effect on the electrolyte and the plates during this charging process is essentially the reverse of the discharging process.

Lead sulfate at the plates and the water in the electrolyte are broken down into metallic lead, lead dioxide, hydrogen and sulfate ions. This re-creation of plate materials and sulfuric acid restores the original chemical conditions including, in time, the original specific gravity. According to John Deere (1984), the amount of energy it takes to recreate the original specific gravity is, of course at least the same as the energy produced by the chemical reactions during discharge. This energy is supplied by the charger in the same form that it was removed from the battery: as volts and ampere-hour (or kilowatt-hours). This means that, if the battery produced 36 kilowatt-hours during discharge, it takes at least 36 kilowatt-hours to recharge it, plus additional kilowatt-hours to make up for losses in the energy-transfer process.

There are numerous methods for charging batteries, however, the basic methods of charging batteries include; constant -current, constant-voltage, trickle, floating, pulse, etc. (Scaddan, 2008).

Constant current chargers vary the voltage they apply to the battery to maintain a constant current flow, and then switching off when the voltage reaches the level of a full charge.

The current is maintained at the same value irrespective of the rise in e.m.f. of the cell.

A constant voltage charger is basically a DC power supply which in its simplest form consists of a step down transformer from the mains with a rectifier to provide the DC voltage to charge the battery. The charging voltage is maintained at a value which is slightly in excess of the e.m.f. of a fully charged cell, (Schultz 2007).

Trickle charger is designed to compensate for the self-discharge of the battery. This method of charging uses a very small current which is passed continuously through a cell or battery to take care of self-discharge, thus keeping it always healthy and in a fully charged state. In some applications the charger is designed to switch to trickle charging when the battery is fully charged [12].

In the float charging system, the battery and the load are permanently connected in parallel across the DC charger source and held at a constant voltage below the battery's upper voltage limit. In this case the battery is 'floated' at about its open-circuit (e m f) voltage. There is thus no compensation for standing losses (self-discharge) and the battery must be given refreshing charges at intervals.

Pulsed chargers feed the charge current to the battery in pulses. The charging rate can be precisely controlled by varying the width of pulses, typically about one second. During the charging process, short rest periods of 20 to 30 milliseconds, between pulses allow

the chemical actions in the battery to stabilize by equalizing the reaction throughout the bulk of the electrode before recommencing the charge.

This enables the chemical reaction to keep pace with the rate of inputting the electrical energy. It is also proposed that this method can reduce unwanted chemical reactions at the electrode surface such as gas formation, crystal growth and passivation. According to Patrick Kelly (2010), pulsed charging also makes it possible to sample the open circuit voltage of the battery during its rest period. This technology as stated by F.G. Francis, works with any size, voltage, capacity or chemistry of batteries, including automotive and valve-regulated batteries. In a lead-acid battery, this breaks down lead-sulfate crystals, therefore greatly extending the battery service life.

Although constant current/constant voltage is the most wide spread method used for charging batteries, it is not ideal as it is slow, inefficient, and prone to gassing of the battery cells, because it does not take into account the state of charge of the battery.

Excessive production of battery gasses is undesirable as it results in wasted energy and a substantial increase in charging time. In addition, if the gas is not properly vented out it will collect and has explosive potential, particularly in environments where electrical sparks are possible.

Ideally a fast charger improves both charge acceptance and charging efficiency without detrimentally affecting the battery life. Such a charger should also operate on any lead acid cell without further complicating battery construction. Recently a new charging

strategy for lead acid batteries called ‘Pulse Charging’ has been developed with the potential to provide most of these needs. Similar pulsing strategies are known to improve charge acceptance in other battery technologies such as Nickel Cadmium, and have been commercially available for many years.

Research has shown that hydrogen and oxygen gas development in a battery is not immediate but has a time constant relating to the state of charge of the battery. Therefore if an applied current pulse is short enough, most of the current will be consumed by the charge reaction rather than producing hydrogen gas. This is the principle used in pulse charging; that is – applying relatively large currents into a battery at periodic intervals with a defined pulse width to reduce or avoid gassing and thus increase charge acceptance and efficiency. An additional advantage is that, this principle can even be applied to almost fully charged batteries.

Again, research has shown that pulse charging produces significant reductions in charging time and an increase of cycle life (Wilkinson and Covic, 1998)

2.3 Advantages of Pulse Chargers

The rapid growth in the use of battery systems to power of computers, communication devices such as mobile phones, tools and entertainment devices has created the need for better batteries and better methods for charging these batteries. Therefore pulse charging offers a lot of advantages over the traditional methods of charging batteries. Some of the advantages include:

- Pulse charging allows for faster charging.
- It improves of the battery life cycle.
- It also allows the battery's user to monitor the charging level of the battery.
- Pulse charging allows the measurement of parameters, such as temperature, voltage, and current in the battery during charging.
- The battery is charged more quickly without undercharging or overcharging.

