DESIGN AND CONSTRUCTION OF A BASIC ELECTRICITY EXPERIMENTAL TRAINER

SOBOWALE OLUWASEUN BABATUNDE

MATRIC NO: [illegible]

JUNE, 2009

DESIGN AND CONSTRUCTION OF A BASIC ELECTRICITY EXPERIMENTAL TRAINER

BY

SOBOWALE OLUWASEUN BABATUNDE
MATRIC NO.06/209

A PROJECT REPORT SUBMITTED TO THE DEPARTMENT OF ELECTRICAL/ELECTRONICS ENGINEERING, ABRAHAM ADESANYA POLYTECHNIC, IJEBU-IGBO, OGUN STATE, NIGERIA. IN PARTIAL FULFILLMENT OF THE AWARD OF NATIONAL DIPLOMA (ND) IN ELECTRICAL/ELECTRONICS ENGINEERING

JUNE 2009

CERTIFICATION

I certify that this project was carried out by SOBOWALE BABATUNDE OLUWASEUN. of the department of Electrical/Electronics Engineering, School of Engineering Technology, Abraham Adesanya Polytechnic, Ijebu-Igbo, Ogun State.

____________________________ __________________

SOBOWALE BABATUNDE O. Date
Student

____________________________ __________________

Engineer Lawrence Oborkhale Date
Project Supervisor

____________________________ __________________

Engineer Lawrence Oborkhale Date
Dean School of Engineering

DEDICATION

This project is dedicated to God. The Almighty Father, the giver of knowledge, wisdom and understanding for given me the grace to scale through my course of study in Abraham Adesanya Polytechnic, Ijebu-Igbo.

Also to Pastor & Mrs P.O Sobowale and Mrs. Sidikat Bello for their encouragement, parental, moral and financial support to my success in life.

ACKNOWLEDGEMENT

To God be the glory, great things He hath done. A student was trained to understand, assimilate and acquire knowledge and apply the knowledge to other situations which are quite different from what he/she was thought for. On this my profound gratitude goes to all who have in one way or the other contributed to the success of this project.

Table of Contents

TABLE OF CONTENTS

CHAPTER ONE

1.1. GENERAL INTRODUCTION

In the study of Electrical/Electronics, there are some basic needs that are to be considered. Parts of this need are:

i. Basic Electricity

ii. Basic Electronic.

In this project I will be discussing the construction of Basic Electricity Trainer.

Firstly, Electricity can be considered from different points of view. The scientist is concerned with what happens in an electrical system and seeks to explain its mysteries. The engineer accepts that electricity is there and seeks to make use of its properties without the need to fully understand them, but this trainer is designed for engineer that needs training on basic electricity.

In fact, dealing with electricity can be summarized into five categories.

i. The production of electricity

ii. The transmission of electricity

iii. The application of electricity

iv. The control of electricity

v. The training of electricity.

Transmission, being the bulk transfer of power by high voltage links between main load centres, deals with extra high voltage, low current and bulk energy transfer. Aluminum conductors are used in transmission.

Individuals and industries in carrying out their daily activities utilize electricity. During electricity transmissions, problems such as shock and fire occur, resulting from over-currents and earth leakage, resulting from a fault. The faults may be due to sustained over-loading, short circuit, bad design and poor installation methods. The above highlighted problems can be minimized by following electrical precautions, using fuses and circuit breakers. Due to numerous complains heard during electrical experiments, this report is being developed and it highlights the problems related to stress and ineffectiveness of apparatus used in carrying out laboratory researches on electricity. Institutions generally are faced with the problems related to the ineffectiveness of apparatus and exactness of values during experiments.

This trainer is designed mainly and specifically for the study and verification of law and network theorem in D.C circuits.

It also enhances the practical aspect of the lecture in classroom.

Part of this practical experience is verification of Ohms law and many more that will be discussed in the objectives of the trainer. It is absolutely self contain and require no other apparatus, for instance using of multi-meter, practical experience, on this bound carries great educative value for science and engineering students.

1.2. OBJECTIVE OF THE TRAINER

The basic objective of the trainer are listed below:

i. Verification of Ohm's law

ii. To draw the V – I characteristics

iii. Curve studying of D.C behaviour of the following:

   a. Ideal resistance

   b. Semi conductor diode

   c. Zener diode

   d. Thermistor (NTC type)

iv. To verify Kirchoff's Current law and voltage law

v. Verification of superposition theorem

vi. Verification of Series and Parallel Law for resistance

vii. Studying of potential divider

viii. Verification of maximum power transfer theorem

ix. To verify Thevelin theory and to find equivalent voltage source circuit

x. To verify Norton's theorem and to find equivalent current source circuit.

xi. To study the design of a multi-meter.

1.3. TRAINER ARRANGEMENT

The trainer is rectangular in shape with the main power on/off switch at one side.

There are many components in this trainer, among them are:

i. 0 – 30v D.C at 100mA continuously variable IC regulates power supply.

ii. + 9v D.C at 100mA, IC regulated supply

iii. + 5v D.C at 100mA IC regulated power supply

iv. Other electronic components like Thermistor, Diodes etc.

The unit is operative on 230v +/- 10% at 50Hz A.C. main. Adequate no of patch cords stackable from rear both ends.

Good quality, reliable terminals, sockets are provided at appropriate place on panel for connection and observation of waveform.

Also sockets value of resistor, a rectified diode and 6.8v Zener diode are provided in the bottom part of the panel.

1.4. LIMITATION OF THE TRAINER

Before this project work could be successfully used for training, its limitation lies on two (2) major factors.

i. Financial factor

Sourcing for funds for the purchase of the material and components needed to execute the project was a little bit difficult due to the high cost of components as a result of the economic meltdown of the nation.

ii. Time and Energy factor

Gathering of the necessary information on the construction of device, getting the component for the construction ready including the construction of the trainer is another problem.

Also problem of poor electrical supply for the soldering process is encountered, it took a very long time to be dealt with.

CHAPTER TWO

LITERARY REVIEW

2.0. INTRODUCTION TO THE THEORY

In the construction of basic electricity training module, some theory which has been taught in class needed to be reviewed.

