DESIGN AND CONSTRUCTION OF 1KVA AUTOMATIC VOLTAGE REGULATOR (AVR)

BY

ISAH MOHAMMED TSADU

2003/15486EE

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

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A THESIS SUBMITTED TO THE DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

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NIGER STATE

DECEMBER, 2009

DEDICATION

This project is dedicated to Almighty God, who has been so wonderful to me. I also dedicated this project to my parents who are my source of finances and inspiration.

DECLARATION

I Isah Mohammed Tsadu declare that this work is done by me and has never been presented elsewhere for the award of a degree. I also hereby relinquish the copyright to t he Federal University of Technology, Minna.

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ABSTRACT

Design and construction of an automatic voltage regulator or voltage stabilizer is described in this report. The automatic voltage regulator serves as a means of safeguarding electronics appliances which are sensitive to voltage fluctuations. This project considers the design and construction of a 1KVA constant output voltage AC automatic voltage regulator which is cost effective and accessible to all users to overcome the problem of fluctuation in line voltage in various residents and establishments. The project is intended to produce a 220v output voltage within a considerable tolerance of ±6% with the input limit of 120v-270v. The design employs the principle of voltage regulator by sensing variations in the input voltage which is compared with a fixed voltage by a zener diode. The output is fed to the based of the 6 transistor serving as switches to the relays which ON with the corresponding output of 220v. Overload fuse protection and voltage indicator meter are introduced at the output.

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CHAPTER ONE

1.0 Introduction

Any electrical and electronics device that is capable of keeping the supply voltage at a constant value within an acceptable limit is called an AUTOMATIC VOLTAGE REGULATOR.

Most electrical and electronic appliances (devices) are very sensitive to voltage fluctuation so that the need to stabilize voltage supply is very important in this part of the country (Nigeria), in the world. The degree (level) of fluctuation is highly dangerous to many voltage sensitive appliances that tolerate a little degree of fluctuation to function effectively. The power line fluctuations and cut-offs causes damage to electrical appliances connected to the line. It is more serious in the case of domestic appliances like electric motor, which heat up and get damaged. For those devices to function effectively (perfectly), it is important to keep the supply voltage at constant value. This is achieved by automatic voltage stabilizer.

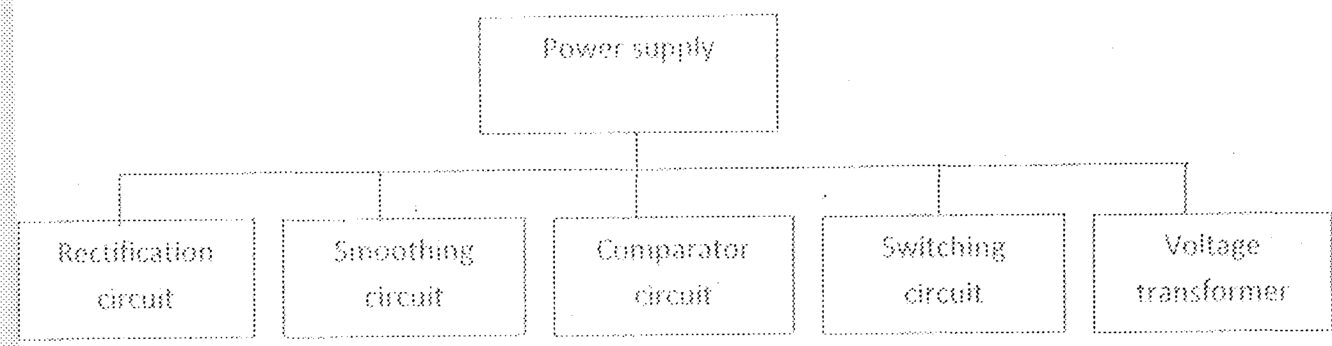
A voltage-regulator is generally used to maintain the voltage of line in the primary feeder voltage generally drops when a large load current is drawn or less voltage is available across the primaries of the distribution transformer. The regulator maintains the voltage at a proper rated value at all time.

This project, 1000VA high and low voltage cut-off automatic stabilizer is intended to meet the instiation of electrical and electronics engineering (IEEE) regulations.

Supply stabilized voltage with the input limit of 120 volts to 270 volts variations. This wide stabilization is a unique feature of this project and it is constructed especially to meet the extreme condition of main voltage fluctuation in Nigeria or any other countries where there is a great irregularity in their main supply.

