DESIGN AND CONSTRUCTION OF AN ELECTRIC CIRCUIT BREAKER

BY

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17 / A/BSCED/0257 /R

PHYSICS REPORT SUBMITTED TO THE FACULTY OF EDUCATION IN PARTIAL FULFILLMENT OF THE REQUIREMENTS OF THE A WARD OF BACHELOR OF SCIENCE WITH EDUCATIONDEGREE OF KABALE UNIVERSITY

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DECLARATION

I, **DAN AKANDW AN AHO** do hereby declare that this study titled" Design and construction of an electric circuit breaker" is entirely my own original work, except where acknowledged and that it has not been submitted before to any other institution of higher learning for the award of an academic qualification.

Sign.~. Date: 06/01/2021

APPROVAL

This is to affirm that this research project was done under my supervision.

Name: MR. HABAKWIHA VIANNEY

Signature .....~

Date:.....06/09/2024.....

DEDICATION

This project is dedicated to Almighty God for his protection, kindness, strength over my life throughout the

whole period and also to my parents Mr. Kakuru Solomon and Mrs. Margret Kakuru for their financial support and moral care towards me. Also to my mentor Mrs. Kapaasika Vastinah for her academic advice she often gives to me. May Almighty God shield them from the peril of this world and bless their entire endeavor Amen.

ACKNOWLEDGEMENT

The successful completion of this project work could not have been a reality without the encouragement of **my** supervisor Mr. HABAKWIHA VIANNEY for his guidance while supervising this project.

My warmest gratitude goes to my parents for their moral, spiritual and financial support throughout my study in this institution.

My appreciation goes to some of my lecturers among whom are Mr. Opio Philip and Mr. Isaac Habumugisha.

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Finally, my appreciation goes to my Elder sister Kansiime phionah, my lovely wife RhodahAkandwanaho and many others who were quite helpful.

ABSTRACT

This project is undertaken to construct and design a circuit breaker using a variable resistor and a fuse as the main components. As we have come to rely upon electricity more in our everyday lives, it is important that we do everything we can to protect it. One common method of protecting electronic components is a circuit breaker. This project takes the standard circuit breaker one step further. The scope of my project was **to** create a circuit breaker designed to trip, detect faults and reclose only after a fault has cleared. This is to **be** done primarily with a fuse, relay, loads, a variable resistor and a power source. The relay serves as a switch. While closed, the main line is stable. After the occurrence of a fault, the switch opens and a fuse blows to prevent excessive current flow. When the fault has cleared, the current will return to a stable level and no longer exceed the threshold.

ACRONYMS

AC - Alternating Current

DC - Direct Current

TABLE OF CONTENTS

CHAPTER ONE

INTRODUCTION

LI Background

A early form of circuit breaker was described by Thomas Edison in 1879 patent application, although his commercial power distribution system used fuses. Its purpose was to protect lighting circuit wiring from accidental short circuit and overloads. A modern miniature circuit breaker similar to the ones now in use was patented by Brown, Boveri and cei in 1924. Hugo stotz, an engineer who had sold his company to BBC. was credited as the inventor. Interconnection of multiple generator sources into an electrical grid required the development of circuit breakers with increasing voltage ratings and increased ability to safely interrupt the increasing short circuit currents produced by networks. By 1935, the specially constructed circuit breakers used at the Boulder Dam project use eight series breaks and pressurized oil flow to interrupt faults ofup to 2500 MV A, in three cycles of the alternating current power frequency.

