# DESIGN AND CONSTRUCTION OF A 3KVA AUTOMATIC VOLTAGE REGULATOR (AVR)


BY

**ADEDOYIN TEMITAYO**

**MATRICULATION NO. 2000/10932EE**

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

SCHOOL OF ENGINEERING AND EGINEERING TECHNOLOGY,

FEDERAL UNIVERSITY OF TECHNOLOGY MINNA NIGER STATE.



OCTOBER 2006

# DESIGN AND CONSTRUCTION OF A 3KVA AUTOMATIC VOLTAGE REGULATOR (AVR)

BY

ADEDOYIN TEMITAYO

MATRICULATION NO. 2000/10932EE

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF BARCHELOR OF ENGINEERING DEGREE B.ENG IN ELECTRICAL AND COMPUTER ENGINEERING, SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY, FEDERAL UNIVERSITY OF TECHNOLOGY MINNA NIGER STATE

OCTOBER 2006.

# DECLARATION

ereby declare that this thesis is my original work and has not been presented in any form for the awards of ;ree or diploma at any University.

information derived from published or unpublished worked of others have been acknowledge in the text.

**iedoyin Temitayo** ...................................................

Date & sign

# CERTIFICATION

This is to certify that the project work titled design and construction of a 3KVA automatic voltage regulator by Adedoyin Temitayo under the supervision of Mr. J.A Abolarinwa and submitted to the department of Electrical and Computer Engineering of University of Technology Minna.

Adedoyin Temitayo ..............................................

Student Date & Sign

Mr. J.A Abolarinwa 9th Oct, 2006

Project supervisor Date & Sign

Engr. M.D. Abdullahi ..............................................

Head of Department Date & Sign

External Supervisor ..............................................

Date & Sign

# DEDICATION

This project work is dedicated to Almighty God for his grace and the knowledge he has granted me to design his project. I also dedicate it to my late father Pa. Johnson Adedoyin, my Mother Remilekun Adedoyin and my dear brother Temitope E. Adedoyin

# ACKNOWLEDGEMENT

I owe gratitude to Almighty God for giving me knowledge, wisdom, guidance and protection. am grateful to my supervisor, Mr. J.A Abolarinwa who not only encourages but was also there to check and echeck my manuscript with great perseverance. I am indeed grateful to my parent for their love, advice, nance and moral support. Also am pleased to thank my HOD Dr. M.D. Abdullahi for his advice and irections.

My gratitude also goes to my lecturers. I am especially grateful to my siblings; David and Bunmi for eir love, encouragement, and sincere wish, for the success of this project. I wish to express my deep gratitude o my friends: Ooye Benjamin (Senator), Ahmed Ibrahim (Oremi, Former Minister), Oyekunle, Janet lowoniyi for their help and support .My gratitude also goes to every body in my family who participated in y way to the successful accomplishment of this project. I must not forget Mr. & Mrs Paul Ajetunmonbi for ving me accommodation and other assistance during my study, may God reward them all abundantly.

# ABSTRACT

his project work is concern with the design and construction of a 3KV Automatic Voltage Regulator, whose rpose is for the regulation of power supply to other equipments and applications. Efforts have been made in past to regulate the terminal voltage of a generator during variation of load s across it. This design attempts solve the problem by the principle of phase control techniques. The design employs a voltage sensor, fferential amplifier, and phase control rectifier that supplies the DC field current to the generator.

# TABLE OF CONTENT

# LIST OF NOTATIONS

| | |
|---|---|
| AGE | V |
| Z | Hz |
| RNATING CURRENT | A.C |
| NDARY VOLTAGE | Vs |
| ARY VOLTAGE | Vp |
| METER | mm |
| | $\phi$ |
| ARY TURNS | Np = N1 |
| NDARY TURNS | Ns = N2 |
| TROMAGNETIC FORCE | E.M.F |
| RY CURRENT | Ip = I1 |
| DARY CURRENT | Is = I2 |
| RE TURNS | A-T |
| MEAN SQUARE | r.m.s |
| | I |
| NCE | Z |
| ANCE | R |
| NT DENSITY | J |
| TANCE | C |
| E | q |
| | $\mu$ |
| | A |
| IODE | ZD |

# CHAPTER ONE

## 1.0 INTRODUCTION

Unregulated voltage may be disastrous and unwelcome for electrical and electronics appliances and in most industrial applications. Great damages are incurred in term of materials and machineries in the process of operation due to fluctuating power supply voltage for optimum efficiency and maximum length of service.

In order to avert the damage by this dangerous trend in our electrical supply we need the automatic voltage regulator (AVR). The device is a small piece of electrical equipment designed to maintained the out pit voltage steady at the prescribed voltage nominal, provided the fluctuation at the input falls within specification 220 + 20 % in this case 220V for Nigeria.

It comes in various shapes and seizes ranging from the small 300VA capacity to 5KVA and above (for domestic and industrial application). To get the best from the automatic voltage regulator (AVR), one as to choose the capacity suitable for the load it is intended to supply. Conventionally, it is advisable that the rating of the AVRs be slightly higher than the equipment it is intended to supply.

This equipment with the help of it's electronic voltage regulating circuit switches off and on automatically in an attempt to regulate voltage either up or down depending on the comparison between the input and output voltage.

