COMPUTER SIMULATION OF THE DESIGN AND CONSTRUCTION OF A VOLTAGE STABILIZER

By

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PGD/MCS/99/2000/976

A PROJECT SUBMITTED TO THE DEPARTMENT OF
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September, 2001

CERTIFICATION

'his project has been examined and found acceptable in partial ulfilment of the requirement for the award of Post-Graduate Diploma n Computer Science, Federal University of Technology, Minna.

Mallam Audu Isah
Project Supervisor

Date

Dr. S.A Reju
HOD, Mathematics/Computer science

Date

External Examiner

Date

DEDICATION

'his project work is solely dedicated with love to the entire nembers of my family and to all lovers of progress!

ACKNOWLEDGEMENT

sincerely thank the Almighty God for all his guidance, Protection and grace through out the duration of this Course and more importantly, this project period.

Salute and appreciate the intellect of my project supervisor in the person of Mallam Audu Isah for his untiring efforts, assistance, understanding and encouragement in making this project work a reality.

Special thanks to the Head of Department, Dr. S. A. Reju for his good leadership, who during the course of this programme made sure that things were put in the right order for the success of this programme

Not forgetting all my lecturers in the Department for their friendship, courage, patience, assistance and understanding during the course of this programme and pray that the Almighty God will bless you all.

Deepest gratitude goes to my family members for their love, moral support and financial assistance. I pray that the Almighty God in His infinite mercies will replenish their efforts more abundantly - Amen!

I appreciate the encouragement, and support of the Director, Pechamm Telecomms & computers throughout the period of this programme and his entire staff, for their assistance to make this project work a success.

Lastly, I wish to express my sincere regards to my friends, Engr. Ozor Michael .M., Mr. Ugwu Romanus and Miss. Attah Priscilla.

ABSTRACT

The project work is **Computer Simulation of the Design and construction of a Voltage Stabilizer**. It is intended to help Stabilizer designers in the efficient design and construction through its user-friendly approach in simulation processes using Computer technique.

The project covers the stages involved in the design through the components used to the construction and testing besides Simulation techniques and processes.

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CHAPTER ONE

GENERAL INTRODUCTION.

1.0 INTRODUCTION

A voltage stabilizer is an electrical appliance that has the ability to maintain a constant voltage output irrespective of variable input voltage. The supply from the National Electric Power Authority (NEPA) in Nigeria for a single phase is at a voltage of about 220 –240v and at frequency of 50Hz. But this frequency may drop by up to 1.5Hz when a very popular television program ends.

This effect is caused by million of people switching on electric kettles to make cups of tea; the frequency drop is usually corrected with in a few seconds as the power stations supply more power. Local voltages drop may also occur, particularly in premises located some distance along a supply cable, as consumers nearer the substation switch on heavy loads. On small electricity grids, voltage and frequency variations may be more marked, and the design of electronic equipment may have to take this into consideration.

Apart from voltage and frequency fluctuations, a.c, supplies may also be subject to momentary interruption (as for example, when the local electricity board switches a substation from one circuit to another) and may also carry electrical interference in the form of high- frequency periodic disturbances, switching transients, or harmonics of the grid frequency. This interference may be caused by other electrical or electronic equipment(s) connected to the supply or by natural phenomena such as lightning discharges, and could have a serious effect on the operation of electronic systems which are not designed to cope with it.

These variation in supply voltage affects the efficiency and reliability of equipment while the low voltage may cause equipment not to function properly such as making some circuit not to switch on, the high voltage on the other hand may cause the damaging (burning) of some of the components in the system.

These phenomena are unacceptable as it is always very expensive and time consuming to sources and replace damaged components of an equipment. In some sophisticated electronic equipment like computer, fluctuation in the supply voltage can be hazardous as it can render the equipment useless and hence data and information's already stored in it will be lost.

To over come all these fluctuations caused by variations due to over load on the supply and its negative effects on the electrical appliances, the use of stabilizer was introduced, hence the need to Simulate its design and construction using computer.

1.1 Simulation and Modeling

Simulation is the process of imitating (appearance, effect) important aspects of the behaviour of the system (or plans or policies) in real time, compressed time, or expanded time by constructing and experimenting with the model of the system.

Types and forms of Simulation: We have two basic forms and types of simulation. These are: - The discrete system simulation and continuous system simulation.

The discrete system simulation: These are Digital computer models of physical systems that are basically discrete approximations. Here, continuous changes in system variables are represented by a series of discrete events, which can be specified and programmed in great details. The discrete system simulation models generally tend to be both stochastic and dynamic in nature. Here, simulation consists of the observation and analysis of the results obtained by generating random events at different points in time in a digital computer model of the system.

Continuous system simulation: This is where the values of the variable attributes change continuously and are generally described by deterministic differential and possibly some algebraic equations. In this form of simulation, four other types of simulation exist. These are **Direct Digital simulation, Digital analogue simulation, Hybrid simulations and Analogue computer simulation.**

Earlier applications of simulations were in the analysis and design of engineering systems by using the continuous approach, and the actual simulation was carried out on analogue computers. Analogue computers are still being used for simulation in specialized areas. However, modern digital computers have become an attractive alternative in many situations because of their accuracy, reliability, flexibility, and the ability to mimic analogue machines under program control.

Finding the numerical values of a set of problem variables at any point in time by solving a system of constrained equations representing the physical or conceptual system is the essence of continuous system simulation. These problem variables are represented by continuous variable voltages (i.e. electrical analogues) whereas in digital simulation the numbers generated by electrical pulses are used for their representation.

(a) Direct digital simulation: In direct digital simulation the program is written directly from mathematical equations describing the model;

(b) Digital analogue simulation: Here the computer program virtually simulates an analogue computer and the programming language contains special instructions to perform analogue functions such as additions, multiplications, summations, and integrations.

(c) Hybrid computer simulation: The complementary nature of analogue and digital computers discussed, led to the development of the hybrid computers and hybrid simulation. The hybrid computer is basically an analogue computer, which incorporates a small amount of digital logic. Hybrid computers are very useful in simulating continuous–discrete systems. For example, the solution of differential equations in the problem can be carried out by the analogue subsystem and the logical operations, storing values, setting initial conditions, etc; can be performed by the digital logic.

In hybrid simulation, the outputs of the analogue and digital computers are linked together through an interface for the purpose of simulation. The communication between analogue and digital computers is achieved through units, which convert analogue signals into their digital equivalents and vice-versa.

Typically, the analogue computer is used to obtain fast solutions to differential equations, and the digital computer is used for arithmetic and logical operations, storing of values, and more accurate numerical integrations, which need not be in real time. The recent developments in cheaper and faster microprocessors have created a renewed interest in hybrid computers and hybrid simulations, especially for dedicated applications.

(d) Analogue computer simulation: The operational amplifiers are the major components of analogue computers and these are connected to resistors, capacitors, potentiometers, and diodes to perform summation, integration, differentiation, multiplication, and function generation. The voltages in the computer are related to the problem variables through scale factors, depending upon the range of problem variables.

The analogue computer is ideal for solving simultaneous differential equations and, in particular, non-linear differential equations. The output of the analogue computer is displayed digitally and/or graphically, and the solution to the given problem is determined experimentally by repeating the simulation several times.

Basic operations and notations: The analogue computer programs are written in the form of analogue flow diagrams using special symbols, and the programs are implemented by making the necessary Connections on the machine. The analogue computer representation of a problem need not be unique. There may be several programs for the same problem, depending upon the variables and scale factors chosen.

What is a Model?

A model is a simplified representation of a system. It can take different forms: mental, physical, or symbolic. Models help us evaluate alternatives without actually conducting live experiments. Model aid learning, design, prediction, and evaluation of alternatives quickly, cheaply, harmlessly and serve as a powerful and concise medium of communication. Models are attractive for training personnel, computer implementation of problems, and expressing ideas clearly and unambiguously.

A model may be linear, nonlinear, discrete or continuous, and stochastic or deterministic. Modeling is an iterative process and hence the need for a modeling methodology. The definition of the problem, systems analysis, formulation of hypothesis, formulation of a simple specific model, verification, validation, documentation and implementation are the most important phases in the modeling process.

Nature of computer modeling and simulation.

A model is a simplified representation of a system, and simulation is the process of imitating important aspects of the behaviour of the system in real time, compressed time or expanded time by constructing and experimenting with the model of the system. A model adapted for simulation on a computer i.e. mathematical/logical relations and operational rules built into the computer program is known as **a computer simulation model or simply simulation model.**

Simulation is similar to the laboratory experiments conducted by physical scientists to gain insight in to the existing theories or to develop and validate new theories, studying the behaviour of the system by this indirect method. Modeling and simulation becomes a necessity in several situations where we have either no other alternatives (e.g. observation, analysis, experimentation, non-destructive testing, etc; not possible) or the alternatives available are not efficient.

For example, the provision of traffic lights at a complex road junction is not a trivial matter. There is no simple analytical method for finding the best traffic signaling policy, which will ensure smooth traffic flow through the junction. The modeling and simulation approach can help us to experiment with different policies on a computer and identify the best strategy for that particular junction without using the general public.

Computer modeling and simulation is the only way of evaluating various designs of a new city or a new computer, which is still on the drawing board. Very often solvable analytic models are of no use for practical applications because some of the conditions assumed (e.g. queuing systems) in the derivation of the analytic model do not hold in the real world. Here simulation can be used to suggest approximate model and determine the validity of the analytic model.