The way our modem power distribution was established requires the implementation of power lines to carry current from the point of generation to the point of consumption. On occasion an abnormal current in a line can occur due to a short circuit. This is known as a fault, faults can be problematic for both utility responsible for supplying power and the client that would like to receive power. To maintain a consistent and reliable distribution system a smart recloser circuit breaker may be implemented across a feeder line to detect a persistent fault and protect against it. One voltage has been transformed down to safer levels for a consumer to use it is divided amongst a network of customers. The cables that carry current for the network to function are called feeder lines. Each feeder line is representative of a connection to a home or business that some power is being given to.(Wollenberg, B.F. 1996)

Electricity is essential to the world we live in today. Our reliance upon electronics and electronic devices has increased at an alanning rate since Edison's invention of the light bulb. Due to the benefits from the advancement of electronics and technology it is unlikely that our society will forfeit them. It is because of this dependence that our aim is to make our electrical systems as efficient, safe, and consistent as possible. Therefore, the project is undertaken to design and construct a circuit breaker which is an electromechanical device that functions like a switch. This switch determines whether or not current will be allowed to flow and without current there can be no power. In hazardous situations such as storms, a power line may be knocked down due to strong gusts or fallen trees. If conductors are struck by lightning, clash together, or cross each other on the ground, then a short circuit can be created. A short circuit is when current begins to follow path that was not intended. This is problematic because the conductors themselves will have little

resistance and be unable to prevent high levels of current from flowing. This is where a circuit breaker becomes useful. (Sternheim and Kane, 2011)

The Uganda Government is emphasizing teaching of science subjects in all learning levels from primary to secondary schools and higher levels of learning like universities and institutions. However lack of man power and instructional materials especially in practical lessons has made most schools (teachers) only to teach theoretical physics ignoring practical aspects of physics which are more important if the country is to excel in technological advancement because of concentrating more on physics theory it's common to find **a** graduate of physics failing to fix an electric bulb in a lamp holder or put dry cells in television remote or even operate a camera.(New vision Page 6, 2006)

Because of the above, researchers felt that it's time we put our theoretical knowledge into practical knowledge so that we can match with the changing world which calls for more practical skills than the theoretical part. This chapter covers the background of the study, statement of the problem, objectives of the project purpose of the project, justification of the project and the scope of the project.

1.2 Problem statement of the construction.

For a long time most teachers have put more emphasis on theoretical physics concept than practical part of

it due to lack of enough apparatus and improvisational skills by most teachers. As a result, graduates of physics faced a big challenge when it came to applying the scientific knowledge into practice in support to the above. Teachers of science subjects need to equipped with improvisational skills where they lack equipment so that they can easily demonstrate theoretical scientific knowledge into practical lessons to ease the teaching and learning of sciences. This project aims at improvising a model fuse to be able to demonstrate circuit braking while teaching current.

1.3 Objectives

1.3.1 Main objective

The main objective of the project is to design and construct an electric circuit breaker to ease the teaching and learning of electric current.

1.3.2 Specific Objectives.

1. To design and construct a circuit breaker.
2. To improve on improvisational skills.
3. To teach and learn more about current electricity

4 **Scope of the project.**

The construction will only be-limited on how a circuit breaker operates using a 6 voltage supply and the performance of the device.

1.5. SIGNIFICANCE OF THE PROJECT.

It provides affinn foundation to those students who may be interested in carrying out further research.

Physics teacher will be encouraged and motivated to incorporate practical skills in their lessons to make use of relevant applications of physics theory into real life.

The theory study will help students to transfer their theoretical knowledge of electricity into practical use. The study will help both the teachers and students to use their theoretical knowledge of electricity to understand the fuse rating required for an electric fuse to work well and blow.

The study will help teachers on school practices and senior teachers to improvise by having their own constructed while looking at circuit breakers.

The study will help school administrations and policy makers especially when it comes to the issue of resource allocation in the physics department.

CHAPTER TWO

THEORY AND LITERATURE REVIEW

2,SMART RECLOSER CIRCUIT BREAKER.

All circuit breaker systems have common features in their operation, but details vary substantially **depending** on the voltage class, current rating and type of the circuit breaker. The circuit breaker must first **detect a** fault condition. In small mains and low voltage circuit breaker, this is usually done within the device itself. Typically, the heating or magnetic effects of electric current are employed. Circuit breakers

r large currents or high voltage are usually arranged with protective relay pilot devices to sense a fault condition and to operate the opening mechanism. These typically require a separate power source, such as **a** battery, although some high voltage circuit breakers are self-contained with current transformers, protective relays, and an intended control power source (Horowitz and Hills, 1989).