2.1 The Self-Running Pulse Battery Charger

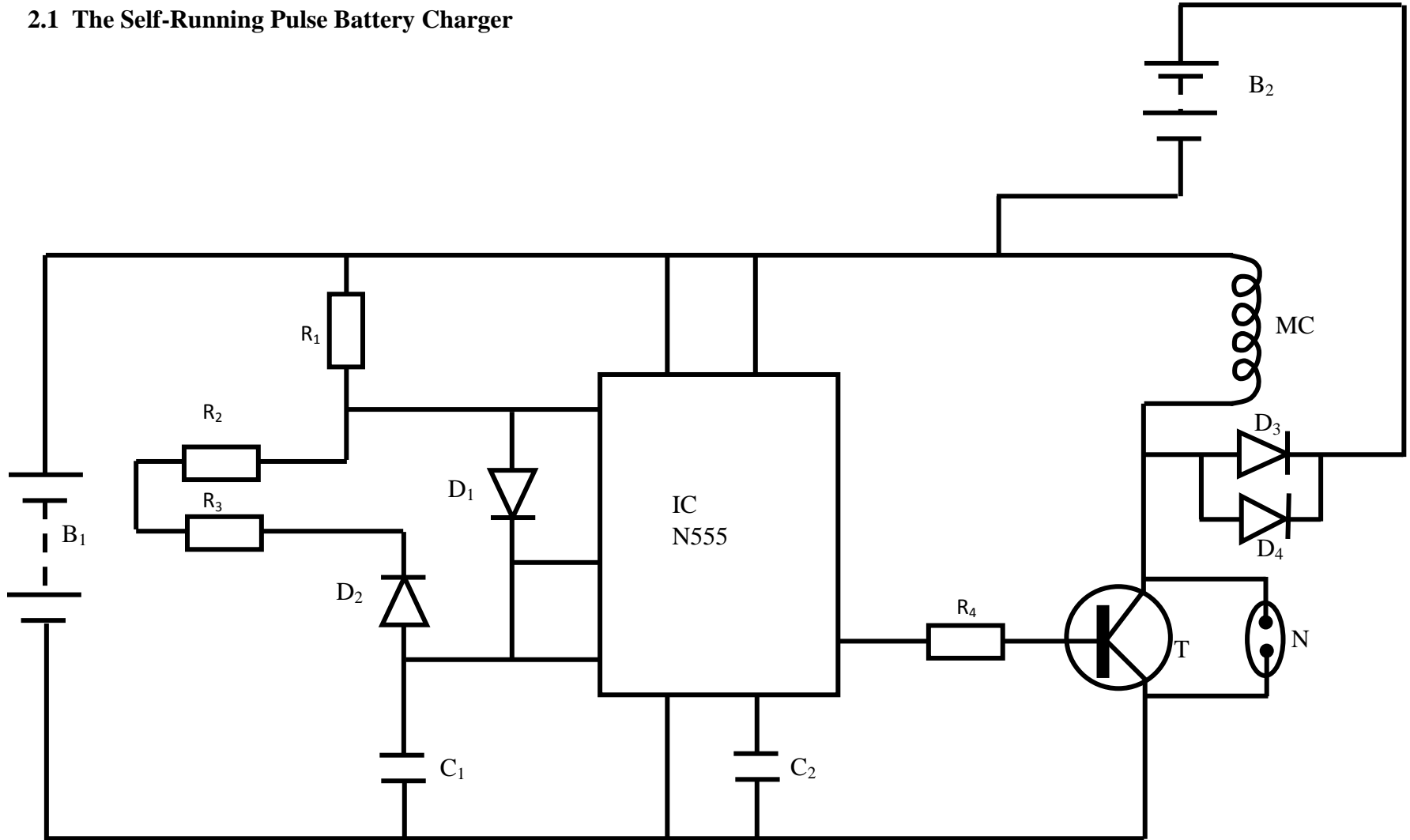


Figure 2.1: Self-running Pulse Charger

CHAPTER THREE

METHODOLOGY

Robert L. Norton (1998) defines design as “To designate, or mark out”. He further explained by stating that “ Designing in Engineering is the process of applying the various techniques and scientific principles for the purpose of defining a device, a process or a system in sufficient detail to permit its realization”.

This chapter therefore deals with the principles and procedure for designing a self-running pulse battery charger using solid-state devices to enhance its the existing charging system. This study and research is divided into two main sections; the hardware component development and software development. The components were obtained from local and foreign markets. Checks and test were performed and measurement was done by using standard digital multi-meter before the components soldered. The development of circuit components started with the design of the block diagram and the prototype design.

3.1 Components Selection

3.1.1 Transistor

Some components were chosen based on their specification and application. The transistor MJ11016 was used in the circuit for ON/OFF switch. When a transistor is used as a switch, the collector current I_C is normally between 0.1mA and 10mA. Any value higher than 10mA will cause heating effects in the transistor.

Table 3.1: Transistor Specification

Parameter	Specification	Application
VBC	70 V	For switching
VCE	70V	
IC	0.4A	
PO	0.6W	
TA	25 ⁰ C	
FREQUENCY	200MHZ (min)	
Hfe	120 (min)	

3.1.2 Fixed/ Variable Resistors

The resistors chosen for the design were a fixed resistors and a variable resistor which where used to limit the current flowing through circuit and the base of the transistor. A small resistor offers little resistance to the flow of current, whilst a large resistor offers a large resistance and therefore causes a small current to flow.

Table 3.2: Resistor Specification

TYPE OF RESISTOR	RESISTOR VALUE	TOLERANCE	TEMPERATURE	MAXIMUM VOLTAGE	POWER RATING
Carbon Resistor	470 ohm	±5%	70 ⁰ C	250 V	1 W

3.1.3 Diode

A diode is an electronic component which passes electricity in one direction and blocks it in the other direction. The diode 1N4007 was used in the designing of the circuit.

Table 3.3: Diode Specification

TYPE OF DIODE	SPECIFICATION			
1N4007	PEAK INVERSE VOLTAGE (PIV)	REVERSE CURRENT(IR)	VOLTAGE	FORWARD CURRENT (IF)
	120 V	75 mA	12V	24mA

3.1.4 Capacitor

A capacitor stores electricity as an electrical stress across a material called dielectric. The applied voltage puts charge electrons in the capacitor. The charged electrons remain in the capacitor, with or without the applied voltage. The capacitor discharges when a conduction path is provided across the plates without any applied discharge electricity produced by the discharge of magnetic field in the main coil.