Computer modelling and simulation process

The theoretical and practical contributions over the past several years have resulted in the evolution of a methodology, which, even though imperfect, has put computer modeling and simulation on a scientific footing. Problem solving by modeling and simulation is an iterative process. Systems analysis; formulation of hypothesis; formulation of mathematical/logical models; identification of solution strategy; numerical solution of equations; simplification and validation of models; computer adaptation of models; computer programming; organization of computer runs; documentations of all the detailing and collection, analysis, and interpretation of results are part and parcel of modeling and simulation process.

The reformulation of the model and subsequent validation and interpretation of results are repeated until the simulation results are satisfactory for the specified application. Unlike mathematical models, logical relations and statistical data from direct observations as well as data derived from probability distributions can be easily embedded into computer simulation models. The adaptations of the model for computer simulation may require approximation and discretization of the model and all the mathematical/ logical relationships must be expressed as a series of explicit computational steps. One of the main aims of systems study is to establish optimum parameters for the design, construction and operation of systems. Simulation models cannot identify optimum solutions; they can only compare several alternative solutions.

Over simplification of simulation models may lead to loss of accuracy and generality while too many built in details may make the model more complex than the real system itself. In general, simulation is expensive and requires for more detailed in put than analytic models. Minor structural changes in models may call for an entirely different approach for solution by analytic methods, where as the over all simulation strategy remains the same.

When to use simulation:

Simulation is a slow, iterative, experimental problem-solving technique. Sometimes it is referred to as the method of last resort. One should contemplate problem-solving by simulation only when.

(a) The real system does not exist and it is expensive, time consuming, hazardous, or impossible to build and experiment with prototypes.

(b). Experimentation with the real system is expensive, dangerous, or likely to cause serious disruptions.

(c). There is a need to study the past, present, or future behaviour of the system in real time, expanded time or compressed time.

(d). Mathematical modeling of system is impossible.

(e). Mathematical models have no simple and practical analytical or numerical solution.

(f). Satisfactory validation of simulation models and results is possible.

(g). Expected accuracy of simulation results is consistent with the requirements of the particular problem.

Limitations of simulation.

(a) Neither a science not an art, but a combination of both.

(b). Method of last resort.

(c) Iterative, experimental problem-solving technique.

(d) Expensive in terms of manpower and computer time.

(e) Generally yields sub optimum solutions.

(f). Validations difficult.

(g) Collection, analysis, and interpretation of results require a good knowledge of probability and statistics.

1.2 Objective of study

At the end of this project work, one can design and construct voltage stabilizer using **QBASIC** language.

1.3 Scope and limitation of study.

This project work is intended to cover the manually designed and construction of a stabilizer to the simulation and modeling-using computer. The computer language for simulation will assist any programmer on how to go about designing and constructing the stabilizer with out consulting the manufacturer. The limitation is that simulation results are not statistically independent, and the estimate of variables based on finite samples is influenced by initial bias.

1.4 Justification of the study.

It is common knowledge that quantitative analysis over the past few years has been enhanced through the use of electronic computers. Problems, which were once textbook example, can now be solved using calculator, which ranges from small wallet size Calculator (computer) to desktop. In a complex setting, several individual steps and endless man-hours are achieved in a matter of minutes. The system performs the computation and displays the results immediately.

With the introduction of computers, one of the greatest problem confronting the manual design and construction, which is inaccuracy, is adequately taking care of. Also with proper programming language design and construction are easily done.

CHAPTER TWO

2.0 LITERATURE REVIEW

Review of Power sources.

All electronic circuits and systems require energy to operate. Energy is required to move electric charge, to produce heat, light or sound, to produce mechanical movement and to manipulate information. Energy is a conserved physical quantity. It can neither be created nor destroyed but can be converted from one form to another. In electronic engineering, we are usually concerned with electrical energy.

As designers of electronic apparatus, we are concerned with the form in which energy is to be supplied to or contained within our equipment. The ultimate source of energy used by our design is of interest only in so far as this affects the form, availability and cost of the energy delivered to our system. There are two main forms of electrical energy, which might be supplied to an electronic system. These are Alternating current (A.c) or Direct current (D.c)

Alternating current (A.c) Mains

Electronic equipment is often supplied with electrical energy from an external A.c. supply. The most common case is the mains supply derived from an electrical grid. The ultimate source of energy provided by a gird may be coal - fired, oil-fired, nuclear or hydroelectric power stations, diesel or gas- turbine generators or wind turbines. Gird supplies are characterized by high reliability and low-cost energy. A.c. Supplies may also be found on board trains, aircraft and ships where the supply will be provided by generators driven from the engines.

A.c supplies are widely used because of the efficiency and ease with which they can be transformed from one voltage to another. They are characterized by voltage and frequency. Nigeria as example for a single phase is about 220-240v of $50H_z$.

2.1 Power supplies.

Electric equipment is often supplied with electrical energy from an external a.c. supply. The most common case is the mains supply derived from an electrical grid. The most obvious and common function of a power supply is to convert electrical energy at the source voltage to some other voltage, higher or lower than the source voltage with or without a change from a.c. to d.c or vice versa.

Types of power supplies

A number of different circuits exist that are capable of converting an a.c. supply into a pulsating d.c. Current and they may be broadly divided into: -

a. Alternating current to direct current (A.c – D.c)

b. Direct current to direct current (D.c – d.c)

c. Alternating current to alternating current (Ac - ac)

Functions of power supplies.

The most obvious and common function of a power supply is to convert electrical energy at the source voltage to some other voltage, higher or lower than the source voltage with or without a change from a.c, to d.c or vice versa. A microcomputer, for example, might be designed to operate from an a.c mains supply and yet contain circuitry operating at 5v D.c.

A power supply would be needed therefore to reduce the voltage and convert the energy to D.C. Within the same microcomputer, there might also be a cathode-ray tube (CRT) display requiring a low-current but high-voltage supply [say 4kv] for the electron gun, requiring an increase in voltage and conversion to d.c. On board, a communication satellite, d.c. Will be available from batteries charged from a solar panel for economy of space and weight, only one voltage will be available from batteries.

Electronic circuits and systems such as microwave amplifiers, attitude controllers and computers, may need a variety of voltages both lower and higher than the battery voltage. D.c – d.c. Converters can produce these voltages at high efficiency without wasting valuable energy as useless heat. Inverters generate a.c from a d.c. input. One common application is on board caravans and boats to generate 240v a.c. $50H_z$ from a 12v battery, allowing low-powered domestic mains-operated equipment such as radios and shavers to be used.

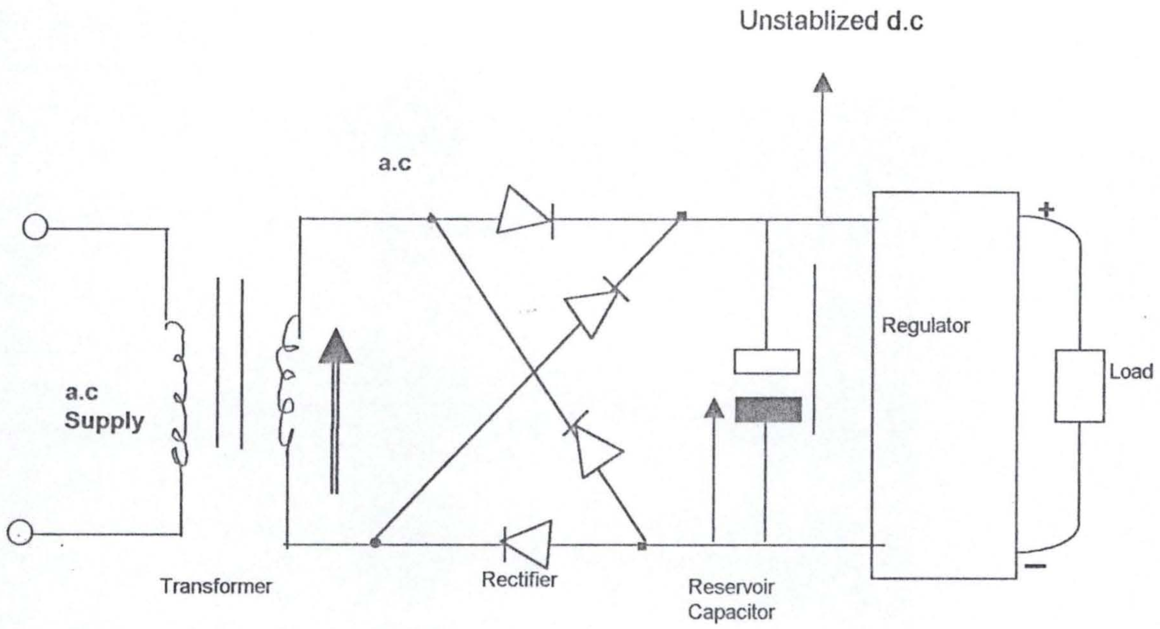
Voltage conversion, whether to a higher or lower voltage, is possible in practical terms only in an a.c. circuit, using a transformer. D. C – d.c, power supplies (or converters) are in reality, then, d.c. to a.c. to d.c. Power suppliers.

Power supplies operating from an a.c. source also have to provide energy storage during the part of the source cycle where little or no energy is available from the supply. It may also be necessary to store energy to supply the output current during momentary loss of the a.c. supply, such that happens when a substation is switched.