Once a fault is detected, the circuit breaker contacts must open to interrupt the circuit; this is commonly **done** using mechanically stored contained within the breaker, such as a spring or compressed air to separate the contacts, circuit breakers may also use the higher current caused by the fault to separate the contacts, such as thermal expansion or a magnetic field. Small circuit breakers typically have a manual control lever **to** switch off the load or resent a tripped breaker, while larger units use solenoids to trip the mechanism, and electric motors to restore energy to the springs (Horowitz and Hills, 1989).

The circuit breaker contacts must carry the load current without excessive heating, and must also withstand the heat of the arc produced when interrupting (opening) the circuit. Contacts are made of copper or copper alloys, silver alloys and other highly conductive materials due to arcing while interrupting the current. Miniature and molded case circuit breakers are usually discarded when the contacts have worn, but power circuit breakers and high voltage circuit breakers have replaceable contacts (Horowitz and Hills, 1989). When a high current or voltage is intenupted, an arc is generated. The length of the arc is generally proportional to the voltage while the intensity or (heat) is proportional to the current. This arc must be contained, cooled and extinguished in a controlled way, so that the gap between the contacts can again withstand the voltage in the circuit (Horowitz and Hills, 1989)

2.2.0 THEORY

Electrical circuits are designed to handle a limited amount electricity. Circuits are made up of wiring a breaker or a fuse and devices such as light bulbs and anything plugged into an outlet

The electricity usage of each device (when running) adds to the total LOAD on the circuit. Exceeding the **rated** load for the circuit wiring causes the circuit breaker to Trip, shutting off the power to the entire circuit. If there were no breaker in the circuit, an overload would cause the circuit wiring to overheat, which could **melt** the wire insulation and lead to fire (De Andrade and Sorrentino, 2010).

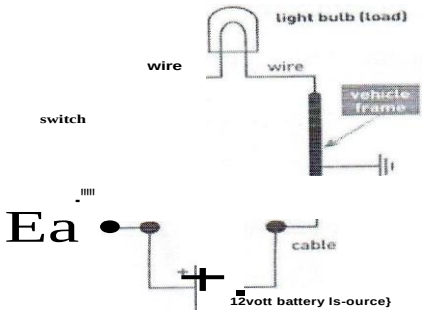
here fuses are unsuitable or in adequate, protective relays and circuit breakers are used in combination to detect and isolate faults. Circuit breakers are the main making and breaking devices in an electrical circuit **to** allow or disallow the flow of power from the source to the load. These carry the load currents continuously and are expected to be switched ON with loads (making capacity). These should also be capable of breaking alive circuit under normal switching OFF conditions as well as under fault conditions carrying the expected fault current until completing isolating the fault inside (breaking capacity). Under fault conditions, the breakers should be able to open by instructions from monitoring devices like relays. The relay contacts are used in making and breaking control circuits of a circuit breaker, to prevent breakers getting closed or to trip breaker under fault conditions as well as for some other interlocks (Agarwul, 2013).

PURPOSE OF CIRCUIT BREAKERS

The main purpose of a circuit breaker is to;

- Switch load currents
- Break normal and fault currents
- Carry fault current without blowing itself.

