DESIGN AND CONSTRUCTION OF 300VA SOLID STATE RELAY CONTROL AUTOMATIC VOLTAGE STABILIZER WITH OVER VOLTAGE PROTECTION.

BY

SULE ABDULLAHI

93/4017

A PROJECT REPORT SUBMITTED
IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE
AWARD OF BACHELOR OF ENGINEERING DEGREE (B. ENG.). IN
THE DEPARTMENT OF ELECTRICAL AND COMPUTER
ENGINEERING, SCHOOL OF ENGINEERING AND ENGINEERING
TECHNOLOGY, MINNA, NIGERIA

MARCH, 2000.

DEDICATION

TO

Allah,

And

Late DR S.O. Aliyu Simpa.

In our deep sorrow over your departure:

The Eyes Weep
The Hearth Grieves

But we say nothing that
Displeases Allah

And we are
Grieved over being
Separated from
You.

DECLARATION

I hereby declare that this project was wholly designed and constructed by me under the able supervision of Engr. M. A. Shehu, Department of Electrical Computer Engineering, Federal University of Technology, Minna, Niger State.

....
(Sign.of Student)
Sule Abdullahi
93/4017
..11-04-2000..........
Date

CERTIFICATION

This is to certify that this project work titled "Design and Construction of 300 VA Solid State Relay Control Automatic Voltage Stabilizer" was carried out by Sule Abdullahi (93/4017) under the supervision of Engr. M. S. Ahmed submitted to the Department of Electrical and Computer Engineering Technology, Federal University of Technology Minna, in partial fulfillment of the requirements for the award of Bachelor of Engineering (B.ENG) Degree in Electrical and Computer Engineering.

Engr. M.A. Shehu
Project Supervisor

Sign and Date 11/04/2000

Dr. Y.A. ADEDIRAN
Head Of Department

Sign and Date 6/4/2000

External Examiner

Sign and Date 15/4/2000

ACKNOWLEDGEMENT

Allah the most High, Bestower of Honour be praised for His infinite mercy Guidance, protection and sustenance throughout my life.

In a work of the kind it is impossible to trace the exact origin of each idea I would therefore like to acknowledge first, with grateful thanks, the Authors listed in the reference and the following people whose works have served as an inspiration for this project. Mall Ado Idris (FRCN Kaduna), Abdulhamid Jidda Ibrahim (Suleja). So goes to my Supervisor Engr. M.A. Shehu whose Co-operation and understanding has made this work a success.

Gratitude is also expressed to my Head of Department, Dr. Y.A.Adediran, my project coordinator Engr. Danjuma, Dr. Sadiq Suleiman, Engr. Raji, Engr Abubakar Kamarudeen, Mr Paul Attach, and host of others.

My grateful thanks goes to my sponsors. The Islamic Development Bank Riyadh and their Nigeria Counterpart IET Minna.

I must appreciate and gratefully thank the late Dr Aliyu's family, my parents, brothers and sisters for their constant encouragement, forbearance, supplication ,financial aid and moral support .

I have learn a great deal from my colleagues who have studied with me and gratefully acknowledge my debt to them, especially, Yabagi M.A., Omadivi U.Sule, Ahmed Sadiq, Akpogu Y.I., Abdulmumini Shehu, Abubakar Abbas and Musa Y. Aliyu

Gratitude is also express to all those who have given their helpful contributions; towards the success of these work.

I am grateful once again to my supervisor for his suggestions and painstaking work in ironing out some of the inconsistencies. Any that still remains are the author's. Any positive and constructive criticism as regard to this work is highly welcome and will be appreciated.

ABSTRACT

This project titled "300VA Solid State Relay Control Automatic Voltage Stabilizer" is designed to keep the standard voltage of 220v ac constant, irrespective of certain deviations from the incoming line voltage. It allows variations within the minimal of 160v ac – 230v ac. Over voltage protection is incorporated to isolate the load from the line voltage if it exceed 230v ac.

To accomplish the aim and objectives of this project LM 324, multitap Transformer, Solid State Relays (SSR), Electro-mechanical Relay and other associated components were used.

TABLE OF CONTENT

		Page
Title Page	- - - - - - - - -	i
Dedication	- - - - - - - - -	ii
Declaration	- - - - - - - - -	iii
Certification	- - - - - - - - -	iv
Acknowledgment	- - - - - - - -	v
Abstract.	- - - - - - - - -	vi

CHAPTER ONE

GENERAL INTRODUCTION

1.1	Aims and objective	- - - - - - - -	1
1.2.	Limitation	- - - - - - - -	1
1.3	Methodology	- - - - - - -	2
1.4	Literature Review	- - - - - - - -	2
1.5	Project outline	- - - - - - - -	3

CHAPTER TWO

SYSTEM DESIGN AND OPERATIONAL PRINCIPLE

	Over view	- - - - - - - -	4
2.1.	Power supply	- - - - - - - -	4
2.2.	Sense and Monitoring units	- - - - - -	11
2.3.	Overvoltage Control Units and Isolation Units	- - -	12
2.4.	Comperator Units	- - - - - - -	14
2.5.	Driver Units and Executioner Units	- - - - -	16
2.6	Driver Blocking Units	- - - - - -	17
2.7.	AutoTransformation unit	- - - - - -	18
2.8.	Operational Principles	- - - - - -	19
2.9	Some General Consideration during the Choice of Components Selection	- - - - -	21

CHAPTER THREE

CONSTRUCTION TESTING AND RESULTS

3.1. Construction - - - - - - - - 22

3.2. Testing - - - - - - - - 23

3.3. Results- - - - - - - - 24

Discussion of Result. - - - - - - - 24

CHAPTER FOUR

CONCLUSIONS AND RECOMMENDATIONS

4.1. Conclusions - - - - - - - - 25

4.2. Recommendations - - - - - - - 25

Appendix A Complete circuit diagram of 300VA

solid state relay control AVS - - - - - - 26

Appendix B Components layout - - - - - - 27

Appendix C LM 324 data sheet - - - - - - 28

Appendix D Casing diagram - - - - - - 29

Appendix E List of Components used - - - - - 30

Appendix F Transistor Data - - - - - - 31

Appendix G References - - - - - - - 32

CHAPTER ONE.

GENERAL INTRODUCTION

In recent times the main utility supply has been very erratic; brown-outs (half current), black-out(power failure) or power surges (burst of excessive currents) are being experience in domestic suppliers[10].

The consequences are damages to home appliance, (e.g. refrigerator, TV, Radios, A/C, etc.) and malfunctioning of office equipment, e.g. PC, Electronic Typewriter, Photocopying machine. This problem becomes evident because all these systems are design and manufactured to operate within certain specifications.

1.1. AIMS AND OBJECTIVES:

This project design and construction of "300 VA Solid State Relay Control Automatic Voltage Stabilizer" is aimed at giving a constant output of 220v ac or there about to meet the specification of home appliances that operators on 220v ac, which the public utility cannot always provide.

From observations and experience very low voltage is mostly experienced – It can be as minimal as 140v ac due to overloading or sagging . And most often when over voltages – 240v and above are experienced is either phase to phase or surges originating from large motorize machines equipment or welding machines.

AVS is a hardware, which gives constant required output (e.g. 220v Ac) irrespective of the certain deviations from the nominal value of 220v ac of the public utility supply. It provide safety when there is very low voltage supply and protection from overvoltage to sensitive equipment.

1.2. LIMITATION

This project allow variation within the minimal (160 – 220v ac) and considered voltage above 230v ac as over voltage.

1.3. METHODOLOGY:

An autotransformer with the voltage level requirement will be designed and constructed. The required voltage inputs are 160v, 190v, 220v ac with appropriate turn ratio to give out 220v ac, at the secondary. With multi tap input autotransformer as the central component, a device that will select the appropriate tap to give the required 220v ac out is needed. The device employ will be series of solid state relays with their contacts connected to a particular voltage level tap. Each of the solid state relay needs to be energized as well as de-energized when required. Comparator unit will be employ here whose output will be amplified by a driver to energize the SSR. It is also a requirement to have the means of monitoring and comparing the incoming voltage supply in other to effect the necessary change.

Power supply unit is a vital requirement for any electronic circuit to work. Therefore, a highly regulated dc power supply unit will be needed[12]. Over voltage protection will be incorporated to isolate the load and line voltage supply.

Proper assembling and casing is also part of a good design, therefore consideration will be given to choice of components, layering and casing.

1.4. LITERATURE REVIEW

A voltage stabilizer may be defined as " a circuit or device usually including one or more electron tube or a semi conductor device which maintain an almost constant voltage across its output terminals inspite of variation in the load or in the supply voltage[6]. Over the years a lot of work has been going on to achieve a stabilizer that will have fast response to fluctuation and provide constant value at the output as much as possible. Some of the earliest approaches were the motorized system and constant voltage transformer methods. But they had the disadvantage of bulkiness, cost, limited regulation accuracy. So also with poor regulation with changing in the frequency [2,11].