Table 3.4: Capacitor Specification

TYPE OF CAPACITOR	SPECIFICATION			
ELETROLYTIC	CAPACITANE	TOLERANCE	BREAKDWON VOLTAGE	TEMPERATURE
	1nF	±20%	220V	-40°C To 85°C

3.1.5 Neon Light

The neon light can run on either AC or DC and are rated for both the voltage needed to light it up, as well as for how much power it uses. This power is measured in milliwatts.

3.2 Testing of Components

Components like Transistors, Diodes, Resistors and Capacitors were all tested at the initial stage to check their reliability before they were soldered onto the CB. This was done to ensure that all the components used in the circuit functioned properly without of any defects.

3.2.1 Testing of Resistors

A multimeter was used to test the resistor. The resistance scale was selected on the multimeter. The black test probe was plugged into the com input jack and the red probe plugged into ohms input jack. The tips of the probes were connected across the leads of the resistor to determine their resistance.

3.2.2 Testing of Transistors

An ohmmeter was used in the testing of the transistors. A low resistance scale range was selected and the negative (black) probe of the ohmmeter was connected to the base of the transistor and that of the positive (red) probe connected to the collector and emitter one after the other. The values recorded were high which indicate that the emitter diode and the collector diode were in good condition. Also, the positive probe was connected to the base of the transistor and the negative probe to both the emitter and the collector. The measured values were low, which indicates a good transistor.

3.2.3 Testing of Diode

The diodes were tested to check any malfunction in them. The multimeter was also used in checking the diodes. The diodes displayed a very low resistance when they were forward biased and a very high resistance when they were reversed biased. The 1N4007 was used.

3.2.4 Testing the Capacitor

The testing of the capacitor was done by using an ohmmeter. The negative (black) probe of the ohmmeter was connected to the negative terminal of the capacitor and that of the positive (red) probe was connected to the positive terminal. The measured value indicated that the capacitor was in good condition.

3.2.5 Testing of other Components

Testing of other components such as the neon lamp was carried out to ensure it was in good condition when used in the circuit.

3.3 The Soldering Process

Soldering is the process of joining a piece of circuit component into the circuit board to make electrical contacts using a soldering iron and solder. A solder connection is the joining together of two metal parts by applying both heat and solder. The heat provided by the soldering iron should be at a very high temperature to melt the solder to make a liquid which would flow into and slightly penetrates the two surfaces that need to be connected.

3.3.1 Tools used in the Soldering Process

The set of electronic tools used in the soldering process included:

1. Solder Wick: It is used to remove solder terminals.
2. Heat Sink: It is a device which is used to clamp onto the lead of heat-sensitive components to conduct the heat generated by the soldering iron.
3. Soldering Brush: It is used to clean off soldering flux after soldering.
4. Pliers: It is used to hold components in position on the circuit board.
5. Long-nose Pliers: It is used for gripping and bending components on the circuit board.
6. Cutters: These are available in many different sizes and are used to cut wires or cables to size.
7. Wire Strippers: The stripper is designed to be adjustable and is used for stripping the insulating sleeve off a wire.
8. Solder: 60/40 rosin-core solder which is the most commonly used in electronics was used.
9. Soldering Iron: It is used for heating terminal connections.
10. Digital multimeter: It is used to check the conditions of components in the circuit.

3.4 Block Diagram of the Pulse Battery Charger

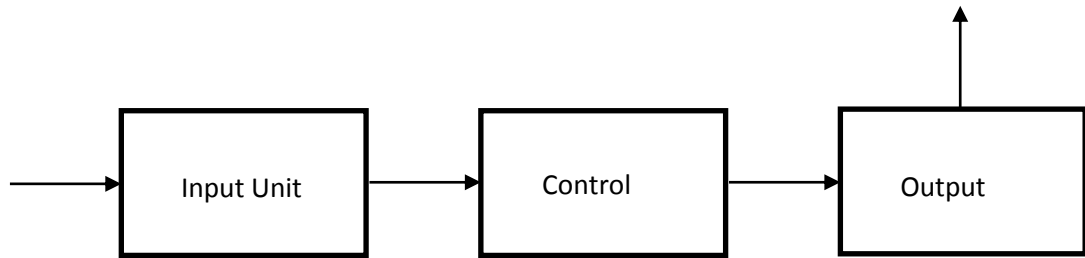


Figure 3.1: The Block Diagram of the Pulse Charger

3.4.1 Explanation of the Block Diagram

The power section:

The power section of this project consists of a battery (B1) which supplies power to the main coil (MC) through its connection to transistor (T). When this function happens, the MC is magnetized, and e.m.f. is produced in the coil.

The Control section:

This is the part of the circuit that tells the Transistor (T) when to turn ON and when to turn OFF. The power to operate this part of the circuit comes from changes in the magnetic field in the coil core and its ability to generate electricity. The control section consists of both Resistor (R4) and the capacitor (C2).

The rise and fall of the magnetic field in the coil core produce an AC wave in the TC. When the current flow (CF) follows the path shown in the diagram, the Transistor is turned OFF. When the CF follows in opposite direction, the transistor is turned ON.

The output section:

The output section delivers the results of the other two sections (power and control). After the transistor turns OFF, the current supplied by B1 stops supporting the magnetic field in the main coil (MC). When this happens, the magnetic field collapses. In doing so, it induces electrical energy in the MC that can be collected. The collapsing of the magnetic field in the MC is the power supply for the output section. With the transistor (T) turned OFF, the only pathway left open is through Diode (D2) and around it to charge up capacitor (C). D2 allows the discharge of the energy in MC to divert around the transistor and also facilitates the charge in the capacitor (C) to build up without discharging. The final output is for the capacitor (C) to discharge into the battery (B2).