Is use as protective device is of great importance to every economy where voltage from it supplies authority is subjected to fluctuation, which sometimes results in equipment breakdown. The use of this equipment reduces the cost of maintenance of various household and industrial electrically operated gadgets and this in turn increase the reliability and efficiency of equipment. The system thus could be represented by a block representation with input and output as illustrated

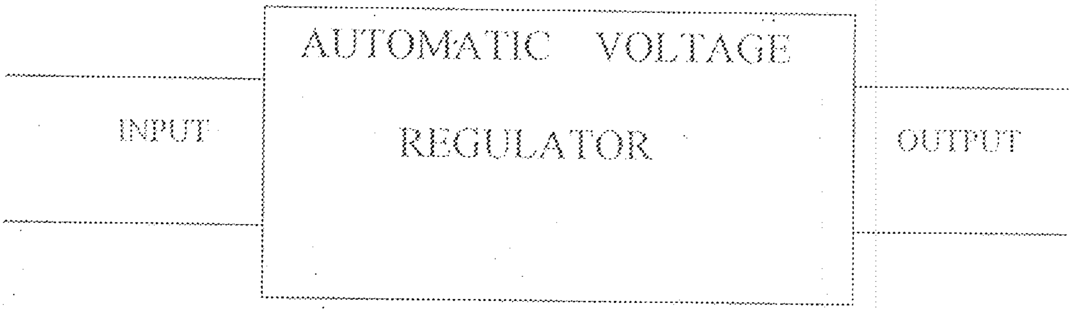


Fig 1.0 Block diagram of a 3 KVA (AVR)

## 1.1 SCOPE OF THE PROJECT

The project work deals with the design and construction of a 3KVA automatic voltage regulator. However, much emphasis is placed on the design parameter, the construction of the transformer and the electronic circuit. The watch word is to leave behind the knowledge of maintenance and improvement in the device.

## 1.2 AIMS AND OBJECTIVES

The objective of this project is to design and construct an AVR. The reason behind that is because some electronic appliances (DeskJet printer, radio, television e.t.c.) are using different ranges of d.c. voltage. So as a future engineer who intends to work on electronic appliance it is good to have an AVR unit, since there is a voltage drop, there is need to stabilize the voltage, since some appliance are sensitive to voltage variation.

## 1.3 METHODOLOGY

Two major methods are commonly used in obtaining a stable d.c. voltage from a.c. mains. The first one is the linear stabilizer method and the second is the switching mode stabilizer method

## 1.4 LIMITATION OF THE PROJECT

This project work considers in it force the three 3KVA automatic voltage regulator, which is use in the protection of household electrical and electronic devices, and it is to maintain a regulated voltage of 240V.

# CHAPTER TWO

## 2.0 LITERATURE REVIEW

Electricity was discovered by Michael Faraday (1791-1867). Economics of scale and relative continuity all combined to promote the growth of central station.

An electrical service which was indeed the brain child of Thomas Edison, voltage drop and losses on the low voltage D.C. distribution circuit were the first limiting factors encountered.

## 2.1 Early Automatic Voltage Regulator (AVR)

One of the major components of power system like transformers, generators, transmission lines, e.t.c, is the voltage regulator. It came into use soon after Thomas Edison's breakthrough (late $19^{th}$ century). Due to damage caused by fluctuating power supply voltage to electrical/electronic equipments discoveries where made by scientists on ways to reduce this effect, and it was discovered that with the help of an automatic voltage regulator this can be achieved.

In an effort to actualise the aim, they employed the use of motors, reactors and inductors that are directed by a control circuit to change the tap on the secondary of an autotransformer in other to step –up or step- down voltage as required. One major drawback of this system was its limited regulation accuracy.

## 2.2 Recent Automatic Voltage Regulator (AVR)

As a result of advancement in technology the need for better quality regulating device rose and this led to the approach known as D.C to A.C inversion voltage regulations, which use the principle of switch mode supplies. The regulated D.C output controlling device. However, the last approach was the improvement on the motorised AVR method which uses a transistor as its controlled voltage regulator. The mechanical tap changer was also replaced by electromagnetic relays. The autotransformer is the major component of the approach, and the turn ratio is varied to give desired regulation. Most system uses two relays for the number of taps on the secondary of the autotransformer.

The position of the relays contact on the top of the transformer is dictated by the control circuit. The circuit determine whether the low supply voltage is to be stepped up or stepped down to desired output voltage. The merit of this approach is that it has good response and regulation ability. An operational amplifier was employed as the comparator to increases it's sensitivity.

Electronic systems that are designed to operate at specified voltage may not function properly if the voltage varies by even 6%. Recently some electronic systems e.g colour television, tape recorder e.t.c are designed to produced an output voltage with 1% variability even if the source voltage powering the regulator circuit varies by up to 25%. Mostly these are achieved with the transistor application (linear operation). [5].

A zener diode can provide the constant reference voltage needed in a regulator circuit. The zener diode however is not capable of providing large changes in currents needed to operate many loads.. To power any load requiring large changes in currents zener diode will definitely not be sufficient to achieve this purpose. [7].

An automatic voltage regulator is designed to meet this demand. Apart from powering many loads, requiring large changes in current, it is capable of regulating fluctuations in power supply and protecting electronic systems from excessively high or low voltage. This achieved with the aid of relays. The relays are powered from the outputs of set of comparators. (Op- amp Lm324). Here zener diode is used to provide a fluctuations in power supply and protecting electronic systems from excessively high or low voltage. This achieved with the aid of relays. The relays are powered from the outputs of set of comparators. (Op- amp Lm324). Here zener diode is used to provide a reference, constant voltage as one of the comparator inputs. Therefore load does not depend on zener diode but on transformer winding, gauge of copper wire use for winding and transformer lamination. [2]

Attempts have been made by various manufactures to produce AVR that will meet this demand of highly stable input voltage demand by electronic appliances. Example of such product includes Binatone, Ginatone, Qlink, Centery, Superb e.t.c. it will be interesting to note that they are all characterised by almost the same internal circuitry, relay switching circuit and also principle of operation.