The most recent works in the department made the following improvement; cost reduction improved and simple circuit control[11]. But the connections to the transformation unit still incorporate an electromechanical relay, which has its own disadvantages because of the moving parts. Another work which has been very impressive too, shows a good circuit control response to fluctuating voltage has also been achieved with direct rectification of the mains supply voltage[4]. By divider network a voltage ratio was obtained to be monitor. Problem may arise if there is no isolation between the main and the control circuit. One of the diode will be short-circuited if one end of the line voltage and the load are both grounded[8]. This problem is solved by using an isolation transformer.

This project employs the use of solid state relay for the voltage level selection and restricted Electro-mechanical relay for isolation of the system from line voltage. The monitored voltage is also isolated from the line voltage through a transformer.

Electromechanical relay has the problem that the contact points arc, then eventually burns out and fails to make contact. This may prove a severe problem to the proper functioning of the control circuit as well as the load. This and other relay problems are solved by using a Solid State Relay that uses a triac switch[5]. Rather than contact points to switch from one level of voltage to the other at the transformer input only one SSR is triggered to come on at certain level depending on the command.

Another feature of this project is the use of LM324. Unlike the previous works where single Op-amp like LM341 are use, their disadvantage are the used of dual power supply and one chip contains single Op-amp. Therefore, more space will be occupied and there will be more surrounding components. With LM324, there are four Op-amp in one IC.

With the above, the set objective of reliability, fast response, stability will be achieved. Thus this work is a hybrid of Solid State Relays (SSR) and an Electro-mechanical Relay.

1.5. PROJECT OUTLINE

In this first chapter, a general introduction to the project work is given. The aims and objectives of the project are highlighted, justification, limitations and methodology of the project are outlined. Literature concerning the project was then reviewed.

Chapter two deals with the system design and operational principles.

Chapter three covers the construction of the system, testing, results and discussions of the result.

Chapter four gives the conclusions and recommendations.

Appendix and Reference list are provided at the end of the work.

CHAPTER TWO

SYSTEM DESIGN AND OPERATIONAL PRINCIPLE

OVER VIEW

In this project design, LM 324 has been chosen owing to its numerous advantage in usage. LM324 consist of four independent high gain internally frequency compensated Op-amps designed specifically to operate from a single power supply over a wide range of voltage[3].

The power supply has been designed specially to meet this requirement of LM324. A working voltage of 12v has been chosen. The use of external feedback components modifies characteristics of these amplifiers and to determine the functions to be performed.

At the differential inputs a voltage ration is compared in millivolts (mV). The result called the error voltage is amplified by the gain of this amplifier. This is further amplified by a transistor driver which energizes solid state relays to execute the changes at the transformer multitap inputs

2.1. POWER SUPPLY:

Most digital and analogue circuits require a highly stabilized and regulated d.c. Power supply to power them. Battery or a rectified power supply from the mains can achieve this, which is commonly available. However, the battery is usually not economical and convenient means of obtaining d.c power supply for this project. Therefore, the requirement of this project leads to the design of regulated power supply unit which will convert the available mains (220/50Hz) supply to the form required by the project (i.e. 12v and 9v dc)

In spite of rather large variations that may occur in line voltage, the load current, and the temperature, the output dc voltage must be maintain within 10% of the desired value, more or less. This is achieved by the following functions[9]

(a) voltage transformation

(b) Rectification

(c) Filtering

(d) Regulation.

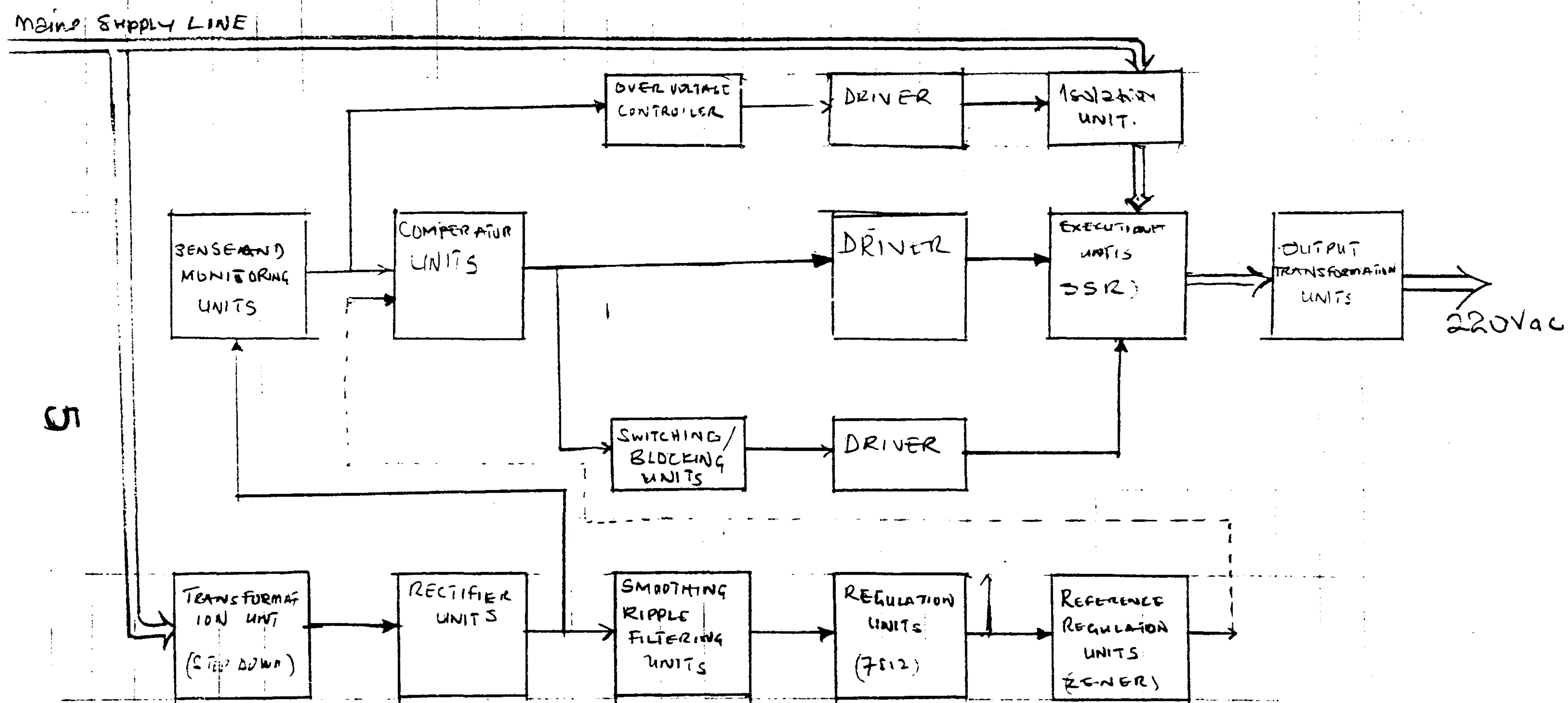


Fig. 2.1. BLOCK DIAGRAM OF SOLID STATE AUTOMATIC VOLTAGE STABILISER

⇒ MAINS SUPPLY LINE
→ CONTROL LINE

2.1.1 VOLTAGE TRANSFORMATION:

Voltage transformation is achieved through the use of 9volts-center tap step down transformer. There is transformation from the standard line voltage 220v AC to the step down voltage of 18v when connected end to end lead and 9v from center tap lead. 18v and 9v are both considered being specification for the required level of the dc regulated power supply and the sense monitoring voltage. It takes care of any wide fluctuation, which probably any other available small size transformer cannot give.

<u>Transformer ratings:</u>

Input voltage = 220vac

Output voltage = 9 –0- 9

Current Rating = 300mA

Size = small in size.

For over current protection due to any rise in the mains voltage supply to the transformer a Current limiter (resistor R_1) has been connected in series to limit the flow of current.

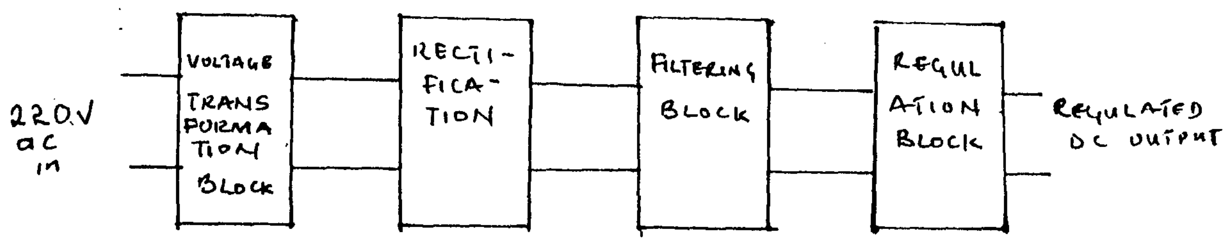


Fig. 2.2 Block Diagram of Regulated dc Power Supply Unit

2.1.2 RECTIFICATION

This is the conversion of ac line voltage and current (whose polarity keeps changing) to voltage and current of constant polarity[9]. This achieved by using diodes in full-wave Bridge configurations – Full-wave Bridge Rectifiers for the 18v. It consists of four diodes D_1 - D_4 with point C always positive with respect to ground. The second rectification is through Full-wave center tap giving 9volts-dc output. It contains only a diode connects to the center lead of the transformer. The rectified output of the diode is always positive with respect to ground[12].