2.1. OHMS LAW

One of the most important steps in the analysis of the circuit was undertaken by George Ohm who found that Potential Difference (P.D) across the ends of many conductors is proportional to the current flowing through them. This, he found, was a direct proportionally, provided that temperature remained constant. Also physically there are some condition that affect a conductor. Examples of these conditions are temperature, density, mechanical strain etc. "If all this condition stated above or a homogenous conductor remain constant, the current flowing through the conductor is proportional to the potential difference between its ends.

Ohms Law For A Circuit

$V = E - I\,r$ where V is the PD

E is the EMF

I is the current

r is the internal resistance.

Differential Form Of Ohm's Law

This is given by d = ÓE although it does not contain any differential coefficient of so called because it refer to value of d and E at a point.

Generally Ohm's law states that as long as physical conditions remain same, the electric current flowing through a conductor is proportional to the voltage applies across it and is given by

$$I = \frac{V}{R}$$

Where R is the resistance of the conductor to current flow in Ohms, V is voltage in Volts and I is Current in Amperes.

The above expression can be put in different form as below:

$$V = IR$$

$$R = \frac{V}{I}$$

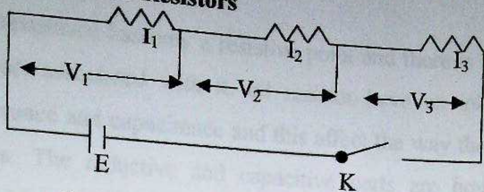
2.2. RESISTANCE

By definition a conductor is said to have a resistance of 1 Ohm if a voltage of 1 volt applied across causes a current of 1 Ampere to flow through the conductor. Resistance of a material is the disruption of the orderly movement of electron by interrelation with its atomic structure. As the electron moves through the material they transfer their kinetic energy to the librating parent atoms through collision whereby their vibrational amplitude increases. This is observed as heating of conductor. This resistance is the name given to the property of a conductor of transforming electrical energy into heat.

Effect Of Temperature On Resistance

In the temperature range 0 – 200^{0}C this effects can be represented for conductor by the equation $R_+ = R_0 (1 + at)$ where R_0, R_+ denote the resistance at 0^{0}C and +^{0}C respectively is called temperature coefficient of resistant of the material defined as the increase in the resistance per unit resistance per ^{0}C risk in temperature.

Series Connection Or Resistors



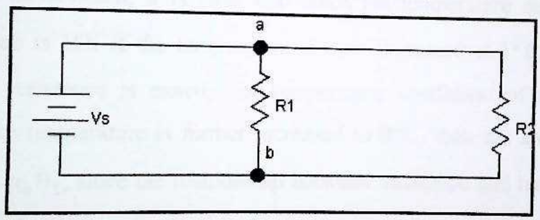
Series Connection Of Resistors

Using the diagram above the resistor R_1, R_2 and R_3 are joined end-to-end so that:

a. The same current flows through all the resistors $I_1 = I_2 = I_3 \ldots\ldots I$

b. The circuit act as a voltage divider $V = V_1 + V_2 + V_3$ and the equivalent resistance is greater than any one of the individual resistance.

Parallel Connection Of Resistors



Also in the diagram above one end of each resistor is joined to a common terminal and the other end to a common terminal B so that.

a. The voltage across each resistor is equal to the source voltage.

$V_1 = V_2 = E$

b. The circuit is a current divider.

$I = I_1 + I_2$

Hence, the equivalent resistance is always less than any of the individual resistance.

Ideal Resistance

An ideal resistance has only a resistive point and there is no inductive or capacitive part associated with it. all resistor have an inherent small amount of inductance and capacitance and this affect the way they behave at high frequencies. The inductive and capacitive parts are however more pronounced at higher frequencies. At D.C voltage carbon composition type resistors are nearly ideal as compared to wire wound and film type resistors.

2.3. TEMPERATURE COEFFICIENT OF RESISTANCE AT $0^oC\ (\alpha_o)$

The temperature coefficient of resistance of a material at $0^oC\ (\alpha_o)$ can be defined as the change in the resistance of a sample of the material having a resistance of 1ohm at 0^oC when its temperature is raised by 1^oC.

From observation, it is clear that when the temperature equals 0^oC, the resistance is 1Ω. If the temperature is now increased to 1^oC, then the increase in resistance is exactly the temperature coefficient of resistance at 0^oC. If the temperature is further increased to Θ_1^oC, then the increase, in resistance is $\alpha_o\Theta_1$, since the relationship between resistance and temperature is assumed to be linear.

The table 2.0 below shows values of temperature coefficient of resistance at 0^oC for some common metals used in electrical engineering.

S/N	Material	α_o at $0°C$ (per°C)
1	Silver	0.00412
2	Copper	0.00426
3	Aluminum	0.00424
4	Tungsten	0.00495
5	Gold	0.00365

Table 2.0: Temperature Coefficient of Resistance at $0°C$

2.4. TEMPERATURE COEFFICIENT OF RESISTANCE AT ANY GIVEN TEMPERATURE (α_θ)

It sometimes occur that the temperature coefficient of resistance of any material at $0°C$ is either not known or cannot be determined. In such cases, temperature coefficient of resistance of the material at any base temperature is useful and is determined as follow:

α_θ Is the change in resistance of a sample of material having a resistance of 1Ω at $\theta°C$ when its temperature is raised by $1°C$. Therefore, if a conductor has a resistance value of R_θ at base temperature $\theta°C$, then, its resistance $R_{\theta 1}$ at temperature $\theta_1°C$ is given by:

$$R_{\theta 1} = R_\theta + R_\theta \alpha_\theta (\theta_1 - \theta)$$

2.5. ELECTRICAL QUANTITIES

CURRENT

The ampere is defined as that current which, if maintained in two straight parallel conductors of infinite length, of negligible circular cross-section and place 1 meter apart in a vacuum would be produced between these conductors a force of 2 x 10^7 Newton per meter of length. The conductors are attracted towards each other if the current are in the same direction. Whereas they repel each other if the current are in opposite directions.

Current symbol: I Unit ampere (A)

The value of the current in terms of this definition can be determined by means of a very elaborately constructed balance in which the force between fixes and moving coil carrying the current in balanced by the force of gravity acting on a known mass.