3.5 Circuit Diagram of the Pulse Battery Charger

A schematic diagram is a diagram which shows the arrangement of the circuit components on the circuit board (CB) or Vero board (VB). In other words it is a working diagram of the circuit. Schematic diagram helps one to understand the flow of signal through the circuit. It also helps in the tracing of fault on the circuit board. The schematic diagram of this project is shown below (Williams 1991).

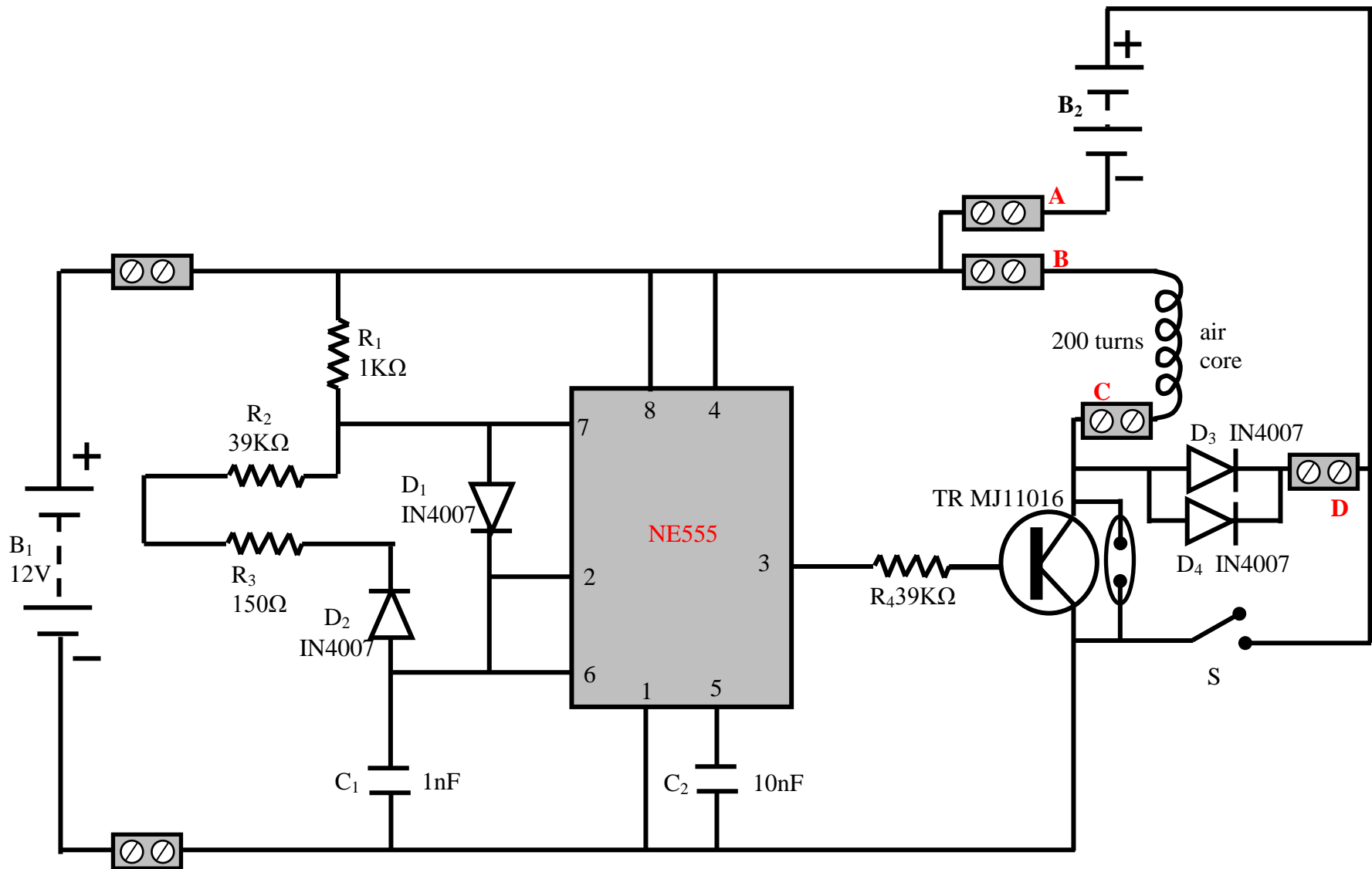


Figure 3.2: The Circuit Diagram of the Pulse Charge

3.5.1 Circuit Diagram Description

The circuit diagram comprises of the power supply, which has 12Volts battery (B1), three resistors (R1, R2 and R3), two diodes D1 and D2 and a 1nanofarad capacitor for storing charges. At the input section a 39K Ω resistor in series with a variable resistor of 150 Ω is used which allows a good standard resistor value to be selected for transistor/ coil pair.

The control part of the circuit has an IC (NE555), one 10nanofarad capacitor (C2), and a 39K Ω resistor (R4) which feed the base of the transistor and the main coil.

The output circuit which feed the pulses to the battery on charge (B2) is made up of a transistor which serves as a switch to the pulsing current from the coil and three diodes (D3, D4 and D5) which are connected in parallel for a better current-carrying capacity and thermal characteristics as compared with a single diode.