2.2.1 Circuit Breaker Diagram



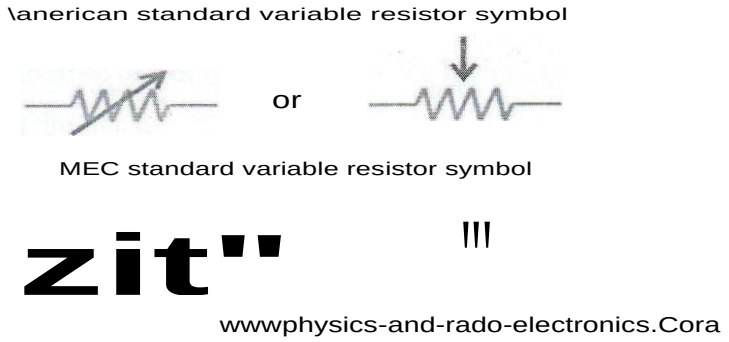
2.2.2 CIRCUIT OPERATION

Here is a simple circuit diagram that will produce visible light when the circuit is completed. The circuit can be powered by a 12 v battery and is very handy to use. The circuit is based on a variable resistor in

senes with the light bulb. When the fuse wire is not connected and the switch is closed, this means the circuit is still open and so no current pulse will be produced, thus the Light bulb will not glow. When the *fuse* wire is connected in series with other components, some current will pass through, the circuit will be closed to some extent, and the Light bulb will produce light as long as the switch is closed. The brightness f the Light bulb will be increased by varying the variable resistor and the separation of the probes be made small and varied according to the supply voltage indicating an increase in the current The circuit of this project is based around the principle that steel wire is a good conductor of electricity.

2.3 VARIABLE RESISTOR

Varying resistance in a circuit will increase or decrease the current. This is used to control other components, for example lamps-brighter or dimmer, motors- fast or slower. A variable resistor is the type of resistor which change the flow of current in a controlled manner by offering a wide range of resistances.



2.4. RESISTORS

A Resistor is a passive component used to control current in a circuit. Resistors are considered to be the basic components in all the electronic circuits. Resistors restrict the flow of electric current in the electronic circuits.

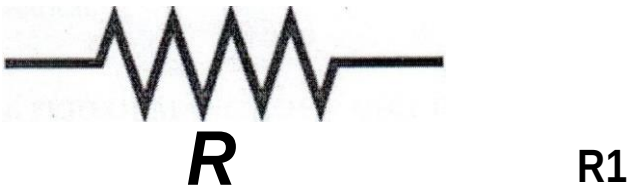


Fig. 2.4, schematic symbol of a resistor

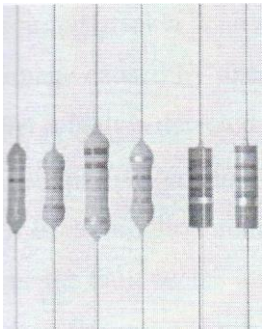


Image of a resistor

The amount of electricity that we want to pass through them depends on the resistors. Resistors control the amount of voltage and current in a circuit because of their resistance. Resistance can be defined as the ease with which something will let electricity flow through it".

The resistance can be defined as the voltage required for making a current of 1 ampere to flow through the circuit.

The resistance of a device is given by the ratio of voltage applied across its terminals to the current passing through it.

From V =IR, R=V/I

where Vis voltage and I is current.

Thus a particular value of resistor, for fixed voltage, limits the current through it. They are omnipresent in electronic circuits. The different values of resistances are used to limit the currents or get the desired voltage drop according to the current-voltage rating.

2.SBATTERY

The battery is the one of the most important component in an electrical circuit, it is used to power the circuit.

It is a collection of one or more electrochemical cells in which stored chemical energy is converted into electrical.

2.6 **PERFORMANCE OF A CIRCUIT BREAKER USING RESISTORS.**

Having connected the circuit, and when the voltage is applied to the simple circuit breaker, with the variable and a fuse wire in position, the. current flows through the circuit and the Light bulb glows. At this point, the current flows through a circuit at a frequency equal to that of the supply voltage.

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breaker is an automatically operator electrical switch designed to protect an electrical circuit from **damage** caused by excess current from overload or short circuit. Its basic function is to interrupt current ±fer a fault is detected.

A circuit breaker can do the following:

) Breaking the circuit when the resistance is higher and current is lower than the required, most of the me the fault occurs on the loading condition for example, over loading, over current, over voltage, reverse **power** flow. But some tirne due to natural phenomena like wind, storm, lightening, and snow fall, there is short circuit in the system.