# CHAPTER THREE

## 3.0 DESIGN AND IMPLEMENTATION

### 3.1 TRANSFORMER

In the design of this project work, the type of transformer use is an autotransformer with number of taps at the output of the transformer. The transformer is design to withstand maximum input voltage of 260v with maximum capacity of 3000VA.

The main purpose of this chapter is to enable us to determine the number and physical size of lamination that would be required for transformer rated in KVA to be design (e.g. 3KVA). Also, we would calculate the diameter of the copper wire, number of turns either for primary (input) or secondary (output) of the transformer. Therefore this chapter explains design of transformer by calculating the size and thickness of the lamination, number of lamination, gauge of the copper wire and number of turns at each tap.

### 3.2 MATHEMATICS DERIVATION

E.M.F = 4.44 FQMN ........................................................3.1

QM = BMA

Where: E.M.F = the voltage (as required)

F = BMA = Flux in welber

BM = maximum flux density (Tesla)

N = number of turns.

Since there are both primary and secondary winding, thus

N1 = turns in the primary

N2 = turns in the secondary

And if: E1 = voltage at the primary

E2 = voltage at the secondary

Then, from equation 3.1 we have

$E1 = 4.44FQmN1$ ----------------------------------3.2

$= 4.44FBmN1$

$E2 = 4.44FQmN2$ ----------------------------------3.3

$= 4.33fbmAN2$

Also E.M.F / turn = 4.44fbmAN2

Also E.M.F/turn =4.44FQm

Therefore E1/N1 = 4.44FQm

$= 4.44fbmA$ ------------------------------------3.4

$E2/N2 = 4.44FQm$

$= 4.44FBMA$ ------------------------------------3.5

Hence output in KVA = 4.44FQm x μ x1000

$=4.44BmAN1 \times 1000$ ---------------------------3.6

From equation (3.5) make Bm to be the subject

$Bm = KVA/ 4.44FAN1 \times 1000$------------------3.7.

Where A is the area of the core

## 3.3 LAMINATION

### CALCULATION AND DESGIN SPECIFICATION

Let;

Centred limb = x

Window width = x/2

Window height = 3x/2

Overall height = 5x/2

Surface area = 23x

Overall width = 3x

Cross sectional area (square stock) = 5x2/2

Volume =15x2/2

Magnetic length = 13x.

ASSUMPTIONS MADE

- That the magnetizing current waveform is sinusoidal and with constant frequency, 50 hz.
- Thus since flux leakage is negligible, there exist no flux leakage between the primary and the secondary windings.
- That the transformer is low current
- That the impedance drop is neglected, hence E = V
- That the current density of about 13A/mm2 is ideal for 3KVA transformer.

From the above assumptions and with respect to mathematical derivation as shown previously, various dimensions needed for designing of appropriate laminations and turn ratio can be determine

Let:

Centred limb = x

Window width = x/2

Window height = 3x/2

Overall height = 5x/2

Surface area = 23x

Overall width = 3x

Cross sectional area (square stock) = 5x2/2

Volume =15x2/2

Magnetic length = 13x.

ASSUMPTIONS MADE

- That the magnetizing current waveform is sinusoidal and with constant frequency, 50 hz.
- Thus since flux leakage is negligible, there exist no flux leakage between the primary and the secondary windings.
- That the transformer is low current
- That the impedance drop is neglected, hence E = V
- That the current density of about 13A/mm2 is ideal for 3KVA transformer.

From the above assumptions and with respect to mathematical derivation as shown previously, various dimensions needed for designing of appropriate laminations and turn ratio can be determine.

## 3.4 LAMINATION DESIGN FOR 3KVA

For power rating = 3KVA

Secondary voltage = 13A/mm2

Choosing x, (i.e length of the centre limb) = 3cm

Area = x2

= (3cm) ^2

= 9cm2

In meter;

Area = 0.9 x 10^-3 m2

Window height = 3x /2 = 3x3 /2 = 4.5 cm

Window width = x/2 = 3/2 = 1.5 cm

Overall width = 3x = 3x3 = 9cm

Overall height = 5x /2 = 5x3/2 = 7.5cm

Surface area = 23x2 = 23 (3)2 = 270cm2

Cross sectional (space stocking) = 5x2/2 = 45/2 = 22.5cm2

Magnetic length = 13x = 13x3 = 39cm

Volume = (25x3) / 2 = 675/2 = 937.5cm3

The lamination chosen has a thickness of about (0.35cm), hence the number of lamination to be in the stocking.

Width of stocking
---
Thickness of lamination

= 3.00cm / 0.035cm

= 85.7

= 86 number of 0.335 lamination.

## 3.5 CURRENT/ CONDUCTOR CROSS – SECTIONAL AREA

Primary current, IP = KVA output / voltage

= (3000)/ 240v

= 13.63A

Also primary conductor cross sectional area = current in Am/density in A/mm2

= 13.63A/13A/mm2

= 0.10489cm2

## 3.6 NUMBER OF VOLTS PER TURNS

E = 4.44FQmN (from equation 3.1)

Also

E = 4.44BmFNSA x 10^-8 ------------------------------3.8

Where:

E = peak square wave voltage

BM = Maximum flux density of the saturating core (gauss)

F = frequency of oscillation (Hz)

N = number of turns

A = cross-sectional area of the saturating core (cm2).