Energy storage is usually in the form of electric charge in the power supply's reservoir capacitors and is usually practical for only a limited time in most systems. Longer–term energy storage requires the use of batteries. A power supply with batteries is an example of an uninterruptible power supply (UPS). A UPS produces constant output even during breaks in the a.c. mains supply.

Another main function of a power supply is maintenance of a constant output irrespective of varying load. This is known as regulation or stabilization and a power supply having these features is called a **regulated or stabilized power supply**. Not all power supplies have this feature as some applications can tolerate variations in voltage or current. A d.c, supply for low-voltage filament lamps and relays is an example of such an application.

The power supply used in this project is the mains derived (ac to dc) whose main requirements are good regulation low noise and ripple, low output impedance and output short circuit protection.



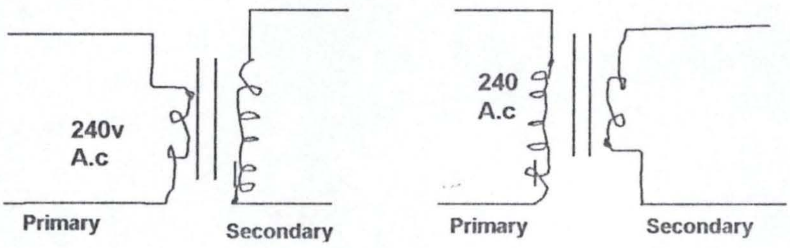
Block arrangement of a typical mains-operated d.c power supply.

Elements of power supply.

1. Transformers

Transformers are widely available commercially in a range of physical sizes, power ratings and electrical configurations and are designed for operation at a specific frequency (usually 50,60 or 400Hz). Transformers consist of one or more electrical windings of low d.c. resistance, wound onto a core of magnetic material (commonly iron). A changing current in one winding induces a changing magnetic field, which links the same or another winding and induces a changing e.m.f in that winding.

The transformer used for this power supply is a 12v transformer, which is used to transform voltages from one level to another at the same frequency by mutual induction. It has two winding known as the primary and the secondary linked by a common magnetic flux but electrically insulated from each other. The transformer winding connected across the power source is called the primary while the transformer winding connected across a load is called secondary. It is either a step-up or step-down. It is a step-up when the winding in the primary is fewer than the windings in the secondary ($V_1<V_2$) and is step -down when the windings in the primary are larger than the winding in the secondary ($V_1>V_2$).



Step-up Step-down

For this power supply the transformer used is a step down transformer since most modern electronic circuit operate at voltages well below 240v.

2. Rectification.

Rectification is the conversion of a.c. to pulsed d.c. The most important rectifying component in modern use is the semiconductor diode. Three types of rectifying circuit in common use are:

- Half- wave rectifier
- Full-wave rectifier (bi-phase type)
- Full-wave rectifier (bridge type)

The type of rectifier circuit used in this work is the half-wave rectifier. The basic circuit of a half-wave rectifier with a resistive load is shown in fig 1.4 below. The alternating secondary voltage is applied to a diode connected in series with a load resistor R_L.

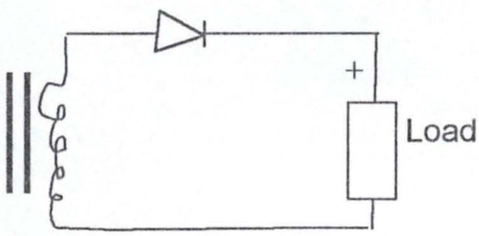
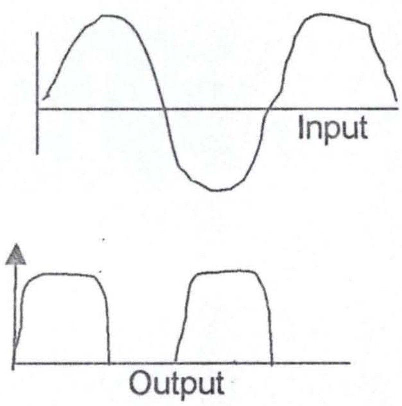


Fig 1.4



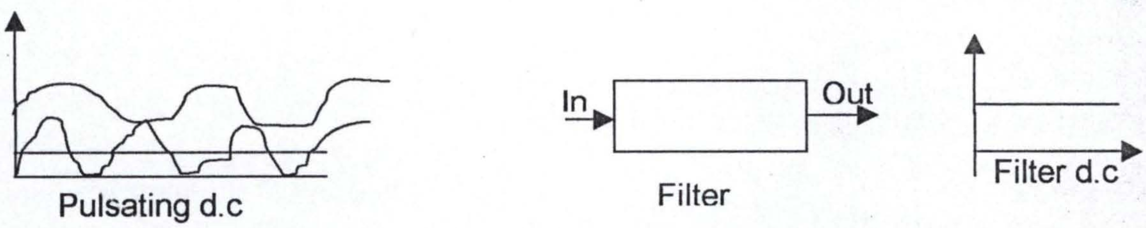
Working principle

During the positive half-cycle of the input ac voltage, the diode is forward-biased (ON) and conducts. While conducting the diode acts as a short-circuit so that circuit current flows and hence, positive half-cycle of the input ac voltage is dropped across R_L.

During the negative input half-cycle, the diode is reverse-biased (OFF) and so, doses not conduct i.e. there is no current flow. Hence, there is no voltage drop across R_L. As seen, the output is not a steady dc but only a pulsating dc wave having a ripple frequency equal to that of the input voltage frequency.

3. Filtration

The main function of a filter circuit is to minimize the ripple content in the rectifier output. As seen, output of various rectifier circuits is pulsating. It has a dc value and some ac components called **ripples**. For the majority of electronic applications, the pulsed d.c output from a rectifier is unsuitable directly. These circuits require a very steady dc output that approaches the smoothness of a dc output.



A circuit that converts a pulsating output from a rectifier into a very steady dc level is known as **filter** because it filters out or smoothens out the pulsation in the output. There are many types of filter circuits such as the LR filter, LC filter, C-L-C filter (PC), shunt capacitor filter e.t.c. But shall be concentrating on the shunt capacitor filter.

In this circuit, a suitable single capacitor c is connected across the rectifier and in parallel with the load R_L to achieve filtering action. This type of filter is known as reservoir capacitor input filter. This filter circuit depends for its operation on the property of a capacitor to charge up (i.e. store energy) during conducting half-cycle and to discharge (i.e. deliver energy) during the non-conducting half-cycle. In simple words, a capacitor opposes any change in voltage. When connected across a pulsating d.c voltage. It tends to smoothen out or filter out the voltage pulsation (or ripples). The filtering action of the simple capacitor filter when used in a half-wave rectifier can be understood with the help of fig. 1.4 b.