QUANTITY OF ELECTRICITY

The unit of electrical quantity is the coulomb, name the quantity of electricity passing a given point in a circuit when a current of 1 ampere is maintained for 1 second.

Charge symbol: Q Unit: Coulomb (C)

POTENTIAL DIFFERENCE

The unit of potential difference is the volt namely the difference of potential between two points of a conducting wire carrying a current of 1 ampere where the power dissipated between these points is equal to 1 watt.

The term voltage originally meant a difference of potential expressed in volts but it is now used as a synonym for potential difference irrespective of the unit in which is expressed.

Electric potential symbol: V Unit: Volt (V)

Potential difference has the same symbol and unit. Electromotive force has the symbol E but has the same unit. Because P.d is measured in volts they are also referred to as volt drops or voltages. By experiment it can be shown that the relation corresponding to the definition is

$$V = \frac{P}{I}$$

This is better expressed as:

$$P = VI$$

It also follows that

$$V = \frac{P}{I} = \frac{W}{t}\ \frac{t}{Q}$$

$$V = \frac{W}{Q}$$

That is the p.d is equal to the energy per unit charge.

2.6. CONDUCTOR AND INSULATORS

Using these rods made from metals permit quite reasonable currents to flow while those made from non-metallic material permit virtually no current to flow. Not all the materials conduct as well as each other. Copper being better than steel, Aluminum being better than zinc and so on. Non-metallic materials permit so little current to flow that no comparison can be made between them, but nevertheless the observation may be made that there are certain material which permit current to flow are the conductor, while those that do not permit current to flow are the insulators.

Examples of conductor are copper, Aluminum, Silver, Platinum Bronze, Gold.

Examples of insulators are Glass, Rubber, Plastic, Air, Varnish, Paper, Wood, Mica, Ceramic, Centain Oils.

Therefore the function of the conductors is to provide a complete circuit at all points where there is material with free electrons. Materials with no energy gap readily provide the free electrons and are used to make up a circuit, but these material with sizeable energy gap between the valence and conduction bonds are used to insults the circuit and to contain the current within the conductors.

2.7. DIODE

a. Semi-Conductor Diode

A Semi-conductor diode are diode that are formed by joining together a P-type and a N-type semi-conductor material.

b. Forward Biased Diode

When P-type is made positive with respect to N-type region, the diode is said to be forward biased the depletion region narrows and electric current flows due to electron – hole recombination inside the diode.

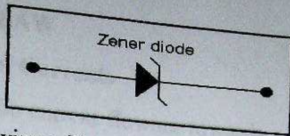
c. Reverse Biased Diode

A reverse biased diode is obtained when P-type made –Ve with respect to N-type region, the diode is said to be reverse biased. The depletion region widens and there is no electric current flow.

2.8. ZENER DIODE

In ordinary semiconductor diodes on certain reverse voltage the diode breaks and the large current flows which permanently damage the diode. This reverse voltage is called Reverse Break-down Voltage V_{BO} and is quite high.

Zener diodes are specially made silicon diode with known V_{BO} ranging from about 2v and above. Thus Zener diodes are always used in reverse biased mode. After reverse breakdown the voltage across the diode remains almost constant to its Zener voltage although current flowing through it may vary. Zener diodes are thus used to give stable fixed voltage reference in voltage regulators. The forward characteristics of regulators. The forward characteristics of a Zener diode are similar to the forward characteristics of an ordinary silicon diode.



The Figure above showing a Zener diode.

The figure above showed how a voltage regulator diode (zener diode) can be used as a voltage stabilizer to provide a constant voltage from a source whose voltage may vary appreciably. A resistor R is necessary to limit the reverse current through the diode to a safe value.

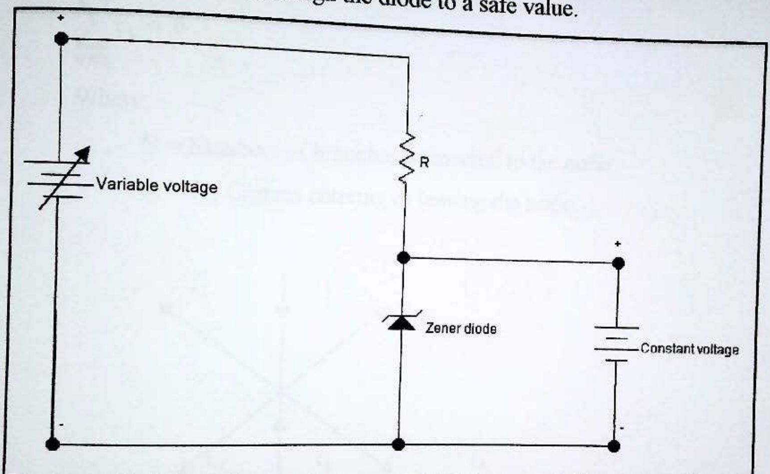


Figure showing the usage of Zener diode as a voltage stabilizer.

(E)THERMISTOR

A Thermistor is a semiconductor device, it comes in two basic types.

NTC Type: In this type, resistance decrease as its temperature is increased.

PTC Type: In this type of Thermistor, its resistance increases as the temperature is increased.

2.9. KIRCHOFF'S LAW

(a). Kirchoff's Law of Currents

This law states that the current flowing towards a point or node in a circuit is equal to the current leaving that point. Also this law can be stated in another form that the algebraic sum of all the current directed toward a point or node is zero.

The law mathematically implies that;

$$\sum_{n=1}^{N} i_n = 0$$

Where:

N = Numbers of branches connected to the node

$i_n = n_{th}$ Current entering or leaving the node.

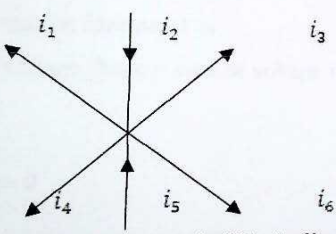


Figure 2.5 showing the proof of Kirchoff's current law.

$i_1 + i_3 + i_4 + i_6 = i_2 + i_5$

By this law, currents entering into a node may be regarded as positive while currents leaving the node may be taken as negative or vice versa.