However, automatic voltage regulation is achieved by some components and circuit connections which include; an automatic transformer which input voltage varies between 120 volt to 270 volt; this equipment operates by means of a control circuit which automatically changes the taps setting on the secondary winding while leaving the voltage applied to the primary winding alone.

The variable voltage in secondary winding can thus be added or subtracted from the incoming voltage resulting in an outgoing voltage which can be kept approximately constant even when the incoming primary voltage may vary.



Block Diagram

1.1 Aims and Objectives

The objective of this project is to provide a regulated voltage supply to electronics devices without fluctuations.

The inherent supply voltage from (PHCN) is inadequate to meet the demand place upon it by most equipment.

When the power supplied by (PHCN) network changes, the corresponding voltage drops along the line also changes accordingly, the voltage as seen by other consumers changes due to the length of the line which causes voltage drop along the line. If these are very frequent, the continuous variation may become annoying or irritating to the consumers. At the same time, voltage fluctuations may adversely affect the operator of many commonly used devices and appliances for examples; computer installations which their power supplies are sensitive to voltage fluctuations and spike. In addition, the continuous process plant can be seriously disrupter in its production. Moreover, the correct operation of equipment depends on a constant voltage within a safe limit. Therefore, voltage stabilization is necessary.

This IKVA automatic voltage regulator is a single-phase network filled with a regulative electro mechanical relays, which control the highly efficient auto-transformer that has the capacity to compensate for defeats in the mains supply with the specified range.

This project is expected to solve the problems of the negative effect or unregulated voltage such as; low heating time and short life of heating element of resistive loads when there is low voltage or high voltage, also to solve problem of overloading.

1.2 Motivation

In an ordinary power supply, the voltage regulation is poor ie d.c output voltage appreciable with load current. Moreover, output voltage also changes due to variations in the input a.c voltage. This is because of the following reasons.

In practice there are considerable variations in a.c voltage caused by outside factors beyond our control, this changes the d.c output voltage of most electronic circuits Electronic circuits will refuse to work satisfactorily on such output voltage fluctuations.

This necessitate the use of regulated power supply, this project is born out of the need for steady power supply to electronics and electrical devices and to equally serve as a guide against damages to electronic circuitry due to incessant power fluctuations as well as outages which are not safe to electronic requirements.

1.3 Methodology

The construction of automatic voltage regulator requires an auto-transformer which provides unregulated voltage supply and under the switching of six (6) relays and six (6) translators to give the regulated standard voltage at the output.

CHAPTER TWO

2.0 Literature Review

The location of electric power stations in long distant areas from the consumers, made the problem of voltage regulation more common, thus years of study and research by engineers has revolutionized the development of transformer.

Due to limiting factors encountered such as voltage drop, power losses on the low voltage distribution voltage regulation were necessary.

The earliest attempt at obtaining an automatic voltage regulator employed a motorized system controlled by a control circuit to change the taps on the secondary of the auto-transformer so to step up the voltage when the input voltage is low, or step down the voltage when the input voltage is high. This came as a result of variations in the transmission voltage. The motorized techniques has some limitations which includes it ease to weaken and wear-off due to the taps changing mechanism that is purely mechanical in operation, thus resulting in improper contacts between the changer and the taps of the transformer. Another problem encountered by the motorized techniques is that it is bulky and costly.

Another approach to the automatic voltage regulator was introduced which is called resonant circuit regulator. In this type of resonant circuit regulator approached. There are few components involve such as inductance of transformer, coupled with parallel inductance and capacitive resonant. Less current is drawn by the inductance and the parallel circuit combination becomes capacitive when the line voltage falls below the rated value. The capacitive current drawn through the transformer rises the output voltage if the line voltage rises above the rated value, the parallel circuit combination becomes less capacitive and the output falls below the line voltage.

Some of the short-coming of this resonant circuit regulator are: it is frequency dependent and was bulky hence it was later replaced by regulated d.c inversion automatic voltage regulator.

Phase controlled automatic voltage regulator, in this system the load is connected in series with the voltage controlling device, which is usually a silicon-controlled rectifier.

This method is very fast in response to the voltage fluctuate at the input. The voltage control is achieved by triggering a phase angle determined by the control circuit, in such a way that the voltage across the load is connected to the output voltage, the limitation of this method is that they have distorted output wave from.

The transistor-controlled regulation is known as the regulated d.c inversion approach. The regulated d.c output inversion approach. The regulated d.c output from the power supply is inverted using push-pull inversion and stepped up to the required constant A.C output voltage using a transformer.