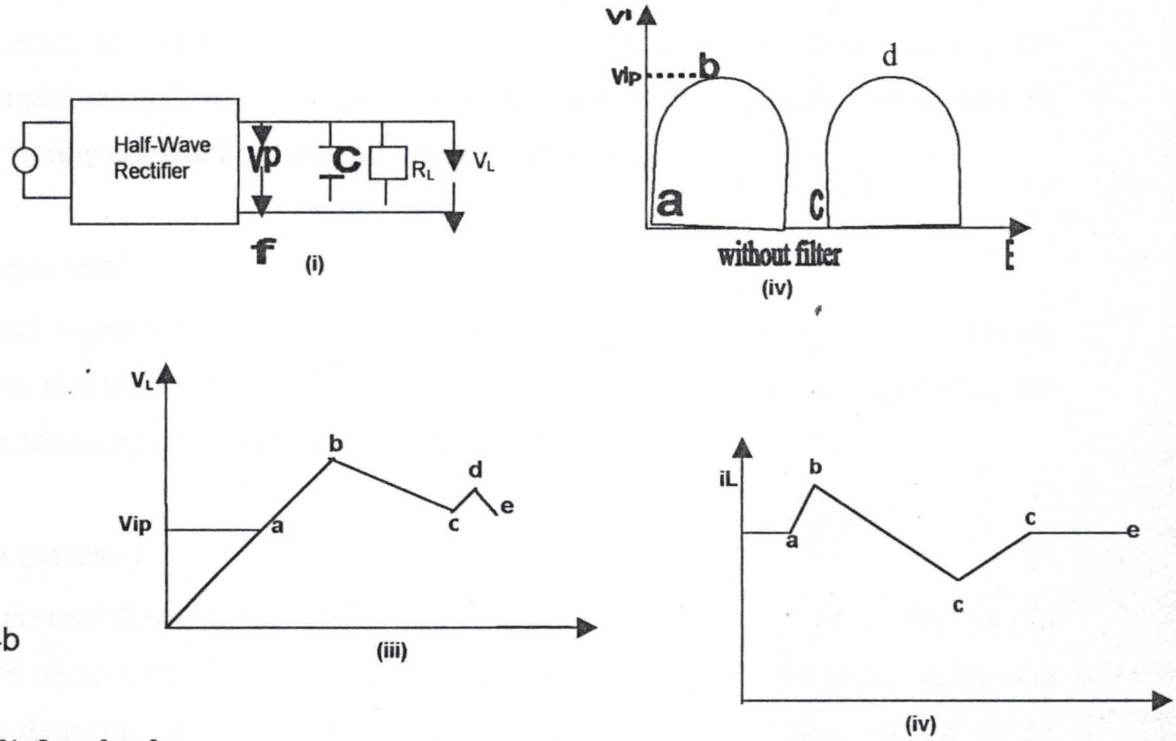


Fig 1.4b

Circuit Analysis

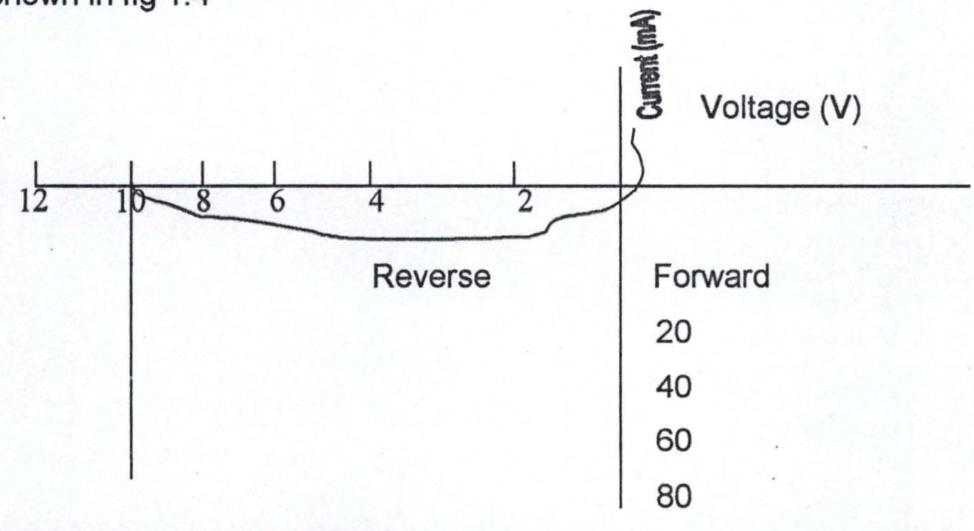
When positive half-cycle of the ac input is applied, the diode is forward-biased and hence is turned ON. This allows C to quickly charge up to peak value of input voltage VIP (Point b in fig 1.4(ii) because charging time constant is almost zero. It is so because there is no resistance in the charging path except diode forward resistance, which is negligible. Hence, capacitor follows, the charging voltage as shown. After being fully charged, the capacitor holds the charge till input a.c supply to the rectifier goes negative.

During the negative half-cycle, the capacitor attempts to discharge. However it cannot discharge through diode which being now reverses–biased, is off. Hence,

Voltage References

All regulated power supplies require a voltage reference, a device or circuit, which can maintain a constant voltage between its terminals independently or nearly independently of variations in current or ambient temperature. The most commonly used voltage reference component, is the zener diode, it is fabricated to breakdown at a precise voltage and to withstand continuous power dissipation in the breakdown region. The name zener diode is actually a misnomer for diodes with breakdown voltages above about 5v.

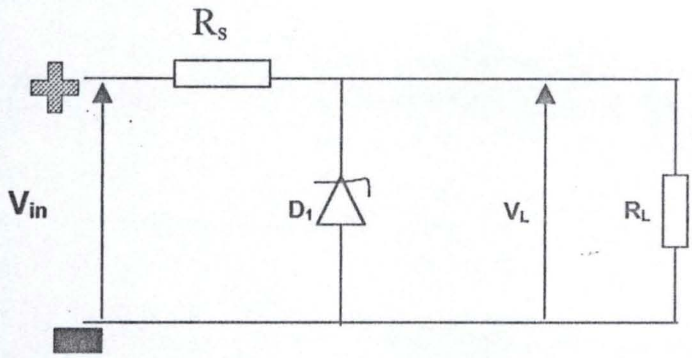
The zener or voltage reference, diode is a semiconductor device which has a normal diode current voltage characteristic in the forward direction; in the reverse direction the current abruptly increases if the voltage across it reaches a critical value known as the **breakdown voltage**. The voltage across the diode will thereafter remain more less constant even though the current through the diode may vary considerably. A typical zener diode current voltage characteristic is shown in fig 1.4



Zener diode characteristics fig 1.5

The zener diode can be used to stabilize the output voltage of a power supply since large charges in the current flowing in the diode produce only small changes in the voltage across the diode. The circuit of a simple zener diode voltage stabilizer is shown below. The voltage V_L across the load is equal to the input voltage Vin minus the voltage dropped across the series resistor R_s; this is equal to the sum of the load I_L and diode I_d currents timer R_s, i.e.

$V_{in} = (I_L + I_d) R_s + I_L R_L$



Zener diode stabilizer circuit

If the input voltage should increase, the diode will conduct a greater current so that the increase in voltage across R_s is very nearly equal to the increase in the input voltage. This means that the load voltage does not vary to anywhere near the same extent, as does the input voltage. Similarly if the current taken by the load should increase, the current flowing in the diode will fall by the same percentage and the voltage drop across R_s will not change.

The voltage across the load $V_L = V_{in} = (I_d+I_L) R_s$ will hence remain approximately constant. The minimum current allowed to flow in the diode must always exceed the breakdown current or the stabilizing action of the diode will be lost, i.e. the voltage across the diode would vary with current. Conversely, the diode current must be limited to the value, which gives a diode power dissipation, which does not exceed the maximum value quoted by the manufacturer.

2.2 Component Parts of a stabilizer.

A voltage stabilizer constitutes the build-up unit. They are either active or passive that controls the flow of current and the distribution of voltages.

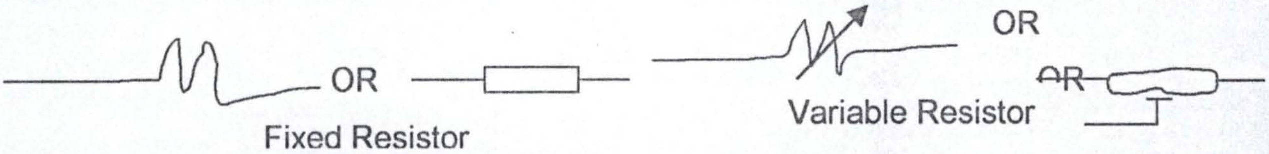
(a) **TRANSISTOR:** - This is a semi conductor device employed to perform mainly amplification and switching functions in electronic circuitry. There are different types of transistors namely:- Bipolar junction transistors (BJT), field effect transistor (FET), Rectifier transistors etc.

Bipolar junction transistor (BJT) has been chosen and used in the project because; its conduction is by two kinds of charge carrier, electrons and holes. A junction transistor is one that depends on the action of Pn junctions. The bipolar transistor is a current controlled device and are of two types: NPN and PNP as shown in fig 1.2

The bipolar transistor is made from silicon and germanium crystals. It has three regions that form the three distinct terminals such as Emitter (E) Collector (C) & Base (B).

Small input current results in large output in bipolar transistor to enhance great amplification. Many circuits use bipolar transistor as a switch where small current is required to switch on a large output. Nevertheless, the base current is such that it is able to overcome the internal barrier voltage of the amplifier (VBE), which is about 0.6v for silicon and 0.3v for germanium transistors.

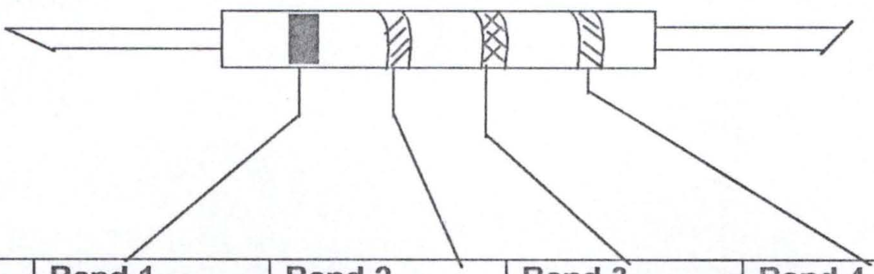
(b) **RESISTIORS**: –They are passive as well as linear element component that offer resistance to the slow of electric current. There are mainly two types of resistors: those that have fixed values and those that are variable. A knob or screwdriver or have resistance may mechanically adjust the variable types, which are dependent on light, heat or pressure. It is also known as potentiometers.



Variable Resistor

Fixed Resistor

Ratings: – Resistors are rated in Ohms and the wattage determined by the size. The manufacturer often gives this. The Ohmic values of resistors are calculated using Colour codes. Below is an illustrative example:



Colour	Band 1	Band 2	Band 3	Band 4
	Decimal	**Digit**	**Multiplier**	**Tolerance**
Black	0	0	0	1%
Brown	1	1	10^1	2%
Red	2	2	10^2	3%
Orange	3	3	10^3	4%
Yellow	4	4	10^4	-
Green	5	5	10^5	-
Blue	6	6	10^6	-
Violet	7	7	10^7	-
Gray	8	8	-	-
White	9	9	-	-
Gold	-	-	0.1	5%
Silver	-	-	0.01	10%
Colourless	-	-	-	20%

Band 1 and 2 gives the decimal digit; band 3 is the multiplier while band 4 is the tolerance.

Example:

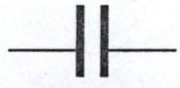
Band	1	2	3	4
Colour	Red	Violet	Brown	Silver
Value	2	7	10	10%

= 27 x10

= 270 ± 10%

(c) **CAPACITOR:** - A Capacitor is put to good use in electronics since it is able to store an electric charge. A capacitor is said to have a capacitance because of its ability to store charge. Capacitance is measured in farads. The farad is a large unit; so, it is usual to use the microfarad (mf or 10^{-6} F), the nano-farad (nF or 10^{-9} F), and the Pico farad (pf or 10^{-12} F).