S = stocking factor of the core

The cores constant are:

Bm = 14,500 gauss

Cross area = 9cm2

Frequency, F = 50Hz

Stocking factor = 0.9

Therefore from equation (3.7)

E = 4.44BmFNSA x 10^-8

E/N = VT = 4.44BmFSA x 10^-8

4.44 x 14,500 x 50 x 0.9 x 9x 10 ^-8

= 0.260739

= 0.26v/ turns

Therefore, volt per turn = 0.3v per turns

## 3.7 NUMBER OF TURNS FOR EACH TAPS

N1 = number of turns in the primary winding

N2 = number of turns in the secondary windings

V1 = voltage in the primary windings

V2 = voltage in the secondary windings

V2I = voltage in the secondary windings (where I represent taps in the secondary windings I = 1, 2, 3...).

Now,for primary windings, since VT = 0.3v/ turns

If V1 = 240v

Then, N2 = 240v/ (0.3/turns) = 800 = 800 turns

Now, if V21 = 17.5v at 240v V1

V22 = 210v at 240v V1

V23 = 238V at 240v V1

V24 = 256V at 240v V1

V25 = 300v at 240v V1

V26 =364v at 240v V1

Where V21 = tap 1

V22 = tap 2

V23= tap 3

V24 = tap 4

V25 = tap 5

NS1 = 17/0.3=56.7 turns

NS2 = 210/0.3 = 700 turns

NS3 = 238/0.3 = 793 turns

NS4 = 256/0.3 = 853 turns

NS5 = 300/0.3 = 1000 turns

NS6 = 364/0.3 = 1213 turns

## 3.8 .CIRCUIT OPERATIONS AND DESIGN.

The following components were chosen, their operational characteristic as stated in the data books as stated below:

(a) IC LM 324

Operating voltage range = 3v to 32v

Maximum different input voltage = 32v

Maximum power dissipation (mw) = 625

Input bias current (mA) = 45

LM 324 is a single power supply IC

(b) Zener diode

Zener voltage = 5.6 v

Zener power (pz) = 150mw

IZ = P2/V2

= (150x 10^-3)/ 5.6

= 26.8 mA

= 27mA

© Transistor (C945)

Power rating = 625mA

Collector current = 500mA (Max)

Collector current = 100mA (Mini)

Life (Mini) = 100

Life (Max) = 600

From the above known parameter we can determine the minimum and maximum base current of the transistor.

If IC = IB

Where, IC = collector current

IB = base current

β = Transistor hfe

IE = IC+IB

Therefore, IB (Mini) = IC (Mini) / β (min)

= 100n/100

= 1.0n

IB, (Max) = IC (Max)/ β(Max)

500mA /100

0.8mA (were hfe is max)

IB2 (Max) = IC (max) / β (Min)

= 500mA / 100

= 5mA (where hfe is mini)

The above result implies that the minimum and maximum base current are 1.0 mA and 5.0 mA respectively. Current outside this range will cause the transistor not to function properly or higher current will damage the junction of the transistor.

To ensure the required current at the base of the transistor, base resistor is used to just as shown in the circuit diagram. Considered the diagram fig £." Below, R1 and R2 ensure that current base bias voltage while R3 limits the current into the base. The value of each of this component can be choosing carefully.

If Vcc = + - 12v

I max = 5.0 mA

RB = 12/ 5 mA = 2400 ohms = 2.4 K ohms Not less than 2.5Kohms resistor must be use as base resistor fig 3.3 is a circuit where OP-AMP is use as a comparator. The zener diode use is 5.6V and it has a max power dissipation of 150mA obviously, the IZ could be determining.

If Vi and V" are the two voltage apply to the amplifier. The different between these two voltages gives the output voltage i.e. V2- V1 = Vout

V1 is constant (called ref voltage)

V2 is varied depend on pot R2

If IZ (Max) = 27 mA

R4 = Vin (max) – V2/ I2 (max)

30-5.6/ 27

= 24.4/ 27 = 903ohms.

Therefore, R4 should not be less than 1 k ohms

Also I + I2 = I1

(28/ 1K) + Iz = I1

28 mA + 27 mA = 55mA = I1

Input bias current (Ib) = (I1 + I2) / 2

45mA = (55mA + I2) / 2

90mA – 55mA = I2

I2 = 35mA.

R1 = 2.2K ohms, R2 is the potentiometer = 10K ohms, R3 = 1K ohms

## 3.9 DESCRIPTION OF COMPONENTS

TRANSFORMER: This is an active component that is used for transfer electric charge from or more circuit to one or more circuit without change in frequency usually with changed value of voltage and current. The purpose of this transformer is to change an alternating from one value to another. To on crease the voltage an A.C supply requires the use of a step –up transformer to decrease the A.C. voltage requires a step down transformer. Transformers make use of electromagnetic induction to transfer electrical energy from one coil to another. A changing current through one coil (know as the primary coil (the secondary coil) these are both current and voltage transformer. Step –down transformer is used in the project. It is rated 220v-240v and 2000mA if the efficiency of a transformer is 100%, the power in the secondary is equal to power in the primary windings.