To prove KCL, assume a set of currents $i_k(t), k = 1, 2$ etc. flows into a node. The algebraic sum of the currents at the node is;

$$i_T(t) = i_1(t) + i_2(t) + i_3(t) + \cdots i_n(t) \qquad equ\ 1$$

Integrating both sides of equation 1, gives;

$$q_T(t) = q_1(t) + q_2(t) + q_3(t) + \cdots q_n(t)$$

Where.

$$q_K(t) = \int I_K(t)dt$$

$$q_T(t) = \int i_T(t)dt$$

The law of conservation of electric charge requires that the algebraic sum of electric charges at the node must not change. That is, the node stores no net charge. Therefore, $q_T(t) = 0 \rightarrow i_T(t) = 0$, confirming the validity of KVL.

Note: The current flowing towards the points are taken as the positive whereas current flowing away from the point are taken as negative.

(b). Kirchoff's Law of Voltage

This law states that the sum of the voltage drops across a series circuit is equal to the voltage applied by the source.

The law can be interpreted as:

Sum of voltage drops = sum of voltage rises. KVL is mathematically expressed as:-

$$\sum_{m=1}^{M} V_m = 0$$

Where:-

M = Number of voltages in the loop or the number of branches in the loop

$V_m = m_{th}$ voltage

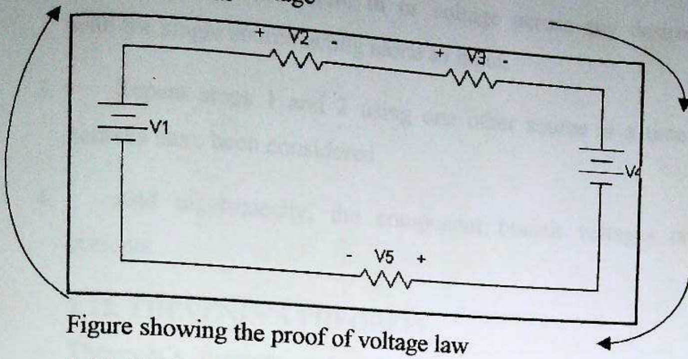


Figure showing the proof of voltage law

2.10. SUPER POSITION THEOREM AND PRINCIPLE

Super Position Principle: This states that the mutual interaction of two charges is independent or the presence of other charges so that the total electric fields of all the charges at the points.

Super position theorem states that in a linear network containing more than one source of E.M.F the resultant current in any branch is the algebraic sum of the current that will be produced by each E.M.F acting alone, all the other sources of E.M.F being replaced meanwhile by their respective internal resistance. In order to verify the theorem we require to know the internal resistance of each E.M.F source. The other method is to connect series large value resistor with E.M.F source in order to be able to neglect the comparative very small internal resistance of E.M.F sources.

2.11. PROCEDURE IN APPLYING SUPERPOSITION THEOREM

The superposition theorem, as stated above, is applied to electric circuits by following the steps listed below.

1. Select one source and replace any other source with a shunt (i.e. V=0) and any other current source with an open-circuit (i.e. I=0).

2. Determine the current in or voltage across any desired branch with the single source acting alone as input.

3. Repeat steps 1 and 2 using one other source at a time until all sources have been considered.

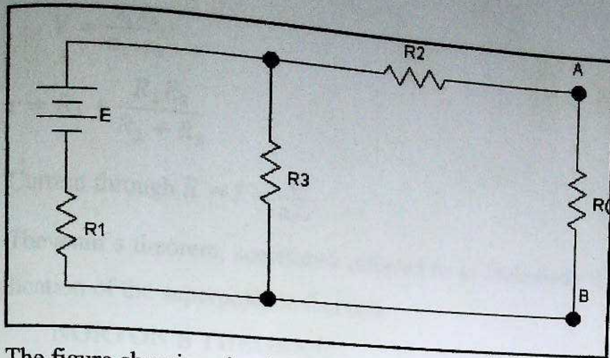
4. Add algebraically, the component branch voltages or branch currents.

2.12. THEVENIN'S THEOREM

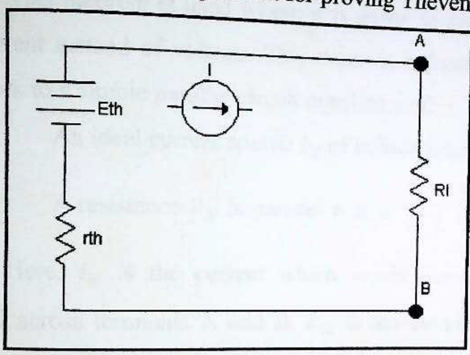
Thevenin's theorem states that the current through a resistor R_L connected across any two points A and B of an active network. (i.e. a network containing one or more source of E.M.F) is obtained by dividing the open circuit voltage V_{OC} (with R_L disconnected) by $R_L + R_{EQ}$ is the equivalent resistance of the network measured between points A and B with R_L disconnected and the source of E.M.F replaced by their internal resistance.

Alternatively, Thevenin's theorem can be stated as follows:-

An active network having two terminals A and B can be replaced by a constant-voltage source having an e.m.f *E* and an internal resistance r. the value of E is equal to the open-circuit potential difference between A and B, and r is the resistance of the network measured between A and B with the load disconnected and the sources of e.m.f replaced by their internal resistances.



The figure showing circuit for proving Thevenin's theorem



The Figure above showing Thevenin's equivalent circuit

Suppose A and B in the above drawn figure to be the two terminals of a network consisting of resistors having resistances R_2 and R_3 and a battery having and e.m.f E_1 and an internal resistance R_1. It is required to determine the current through a load of resistance R connected across AB.

Current through $R_3 = \frac{E_1}{R_1+R_3}$ and,

P.d across $R_3 = \frac{E_1 R_2}{R_1+R_2}$

Since there is no current through R_2, P.d across AB is:

$$V = \frac{E_1 R_2}{R_1 + R_3}$$

$$r = R_2 + \frac{R_1 R_3}{R_1 + R_3}$$

Current through $R = I = \frac{E}{R + r}$

Thevenin's theorem, sometimes referred to as Helmholtz's theorem, is an application of the superposition theorem.