Structure of a capacitor:

The general symbol used for a fixed value capacitor is  The general structure of capacitor shown above consist of a dielectric on each side of which is a metal plate connected to one of the two leads of the capacitor.

Operating characteristics of a capacitor break down voltage. This is the maximum voltage, which should be applied across a capacitor. It is usually marked on a capacitor as the working voltage, for example 1000V/W/kg. If the working voltage is exceeded, the capacitor may be permanently damaged. Always choose a capacitor, which has a working voltage above the voltage, which you are going to apply to it.

Tolerance. This tells you the range of a value that a particular capacitor could have above and below the stated value. For instance, a $1\mu^f$ capacitor with a tolerance of ±2% could have any value between (1 - 0.2x1) μ^f and (1+0.2x1) μ^f that is, 0.8 μ^f and 1.2 μ^f

Stability: The value of a capacitor changes with age, temperature and other conditions. A capacitor with good stability is one within the tolerance range as those conditions alter.

Power factor: This measures the fraction of the energy, which is lost in the dielectric of the capacitor. This energy appears as heat during charge and discharge of capacitor in an alternating- current circuit. The power factor is zero for a perfect capacitor and has a maximum value of 1 for a very poor capacitor. It is low for mica, ceramic and polystyrene capacitors, which are suitable for high-frequency operation.

Leakage current: The dielectric is an insulator; hence current should not flow through it. However, a perfect electrical insulator does not exist and a small leakage current does flow. A good capacitor has a low leakage current.

Types of capacitor:

Silver- mica:- It is known to have high breakdown voltage, low leakage current and small tolerance.

Polystyrene: They are generally tubular in shape and have a similar capacitance range to, but are cheaper than mica capacitors.

Ceramic capacitors: They are made in a variety of shapes, their stability is often poor, and some types are very sensitive to heat, but they do have a low leakage current.

Polyester type: - These are popular with electric enthusiasts. Their small size and rectangular shape make them useful for assembly on printed-circuit boards. These capacitors are Colour- coded for identification, the code following the international resister code.

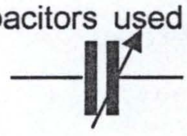
Polycarbonate capacitors: - have a similar capacitance range to the polyester types, but higher valves are available. They are a little more expensive than the polyester types.

Tantalum capacitor: - Are polarized. This mean, that they should be connected in a d.c circuit. Tantalum capacitors have small size, high capacitance and low leakage current. They are usually made in bead form. These capacitors are generally Colour – coded for easy identification.

Electrolytic capacitors: - Are mainly tubular or can-shaped, their operation depends upon the formation of an oxide film by electrolytic action inside the can as soon as they are connected in a circuit, it has a high leakage current.

Variable capacitors:- Are mainly used for tuning in a radio receiver while trimmer capacitors are small value variable capacitors used for time, present adjustment of capacitance.

Polarized Capacitor

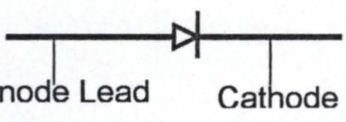


Variable Capacitor

(b) DIODE

A diode is an electronic component, which is sensitive to the direction in which current flows through it, Infact it allows electrons to flow easily one way through it but opposes flow in the opposite direction. The electronic symbol for a diode is shown below. The current flows in the directing of the arrow.

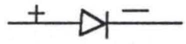
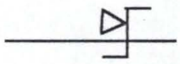
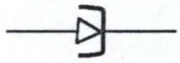
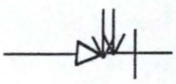
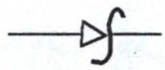
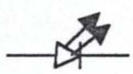
The diode has two leads known as anode and the 'cathode'.



The cathode lead is usually marked with a colored band, the cathode is the terminal from which convention and current flows when the diode is carrying current in the easy direction. Thus, conventional current flows from left to right. On some diodes the symbol is marked, so that there is no confusion as to which is the cathode and which is the anode lead.

There are various types of diodes and their uses are many in real life.

Types of diode uses and circuit symbols:

Names	Uses	Symbols
PN junction diode	as rectifiers as voltage multiplier	
Zener diode	as voltage stabilizer As voltage reference	
Tunnel diode	as switching element In computer circuit	
Photo diode	for information Transfer	
Schottky diode	Power generation Hiss frequency applications	
Light emitting diode (LED)	as lamps digital or visual display	

RELAY

A relay is simply a mechanical switch operated by an electromagnet. A simple form of relay is shown below.

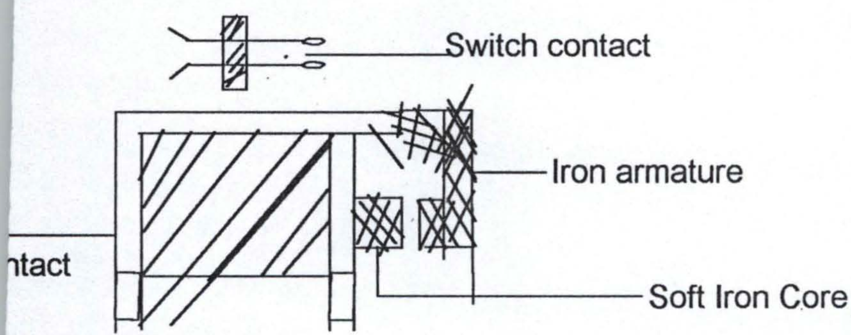


Fig. 1.8 (a): The diagram of a relay

Electromagnetic relays utilize a current through a cut to provide a magnetic field that moves the switch contacts as in an armature relay. The minimum current required to move the armature is called the pull-in current, because at or above that current the armature "pulls in" to close the normally open (NO) contact. At a somewhat lower current, the armature "drop out", and the NO contacts opens.

The electro magnetic relay is a fine-terminal device in which the adjusting terminals and electrically isolated from the switch signal terminals. They have activation response timer of a few millisecond, very high open-circuit resistance, very low contact resistance and often, the ability to switch high current and low voltage.

(e) AUTO-TRANSFORMERS

Transformer accomplishes not only the transfer of power between power system components operating at different voltages, but also the electrical isolation of these components from one another. There are many cases when this later feature is quite important. For instance, considerations of safety of accidental failure demands that low-voltage–circuits be physically separated from high voltage transmission lines.

But in many cases, particularly when the two different voltages are in the same order of magnitude, that separation is not needed, and in those cases, considerable savings in both cost and operating expenses can be accomplished by using transformers in which the primary and secondary circuits are connected to each other to form an auto – transformer circuit.

Consider the circuit diagram of fig 1.2.e. It can be Considered either as two coils concerted to other or as a single coil with a lap (i.e. a connection from inside the coil to a third terminal). The latter view is the one that gives rise to the name autotransformer. Auto is Greek for say (as in automobile that strange horseless carriage that seems to move by it say), and the single winding acts as a transformer all by it self, for purpose of analysis.

However, it is preferable to view the autotransformer as consisting of two coils, called S (for series) and C (for common), coil S is in series with the source or with the load, and coil C is common to both the primary and secondary circuits. Of course, the two coils are wound around the same ferromagnetic lose.

To study the principles of the Autotransformer, all of it imperfection (magnetizing current, core losses leakage fluxes, and coil resistance) will at first be discussed.

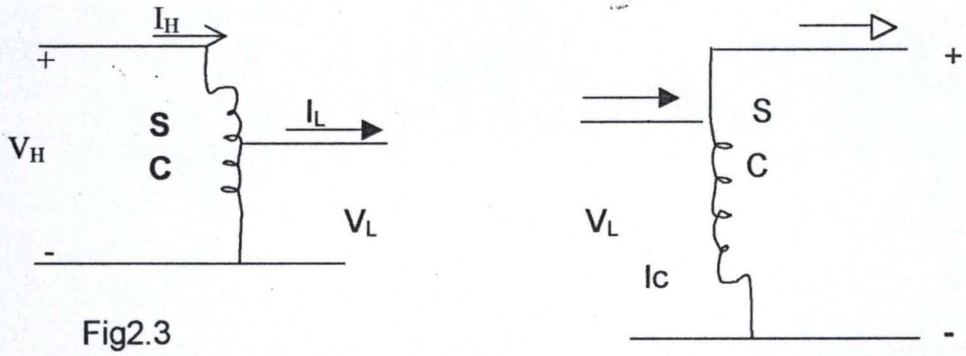
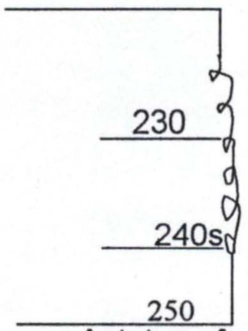


Fig2.3

Step-down Autotransformer

Step-up

Connecting the two left-side (primary) terminals of the transformers to a voltage source determines the value of the value of the flux in the core, the two turns number of the coils are Ns and Nc respectively. The ratio of the voltage phasor is $VH/VL = (NS+NC)/NC$ where H and L stands for higher and lower voltages. The autotransformer used in this project is wounded in such away that both the primary and secondary has only one electrical continuous windings. Below is a typical diagram of an autotransformer used in this project. Its winding serves both primary and secondary functions.



Autotransformer.