Transistorized automatic voltage regulator is a present techoology approach, which brings an improvement on motorized automatic voltage regulator method. It overcomes difficulties or limitations realized in the previous approaches. It is relatively cheaper, light in weight and it has good regulation.

An electromechanical, relay replaces the mechanical tap change. It has an automatic transformer, which the turn's ratio can be varied to give desired regulations. The control circuit determines the position of the relay contact on the taps of the transformer. The control determines whether the low or high suppty voltage is to be stepped up or to be stepped down to the rated value at the output as the case may be.

The current drawn is detected by the load, the position of the relay contacts on the tap of the transformer is detected by the control circuit.

This automatic voltage regulator is lighter in weight and the size reduced. But like the previous approaches, it has its short comings namely; a fairly good percentage regulation and though the system response time is an improvement on the motorized automatic voltage regulator (AVR) approach, it is not fast enough.

As the development in technology continued there was need for another approach. In the 1960's a new field of micro-electronics was born primary to meet the requirements of military which wanted to reduce the size of its electronic equipment to approximately one-tenth of its then exising volume. This drive for extremely reduction in this size of electronic circuits led to the development of microelectronic circuits called integrated circuits (ICS) which are so small that their actual construction is done by technicials using microscopes.

2.1 Principle of Operation

When the circuit is connected to the mains supply, the voltage is stepped down to 12v by the auto-transformer. The output is rectified to d.c by a full wave bridge rectifier. The rectified output voltage is filtered by capacitor C_1 to remove ripples from it and it is passed through the regulating circuit consisting of zener diode, which holds the base potential irrespective of the variation in the load.

The input voltage is connected to the normally closed contact of relay (RLY). If the input voltage is up to 120v, the input of IC6 remains the same and relay 6 is not energized hence the normally closed contact of relay 6 remain closed so input is still gated into the auto transformation. However, if the input voltage goes below 120v, the inverting input falls below the zener voltage and the comparator output a high which energized relay 6 and the normally open contact of relay 6 close hence the input is disconnected.

There are main-conditions for operation of this switching circuit: for the first case when the input voltage is between120v to150v, the input of IC_1, goes higher than its reference voltage hence IC_1, outputs high. The normally open contact of relay 1 is closed at thee voltage level approximately 220v. The 220v is connected to the output through NO1 and $NC_2 - NC_8$

For the second condition which the input voltage is between 150v to 180v, the inputs, of IC_1 and IC_2 go higher than their reference voltages hence $IC_1 - IC_3$ output a high. The normally open contact of relay 3 closes at the voltage level approximately 220v. The 220v is connected to the output through NO_3 and NC_4. go higher than their reference voltage hence IC_1-IC_3 output a high. The normally open contact of relay 4 closes at the voltage level approximate 220v. The 220v is connected to the output through NO_3 and NC_5 – NC_8. It continuos for the third, foath, and the fifth conditions until it get to the six condition.

I the sixth condition, if the input voltage is between 240v to 270v, the inputs of IC_1 – IC_7 go higher than their reference voltage hence output a high. The normally open contact of relay 6 closes at the voltage level approximately 220v. The 220 is connected though NO_7 and NC_8. For the last condition, when the input voltage is 270v, the inputs of IC_1 – IC_8 go higher. The normally open contact of relay 6 closes at the voltage level approximately 230v. The 230v is connected to the output through NO_7.

CHAPTER THREE

This part discusses the basic theory underlying the operation and application of the various component and devices used in the design and construction or the stabilizer in this project. This is because the description of components' behavior is important for the prediction and understanding of the combined behavior and operation of the devices as one unit.

3.0 Theory of Operation

The main supply is stepped down to 12v by auto transformer the output voltage is rectified by diode DI-D4, as full wave bridge rectifier mode to D.C voltage .A capacitor C1 is connected across it to smoothen the in pulsation of the d.c voltage. The output from the filter network is connected directly to the other parts of the circuit. The output voltage from the limiting resistor R1 reduces the current flowing into the zener diode. The zener diode holds the base potential irrespective of variation in the input voltage.

In this project, six variation resistor Vrl-Vr6 are used, each of the variable resistors are connected to the input of non-inverting of op-amp 324 Icl - Ic6 respectively.

The non- regulated input are connected to the inverting pins of the op-amps so that the op-amp output will be in phase with the input.