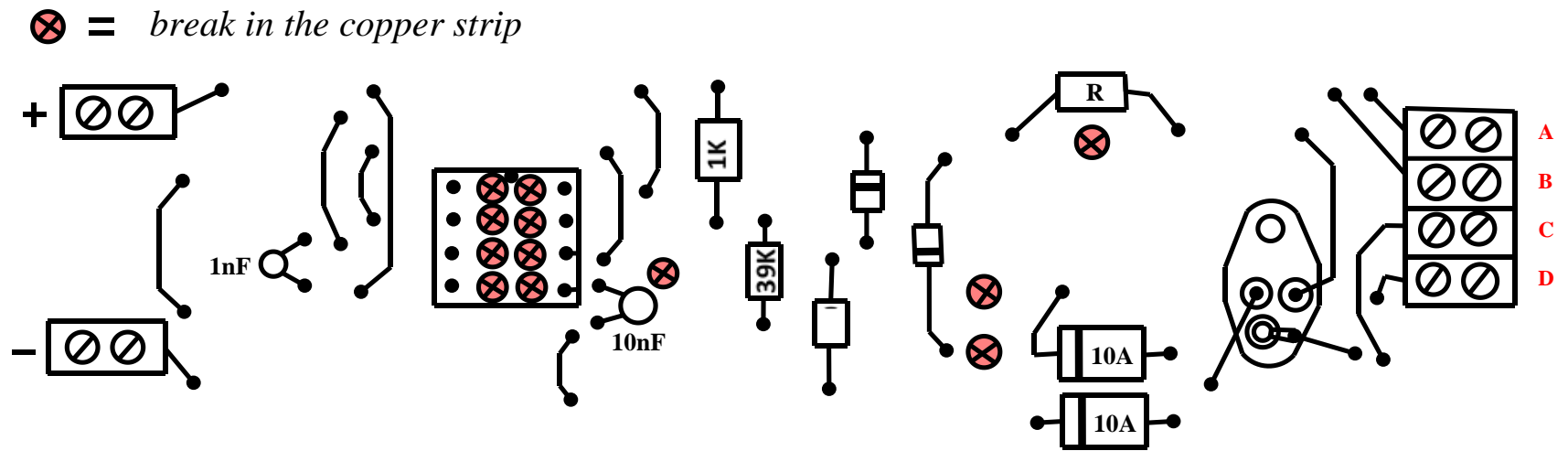


Figure 3.3: Component layout of pulse charger



Figure 3.5: Picture of the completed coil

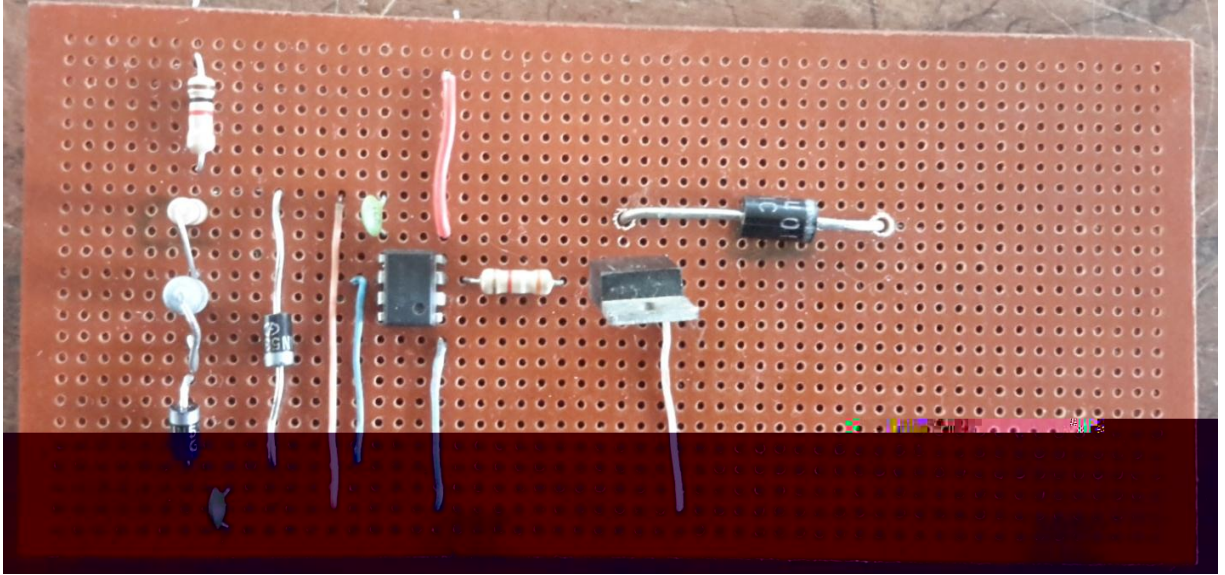


Figure 3.6: Picture of the Pulse Charger at Assembling Stage

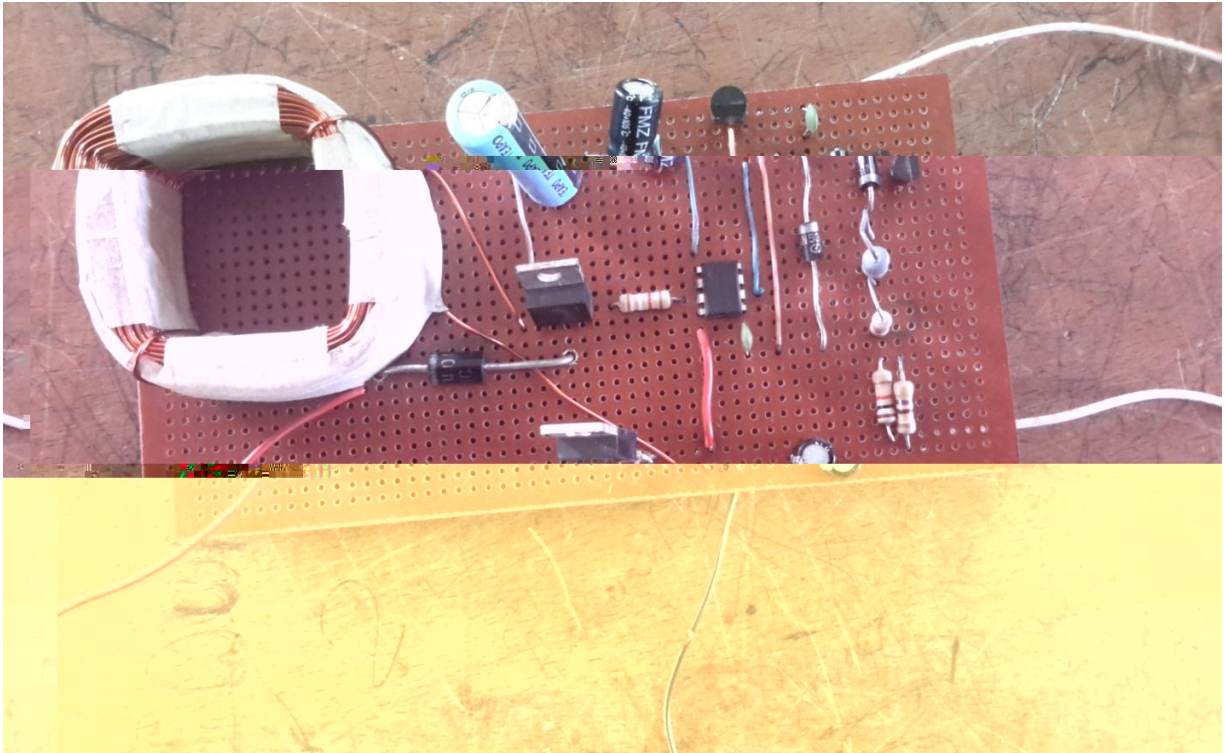


Figure 3.7: Picture of the Pulse Charger at the final stage

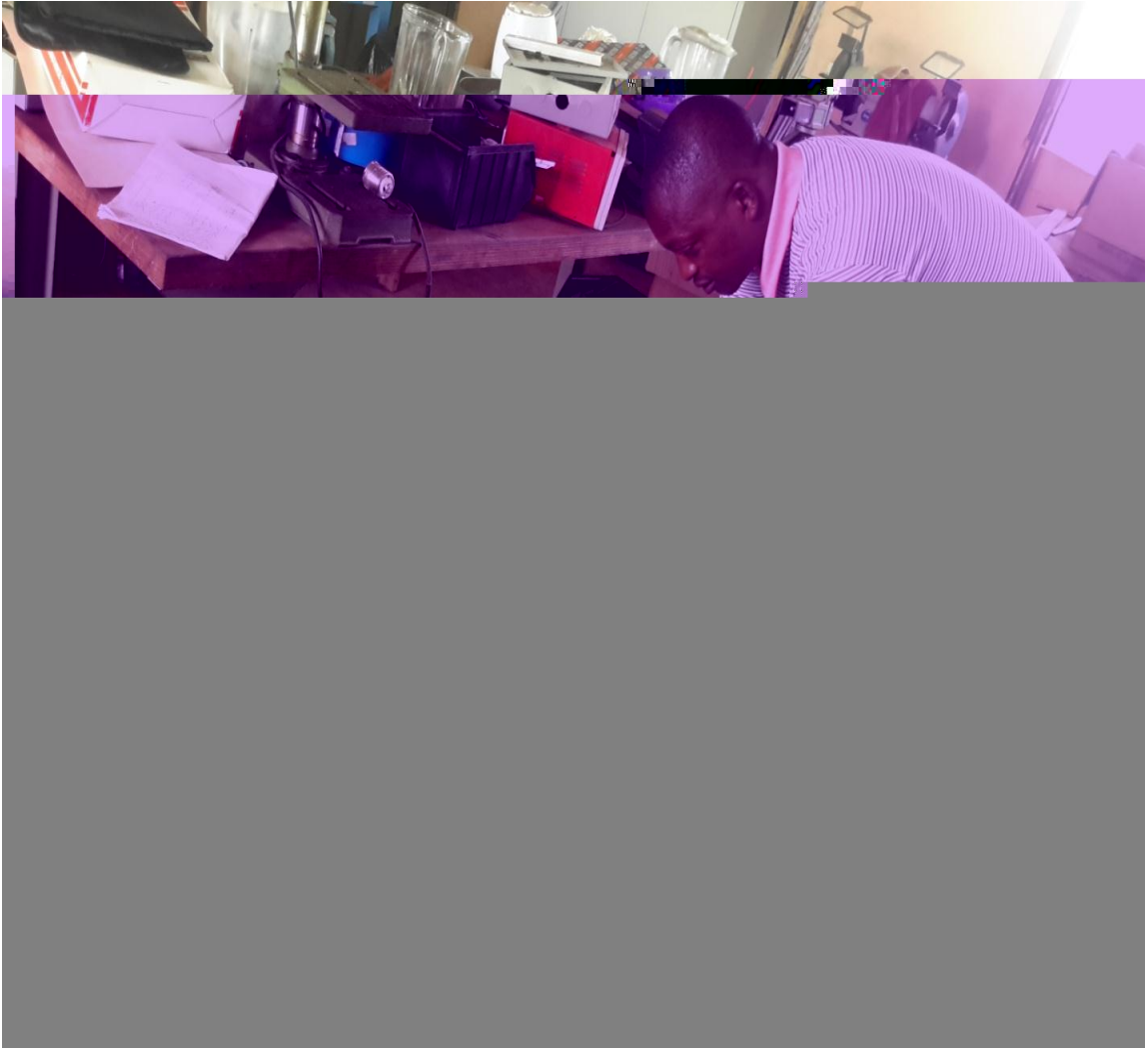


Figure 3.8: Picture showing the connection of the Pulse Charger



Figure 3.9: Picture showing Voltmeter recording of the Pulses across the Capacitor

3.5.2 Circuit Operation

The design deals with a battery pulse charger which use solid-state devices and method in which the current going to the battery is not constant. A quantity of electricity is taken from Battery (B1) and used to produce a magnetic field in the main coil (MC). The coil is wound with a 200 turns and 0.7mm^2 enamel copper wire.