(f) CASING

The following tools / materials were used for constructing the casing:

(1) Metal sheet
(2) Metre rule
(3) Screwdriver
(4) Punch
(5) Drilling Machine
(6) Micrometer screw gauge
(7) Tightening knot and bolts
(8) Hammer
(9) Bending Machine

Casing is the housing unit of a stabilizer, which is usually made of metal sheet. The dimensions were chosen after considering the size of the trans formers, the length and winding of the circuit board and allowance. Bending machine was used in shaping the casing. Holes were made for ventilation and the screw that will be used to fasten the drilled metal using the drilling machine.

The size of the hole and the drill bits used were determined by the size of the screws available. Also points for socket outlet, light and switch, line cord were marked and drilled with the appropriate drills. Measurements and thickness done with the metre rule and screw–gauge as shown below. Screws available. Also point for the socket outlet, light and switch, line cord was marked and drilled with the appropriate drills. Measurements and thickness done with the metre rule and screw-gauge as in the **Appendix 2.1**

2.3 WORKING PRINCIPLE OF A STABILIZER.

After the construction of the casing, the autotransformer was installed on the body; screws are used to fasten it to the body. It was positioned in such a way that the weight is evenly distributed within the casing. The circuit board was also mounted in the casing; circuit board comprises the assembling of all the electronic components that was used. It was initially laid the breadboard for testing purpose and transferred to Veroboard when confirmed winding for soldering. The soldering was done with soldering iron and lead.

The operation of the circuit depends on the relay. Two relays were used, one for low voltage signal and the other for high voltage signal. When the voltage is normal at 240v the contact for low signal will be closed and that of high voltage will be open. But when there is extra low voltage the contact for low voltage opens while that of high voltage is closed and act as step-up to 240v. Thus, in this way the circuit is able to keep the output voltage constant. **See Appendix 2.2 for the circuit diagram of a stabilizer.**

CHAPTER THREE

DESIGN AND CONSTRUCTION.

3.0 In the previous chapters efforts have been made to review the power sources and to explain the electronic circuit of a voltage stabilizer. This chapter shall be taking a critical look at the actual design and construction of the stabilizer.

3.1 DESIGN OF STABILIZER

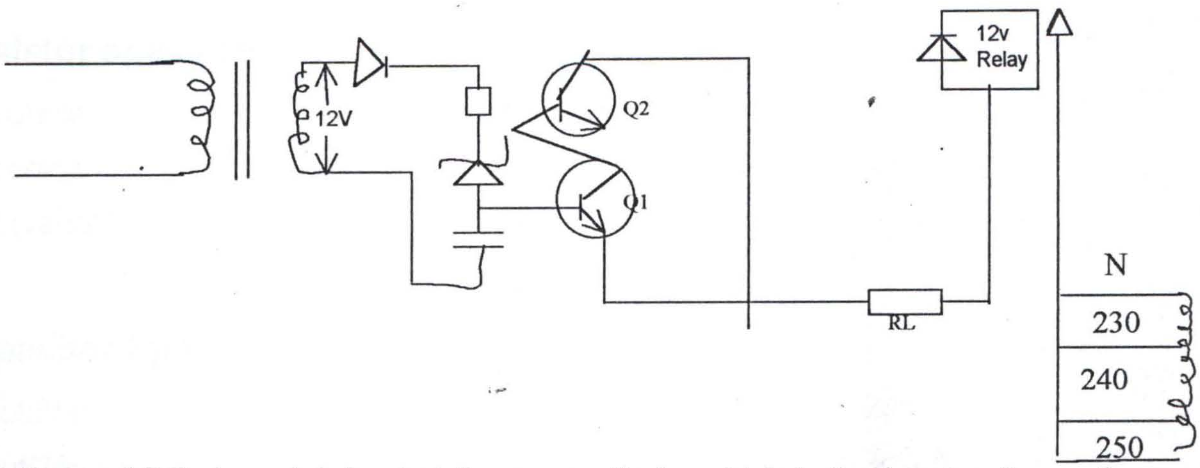
The electronic circuit of the stabilizer is designed to deliver an assumed current of 20mA at a stable voltage of 6.5v. The Unstabilized voltage need not be less than about 1v greater than this; so 7.1v is the minimum. The voltage from the rectifier is always less than that from the transformer because of forward voltage drop in the rectifying diode. The forward voltage drop is 0.6v; the transformer output must not be less than the minimum voltage and the voltage drop. A 12v transformer would therefore be a suitable choice. Forward voltage drop reduces this to 11.4v (i.e. 12 - 0.6v).

At an assumed current of 20mA the voltage at the zener diode must not be less than 6.5v. This means that the voltage from the rectifier (11.4v) must be dropped to 6.5v or just about this when a current a current of 20mA is flowing. For this purpose a dropping resistor is used the value of this can be calculated:

$$\mathbf{R = V/I = \frac{11.4 - 6.5}{20x10^{3}} = 245\Omega}$$

The nearest preferred value is taken, this being 220Ω. If the current through Resistor is 20mA and its resistance is 220Ω, the voltage drop is V = IR; i.e. $\mathbf{V= 20x10^{3} \times 220\Omega = 4.4V}$. The rate of conversion of energy is $\mathbf{P = IV = 20x10^{3} \times 4.4v = 0.08w}$. A resistor rated at approximately 0.125w is therefore needed.

Below is part of the switching circuit of the stabilizer.



A voltage of 6.5v is maintained at the zener diode, which is the input voltage of the transistor. The output voltage is calculated using direct-coupled amplifier method. For directly coupled amplifier, the output is twice the input voltage i.e. $V_0 = 2V_i$. So, since Vi = 6.5v therefore Vo = 2 x 6.5 = 13v. **This stabilizer is designed to deliver 500w**, so the current (I) will be power divided by voltage, which is equal to 2.08A (i.e. P/V = 500/240)

3.2 DESIGN SPECIFICATION.

These include all the electronic components used in the design and construction.

Transformer specification.

12v transformer	1 used
Input reference voltage (VP)	240v/ac
Frequency of supply (F)	50Hz
Output stabilized voltage (VL)	240/ac
Reactive power output (KVA)	500W
Current factor (KW)	0.5
Efficiency	-0.92
Flux density (BM)	1.4T.

Relay specification.

5A, 12dc power supply -	2used
Contact rating - SPCO	5A 250V/ac
DPCO	5A 250V/ac
Operate/release -	20m/sec
Cool sensitivity -	0.9W

3.4 LAYOUT DIAGRAM.

See Appendix 3.1 for the layout diagram

3.5 INSTALLATION ON CASING

After the construction, the circuit board was mounted in the casing. The autotransformer was also installed on the body; screws are used to fasten it to the body. It was positioned in such a way that the weight is evenly distributed within the casing. Final connections to the various points were made as shown in Appendix 3.2.

CHAPTER FOUR

4.0 PROGRAMMING LANGUAGE

COMPUTER LANGUAGE FOR SIMULATION.

Simulation programs can be written in a variety of computer languages. Subsets of several programming languages are now available on micros, which are becoming popular for small-scale simulation studies. The availability of inexpensive machines and users-friendly languages is bound to offer new opportunities for the application of simulation in several untired areas.

Characteristics of a good language.

In addition to the normal requirements of a good computer language, programming languages for simulation must also provide efficient mechanisms for:

1. Describing the system being modelled;
2. Advancing simulation time;
3. Keeping tract of events, activities, and process interactions;
4. Creation and deletion of events, and maintenance of associated data structures;
5. Scanning operations and execution of appropriate program segments;
6. Database management (for storing and retrieving data, results, and the model);
7. Detection and correction of errors;
8. Generation of stochastic variables from appropriate distributions;
9. Interactive graphical simulation;
10. Collection, analysis and presentation (flexible reports, colour graphics, animation) of result;
11. Self-documentation (listing must be understood by analysts who are not programmers).

4.1 Selection of a simulation language

The selection of a simulation language depends upon several factors. The simulation language chosen for this project is **QBASIC**.

4.2 Features of selecting a simulation language

The choice of QBASIC is because of the following reasons and features possess by the application software:

1.The availability of the language

2 Nature of the problem under study

3 Ease of installation and use

4 Understanding of simulation concepts and ease of learning the language by the local staff.

5 Accuracy of simulation results

6 Facilities for collection, analysis and display of results

7 Availability of use-friendly document

8 Features that reduces cost of programming and simulation.

9 Cost –effective maintenance and enhancements facilities

4.3 Program testing

The design of a program is never complete until it has been tested. Efforts have been made to make sure that the program is well designed and working as can be seen in the computer-generated output shown in the **Appendix 4**

CHAPTER 5

5.0 LIMITATIONS, SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 LIMITATIONS.

On the course of carrying out this project work, I encountered so many problems among which are: -

- Access to computer system for the programming work.
- Power failure problem
- Access to window based package for better output
- Access to Qbasic Compiler
- Simulation effects not as expected

5.2 SUMMARY

The computer simulation of the design and construction of a voltage stabilizer that was hitherto, often done manually by manufacturers of stabilizers is the main focus of this project.

The aims and objectives were achieved; as I was able to, in the first instance, introduce stabilizer, its design and construction, components used and then simulation of the processes involved.

The next step I took was using computer to simulate this manual design and construction and the result of the simulation produced as can be seen in **Appendix 4.**

The language used in the programming is **QBASIC.**

5.3 CONCLUSION AND RECOMMENDATION.

The demand for the computerization of every aspect of our day-to-day activities is on the increase. There is also rapid growth and development of this Information Technology tool called computer.