2.13 NORTON'S THEOREM

This theorem is used where it is easier to simplify a network in terms of current instead of voltage. This theorem reduces a normally complicated network to a simple parallel circuit consisting of:

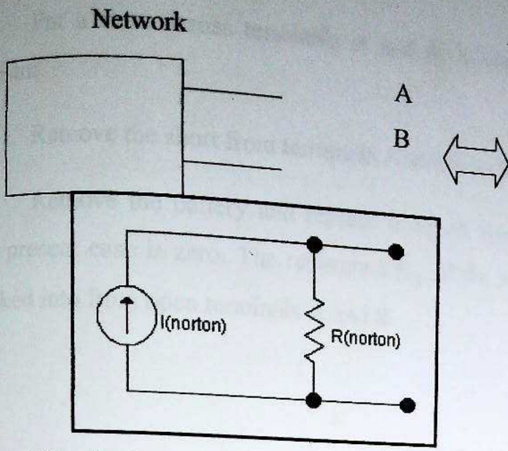
a) An ideal current source I_N of infinite internal resistance and

b) A resistance R_N in parallel with it.

Here, I_N is the current which would flow through a short circuit placed across terminals A and B. R_N is the circuit resistance looking from the open AB terminal. These terminals are not short circuited from finding R_N are open as for calculating R_{TH} for Thevenin's theorems.

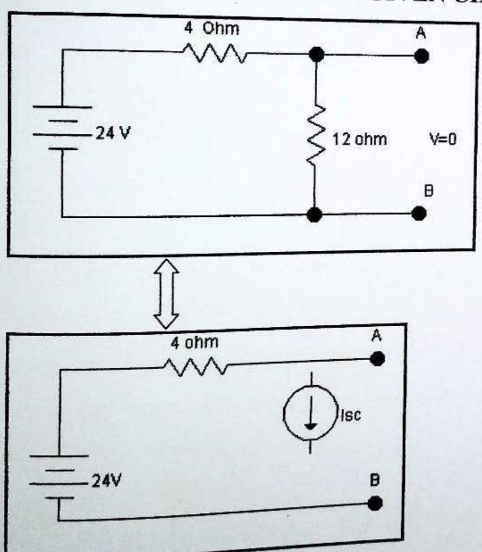
When a branch in a circuit is open-circuited, the remainder of the circuit can be represented by one source of e.m.f in series with a resistor.

Norton's theorem states that the current which flows in any branch of a network is the same as that which would flow in the branch if it were connected across a source of electrical energy, the short-circuit current of which is equal to the resistance which appears across the open-circuited branch terminals.



The circuit explaining Norton's theorem

HOW TO NORTONISE A GIVEN CIRCUIT



The circuit proving Norton's theorem

Steps to nortonising the above circuit are as follows:-

Put a short across terminals A and B. it results in shorting out 12Ω resistor.

1. Remove the short from terminals A and B so that they are again open.

Remove the battery and replace it by an internal resistance which in the present case is zero. The resistance R_N of the circuit as viewed back or looked into from open terminals A and B.

CHAPTER THREE

3.0. CONSTRUCTION AND DESIGN

Before this basic electricity training module is useful for students in the laboratory, it has undergone different steps and the first of this steps is the design and construction of the trainer. In this chapter, the procedure and the steps used in constructing the trainer will be discussed. Also under this chapter, the circuit components will be highlighted and parts of this are:

i. The Case (Housing)
ii. Transformer
iii. Power Supply
iv. Power Cords
v. Resistors
vi. Capacitors
vii. Rectifiers
viii. Diodes
ix. Panel
x. Thermistor

3.1. THE CASING (HOUSING)

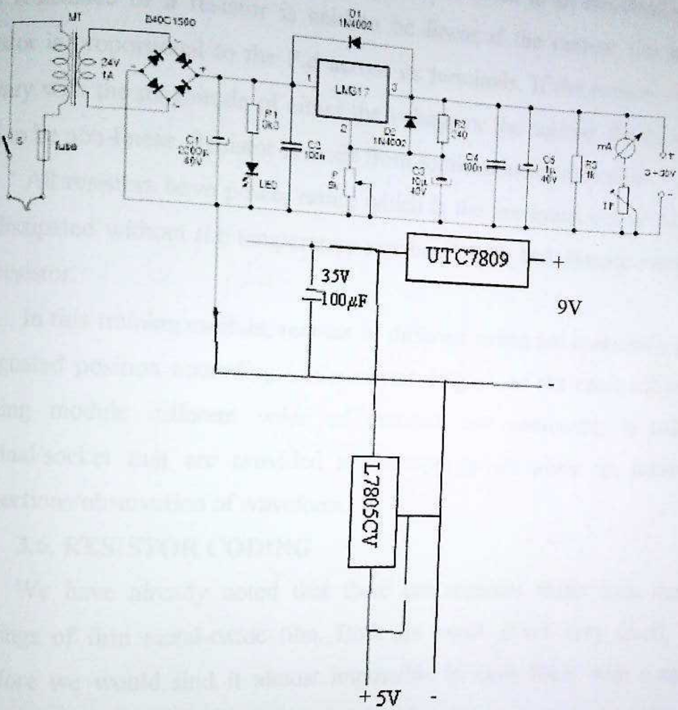
The housing of the trainer is constructed with a wooden case, constructed to a desired rectangular shape and well painted to avoid decaying of the plank and to make it attractive to anybody looking at the it.

3.2. TRANSFORMER

The transformer rating is 30v D.C at 100mA, continuously variable IC regulated power supply. Its function is to step down the A.C supply that is entering into the component within the trainer.

3.3. POWER SUPPLY

The mains On/Off switch, fuse and jewel light is located at extreme left hand lower part. The power supply supplies through the transformer and it is regulated through IC.



3.4. POWER CORDS

Connection of adequate patch cords are made to the fuse and the switch terminals and socket are provided at appropriate position on the panel for connections or observation of wave forms.

3.5. RESISTOR

In this basic electricity training module, two type of resistors are used, one is the fixed resistor and the other ones are variable resistor.