The peak inverse voltage (PIV) is a significant factor to be considering in the diode selected for the rectifiers. Therefore, for each input diode:

Let transformer input voltage = 220v ac/50Hz

Transformer output voltage = 24v ac end to end = Vrms.

Let no load voltage = Peak voltage (Vp)

Then

$$Vp = \sqrt{2} \times Vrms$$

$$= \sqrt{2} \times 24$$

$$= 25.45v\ ac$$

Therefore in choosing the diode the maximum peak voltage that each diode has to sustain is when the anode is at the negative peak of 25.45v given a

PIV of 2 x 25.45 = 50.90v ac.

It can therefore be seen that the PIV is twice the peak voltage of the ac. This gives the advantage of the use of Bridge rectifier in the project.

Considering the maximum mains voltage allowable for the power supply in this project, the PIV is given by:

PIV = 20.0 x 2 = 40.00v ac.

Therefore 1N4004 has been specified for this work because of its high PIV of about 500volts.

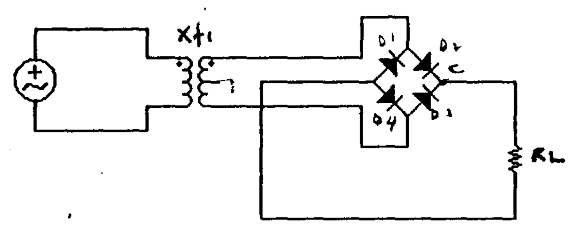


Fig 2.3 Transformation and rectification circuit

2.1.3 FILTERING CIRCUIT:

The output waveform contains ac components as ripples. Filtering is done to remove this ripples and provide smooth dc voltage. The filtering circuit consists of C_1 Electrolytic capacitor and C_2 a mica capacitor[9].

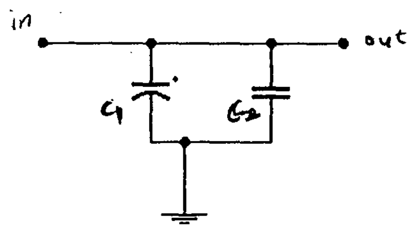


Fig 2.4 Filtering circuit

C_1 is used as a reservoir capacitor. It charges up to the peak voltage and then discharges through the Load R_2 preventing the voltage from falling rapidly. For good filtering, the size of the capacitor is chosen sufficiently large to make the discharge time constant RC much longer than the period of the source waveform. As R_L is the load (fixed in value) only C can be chosen at will. By using a large value of C = 3300µF 35v a smooth waveform was achieved. The 0.1µF capacitor suppress Radio frequency (Rf).

2.1.4 REGULATION

Voltage regulation is a vital factor in any circuit where ICs are concerned. Voltage regulation is a measure of a circuit's ability to maintain a constant output voltage[9]. The output voltage of the power supply therefore must remain reasonably constant under a number of varying conditions such as the line voltage fluctuation and changes in current drawn by the load as this can greatly affect IC parameters.

IC regulators offer fixed output voltage with typical load regulation of less than 1% internal thermal overload protection, as well as short-circuit protection[3]. Therefore, 7812 IC regulator was chosen for the project. However, zener diode regulator has been chosen for the provision of the 9v reference voltage.

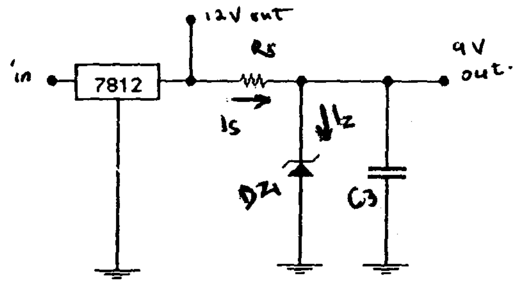


Fig 2.5 The regulator circuit

Design Calculations

The worst case is taken: when the full load current is allowed to pass through the zener diode when Is = Iz

let Iz = Zener current

P = Power rating

Rs = Current limiting Resistor

Vo = Voltage out = Zener voltage (Vz)

Vi = Voltage in

Is = Full load current through the resistor.

For

P = 0.5w; Vz = Vo = 9v

Then

Iz = p/v = 0.5/9 = 0.056A

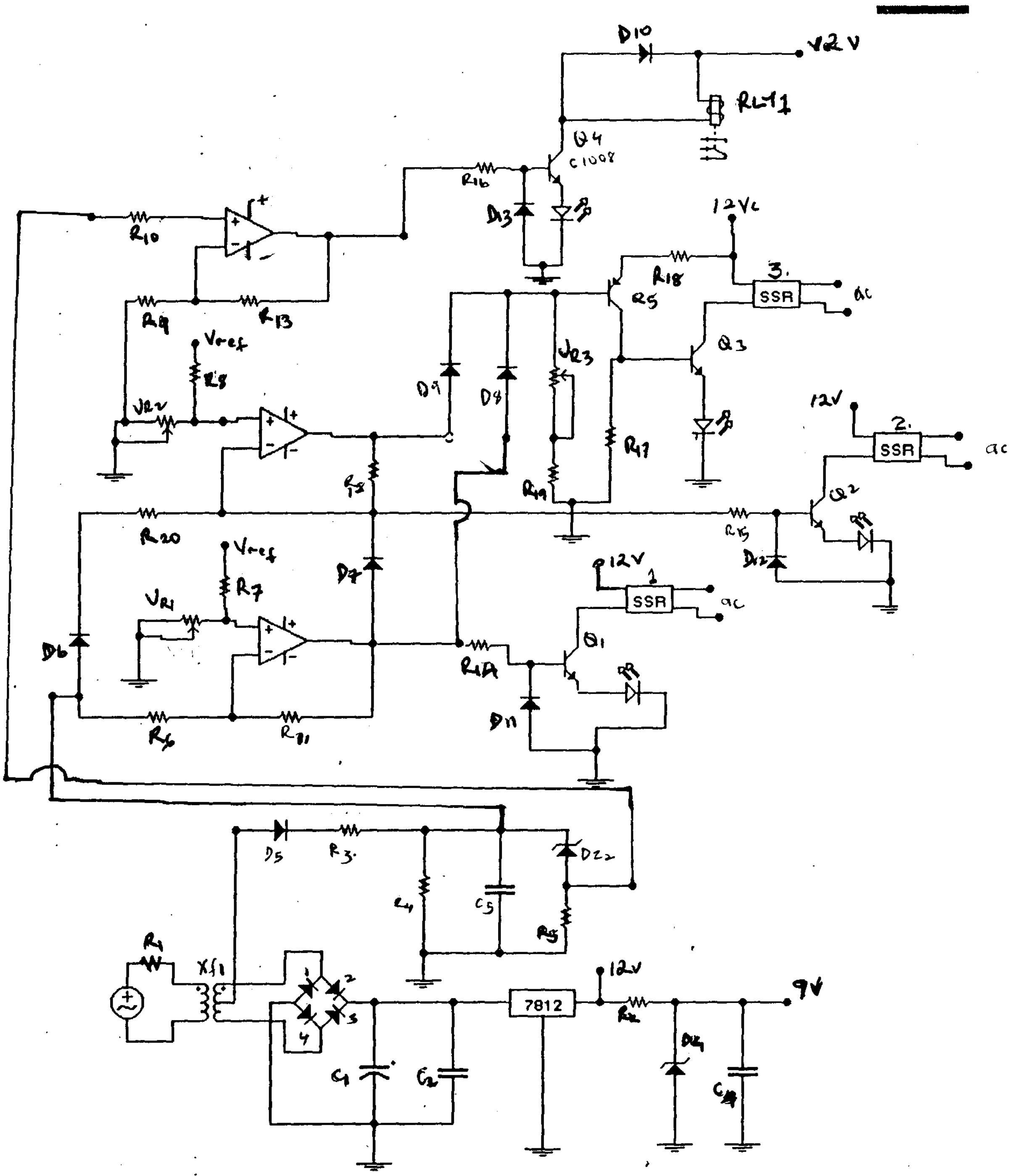
But

Iz = Is = 0.056A

Therefore

Rs =Vi/I = 12/0.056 = 215.82Ω

Aprox. = 216Ω



g 2.5A Complete Circuit Diagram of 300VA Solid State Relay Control Automatic Voltage Stabilizer.

2.2.ʾ SENSE AND MONITORING UNIT

This unit monitors the incoming line voltage supply and gives appropriates ratio at the output. It sense when there is over voltage, normal, low voltages.

The input is taken from rectifier diode output.