An over load current occurs when a device draws current above its rated value, but not by a drastic margin. **or** example, a motor that is rated at 60ampares but drawing 75 amperes is likely suffering an over load condition.

Also by increasing the resistance, decreases the current passing through the circuit and as a result the applicant will not work, for example, cookers, flat iron, refrigerators and air conditioners.

Iii) Breaking the circuit when the current is beyond the required and the resistance is low, the fuse melts or metal that is when the circuit is under loaded. This implies decreasing the resistance and increasing the current more than the required and the fuse blows. This occurs only when power exceeds the rated value. Voltage from the grid to the house is constant which means no matter how much load varies [switch on or off home appliance, voltage becomes constant. Whenever load is varied it is the current which changes. So, when you switch on various electrical appliances you are changing the amount of current.

Eventually power in take in house increases which is given by P=Vxl and whenever power in take exceeds the voltage rating, the fuse blows (Halliday and Resnick, 2005).

CHAPTER THREE

MATERIALS AND METHODS

- Ltroduction

chapter is concerned with the circuit diagram, components used or materials used in the construction **a circuit breaker,** and assembling of materials used.

31 MATERIALS

(i} A **variable** resistor R and a load,

(ii} Apiece of wooden block (13 x 18) which acts as a circuit board. (iii)

lLight bulb (Torch bulb)

(iv) Battery: 6 volts

(v) Steel wire (3cm) which acts as a fuse and small nails

3.2 METHODS

(Assembling of the materials)

In my design I got two small nails and stuck them on one side of the wooden block. Then inserted the strip of steel wire between the small nails which acts as the fuse. Then also connected up the circuit, but with only one light bulb in the circuit to determine the current needed to blow (melt) the fuse. Connected the four dry cells by taping one wire to the positive side of the first cell and the other end attached to the negative side of the second cell in series with the fuse, light bulb, a variable resistor.

Got another wire removed part of the insulating in the middle, and tapped the end of the positive side of the second cell, Then attached the other end to the left small nail on the wooden block. Also attached another wire to the negative side of the first dry cell and connected it to the· left hand side of the light bulb. Removed a part of the insulation in the middle wire and attached the end to right hand side to the light bulb. Then wound the other end to the right thumb tack and also added some load in series with the circuit on the wooden block. The circuit can be powered by a 6v battery and is very handy to use. The circuit is based on the variable resistor, a fuse, a load connected in series with the light bulb. When the fuse wire is not connected and the switch closed, this means the circuit is still open and so no current pulse will be produced, thus the light bulb will not glow. When the fuse wire is connected in series with other components, some current will pass through, the circuit will be closed to some extent, and the light bulb will glow.

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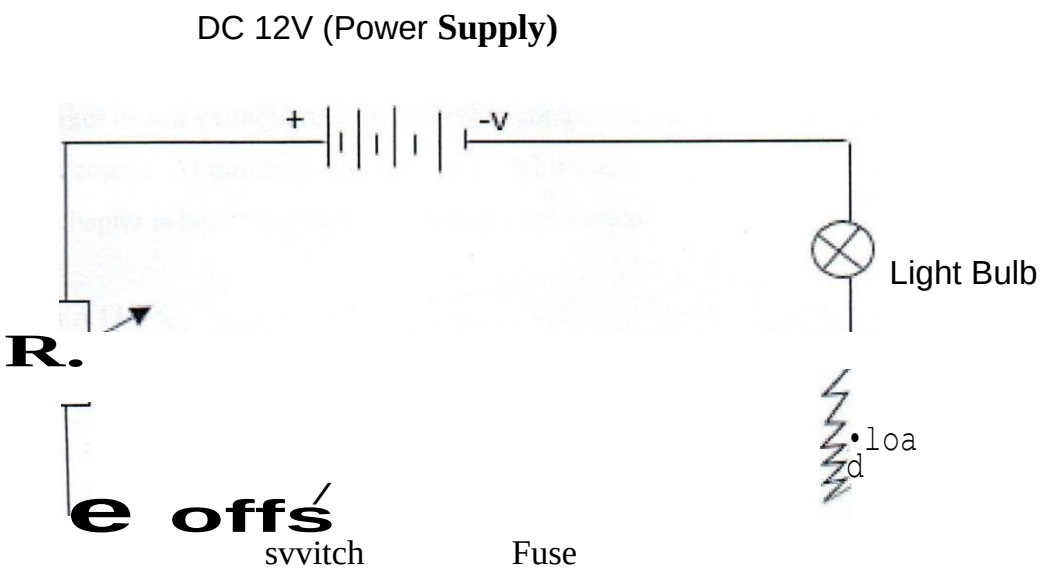
***33*CIRCUIT BREAKER DIAGRAM.**