A resistor is a device which provide resistance in an electrical circuit. The resistance of a resistor is said to be linear if the current through the resistor is proportional to the P.d across its terminals. If the resistance were to vary with the magnitude of either the voltage or the current, the resistor is said to be non-linear. Resistor is made from semiconductor materials.

All resistors have power rating which is the maximum power that can be dissipated without the temperature rise being such that damage occurs to the resistor.

In this training module, resistor of different rating are connected at the designated position according to the circuit diagram of the basic electricity training module different value of resistors are connected to reliable terminal/socket that are provided at the appropriate place on panel for connections/observation of waveform.

3.6. RESISTOR CODING

We have already noted that there are resistors made from carbon moldings of firm metal-oxide film. Both are small, if not very small, and therefore we would find it almost impossible to mark them with a rating such as $4700\Omega, {}^{1}/_{4}\, watt.$

In the case of carbon resistors, it is usual to identify the ratings by means of rings, painted around the resistors. One of the bands is always placed near to the end of the resistor and should be taken as the first band. The first, second and third bands are used to indicate the resistance of the resistor by means of a colour code.

The application of this code is best explained by the diagram shown in figure 1.6. Here, the first two bands are orange and blue which from the table are 3 and 6 respectively. The third band is the number of zeros to be put after that number. In this case, the third band is green and there should be five zeros. The resistance then becomes 3600000Ω.

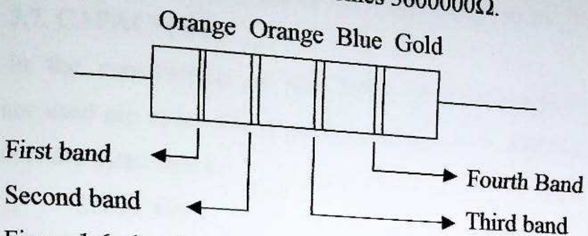


Figure 1.6: the diagram of a resistor showing the colour codes.

The arrangement of colours and the percentage of their tolerance are shown in table 1.1 below.

Table 1.1: colour codes and tolerance of resistors.

Digit	Colour
0	Black
1	Brown
2	Red
3	Orange
4	Yellow
5	Green
6	Blue
7	Violet
8	Grey
9	White

Tolerance	Colour
5%	Gold
10%	Silver
20%	No colour band

The standard values of resistances range from 0.1Ω to $22.0M\Omega$.

3.7. CAPACITOR

In the construction of this basic electricity-training module, the capacitor used are seven (7) in number which are of different rating. These capacitors are listed below:

i. 2200μ/40v

ii. 100ηf/40v

iii. 10μf/40v

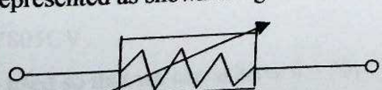
iv. 100η

v. 1μ/40v

vi. Booster Capacitor

3.8. THERMISTORS

A Thermistor is a temperature-sensitive resistor, that is, its terminal resistance is related to its body temperature. It is not a junction device and is constructed on germanium, silicon and a mixture of oxides of cobalt, nickel, strontium or manganese. The compound employed determines whether the device has a positive or a negative temperature coefficient. A Thermistor is schematically represented as shown in figure 2.4.



The figure showing the symbolic representation of a Thermistor

At room temperature which is $20°C$, the resistance of the Thermistor is approximately 5000Ω, whereas at $100°C$ $(212°F$, the resistance decreases to 100Ω. A temperature span of $80°C$ results in a 50:1 change in resistance. The change in resistance is typically 3% to 5% per degree change in temperature. The change can either be internal or external. An external change requires changing the temperature of the surrounding medium or immersing the device in a hot or cold solution.

3.9. DIODE

Diode is used in this construction as a component to achieve rectification in the power supply, also in this construction of basic electricity training module, a zener diode is used and it work is to regulate the voltage in the circuit.

3.10. RECTIFIER

A rectifier is a component which employs one or more diodes to convert A.C voltage into pulsating D.C voltage.

3.11. VOLTAGE REGULATOR

The purpose of the voltage regulator in this construction is to keep the D.C output constant despite variation in the A.C. supply voltage (deviation from 220 are common) and the D.C bad current. The regulator used in this basic electricity training module construction are:

i. LM 312

ii. UTC 7809

iii. L7805CV

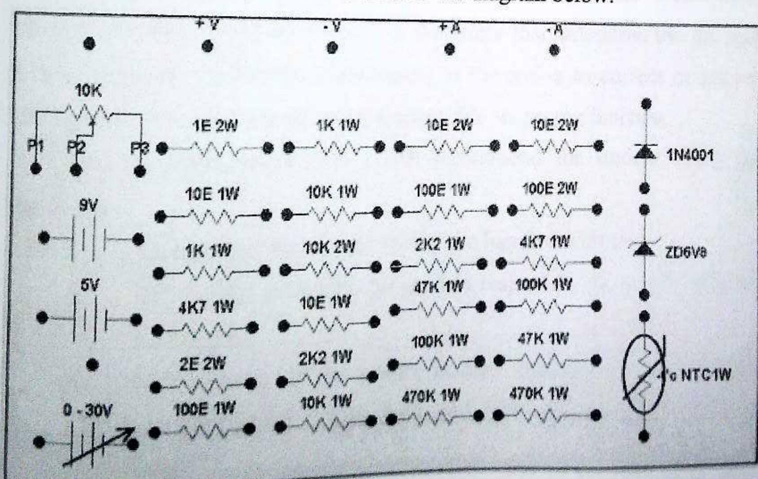
They are used so that we can achieve 0 – 30v, 9v and 5v.

3.12. THE PANEL

The panel is constructed using Vero-board and it consist of the Resistors, Capacitors, Diodes, Regulators, Connectors and Transformer. All this components were connected on the panel by soldering, the Vero-board is a ready made type which is practically recommended for use in the laboratory or electrical workshop. The Vero board is drilled so that the socket will be inserted into the drilled how from underneath.

The components are brought together and constructed using a functional circuit diagram of a basic electricity training module through electronic simulator. The weight of the assembled basic electricity training module is light and the number of the component used in construction are quite low in nature.