I IpVp =Is ------------------------------- (1)

Therefore Vp/Vs = Is/Ip ------------------------------- (2)

Vs = voltage in the secondary windings

Vp= voltage in the primary winding

Ip = current in the primary winding

Is = current in the secondary winding

Since the product of the number of turns in the secondary winding and the voltage in the primary winding hence:

Vs * Np = Vp * Ns ..................... (3)

Therefore equation (1)

Vp/Vs = Is/Ip = Np/Ns

Where Np = number of turns in the primary winding

Ns = number of turns in the secondary winding

Efficiency of the transformer, efficiency of any machine is the ratio of the output power of the input power to the input power which express as a percentage. Efficiency of any machine can never be 100% due to losses. This is applicable to transformer. Efficiency = power in secondary/power in primary X 100%

Efficiency = Output power/input power X 100%

Also efficiency can be express as

Effic = input power losses/ input power X 100%

(Effic) = 1- losses/ input power X 100%

TRANSISTOR: it is an active semi conductor device. Transistor has three electrode, these electrodes are named base, emitter and collector. It can amplify, oscillate and be used for switching and other purposes. Germanuim and silicon are commonly materials used for production of a transistor. The transistors are of two types circuit for current amplification and to provide the switching effect for the relay.

INTEGRATED CIRCUIT: This is an operational amplifier; it is a general purpose electronic devices i.e a modular multi-stage amplifier. It has the following characteristics

1 very high voltage gain

2 Infinite input impedance

3 Zero output impedance

Zero output voltage and wide band width. with high degree of stability against temperature and any other environment changes. IC can also be use as an integrator differentiator perfect buffer, voltage regulator e.t.c there it is use as a comparators. The common integrated circuit uses is 741.

ZENER DIODE: this is a special kind of diode which is used to provide a standard or reference voltage for this reason: the zener diode can be used to stabilize this d.c voltage so that a circuit is provided a stabilized supply voltage. It can be used as a discrete device in a circuit or it may be one of the components in a special IC called voltage regulator as in this project. It main function here is to keep the terminal voltage of the supply constant even when both load and input voltage varies.

The zener diode is allowed to operate the forward bias and behaving almost as an insulator when reverse biased hence used as rectifier.

FORWARD CHARACTERISTICS: When the diode is forward biased and the applied voltage is increased from zero hardly current flows through the device in the beginning. It is so because of external 0.3v for Germanium and 0.7v for silicon. As soon as base voltage increasing applied voltage It is discovered at as little as voltage of 0.1v produces a forward current of about 50A, a burn out is likely to occur if forward voltage is increased beyond a certain safe limit.

REVERSE CHARACTERISTICS: when the diode is reverse biased carners are blocked and only small current due to minority carriers flows through the diode as the voltage is increased from zero, the reverse current quickly reached it maximum or saturation value current which is also known as leakage current.

VARRIEABLE RESISTOR: this is a resistor with a suitable mechanical feature that enables the variation. It's resistance from zero to maximum rated value. In this project variable resistor are used. It is provided with a node or handle which varies the resistance as if IC turned left or right. This action is called presetting and can be used to preset the voltage range with which the stabilizer works.

RELAY: a relay is an electromagnetic switch by design, a movable spring armature is mounted above the core of an electromagnet contact point open or close by responding to a change in some physical quantities as current, voltage frequency, high sensitivity, temperature , pressure e.t.c. a relay in normal closed position open when activated and normally open relay closes when energised when energising potential is removed the spring action return the armature to it original state switch point may be set several contacts for double pole and move complicated switching operations. Relays can be categorised as an under current and under voltage relay. An over current and over voltage relay operates when the actuating quantity (current or voltage) exceeds its operating or pick values. And under current and under voltage relay operates when the actuating quantity ( of current or voltage ) fall below the reset or drop out value.

## ADVANTAGES OF RELAYS

One of the advantages of a relay includes the rapid and positive switching control of machinery and device from a remote locate. This provide safety for the operating person since the relay operating voltage and current can be relatively small when compared to level required for running the machine. Also, the relay permits the use of small wire and low current for switching a machine. The contact points only have to be heavy enough to carry the line current to run the machine. Relays eliminates the use of heavy wires also electricall magnetic can be more rapid than had switching.

## 3.10 CONSTRUCTIONAL PROCEDURE.

The necessary procedure adopted for the construction of an appliance depends on the design of the appliance, the available material, tools to be used as well as economic convenience.

In relation to the above mentioned factors, the under listed materials and components where utilized in this project work

TABLE 4.0 COMPONENTS USED.

| S/NO | MATERIAL AND COMPONENTS |
|---|---|
| 1 | Metal sheet for casting |
| 2 | 13 Amp socket outlet |
| 3 | 13Amp plug (fused) |
| 4 | 240 A.C indicator / lamps |
| 5 | Flexible wires |
| 6 | Bolts and nuts |
| 7 | Laminations |
| 8 | Gauge copper wire |
| 9 | Diode IN 4007 |
| 10 | 12V d.c Relays of 5A |
| 11 | Resistors 1 K, 2.2K, 3K, 4.7K |
| 12 | Variable resistor 10K |
| 13 | Capacitor 50v, 1000uf, 7.5v 220uf |
| 14 | Zener diode 5.6 v |

| | |
|---|---|
| 16 | Connecting lead |
| 17 | Insulation tape |
| 18 | Shellac |
| 19 | Transformer |
| 20 | Transistors C 945 |
| 21 | IC LM 324. |

LIST OF TOOLS AND MACHINES USED.