CHAPTER FOUR

RESULTS AND DISCUSSION

INTRODUCTION

A circuit breaker uses a variable resistor and other components connected in series with the Light bulb. The insulated coper, Aluminum wire (steel wire which acts as a fuse) which acts as a fuse) also connected in a series with the circuit. This chapter is based non-observation and explanation.

4.1 OBSERVATION

By gradually decreasing the resistance in the circuit and over loading the circuit the current thus causing a short circuit because steel wire (which acts as a fuse) heats up, blows/ melts and breaks the circuit, hen also light is cut off which prevents the power misuse in the electric appliances like bulbs.

The purpose of this project is to construct and design circuit breaker with a variable resistor and a fuse wire being the main components. According o my firshecircuit works when:

- The steel wire which acts as a fuse conduzs el rre
- The input voltage is in the range of **6.0V-9.0V**
- This circuit will work only when the variable resistor is oed in series with the Light bulb and other components.
- The brightness of the light bulb increases when dle~~"l::.O!~pmbes is averagely small. This is as a result of a low resistance across the probes since the resistance decreases with decrease in length, thus large current is carried across the probes.
- The brigh~ of the torch bulb is low, I suppose that this is because of a low current that the light bulb might be receiving.

4.2 **EXPLANATION**

From the above obsera it can be explained that there are two conditions that can cause a fuse to blow;

When too many lights or --=- ::n appliances draw power from the circuiL ir ca!l. overload the capacity of the fuse and ca~5.'" ~ ~ ----.oon inside the fuse to melt through. Toe result is mac all lights, outlets and appliances powered by the ruit will go Dead suddenly, Appliances that heat such as those with motors like vacuum cleaners seally prone to causing overloads since their power draw is fairly large. ~--::::.::.

Another cause C: z:..... when a hot wire somewhere in the system touches either the grounding s what is --.~ pathway or a neru as a short circuit, and loose wire connections, damaged

ire somewhere along the circuit, or an internal wiring problem in some appliances plugged into the circuit. Amis-wired lamp, for example, can cause a short circuit and blown fuse if it is plugged into an outlet.

CHAPTER FIVE CONCLUSION AND RECOMMENDATIONS

5.0 INTRODUCTION

This chapter focuses on the conclusion and recommendations based on findings of the study for further **search** projects.

5.1 GENERAL CONCLUSION

I therefore, recommend that the government of Uganda through the ministry of education and sports to **provide** necessary equipment required in the laboratories and give remuneration to physics teachers in order emphasize practical work rather than theoretical work in physics.

5.2 RECOMMENDATIONS

Below are the recommendations for the construction and design of an effective circuit breaker:

- The device should be used with the lowest in put voltage of about 6.0V and a maximum in put voltage of 9.0V.
- Test the printed circuit board before construction
- The voltage should be increased to at least 12.0V, to enable the torch bulb receive sufficient current.
- The separation of the probes should be made small and varied according to the supply voltage.
- The brightness of the torch bulb can also be increased by amplifying the signal (current) by using an amplifier.

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