The panel description are shown in the diagram below:



CHAPTER FOUR

4.0. MAINTENANCE PRINCIPLES AND TESTING

In every construction there must be good maintenance and one must take a proper care of the construction. Also before anything is constructed there must be a purpose of constructing the instrument and at the end of this construction, the instrument should undergo testing. In this chapter both the maintenance principle and testing will be discussed.

4.1. MAINTENANCE

Maintenance of an instrument or a machine is the act in which the machine or instrument is take care to be in good order.

Maintenance is the preventive measure put in place in order to ensure a continuous safe and proper working condition of basic electricity training module. Maintenance may be preventive, control, repair etc. maintenance are very important because its part of the factor that determine the life-span of an equipment. Generally, maintenance is the action to correct or prevent problem that delay the use of an equipment. For its proper function.

Part of maintenance that I will recommend for student using this trainer are:

i. To maintain the trainer, it must be handled with care.

ii. The trainer must also be used in respect to the power rating of the trainer.

iii. Maintenance of the trainer is also important for the user by checking short circuit fault and high values series resistance fault.

4.2. SPECIFICATION FOR BASIC ELECTRICITY EXPERIMENTAL TRAINER MODULE

Input Voltage: 230v ± 10% at 50Hz A.C Mains.

Output Voltage: 0 – 30v, 9v, 5v D.C Power

4.3. TESTING AND RESULT

The basic electricity training module has been purposely designed specifically for the network theorems in D.C. circuit. The board is absolutely self contained and requires no other apparatus. Practical experience on this board carries great educative value for Science and Engineering Students.

Some of the experiment that are listed in chapter one will be considered in this chapter and they are:

1. Verification of Ohm's law
2. To verify Kirchoff's current law and voltage law.
3. Verification of the series and parallel laws for resistance.
4. Study of potential divider.

4.31. EXPERIMENT NO. 1: Verification of Ohm's Law

Ohm's law can be verified by varying the D.C voltage applied across a resistor and recording the values of the corresponding circuits.

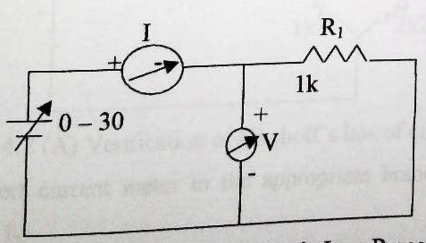


Figure 4.1. Circuit for verifying Ohm's Law Procedures.

i. Assemble the circuit of Fig. 3.3 keep the 0 – 30v supply knob to fully anti-clockwise position.

ii. Switch On the supply to the training board. Vary the applied voltage in volt steps and record the responding values of current in table 4.2 below:

S/N	$V_{(V)}$	$I_{(A)}$	S/N	$V_{(V)}$	$I_{(A)}$
1	5.0	$5x10^{-3}$	6	10	0.010
2	6.0	$6x10^{-3}$	7	11	0.011
3	7.0	$7x10^{-3}$	8	12	0.012
4	8.0	$8x10^{-3}$	9	13	0.013
5	9.0	$9x10^{-3}$	10	14	0.014

iii. Verify Ohm's Law for different values of resistor R.

4.32. EXPERIMENT NO. 2 to verify Kirchoff's current law and voltage law.

Procedure: (Law of Current)

i. Assemble the circuit of 3.4(A)

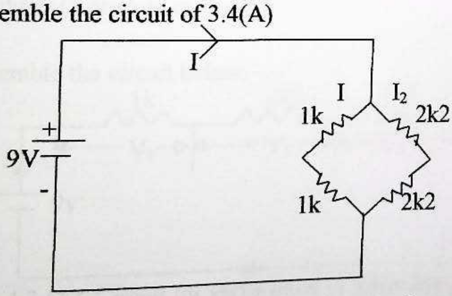


Figure 4.2 (A) Verification of Kirchoff's law of current.

iii. Insert current meter in the appropriate branch of the circuit and measure I, I_1, I_2.

Procedure: (Law of voltage)

i. Assemble the circuit below.

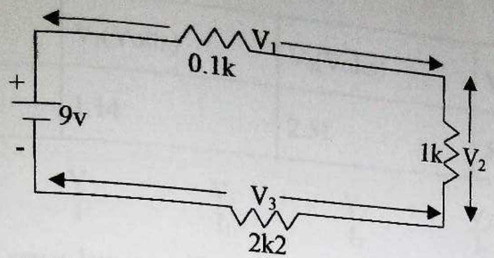


Figure 4.2 (B). Verification of Kirchoff's law of voltage.

ii. Measure voltage V_1, V_2 and V_3 across R_1, R_2, R_3 respectively using the voltmenter.

iii. Kirchoff's law of voltage is verified if:

$V_1 + V_2 + V_3 = 9v$

4.33. EXPERIMENT NO. 3: Verification of series and parallel laws for resistance.

Procedure: (Resistors in Series)

i. Assemble the circuit below.

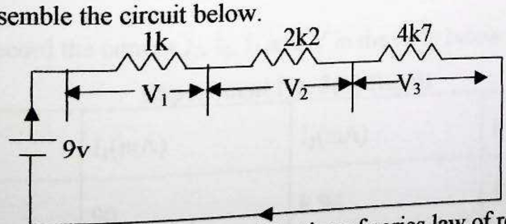


Figure 4.3 (A). Circuit for verification of series law of resistors

ii. Record the current I and voltage drops across each resistor in table below:

I(mA)	V_1(Volts)	V_2(Volts)	V_3(Volts)
1.14	1.14	2.51	5.35

When $\frac{V}{I} = \frac{V_1}{I_1} + \frac{V_2}{I_2} + \frac{V_3}{I_3}$

Hence, series law is verified.

Procedure: (Resistors in parallel).

i. Assemble the circuit of the figure below:

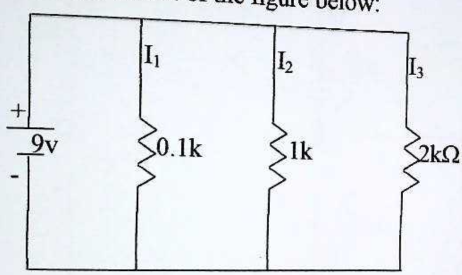


Figure 4.3(B). Circuit for Verification of parallel law of resistors.

ii. Record the current I_1, I_2, I_3 and V in the table below:

Experiment No. 3(b) Result

V (Volts)	I_1(mA)	I_2(mA)	I_3(mA)
9	90	8.94	4.06

Hence, parallel law of resistors is verified.