1. Hammers
2. Screw drivers
3. Shear
4. Pliers
5. Knife/ cutter
6. Hacksaw
7. De-soldering pump
8. Vice
9. Drilling machine/ drill-bit
10. Bending machine
11. Soldering iron
12. Punch

Measuring Instruments Used

1 Scale mile

2 The multimeter digital, analogue

## 4.1 WINDING INSTALLATION.

The required materials were gathered after which the transformer of 3000KVA, 240V for this project was made. Based on the lamination, an already made former was used and the purpose of using an already made core in this project was due to the non- availability of lamination cutting machine and right steel sheet for lamination as well as the inaccuracy, inefficiency and tediousness of the manual method. The next step to be taken is to carry out the transformer windings, a standard wire gauge of 18 was used in this project, and the number of turns are determined by the voltage output and volt- ampere ratings.

The transformer used in this work is an autotransformer with a single winding but different tapings from the secondary. After mounting the transformer core, counting of various turns was made for specified output voltage.

A diagram, showing the dimensions of the already made transformer core and the windings on it is as shown in fig 4.1 a and fig 4.1b

## 3.2 CONDUCTOR INSULATION AND FITTING OF THE LAMINATIONS.

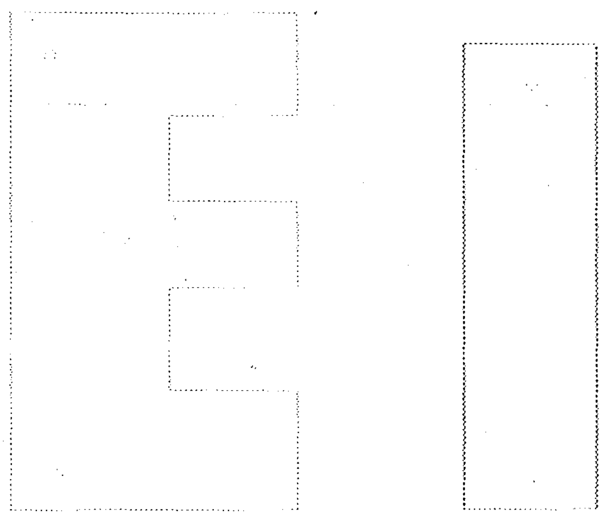

Fig 4.2a Diagram Showing a single Lamination

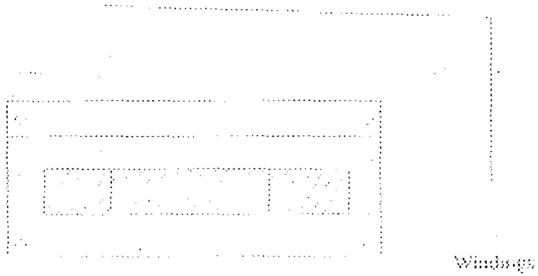


Fig 4.2b Diagram Showing bunch of Laminations fitted on Transformer Windings.

After the winding process has been completed, the winding is then insulated with insulation tap so as to prevent electrical contact with the lamination when it is before the lamination were fitted, it was treated with shellac which is used to provide insulation between the laminations.

The lamination are fitted into the former in such a way that the "E" shape is fitted into the space between the former, and the "I" shape at the base end of it. This process is carried on continuously until the required numbers of laminations needed has been fitted completely and screwed.

The essence of this lamination is to give room for mutual inductance between the primary and secondary windings of the transformer as well as reduction of eddy current and easy lamination. The diagram in fig 4.2a and 4.2b showing a single lamination and a complete bunch of lamination in the winding circuit.

## 3.13 CIRCUIT OPERATIONS AND SETTINGS

The whole system operation is divided into three main stages just like any other AVR. Each of the stages performs a specific operation. Each stage is made up of one or more comparator circuit but with different setting of their potentiometer. Briefly we shall explain the operation and the setting of each stage.

## 3.14 TRANSFORMER – MAIN SUPPLY (STAGE ONE)

This stage is mainly consisted of transformer having two terminals at the primary (connected to mains) and five taps at the output. These five taps are at different voltage level at the main supply. The diagram shown in fig 3.5. consist of 5 terminals Lx to L4 where C terminal is common to all. Lx terminal has the lowest potential, which is use to provide d.c voltage supply to the circuit L1, L2, L3, and L4 are taps connected to the switching relays of stage 2. L4 has the highest potential while L1 is at the lowest potential.

## 3.15 MAIN SWITCHING SYSTEM (STAGE TWO)

This stage, consist of three different comparators in which their output are amplified by TR1 and TR3 to control the switching of the relay connected across the transistors. Each of this comparators is set ( by R8, R9 and R10) to give an output at a specific voltage level so that whenever this voltage level is reach, the relay connected across the collector of the transistor is energize. The relay as shown in the circuit of fig 3.6 are connected in "parallel in series out" i.e Lx = P1 or P2 or P3 or P4. P1, P2, P3, P4 are extremely connected to L1, L2, L3, and L4 respectively. For proper switching of this stage relays R8, R9 and R10 are set to the appropriate value. To do this, the following steps are followed

1. Connect stage one to the mains
2. Connect L1 to L4 of stage 1 to P1-P4 of stage 2 respectively
3. Connect the circuit to supply
4. Use autotransformer (varaic) for your mains
5. Connect voltmeter across Lx to measure output supply (to be regulated) and another voltmeter to the input at main to measure the precise input voltage
6. start by increasing the output of varaic from 100v up the level such that voltage obtain at LX is about exceeding 220v + 8 % then set potentiometer R8 of third comparator such that RL2 is energize.
7. In the same manner R10 is set such that RL1 is energised at appropriate voltage level. The above setting will effect the switching of the relay to select the require voltage level of the transformer taps to the output as regulated output supply. Note that the output is 220v + - 8 5 over the input range of 140v to 240 v. if this range is exceeded the output will also exceed 220v +- 8%.