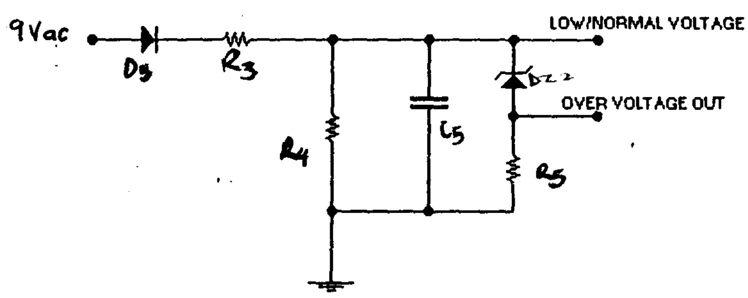


Fig 2.6 Sense and Monitoring Circuit

Through a voltage divider ratio rectified ac is sampled for comparism at the comparator inputs. The capacitor is provided to enhance the performance of the circuit. It helps in suppressing ripples that can lead to indecision at the comparator output.

The zener diode DZ_2 used is provided to monitor overvoltage. As soon as the set limit of the system is exceeded the diode will conduct and there will be voltage drop across the resistor. R_5. This voltage is taken to the overvoltage amplifier through current limiting resistor R_{10}.

In the divider network R3 and R4 were chosen to give voltage ratio of 1:2

Design Calculations

Assumptions.

Let incoming peak voltage = Vp = 9v

Let R4 = 4.7k (Chosen arbitrary)

Maximum allowable voltage is calculated thus:

from the voltage ratio of 1:2

$V_4 = 2/3 \times 9 = 6\text{Volts}$

$V_4 = (R_4/(R_3 x R_4)) \times Vp$

$V_4 = 4.7/(R_3 + 4.7) \times 9 = 6v$

$6R_3 = 28.2\ 4.7 \times 9$

$6R_3 = 42.3 - 28.2 = 14.1$

$R_3 = 14.1/6 = 2.36k\Omega$

:. 2.2k will be chosen (preferred values)

If R $= 2.2k$

I $= 9/2.2$

$= 4.1mA$

:. Current through R_4 (I) = 6/4.3 = 1.28 mA

:. Iz $= 4.1 - 1.28$

$= 2.82$ mA

:. Voltage across R_5 = 470 x 2.82

= 1.325volt

Where Iz = zener current

Capacitor 0.1uF is chosen to give a low discharge time constant which is preferable in this circuit. This helps in quick response to any jittering voltage.

2.3.1 OVER VOLTAGE CONTROL UNIT AND ISOLATION UNIT

2.3.1 OVER VOLTAGE AMPLIFIER

Over voltage control unit sense any voltage over 230V as over voltage and this triggers the isolation unit.

Op amp 1 in the LM 324 has been incorporated for the purpose.

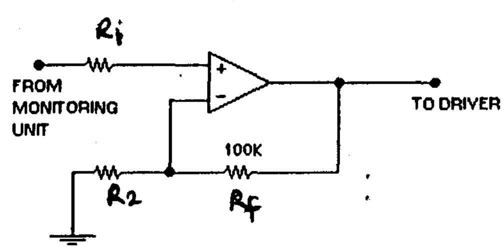


Fig 2.7 Over voltage amplifier

Op Amp1 is designed as a voltage amplifier in the inverting mode configuration. The input (which comes from the monitoring circuit) is applied to the non-inverting terminal while feedback is applied to the inverting input terminal.

Non inverting amplifier close loop voltage gain is given by [1].

$Av = 1 + R_f / R_i = 100$

If R_f = 100k (chosen arbitrary)

$R_i = R_f/(A - 1)$

$R_f = 100/100 - 1 = 1.01k$

Now let

V_0 = Output voltage of the amplifier

V_i = input voltage at the non-inverting input

$V_0 = V_i\,(1 + R_f/R_i) = 1$

$\because I_1 = I_2$

$V_2/R_i = V_0 - V_i/R_f$

$V_0 = V_i\,(1 + R_f/R_i)$

$A_0 = 1 + R_f/R_i$

For the output voltage V_0 is given by taken

$V_0 = Vcc - Vint$

Where Vint = internal drop of the IC (form data)

$\therefore V_0 = 12 - 1.5 = 10.5$volt.

Ref voltage Vref = 1k x 10.5/101k

= 0.1v

2.3 ISOLATION UNIT

The isolation unit provide the action of isolating the system from the mains power supply when over voltage is sense.

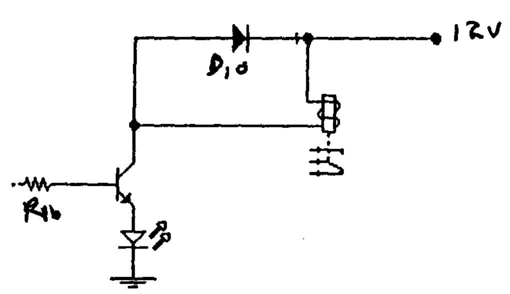


Fig 2.8 Isolation unit driver

As soon as the output voltage V0 of the amplifier goes high transistor Q4 is forward bias through 1k resistor to limit the current. As the transistor biases it conducts and current will flow through the relay via the transistor to ground. When the relay energises, the normally close (NC) contact is open. By this action the system is isolated from the line voltage.

2.4. COMPARATOR UNIT

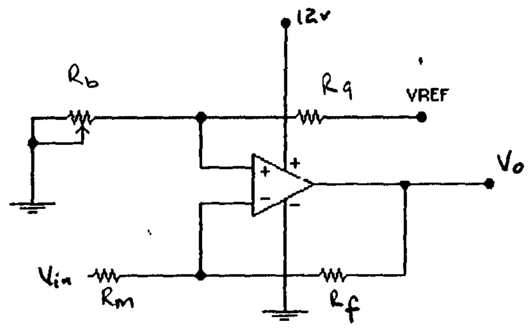


fig 2.8 Comparator unit circuit configuration

IC in the 0p–Amp LM 324 has been specifically design to work as a voltage comperator for this project.

The voltage supply Vcc is taken from regulated qutput of 12v dc supply. The voltage reference supply is from the zener regulator of 9v from the supply. The divider network consisting of Ra and Rb establishes a voltage level equal to the voltage across Rb at the non-inverting input. This voltage level so establish is the threshold to which the monitored voltage will be compared with.

The Feedback network is provided by Rf to the inverting input. This help in stability and gain. It provides operation of the 0p–amp in a linear region by pulling V- (inverting input) toward zero when there is decrease in V_0 [12]. Thus a balance is achieved, in which V– is driven just positive enough to drive V0 just enough to keep V – from rising further.

Thus for linear operation the following inequity must be satisfied.

$$Vin < Vce / (Rf/Rin.)$$

Furthermore, the effect of the feedback is

- to reduce the overall gain.
- To permit correspondingly higher Input voltage. Vin without saturation.
- to produce an inverting closed-loop gain Rs/Rin that depends only on the positive external components Rf and Rin and not on the open-loop gain[12].

Therefore the resistor value chosen such that the amplifiers are not driven into saturation.

Specification for the comparators:

Assumptions:

- Rf = 100k
- Gain = 100
- $I_1 = I_2$

A = 1 + Rf/Rin

100 = 1 + Rf/Rin

Rin = 99/100 = 0.99 Rin = 1k

∴ Rin = 99/100 = 0.99 Rin = 1k

For 190v IC.0p.Amp

Ra & Rb are arbitrary chosen

Ra = 20k; Rb = 100k; V_{Th}? = Threshold voltage

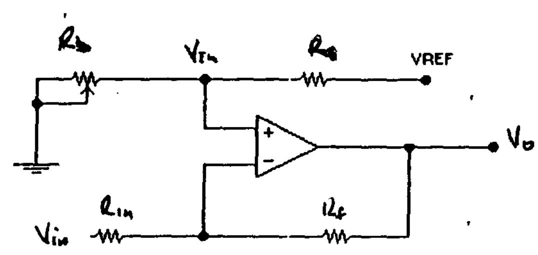


Fig.2.10 190v ac comparator.

When set to value of less than 25% e.g 20%

V_{th} = 20/40 x 9 = 4.5v

For lower voltage of 160V AC

Ra = 47k; Rb = 100k, V_{th2} = Threshold voltage

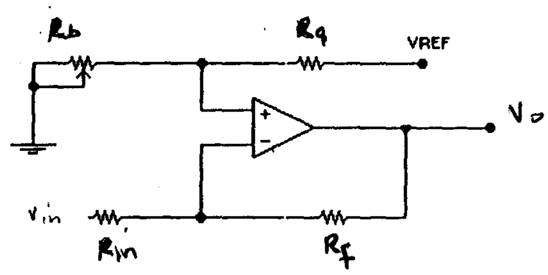


Fig.2.10.160v ac comparator cofiguration.

When set to 25%

VTh2 = 25/75 x 9 = 3.126v

:. Comparator IC3 will operate at a voltage of ≤4.5v whlie IC2 operate at ≤ 3.13v

It implies that V0 only goes high when Vin falls below 4.09v for IC3 and 3.13v for IC2 As long as Vin is above these thresh hold V0 is remains low (zero) (Normal).

Therefore at normal line voltage of 220v ac, IC1, C2 and IC3 and are dormant.