There are six main conditions for the operation of this switching circuit. For the first case, when the input voltage from the supply between 120v-150v, the changing s reflected or sensed by the variable resistors. The ICl-IC6 compares the input voltage and the fixed threshold voltage V_{ref} [The voltage across Zener diode]. Since Vrl-Vr6 are adjusted in a such a way that only V_{r1} voltage is greater than the reference zener diode voltage which makes Icl output go logically high. The base of the T_{r1} will be at high potential, hence go forward in its emitter base region, the collector current flows to operate the relay coil RLY1 the normal open contacts closes at the voltage level approximately 220v, the remain in it position unit another condition arise.

For the second case, when the input voltage is between [120V - 150V] the comparator ICl-IC6 compares the input voltage and the reference voltage Vref. Since Vrl and Vr2 are highly potential, the ICl and IC2 output go logically high. The base of the transistor the transistor Tr1 and Tr2 will be at high voltage hence, RLY 1 and RLY2 operates at voltage level approximately 220V, the ICl and IC2 remain in their position until another condition at arises.

For the third case, when the input voltage is between [150V -180V] the comparator ICl-IC6 compares the input voltage and the reference voltage Vref. Since Vrl - Vr3 are highly potential, the ICl - IC3 output go logically high. The base of the transistor Trl -Tr3 will be at high voltage hence, RY 1 - RY3 operates at voltage level approximately 220V.the SCl - IC3 retain in their position until another condition arises.

For the fourth case, when the input voltage is between [210V -240V] the comparator ICl-IC6 compares the input voltage and the reference voltage Vref. Since Vrl - Vr4 are highly potential, the ICl - IC4 output go 'logically high. The base of the transistor Trl -Tr4 will be at high voltage hence, RLY1 - RLY4 operates at voltage level approximately 220v, the Ic1 - Ic4 remain in their position until another condition arises.

Finally, for the last case, when the voltage is between [240v-270v] the comparator Ic1 – Ic6 compares the input voltage and the reference voltage Vref. Since Vrl - Vr5 are highly potential, the ICl - IC5 output go logically high. The base of the transistor Trl –

Tr5 will be at high voltage hence, RLY1 - RLY5 operates at voltage level approximately 220v, the ic1 - ic5 remain their position until another condition rises.

3.1 Power Supply and Rectification

For electronic device to operate correctly there should be a suitable power source or supply which is in formed of D.C voltage or currents. This power is required especially for the active components used in the project such as diodes, and integrated circuit.

The currents supply for such devices is not always available from the main supply, so power equipment is necessary to convert the available supply.

3.2 Fuse

Fuses are electro thermal devices that are used to interrupt current flow through an electrical circuit. If the heating exceeds the thermal rating of the fusible element within the fuse. As current flows through the fuse element, heat, which is proportional to the square of the current, is produced. If the current exceeds the rating of the fuse then the heat generated by the current melt the fusible element thereby interrupting the current flow.

For this project at the input of the power supply to the TX due to the maximum load current of the transformer, which almost solve the problem of overloading and short circuit, which are enemy of electrical circuit design.

3.3 Rectifying Circuit

A rectification is defined as the process of producing a D.C voltage from an AC source mains supply. Rectifier must be able to pass current with ease in the forward, and block its flow in the reverse direction. The variable A.C voltage rectified is through a rectifying circuit. Here, a full wave bridge rectifier is used. At every positive half cycle, two diodes conduct, one in forward and the other in reverse biased mode and during the negative half cycle, the capacitor charges to peak applied voltage. When the voltage drops, the capacitor discharged IC through the load. Since electrolytic capacitor is usc to charge, the voltage is nearly a steady voltage but with variation called **"RIPPLE"**.

The DC output voltage can change for several reasons. The A.C voltage might increase, or decrease. If this happens, the output D.C voltage increases or decreases proportionately, to the input charge.

Because of this action, regulation in the circuit becomes very important. This supplies a constant voltage regardless of changes, in the current . For this project, IC regulator is used for reasons that they are easier and quicker to use they are versatile and relatively inexpensive.

3.4 The Bride Rectifier

In bridge rectifier, both the positive cycles and the negative cycles are utilized with the help of two diodes working alternatively. For full wave rectification, use of a transformer is essential (though it is optional for half wave rectification). Fig 1 shows a bridge rectifier circuit.