The aspect of computerization done in this project is simulation. This carries out calculations based on information's in the design of the stabilizer. The package or language used is **QBASIC.**

In view of the above, the importance of this computerization cannot be over emphasized as it goes a long way to minimizing poor components, selection and improve the reliability of decision making.

I therefore recommend this program (simulation of the design and construction of a voltage stabilizer) for use in the general decision and construction of any stabilizer.

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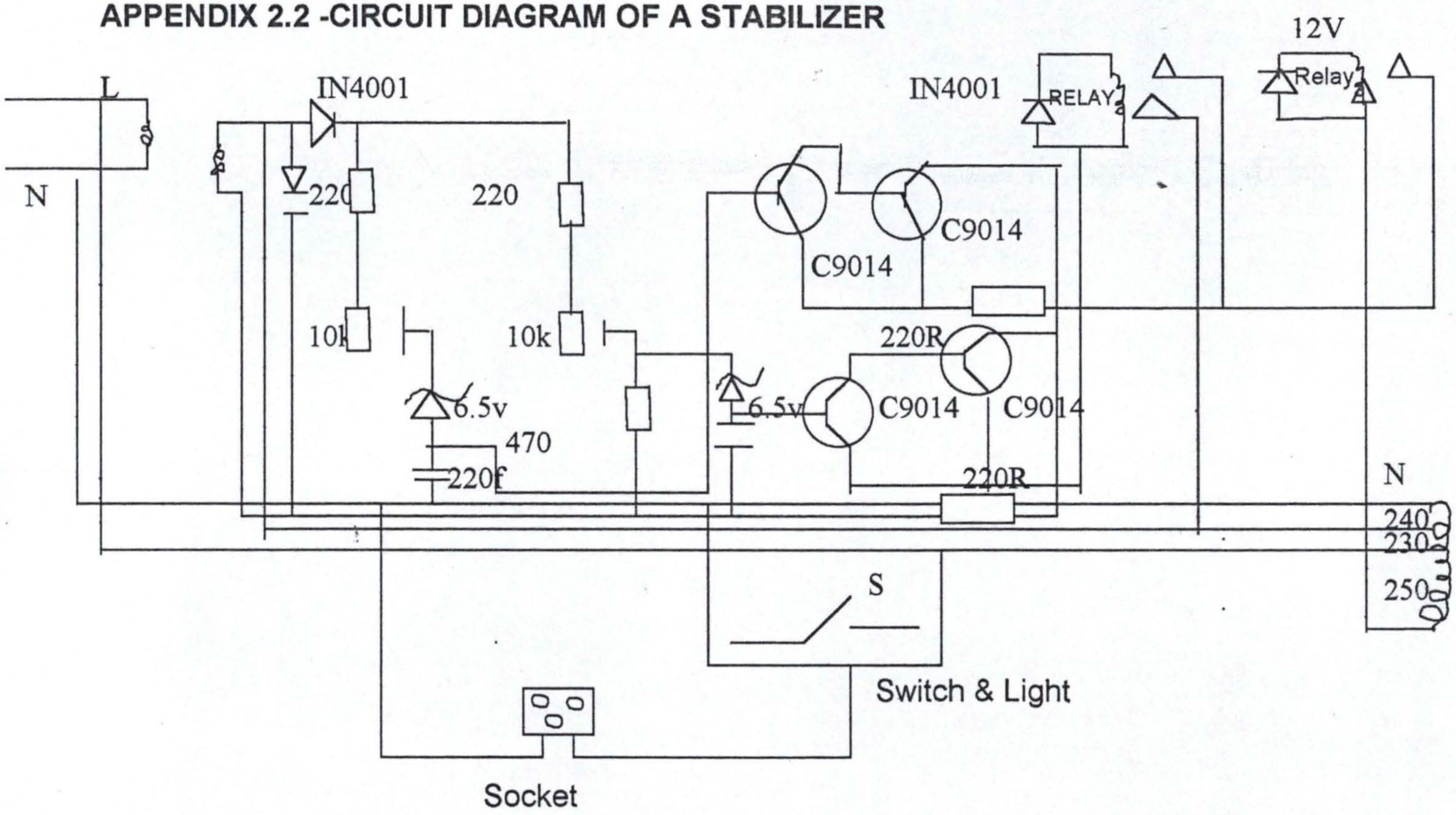
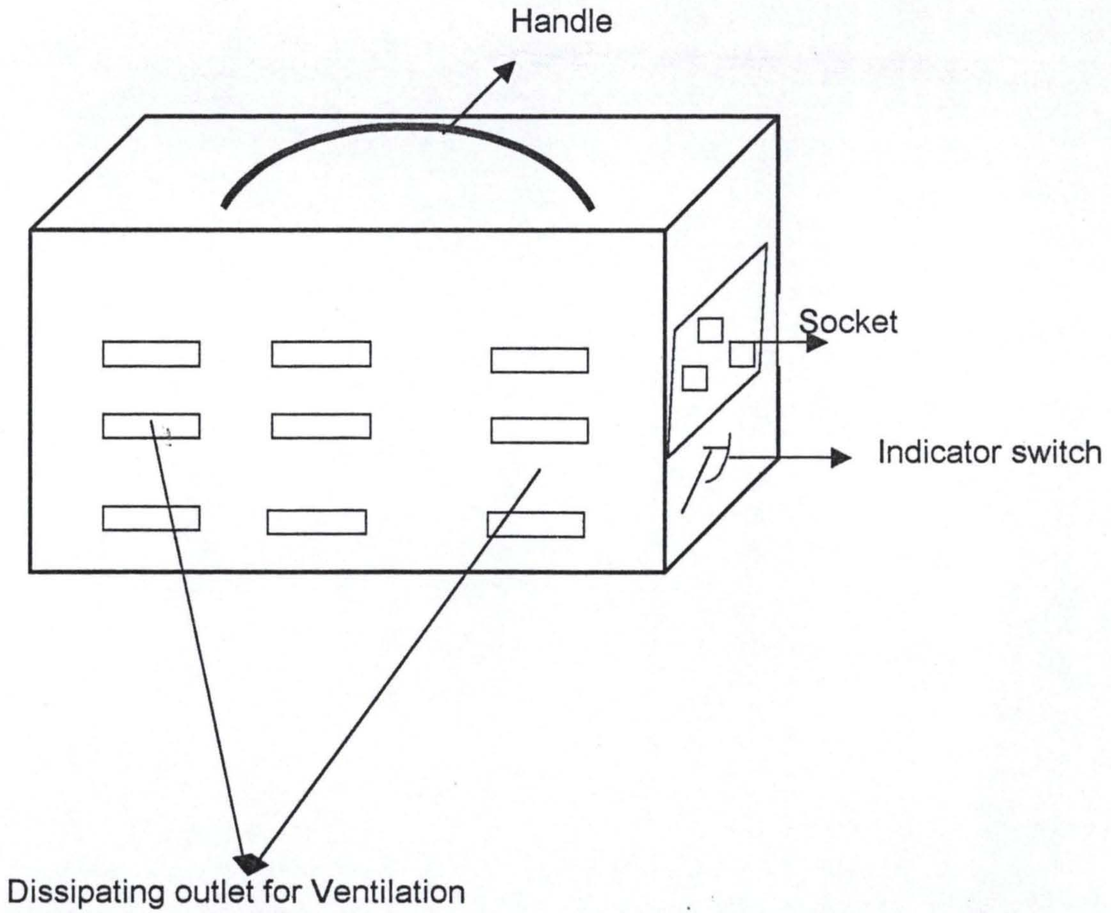
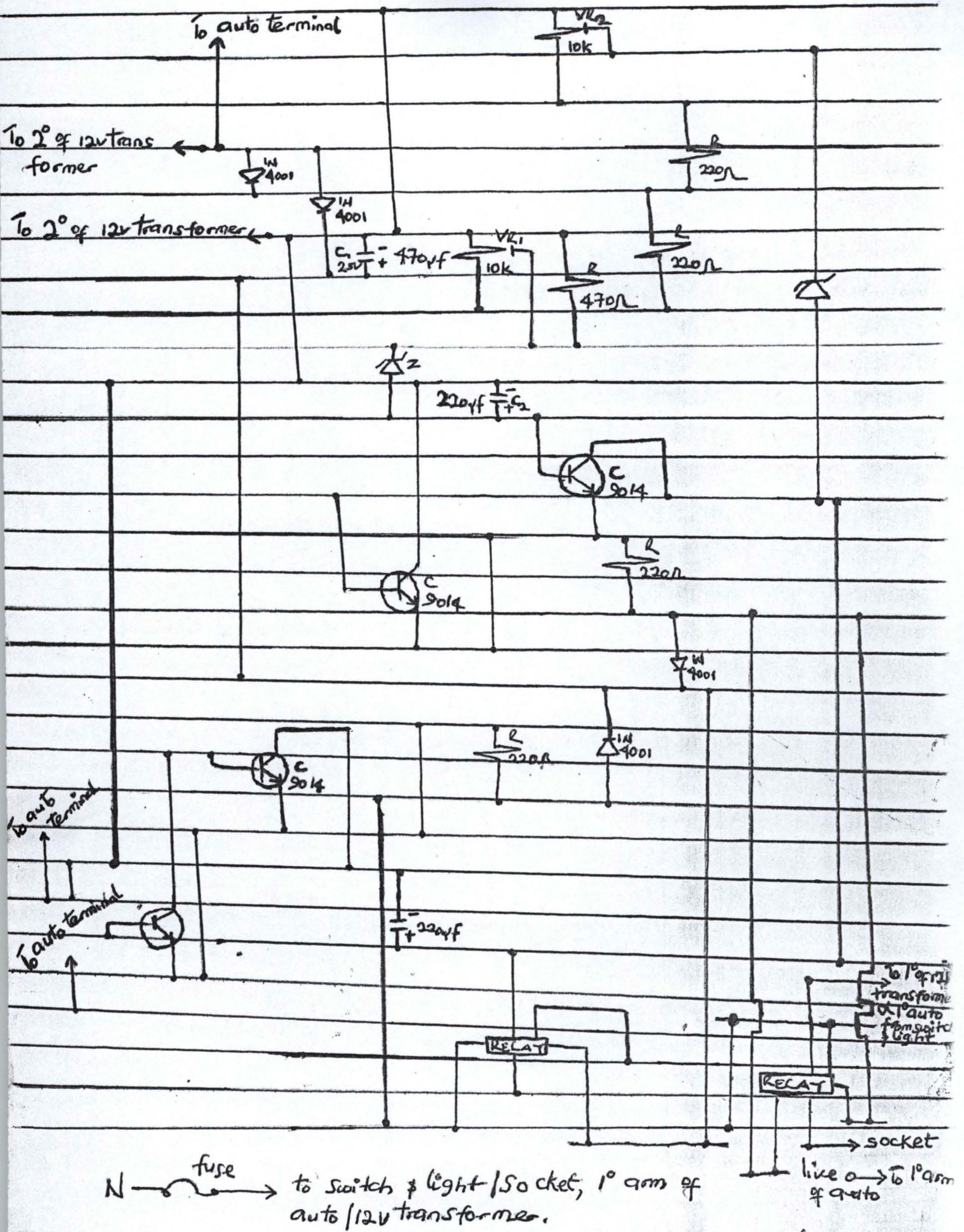
APPENDIX 2.2 -CIRCUIT DIAGRAM OF A STABILIZER