4.34. EXPERIMENT NO. 4: Study of potential divider.

A resistor network as shown in the figure below is widely used in electronic and electrical circuit for dividing the potential of a voltage source as required for a potential application.

Procedure:

i. Assemble the circuit of the figure below:

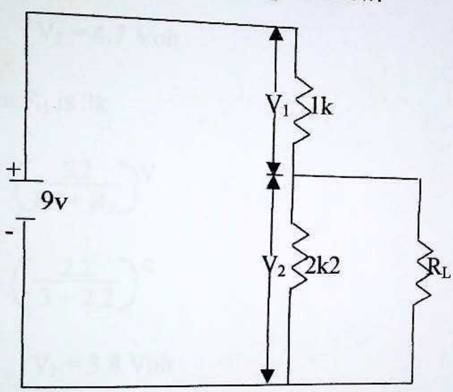


Figure 4.4. Study of potential divider.

ii. Measure voltage V_2 and verify that

$$V_2 = \left(\frac{R2}{R_1 + R_2}\right)V$$

$$V_2 = \left(\frac{2.2}{3.2}\right)9$$

$V_2 = 6.1$ Volt.

Note: In all experiment result, there may be slight errors due to error in meter readings.

V_2 = When R_1 is 2k

$$V_2 = \left(\frac{R2}{R_1 + R_2}\right)V$$

$$V_2 = \left(\frac{2.2}{2 + 2.2}\right)9$$

$$V_2 = 4.7 \text{ Volt}$$

V_2 = When R_1 is 3k

$$V_2 = \left(\frac{R2}{R_1 + R_2}\right)V$$

$$V_2 = \left(\frac{2.2}{3 + 2.2}\right)9$$

$$V_2 = 3.8 \text{ Volt}$$

V_2 = When R_1 is 4k

$$V_2 = \left(\frac{R2}{R_1 + R_2}\right)V$$

$$V_2 = \left(\frac{2.2}{4 + 2.2}\right)9$$

$$V_2 = 3.2 \text{ Volt}$$

V_2 = When R_1 is 5k

$$V_2 = \left(\frac{R2}{R_1 + R_2}\right)V$$

$$V_2 = \left(\frac{2.2}{5 + 2.2}\right)9$$

$$V_2 = 2.8 \text{ Volt}$$

$R_1(K\Omega)$	1K	2K	3K	4K	5K
V_2(volt)	6.1	4.7	3.8	3.2	2.8

CHAPTER FIVE

5.0. SUMMARY

Summarizing all that have been discussing from chapter one to chapter four, the basic electricity trainer module has been designed and also to function as to verify laws and network theorems in D.C. Circuits. Many components has been used to build the main circuit and the power supply, and part of it is the Vero-board, resistors, capacitors, diode, regulators, thermistor, fuse, jack and socket plugs, transformer, power switch and many more.

Electronic work bench is used for the drawing of the original circuit diagram after the diagram has been simulated, it was printed out and after the printing, it was laminated so that it looks attractive and also to be able to withstand humidity to some level.

The essence of the power supply circuit is to achieve the D.C sources of 0 – 30v, 5v and 9v that are needed in carrying out experiments.

Adequate care and proper maintenance should be given to this construction to ensure a longer life which will give chance to the trainer to serve the purpose in which it was built for.

5.1. CONCLUSION

Conclusively, the construction has enabled us to know and identify the various electronic components and their uses. Also during this construction, we had the experience of using electronic simulators constructing electric circuit on a Vero board. We had the experience of using Vero board for panel, using a multi-meter efficiently and also had been thought series of self correction before achieving a positive result. This construction also exposes us to various faults arising from improper soldering, short-circuit, and open circuit.

5.2. RECOMMENDATION

The following are recommended for the construction of a Basic Electricity Experimental Trainer so as to achieve a positive result.

- The recommended AC voltage for the trainer is 220 – 230v
- The project work should be repaired and maintained by a specialist when there is a specified fault.
- The moisture part of the trainer should be regularly cleaned to avoid rusting

BIBLIOGRAPHY

1. B.L. Theraja "Basic Electronics Solid State" S. Scand and Company Limited 6th Edition 2005.

2. Cited Engr. Lawrence Obhokhale "Electronic Maintenance and Instrumentation" Abraham Adesanya Polytechnic, 2008.

3. John Hiley, Keith Brown and Ian MCKENZIe Smith, Huges "Electrical and Electronic Technology" Pearson Education Limited, 8th Edition 2002.

4. P.C. SEN "MODERN POWER ELECTRONICS" S. Chand and Company Limited 6th Edition 2006.

5. V.K. Mehta and Rhit Mehta "Basic Electrical Engineering" S.Chand and Company Limited 6th Edition 2005.

APPENDIX

COMPONENTS LIST AND COST ANALYSIS

COMPONENT NAME	SPECIFICATION	QUALITY	AVERAGE COST (₦)	TOTAL (₦)
Wooden case	Casing	1	1500	1500
Vero board	Panel	3	200	600
Transformer		1	800	800
Printing of the circuit diagram and lamination		1	200	200
Diode	1N4001	7	20	140
Resistor	Different Value	27	20	540
Variable resistor	10k	2	50	100
Variable resistor knob	Knob	2	30	60
Regulator	LM317,UTC7809,L7805CV	3	100	300
Socket		68	20	204
Plug		10	20	200
Capacitor	2200N, 40V	1	100	100
Capacitor	10N, 40V	1	50	50
Capacitor	100n	20	3	60
Power ON/OFF		1	50	50
Zener Diode	Z06V8	1	50	50

Power supply adjustment			1000	1000
Power Cord		1	200	200
		Total		7880
		Miscellaneous		500
		Total		8400

SPECIFICATION FOR BASIC ELECTRICITY TRAINER MODULE

- Input Voltage: 220 – 240V A.C
- Output Voltage: 0 – 30V, 9V and 5V D.C.