Below the threshold of IC2, IC3 output V0 may still remain high therefore a diode D7 switch is taken form IC2 output to IC3 inverted input to raised it above its threshold voltage in order to lower the output. D6 is to provide a blockage against any feedback from output directly to the input of IC2. (fig. 2.11).

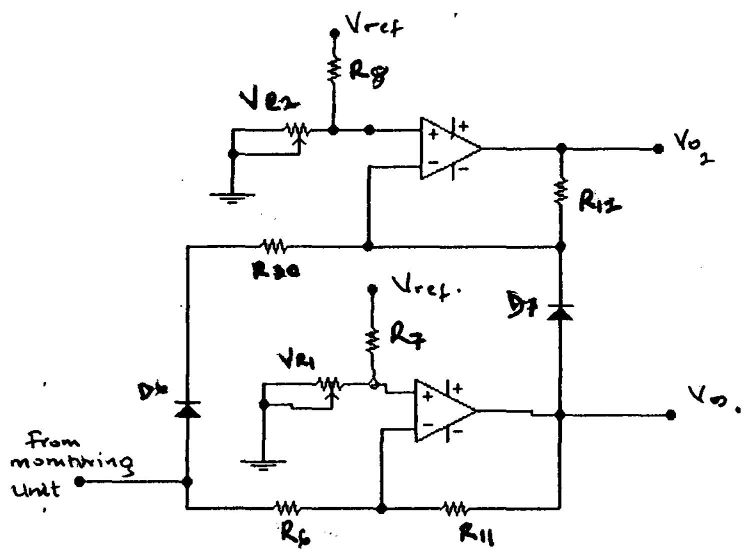
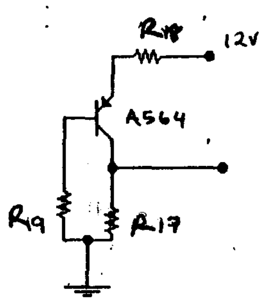


Fig. 2.11. complete low voltage comparator unit showing blocking diodes connections.

2.5. DRIVER UNIT AND EXECUTIONAL UNIT

Driver unit is designed with an NPN transistor in the common emitter configuration. It amplifies the current when forward biased by the comparator output voltage through a bias resistor R. In the case of 220v ac SSR driver, it is bias by a PNP transistor Q5.



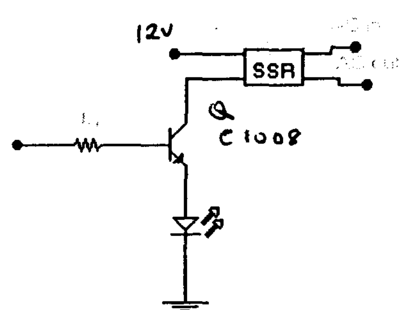


Fig. 2.12a Blocking Transistor unit. fig.2.12b Driver Transistor unit

The Executioner units are solid state relays [SSR] coupling the driver output to the transformer taps fig 2.14b.

Specifications

NPN-silicon transistor.C!008.

Hfe	=90
Ic	=1 Amp
Power	= 1 W

SSR. Type 2N01LF

Rated current =1Amp Rated voltage (dc) = 10---18 volts dc

Rated voltage (ac) = 240 volts ac

Calculations.

Let

.Ic = Collector current

Ib = Base current.

Ie = Emitter current.

If

$$Ib = Ic / hfe$$

Then

$$Ib = 1 / 90 = 0.011 \text{ Amp.}$$

Therefore the allowable Ib is 0.011Amp.and in order to operate the transistor within this value, base resistor Rb is given by;

$$Rb = Vb / Ib$$

[where Vb is the base voltage to bias the transistor]

But, Vb = Vo = 10 volts.

[where Vo is the output voltage of the comparator .]

.therefore,

$$Rb = 10 / 0.011 = 909.01 \text{ ohms}$$

$$Rb = 1K \text{ [preferred values]}$$

2.6 220 VOLTS DRIVER BLOCKING UNIT.

A PNP transistor Q5 [A564] is provided to bias transistor Q3 when 220v AC is present and to cut off when absent .

Bellow 220v AC D7 and D8 are ingeniously connected to stop Q5 from conducting which eventually cut-off Q3.

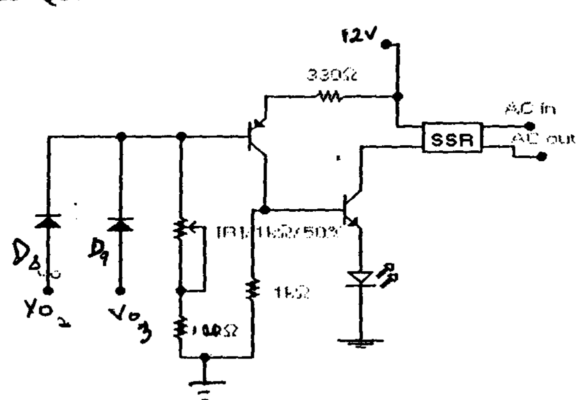


Fig. 2.13 PNP Blocking circuit for 220v a.c diver unit

2.7. AUTO-TRANSFORMATION SYSTEM DESIGN

In carrying out the design of the auto-transformer certain assumptions were made ;

line frequency = 50 Hz

efficiency = 80%

volts/turns ratio = 0.33

Design requirements:

At input

normal voltage 220vac

under voltage 1 ----- 190vac

under voltage 2 ----- 160vac

At output

constant 220 Vac with 5% deviations

power capacity -------500VA.

Current rating ------ 500 /220 = 2.37Amp

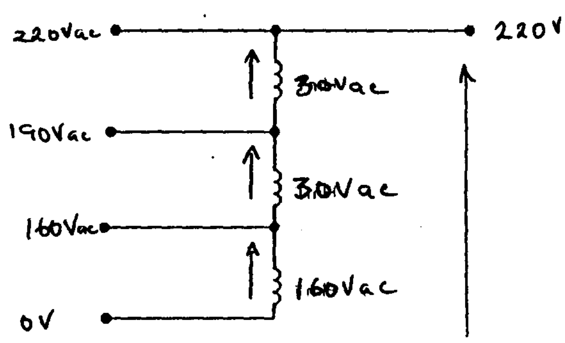


Fig. 2.14 Multitap autotransformer connections

From the volt/turns ratio of 0.33,

160vac = 480 turns.

30vac = 90 turns.

It implies that ;

160v + 30v + 30v = X turns

480 + 90T + 90T = 660Turns

:. For the transformer to withstand the first initial surge of 220V the 160vac must have turns that can withstand it.:. 160vac will be carrying the 660 Turns for cupper gauge of 22. and 700Turns if 23 gauge, is used. The 22 gauge was chosen for the 160 vac while 23 gauge was used for the remainder of the windings for convenience.

Now 660 – 480 = 180Turns

180 Turns required for the remaining windings :. For 160V = 660 turns

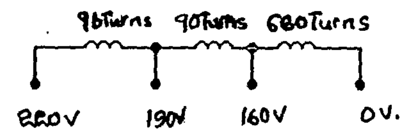


Fig.2.16 Auto transformer Turns ratio

:. Total no. of Turns = 660+ 90 + 90

= 840 Turns.

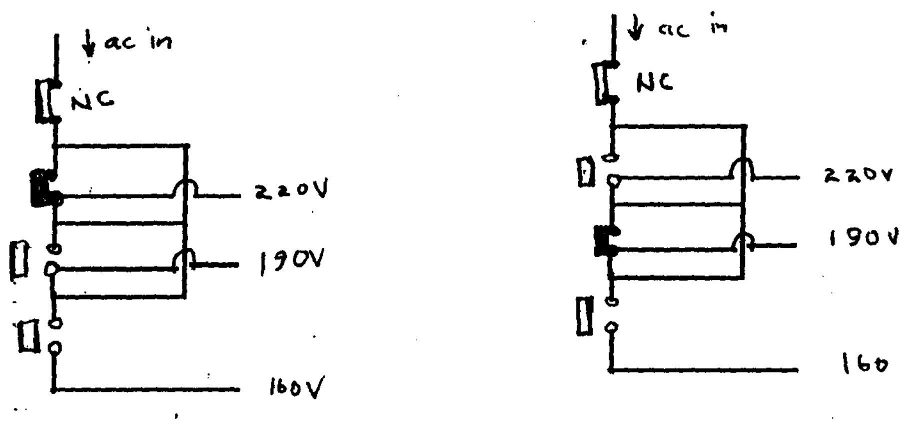
2.8. OPERATIONAL PRINCIPAL

Normal voltage:

At normal voltage of 220 Vac or there about, PNP Transistor Q5 is biases there by biasing NPN transistor Q3 to conduction. When it conducts SSR3 is energized by the current driven from it Q3. When energized the trice in the SSC is triggered thereby connecting the 220v line voltage to the 220v terminal of the Auto-transformer. Fig. 2.17a At this normal voltage sensing the comparator circuit will be dormant.