APPENDIX 2.1 - CASING OF A STABILIZER



LAYOUT DIAGRAM.



N —fuse→ to switch & light / Socket, 1° arm of auto / 12V transformer.

live from switch / light to 1° arm of auto, 2° arm of auto; and relay respectively. N → To socket

```
EP 10: CLS : COLOR 15, 1
ATE 5, 10: PRINT
ATE 8, 18: PRINT "Capacitor Specification"
ATE 10, 10: PRINT "220 microfarad/25v                    2 used"
ATE 11, 10: PRINT "470 microfarad/25v                    2 used"
ATE 12, 10: PRINT
ATE 13, 18: PRINT "Diode Specification"
ATE 14, 10: PRINT "PN Junction diode"
ATE 15, 10: PRINT "IN4001                                4 used"
ATE 16, 10: PRINT "Zener diode 6.5v                      2 used"
ATE 18, 10: PRINT
EP 10: CLS : COLOR 15, 1
ATE 5, 18: PRINT "Transistor Specification"
ATE 8, 10: PRINT "NPN C9014                             4 used"
ATE 9, 10: PRINT "hfe                                      60"
ATE 10, 10: PRINT "maximum current                      100mA"
ATE 11, 10: PRINT "ICBO                                  50mA"
ATE 12, 10: PRINT "Power dissipated                      310W"
ATE 13, 10: PRINT "CBO                                    20v"
ATE 14, 10: PRINT "VCO                                    18v"
ATE 15, 10: PRINT

 'calculation of circuit parameters

  i = 20 ^ -3

CATE 16, 13: INPUT "enter amplifier method used"; amp$
 amp$ = "direct coupling" THEN
 GOTO 10
SE
LS : LOCATE 15, 13
RINT "sorry,you are out of the range,try again"
ND IF
OTO 5
PUT "enter your transformer voltage rating in(volts)"; v
PUT "enter zener diode reference voltage in (volts)"; vi
PUT "enter the AC mains voltage in (volt)"; vmains
PUT "enter the stabilizer's reactive power in (watt)"; prect

F r > 220 THEN
  r = 270
LSE
F r = 180 OR r < 220 THEN
 = 220
ND IF

  r = (v - vi) / i
  vr = v - .6
  vl = i * r
  p = i * vl
  vo = 2 * vi
  istab = prect / vmains

  CLS : LOCATE 12, 8: PRINT "The value of the dropping resistor is"; r; " c
  LOCATE 14, 8: PRINT "The stabilizer voltage drop is"; vl; " volt "
  LOCATE 16, 8: PRINT "The rate of conversion energy is"; p; "watt(s)"
  LOCATE 18, 8: PRINT "The stabilizer output is"; vo; "volt(s)"
  LOCATE 20, 8: PRINT "The stabilizer current is"; istab; "amperes"

ND IF
```

HE DESIGN AND SPECIFICATION OF THE STABILIZER

The specification include all the electronic components used in the design onstruction

The transformer Specification

12 volt(s)	1used
Input reference voltage(vp)	240v/ac
frequency of supply(f)	50Hz
output stabilized voltage(vl)	240v/ac
Reactive power output(kvA)	500W
current factor(kw)	0.5
Efficiency	0.92
flux density(Bm)	1.4T

Relay Specification

5A,12v dc power supply		2 used
Contact rating	Spco 5A	250v/ac
	Dpco 5A	250v/ac
Operate/release		20m/sec
Cool sensitivity		0.9W

Resistor Specification

220 ohms	4 used
470 ohms	1 used
10K(variable)	2 used

Capacitor Specification

220 microfarad/25v	2 used
470 microfarad/25v	2 used

Diode Specification

PN Junction diode

IN4001	4 used
Zener diode 6.5v	2 used

Transistor Specification

NPN C9014	4 used
hfe	60
maximum current	100mA
ICBO	50mA
Power dissipated	310W
CBO	20v
VCO	18v

```
0 CLS
  'program to simulate the design and construction
  'of a voltage stabilizer
  FOR x% = 2 TO 23
  FOR y% = 2 TO 79
  LOCATE x%, y%: PRINT CHR$(219)
  FOR j = 100 TO 200: NEXT j
  NEXT y%, x%: COLOR 4
  FOR x1 = 5 TO 20
  FOR y1 = 5 TO 76
  LOCATE x1, y1: PRINT CHR$(219)
  FOR j = 100 TO 200: NEXT j
  NEXT y1, x1
  COLOR 15, 4
  text$ = "This project is designed by Bawa Jummai B. in partial fulfilment"
  text1$ = "for the award of Post-Graduate Diploma in Computer Science."
  text2$ = "in the Department of Mathematics/Computer Science"
  text3$ = "School of Science and Science Education"
  text4$ = "FEDERAL UNIVERSITY OF TECHNOLOGY,MINNA."
  FOR x = 1 TO LEN(text$)

  LOCATE 7, 10: PRINT LEFT$(text$, x)
  LOCATE 8, 12: PRINT RIGHT$(text1$, x)
  LOCATE 9, 15: PRINT LEFT$(text2$, x)
  LOCATE 10, 20: PRINT RIGHT$(text3$, x)
  LOCATE 11, 20: PRINT LEFT$(text4$, x)
  FOR j = 100 TO 110: NEXT j
  NEXT x: SLEEP 3


   'CLS : LOCATE 12, 25: PRINT "selection menu"
   'LOCATE 14, 18: PRINT "select number(s) one to four"
   'locate 15,15:input"please enter a choice"

   COLOR 15, 1: CLS
   LOCATE 3, 10
   PRINT "THE DESIGN AND SPECIFICATION OF THE STABILIZER"
   LOCATE 5, 12: PRINT "The specification include all the electronic compone
   LOCATE 8, 10: PRINT "The transformer Specification"
   LOCATE 10, 10: PRINT "12 volt(s)                             1 used"
   LOCATE 11, 10: PRINT "Input reference voltage(vp)           240v/ac"
   LOCATE 12, 10: PRINT "frequency of supply(f)                50Hz"
   LOCATE 13, 10: PRINT "output stabilized voltage(vl)         240v/ac"
   LOCATE 14, 10: PRINT "Reactive power output(kvA)            500W"
   LOCATE 15, 10: PRINT "current factor(kw)                    0.5"
   LOCATE 16, 10: PRINT "Efficiency                           -0.92"
   LOCATE 17, 10: PRINT "flux density(Bm)                      1.4T"
   LOCATE 18, 10: PRINT
   SLEEP 10: CLS : COLOR 15, 1
   LOCATE 5, 18: PRINT "Relay Specification "
   LOCATE 8, 10: PRINT "5A,12v dc power supply               2 used"
   LOCATE 10, 10: PRINT "Contact rating              Spco 5A 250v/ac"
   LOCATE 11, 10: PRINT "                            Dpco 5A 250v/ac"
   LOCATE 12, 10: PRINT "Operate/release                     20m/sec"
   LOCATE 13, 10: PRINT "Cool sensitivity                       0.9W"
   LOCATE 14, 10: PRINT
   LOCATE 15, 18: PRINT "Resistor Specification"
   LOCATE 16, 10: PRINT "220 ohms                              4 used"
   LOCATE 17, 10: PRINT "470 ohms                              1 used"
   LOCATE 18, 10: PRINT "10K(variable)                         2 used"
```

The value of the dropping resistor is 44000 ohms
The stabilizer voltage drop is 5.5 volt
The rate of conversion energy is 6.875001E-04 watt(s)
The stabilizer output is 13 volt(s)
The stabilizer current is 2.083333 amperes