The resistor feeding the base of the transistor is $39\text{k}\Omega$. At the input section a $39\text{k}\Omega$ resistor in series with a variable resistor of $1\text{k}\Omega$ is used which allows a good standard resistor value to be selected for transistor/ coil pair. To achieve the best result, a (1000v, 10A) diode was used.

When the switch (S) is switched ON, the transistor is switched on, powering the coil which is then effectively connected across the driving Battery (B1). The trigger pulse is quite short, so the transistor switches off immediately. This is a point at which the circuit operation gets subtle. The coil characteristics are such that this sharp powering pulse and sudden cut-off cause the voltage across the coil to rise very rapidly, dragging the voltage on the collector of the transistor up to several hundreds of volts. This rise in voltage, effectively “turns over” the set of three 1N4007 Diodes which then conducts strongly, feeding this excess free-energy into charging the battery B2. Using three diodes in parallel makes the circuit more efficient as they have a better current-carrying capacity and thermal characteristics than a single diode.

Another possible operation of the circuit is the safety by-pass. When the magnetic field collapse happens in the main coil (MC), the energy must discharge somewhere. If, for instance, it is prevented from discharging through Diode (D2), a secondary path must be available to dissipate this energy, or the transistor (T) will be damaged. This is achieved through the neon light which allows the energy to be safely dissipated without damaging the transistor (T) by subjecting it to high voltage spike.

3.6 Experimental Work

The pulse charger was tested at the Electrical and Electronic engineering laboratories and the Automotive Engineering workshop of Abetifi Technical Institute at Abetifi, Kwahu. Digital voltmeter, capacitor and a 12V battery were used to record the pulses. A cathode ray oscilloscope (CRO) was also used to display the strength of the pulses. All the circuit

and block diagrams were designed with the aid of a computer software such as multiSim and paint. The electronic components used in the design and construction of the pulse charger were purchased from the Ghanaian open market and online and soldered on the printed circuit board.

CHAPTER FOUR

RESULTS AND FINDINGS

4.1 Pulse Charger Output

The measured d.c. output pulse current of the device was varied from 800mA to 2A depending on the transistor / coil pair. The pulse feeding the battery on charge (B_2) was within the time frame of 2 seconds. The pulse rate was about 1.8A/second. The circuit is to be operated within a ventilated environment and should not be operated above 48v due to the components used in the construction of the circuit. The charger input pulse was fed to an oscilloscope to determine the pulse characteristics to select transistor / coil pair, if not it will take more time to charge the battery of a particular rating, as shown in figure 4.1.

The pulses were successfully tested and recorded with the various transistor/coil pair. After measuring the output pulses at various levels of the transistor / coil pair, the pulse in amperes were plotted against frequency on the oscilloscope. It was noticed that the more number of turns in the coil and the higher the value of the transistor, the better the output pulses that are fed into the battery on charge.



Figure 4.1: Picture showing output pulse on the oscilloscope

4.2 Testing of Transistor/ coil pair and Pulse Strength

When the pulse charger was found to be functioning well, two tests were conducted.

The charger was connected to a 12V battery with a 200 turns coil and MJ11016 transistor and the output pulse measured was strong. When a coil with less number of turns and a different transistor were paired, it was found that the pulse strength weakened as the e.m.f. produced by the coil was not high enough to give the transistor a good triggering voltage.

For the second test, a 24V battery with a coil of 250 turns and IRF510 transistor were used. As the battery rating increased, the pulse strength becomes stronger. In fact when two 200 turns coils and two or more IRF510 transistor pair were used they produced the best pulse strength to feed the battery and fast charging was achieved. This means that

when two or more coils are used with IRF510 transistor pair, a better and stronger pulse output can be produced with even a 9V battery.

Table 4.1 Output pulses for transistor/coil pair

Number of turns in coil	Type of transistor	Battery rating	Output pulses (Amperes)
150	BD243C	9V	0.8A
200	MJ11016	12V	1.2A
250	IRF510	24V	2A