Under voltage (190 V)

As soon as the voltage supply goes below 220 Vac says 190 Vac or there about, it is sense by the monitoring unit and send to the comparator IC where it is compared with the reference voltage. The output rises from zero to high. This biases the driver transistor Q2, to energise SSR2. When energise 190 tap of the transformer is connected to the supply line. At the same time a pulse signal voltage is ingeniously taken from the output of the comparators to block the P.N.P transistor Q5 to cut off bias to Q3 which de-energises SSR3 (see fig2.17b).



(a) (b)

Fig. 2. 17 Line Diagram Representation of the switching controls

(a) Normal Voltage supply (b) Under Voltage of 190V

(c) Under Voltage of 160 V (d) Over voltage above 230V

Under voltage (160)

Similarly, when the voltage falls below 190 say 160 v or there about; it is again sense by the monitoring unit. This sense voltage is then compared with the reference voltage of the comparator. The output voltage which is low (or 0v) will now rise high to bias the transistor Q1 .

The current drawn by it energises SSR1. As SSR1 is energized SSR2 and SSR3 are both cut off. This is done by ingeniously sending a pulse signal voltage from the output of IC2 through a switch diode to the inverting input of IC3 and to block transistor Q5. IC2 output now falls to zero while Q5 cut off the bias to Q3 (see fig 2.17c).

Over Voltage

Subsequently, when over voltage above 240v is sensed it is taken to the over voltage amplifier IC1. This is amplified to bias the driver transistor Q4 which energise the Relay RLY1 to cut off the supply line thereby isolating the system from the mains supply. (See fig.2.174)

When normal voltage is restored there will be no voltage at the input of the amplifier, therefore no output and no bias to Q4. Relay is now de energized and the normally closed contact is restored too. However IC2 and IC3 remain dormant.

2.9. SOME GENERAL CONSIDERATION 'N THE CHOICE OF COMPONENT SELECTION.

1. LM – 324 has be chosen because it consists of four independent high internally frequency compensated operational amplifier and can be operated from a single power supply[3].

2. Solid State Relay (SSR) is used because it employs a Triac switch rather than contact points to switch the large currents. Since the switch is done inside a semiconductor device, there is no arcing. It prevents spikes and noise from being impressed on the power line[5] . Other feature include:

- Total isolation between command side and load side, Fast switch (speed) because the only relationship between the command side and load side is light[7].

- Operates silently, Very compact, High efficiency and Reliability (i.e. No carbonization as in Electro mechanical relay)

3. C1008 Transistor:- was chosen for its high collector current rating 1A. See the Appendix F where it is compared with equivalent values. A564 Transistor chosen arbitrary and any switching transistor equivalent will be ok e.g. A733.

4. Auto transformer is chosen for this design because of the high efficiency and voltage regulation over 2 winding transformer. It is also cheaper and lighter [13.]

5. Center tap 9v transformer is chosen because of its small size and its center ap. The end to end connection is used to obtain 18v. In case of any wide control in line voltage, the output of the transformer is still adequate for our regulation power supply. Centre tap too was useful for the voltage sampling to be monitored. The transformer is also protected from any over voltage surge through a series resistor R1 to limit the over current that may go through it.

6. Rectifier diodes D1 – D4: IN 4004 was chosen for its high PIV of 500 V. Shunt Divide D10 is also IN 4004 is used to take care of back emf rapidly discharging when the supply is rapidly removed.

7. Ic regulator 7812: has a wide input voltage over voltage protection, temperature protection and short circuit protection Input range – 13.5 to 40v; Rated current 1.5A

8. Diode D11, D12 and D13 are to prevent reverse base emitter breakdown (Op-amps easily bring more than – 5v).

CHAPTER THREE

CONSTRUCTION, TESTING AND RESULTS

3.1. CONSTRUCTION

The construction involves three segment.

1. The Auto-transformer
2. The control circuit
3. The casing

1. The Auto-transformer was constructed base on the design specification

current rating = 1.5A

Capacity = 500VA

160V winding = 600Turns of 22 gauge

190V winding = 90 turns of 23 gauge

220V winding = 90 turn of 23 gauge

Control circuit: Following the control circuit design the component layout was first sited. Taking good note of component spacing, clearance, direction and proximity. The output component where first laid and soldered after which the IC position was then centralized. All other components were then position as shown in the component layout diagram. Cupper strips that are unused are scrape off and at point where component terminate, to ensure that short circuit is avoided. These was follow until all the components were assembled according to the design. In constructing the casing the various component, transformer, control circuit, freeboard were put into consideration because the size and spacing of the casing matters. A metal steel material was chosen for the casing because of strength, fire hazard and earthling. It also serve as heat sink which the wooden material cannot provide. Ventilation too was provided for the transformer cooling. Projection diagram of the construction casing is shown in fig .

3.2 TESTING

The system was tested as follow after the construction.

1. When unconnected with Auto-transformer fig

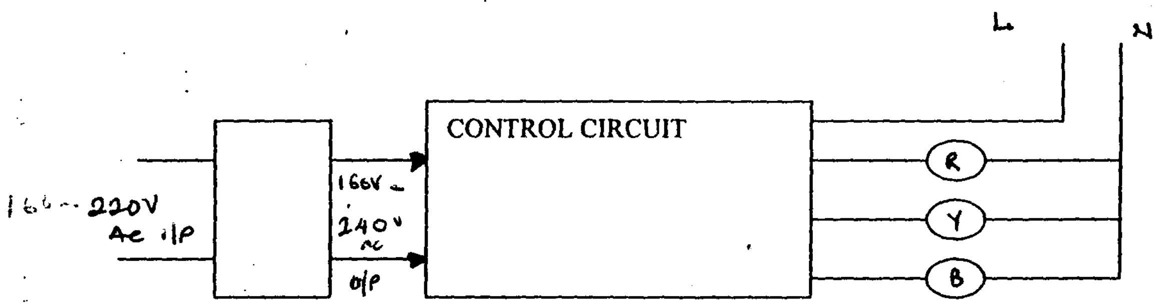
2. When connected with Auto-transformer

1. When unconnected with Auto transformer, as show in the fig3.1a. Bulbs label R, Y, B, where connected to the SS R3, SS R2, and SS R1, respectively

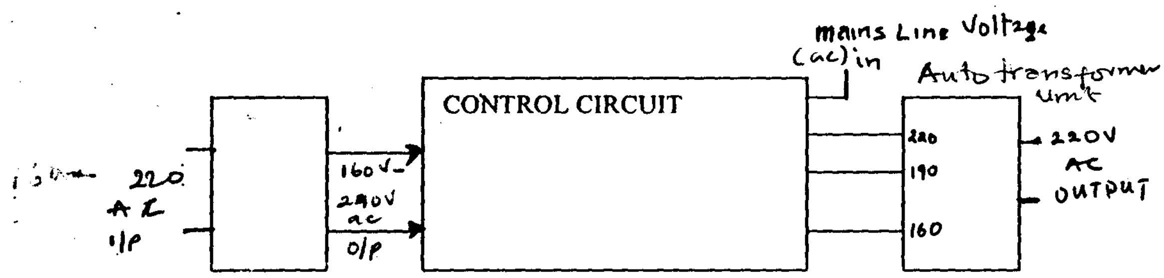
A verector is connected so as to vary the voltage to 160, 190, 220.

The result is as shown in the table 1.

1. When connected to the Autotransformer measurements were carried out at the 220VAC output with a voltmeter and the results achieved, are as shown in table 2.



(a)



(b)

Fig. 3.1 Testing connections (a) when connected to 3- bulbs (b) when connected

Auto transformer

3.3. RESULTS

Table 1

Supply voltage	Red	Yellow	Blue
160	-	-	on
165	-	-	on
190	-	on	-
220	on	-	-
230	on	-	-

Red – 220 Vac SSR output

Yellow – 190 Vac SSR output

Blue – 160 Vac SSR output

Table 2.

1. When connected with Auto transformer

Supply voltage	Output voltage from transformer secondary
160	225
165	230
190	225
220	220
230	230
240	-

Discussion of results.

From the table of results it implies that working margin was reached on no load condition. It could be observed that the output voltage is above the nominal value of 220v of the expected voltage and allowable.

CHAPTER FOUR

CONCLUSIONS AND RECOMMENDATIONS

4.1.0 CONCLUSTION

Going by the scope of this project work, the set objective of the design has been fairly achieved as desired; silence, fast responds to fluctuation and reliability. However because of its limited current rating of 1A, the capacity of the system is limited too.

During testing humming noise could be heard from the transformer due to vibration of the laminations, which might have resulted from improper packing.

4.2. RECOMENDATIONS

However, for further works on similar project, SSR with higher current rating should be use to enhance the capacity of the system. The redundant op-Amp in the IC could be put into use e.g. to take care of voltage below 160v Ac or above 230v Ac.

In addition an IC with 4 comparators in one chip could be use with appropriate associating components.