## 3.16 CIRCUIT ASSEMBLY AND LAYOUT.

Assembly of the components are done on the vero board (PBC). During assembly, there were precautions taken. The precautions are clearance of 1.5mm to 2mm between the components. When arranging the components on the board, the method is to give maximum separation within the components, so that they will not be allowed to touch each other in order to prevent short circuiting. A 40W soldering iron was preferred to prevent damage to electronic components by excessive heat with the help of the soldering lead and the iron, the connection on the circuit board was made.

## 3.17 CONSTRUCTION OF CASING.

After the required length of metal sheet bought, before I could do the construction of the case, various designs were compared. The metal sheet for the top of the case was cut into a dimension of 15cm by 35cm. With the aid of the bending machine, the metal sheet was bended into a rectangular shape with dimension of 34cm 15cm

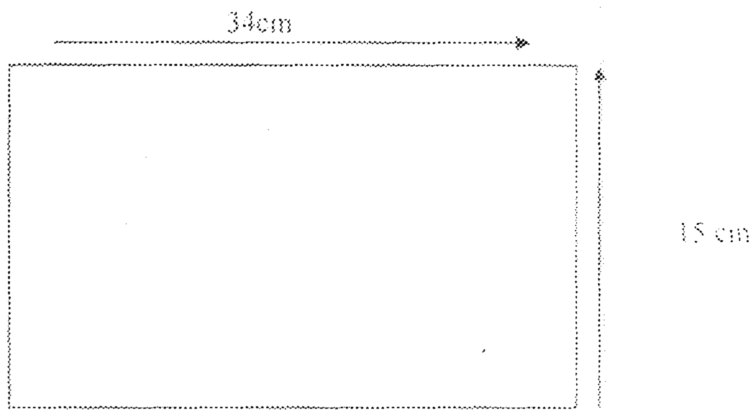


Figure 4.5a diagram showing plane metal sheet

Consequently, the metal sheet for the base of the casing was cut into shape with a dimension of 21cm by 32cm. it was bended to shape also with the bending machine. The shape inside the box is wide enough to give enough space for the transformer and the circuit board. The sides are perforated for the cooling effect of the temperature.

## 3.18 INSTALLATION OF CIRCUIT BOARD AND TRANSFORMER-CASING.

After the construction of the casing, the transformer was installed on the base of the casing and held firm to the casing by a screw. This was positioned in such a way that the weight is not so concentrated on a particular area inside the casing. The circuit board is also mounted in another part of the casing after which the final connections to various points were made.