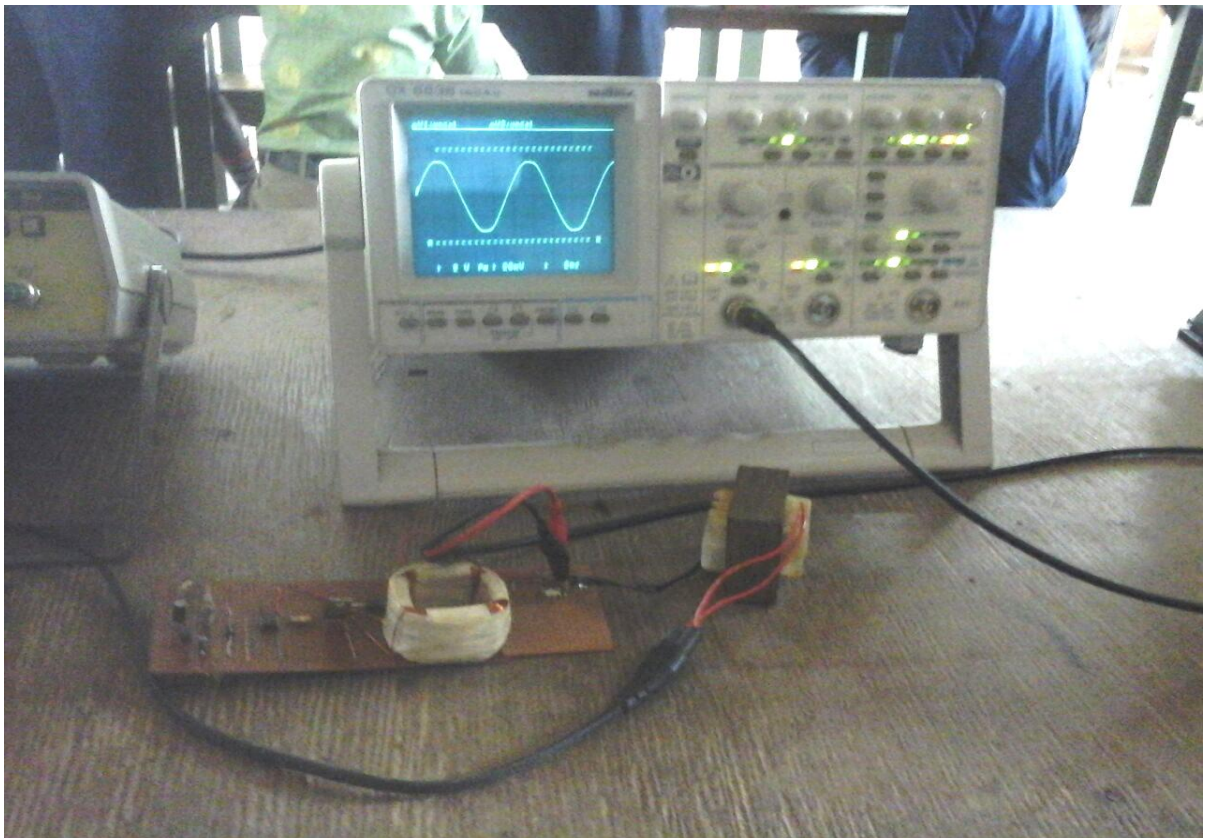


Figure 4.2: Picture showing the strength of e.m.f. induced in the coil on the oscilloscope

4.3 General Discussion

The project was built on a printed circuit board (PCB) with premade traces. The components on the PCB can well be secured by using screws where necessary. The leakage flux of the coil can be reduced drastically by sheardizing the copper wires and using proper lamination since the metal piece closer to the coil was magnetized which could affect e.m.f. generated by the coil.

Moreover, the heat generated by the coil due to eddy current can affect the performance of some of the components and the soldered joints. As stated earlier, in order to ensure maximum generation of e.m.f., the copper wires must be sheardized. Also to enhance the performance of the device, it must be encased in a properly ventilated box for adequate cooling.

4.4 Financial Requirement

This section deals with the cost associated with this project work. Apart from the material cost, the cost of labor cost was also considered. The table below shows the cost of the components based on their market price.

Table 4.2: List of Components and their cost

NO.	COMPONENT	QUANTITY	UNIT PRICE (GH¢)	TOTAL (GH¢)
1	1KΩ variable Resistor	2	90p	1.80P
2	150Ω Resistor	1	80p	80p
3	39kΩ Resistor	1	90p	90p
4	390Ω Resistor	1	80p	80p
5	1nF Capacitor	1	90p	90p
6	10nF Capacitor	1	90p	90p
7	IN4007 Diode	4	90p	3.60P
8	MJ11016 Transistor	1	4.50p	4.50p
9	NE555 IC	1	4.50p	4.50p
10	200- Turn Coil	1	25.00	25.00
11	2W Neon Bulb	1	1.50p	1.50p
12	Printed circuit board	1	4.00	4.00p
13	Miscellaneous (Cable, soldering lead etc.)		23.00	23.00
			TOTAL	72.20p

Cost of Labor = GH¢50.00

Transport and Travelling (T&T) = GH¢25.00

Total cost = Material cost + Labour cost + T&T

$$= \text{GH¢ } 72.20 + \text{GH¢ } 50.00 + \text{GH¢ } 25.00$$

$$= \text{GH¢ } 142.20$$

Overall cost = total cost + 10% of total cost

$$= \text{GH¢ } 142.20 + \text{GH¢ } 14.72$$

$$= \text{GH¢ } 156.92$$

The cost of a normal battery charger in the market is about GH¢350. Also the cost of a 1500W generator set is around GH¢650.00. However, the cost involved in constructing a 12V pulse charger using solid-state devices was approximately GH¢157.00 which is comparatively cheaper than the traditional charging equipment or generator set. Furthermore, most of the components required for replacement are also available in the local market with exception of a few of them.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

This project successfully constructed an improved battery charger using solid-state devices with the aim of solving the problem of rural electrification in order to increase the study time and make access to ICT gadgets possible for students in rural communities.

In view of the positive results of this project, it is possible to venture into mass production of the pulse charger for distribution to off-grid communities to reduce dependence on gasoline generators for charging their mobile phones and batteries.

5.2 Recommendations

This project is recommended for use in rural communities where it is not possible to connect them to the national grid due to their location. Further improvement on this project is recommended such as; using an actuator and a timer to control the discharging of pulses into the battery and tapping the pulses dissipated in the neon bulb to charge another battery.

Finally, it is recommended that the Government of Ghana, through Ministry of Education should support and finance this project for mass production for distribution to schools in off-grid communities to improve study time and access to ICT.

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