APPENDIX A

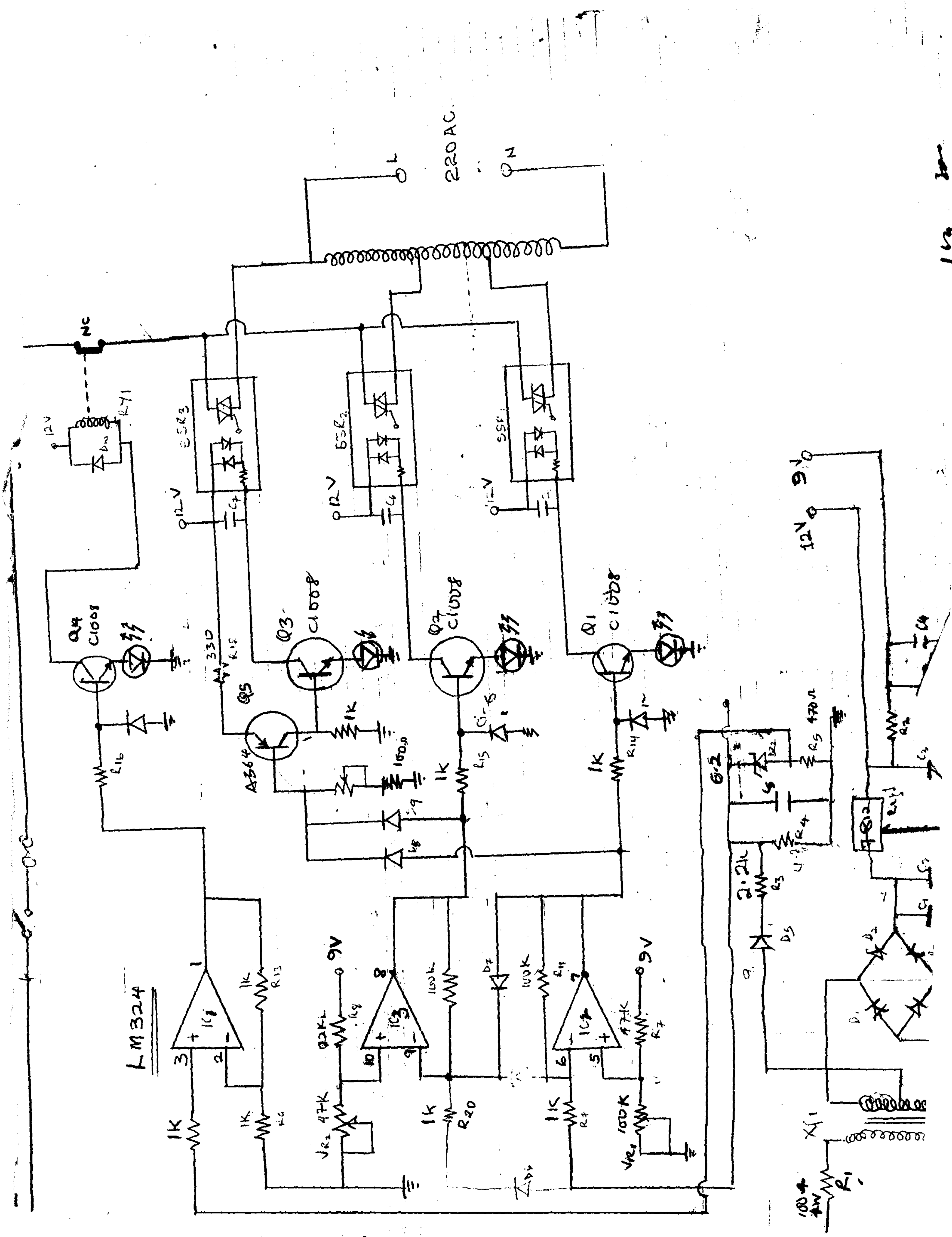


Fig A. complete circuit diagram of 300VA AVS

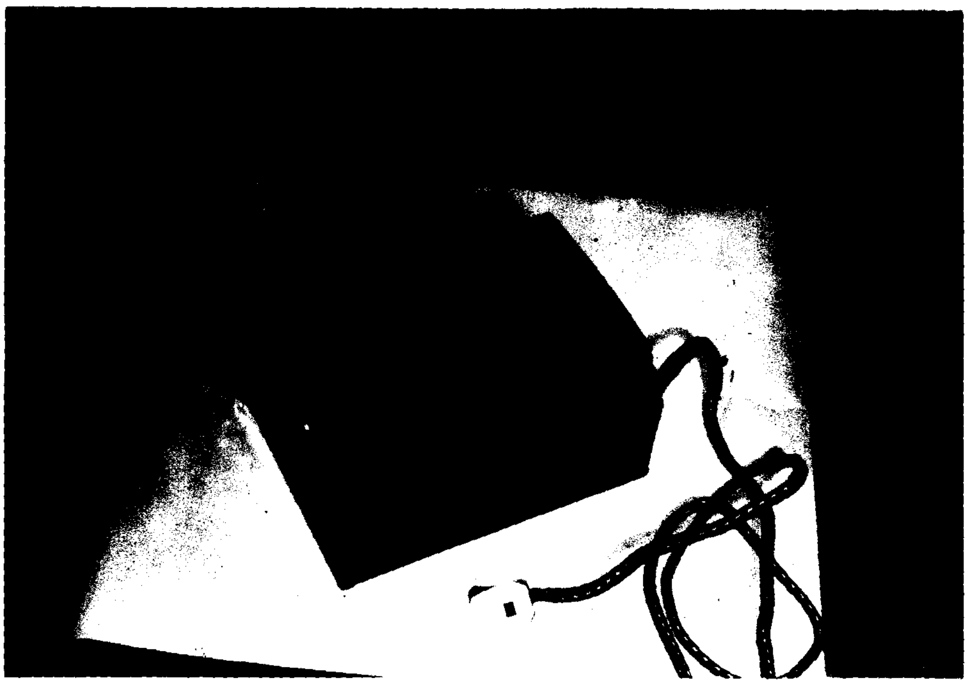


Fig B. PLATE A: COMPONENT LAYOUT

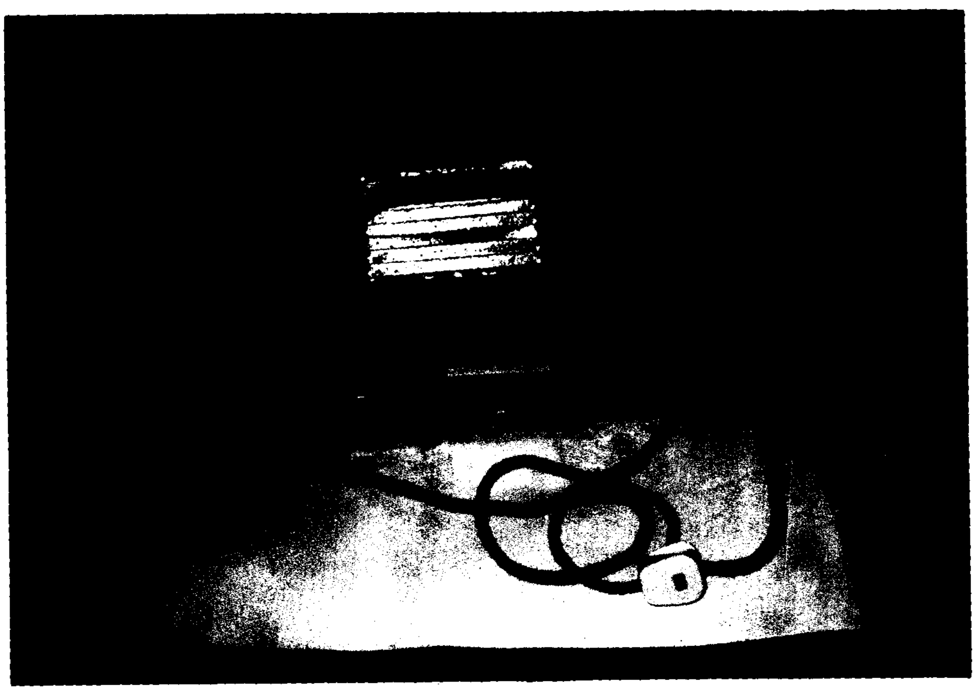


Fig B PLATE B: PACKAGED CASE.

APPENDIX C

THE SPECIFICATION DATA FROM THE MANUFACTU ON THE USED LM324 QUAD OP-AMP.