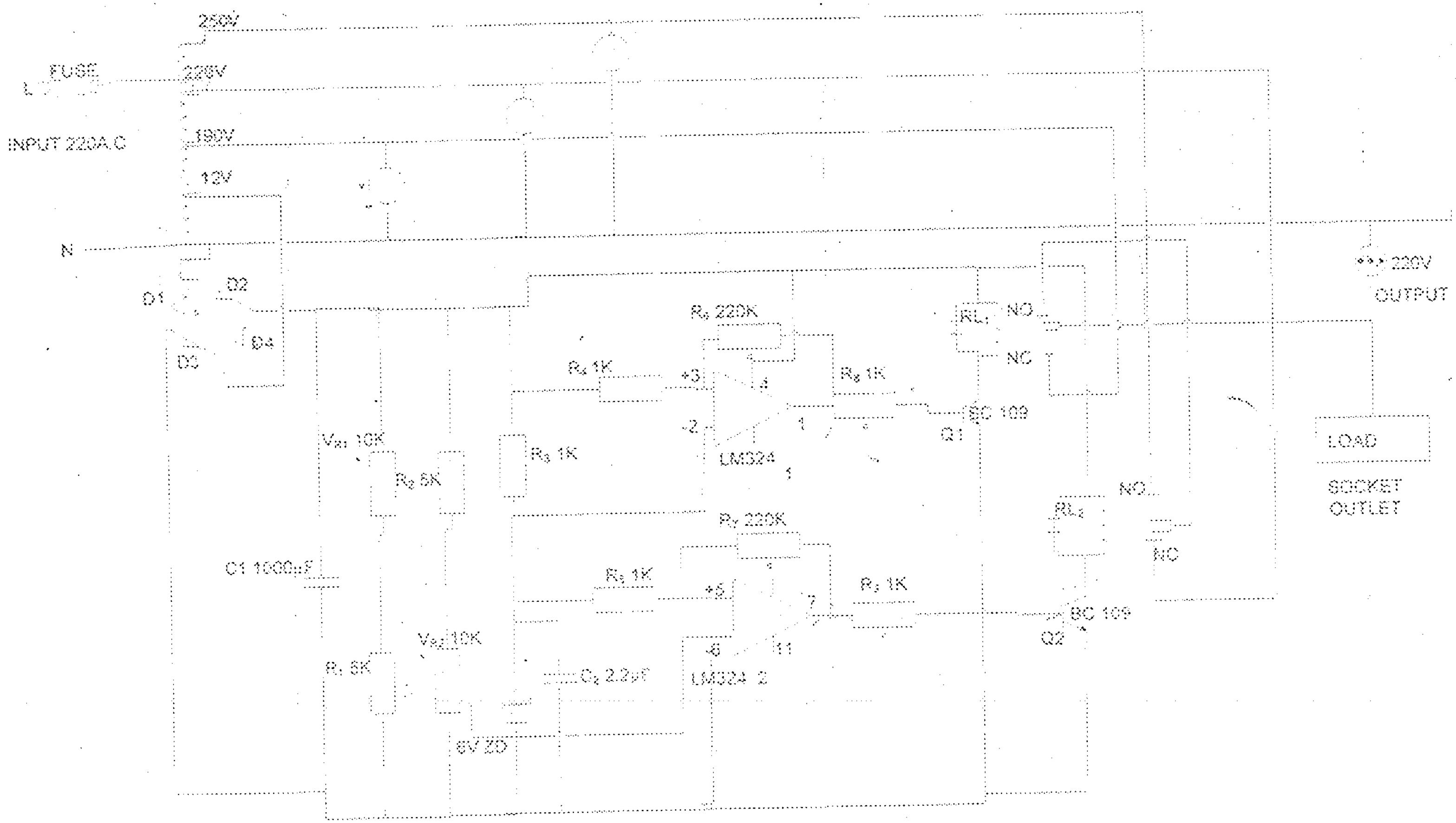


FIG.3 CIRCUIT DIAGRAM FOR A 3KVA (AVR)

# CHAPTER FOUR

## 4.0 TESTING AND CONTROL

Just before the coupling of the project and after the whole assembling, various testing were carried out to ensure that working operation of the design work meet the desire expectation. After successful coupling the output was tested and was up to the design expectation.

The following instruments were use to carry out the testing:

1. Multimeter: Digital multimeter which can use to measure voltage, current, resistance, continuity, and frequency.
2. Variac: This is made up of auto-variable transformer, which could be varied manually. It is made with ranges from 0V – 260V or more. This variac is use to vary the main supply, hence the performance of the circuit could be noticed by varying the mains.

There are two major tests that were carried out transformer output testing and input/output relationship. These are explained below.

## 4.1 TRANSFORMER TESTING

This testing was carried out after winding of the transformer. A test was carried out to ensured that their is continuity in both the windings.

## 4.2 INPUT/ OUTPUT RESULTS

This result helps us to know whether the expected output that is 220v +/- 10% is obtained over the input rang of 140V to 240V. the result are shown on the table below

LOAD TEST

Table 5.2 Result of input/ output of various voltage

| Input Voltage | Output Voltage |
|---|---|
| 100V | No output |
| 120V | No output |
| 140V | 200 |
| 160v | 226 |
| 180V | 213 |
| 200V | 218 |
| 220V | 222 |
| 240V | 215 |
| 260V | No output |

From the table showing it will be observed that at input voltage below 140V, the output supply is zero.

Consequently, at high voltage that is above 240V No output supply. This shows that stage 3 of the circuit is performing expected function. Also, the outputs obtained are perfectly ranges within 220V +/- 10%. This also was a result of stage 2, main switching system performing its expected switching work. Also from the output results, it shows that it is suitable for electrical and electronic equipment to function perfectly.

Hence, the aim and the objective of the project work is achieved

Consequently on final assemble of the equipments, a test was carrying out on insulation of the case, and it was observed that it was well insulated.

## CHAPTER FIVE

### 5.0 CONCLUSION

This project involved the design and construction of an automatic voltage regulator. It is designed to operate at varying input voltage but a regulated output with minima variations and at constant frequency.

From the test carry out, it was observed that when input voltage is varied from 140V -240V, the output voltage of the device is also carried out from 200V – 226V, that is still suitable for our electrical and electronic equipments to function perfectly. Hence the aim and objective of the project is achieved.

### 5.1 RECOMMENDATION

For proper utilization of this AVR, it rating must be higher than the equipment it intends to supply. Also the rating of the system could be improved by replacing the transformer with a seize wire gauge of large core seize.

## REFERENCES


1. Charles A. Schular & Richard J. Fowler (1992) Electrical Circuit Analysis (pp641) Mc CREW –HILL. United State of America.

2. Robert F. Coughlin & Fredrick F. driscoll (1977) operational amplifier and linear integrated circuit, pp 70, 84 and 337 (Third Edition). Pretice-Hall Inc: New Jersey.

3. Ronald J. Tocci & Neal S. Windner (19770. Digital system: principle and application 7th edition). Prentice –Hall Inc : New Jersey

4. Jerald G. Graeme, Gene E. Tobey & Lawrence P. Huelsman (1986). Operational amplifiers: design and application ( pp 69 & 229). Mc CREW –Hill. New Year.

5. Edward Hughes (1993). Electrical technology, pp 259 & 453 (6th Edition). EL & BS with Long man U.k.

6. Paul Horowitz & Wind field Hill (1997). The art of electronics, pp 175,323 (2nd Edition). Cambridge University Press U.S.A.

7. Ralph J. Smith & Richard C. Dore (1992). Circuit device and systems pp 517,658 to 688 (5th edition). John Wiley & Sons, Inc: New York

8. T.h Hewitt (1963). Electrical drawing. Macmillan & Co.Ltd. London C.o oroge (1991). Fundamental of reliability and testing method (1st Edition) sooji press Limited: Kaduna, Nigeria.

9. J. Shepard, A.H. Morton& L.F. Spence (19850. Higher electrical engineering (2nd edition). PITMAN: London.