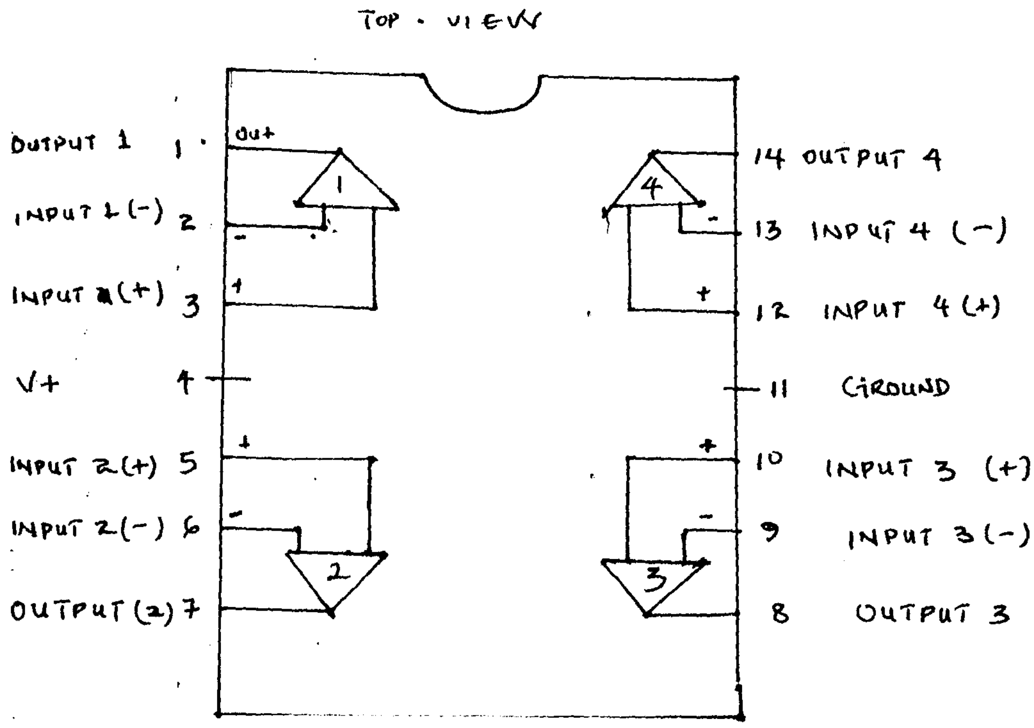


Fig C Internal Configuration of LM324 QUAD OP-AMP

Absolute Maximum Rating

Supply voltage V+ - 32Voc or 16Voc

Difference input voltage 32Voc

Input voltage – 0.3 Voc to + 32Voc

Power Dissipation 570mw

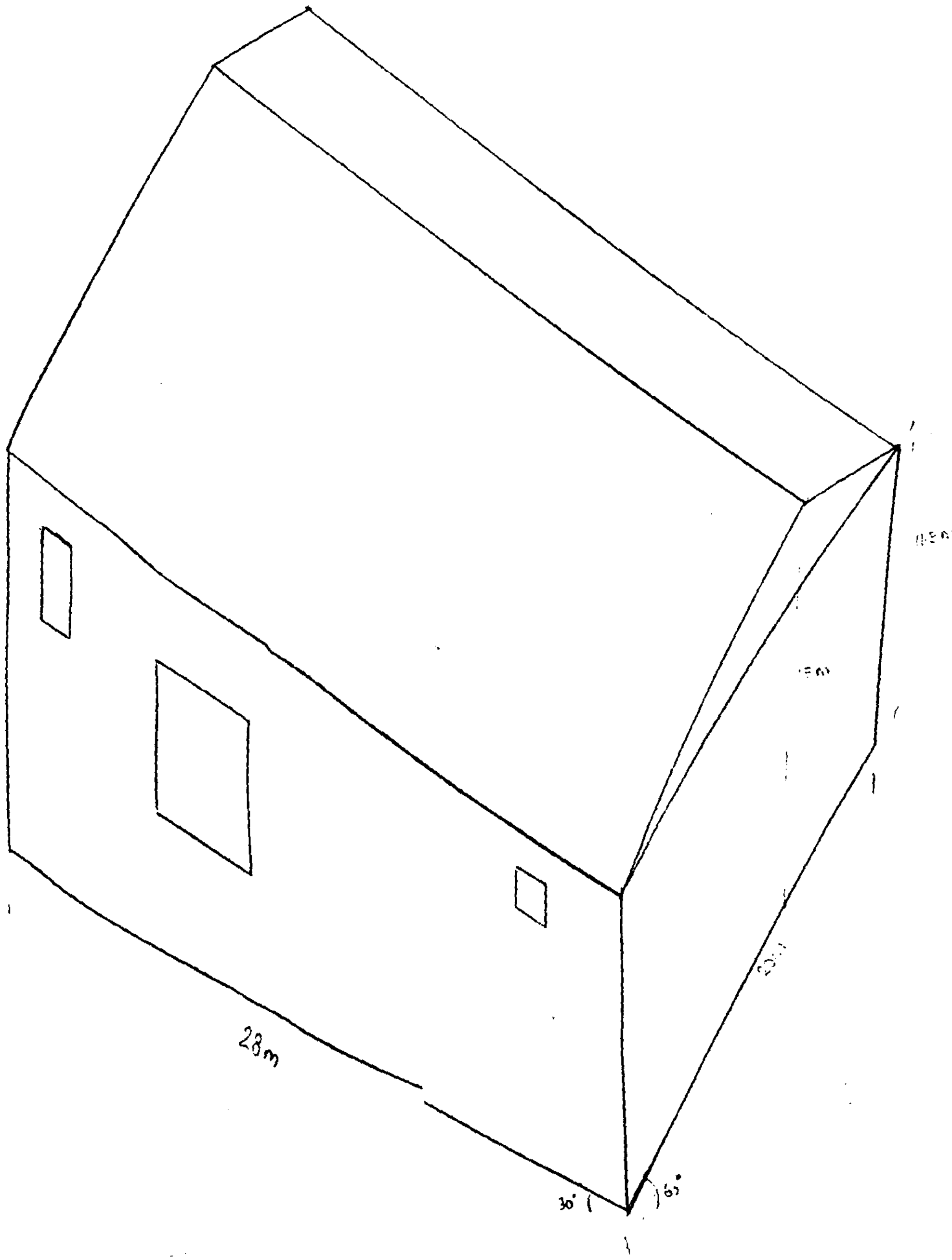
Input current – 50 WA

Output short – Current to grow 00c – to 700c.

Soldering temperature 3000c for 58sec

APPENDIX D

CASING DIAGRAM



SCALE 1:200

fig D. Casing Diagram of SR. AVS.

APPENDIX E

LIST OF COMPONENT USED

Name of Component	Abb	Type	Qty	Values
Solid sate Relay	SSR	ZN 2 OIL	3	1A 240 Ac10– 18v Ac
Electrochemical Relay	RLY		1	5A, 240v Ac 12v Dc
Transformer	XF1	Step down	1	3A, 9 – 0.9 Sec, 240VAC
Capacitor	C	Mica	2	104 (0.11)
	C	Electrolyte	3	(1000p 35v), (2204f 16v)
Diodes	D	Rectifier	6	IN 4004 Piv 500v
	D	Switch 4	4148	
1C sucked	D2	Zero	2	9.v, 6.2v
Integrated cct	IC	op-amp	1	LM324
		Regulator	1	7812
Transistors	Q	NPN (si)	4	C1008
		PNP (si)	2	A564
Resistor	R	Metallic	22	
Variable Resistor	VR	Presets 2	100k	
Switch	SW	toggle	1	240v
Fuse	f	wire fuse	1	
Socket	ST	Conduit type	1	13A, 250v
Veroboard	VB	Stripe Bus	1	14 x 10
Casing	Case	metal steel	pack	
Cable	cable	flexible	1 yard	
Plug	Plug	3 pin plug	1	13A, 240v

APPEDIX F

Data Comparasum Table for the Chric ..

DATA	C212V	D261	C1008	C1175
C_{BO} (V)	100	75	120	75
BV_{CEO} (V)	80	4	80	40
BV_{EBO} (V)	5	6	7	6
Ic (A)	0.5	0.8	1	0.8
Power (w)	½	½	1	½
BW (MHz	120	250	120	300
H_{FE} (B) Typical	100	200	90	50

REFERENCE

1. Ahmed shehu; Advance Circuit Techniques: F.U.T Minna 98/99 season

2. Akinsany M. F. 500VA. AVR Electrical Computer Department FUT. Minna (Feb. 1998) pp

3. Archer: Semiconductor reference guide 1990 pp. 45

4. Dan baba B. H. AVR College of Engineering KAD. POLY. 1996.

5. Douglass V. Hall: *Microprocessor and Digital System (Second Edition)* 1983. Mc. Graw-Hill Book Company pp. 50-51

6. G.K. Mithal: *Industrial Electronics: Romesh Chowder Khanna* 1975. Khanna Publishing Company. pp 250 -256

7. Horonitz P. Hill Winfield: *The art of Electronics* 1989 Cambridge University Press pp. 589, 595.

8. Fisher J. Garland B: *Electronic: from theory into practice (second edition)* 1976. Perganon Press pp. 31 –36, 305- 307

9. Manera A.S: *Solid State Electronics circuit: for Engineering Technology Mc Grow Hill Book Company* (1973) pp.

10. Microbyt magazine: July 1999 vol. 3. No3: *Microbyte International Nig Ltd.*

11. Muhammad A.I Dec. 98 500VA AVR *Electrical computer F.U.T, Mx*

12. Senturia D. S and Bruce D.W: *Electronic Current and Applications* 1975

    WILEY International Edition. John Wiley and Sons. pp. 94 - 120

13. Theraja .B. L.: *Electrical Technology Nirja Construction & Development Co. (p) Ltd.* (19). pp.