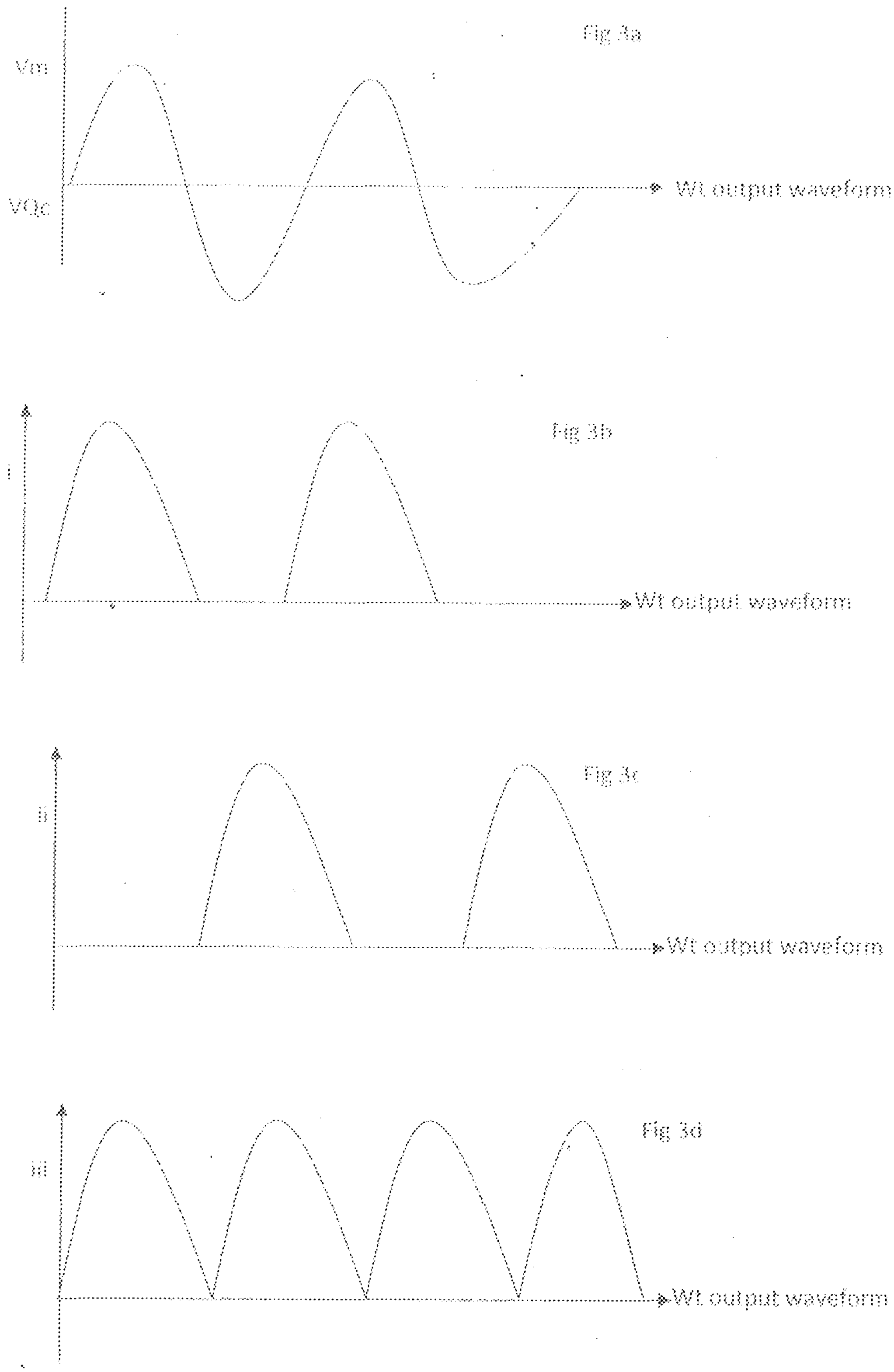


Fig 3.2 filtration unit or filter net work

These waveforms are the output waveform for bride rectifier circuit

All rectifiers allow current to flow in one direction only, but as the waveform shown in figure 3a. Though the current is unidirectional, it varies considerable in magnitude with a pronounced ripple is not a serious drawback. If the D.C is used to supply radio and amplifier cause an intolerable hum. In addition, there are circuits that may be adversely by the harmonic content of an un-smoothening rectifier current. Thus, there are many cases where some form of smoothing circuits must be added to the rectifier output. For this purpose, there are several forms of filter than can be employed. These include shunt capacitor filter, series inductor filter, choke input/L_C filter, R_C filter and C_L_C or Pi filter. For the purpose of this project a capacitor filter was used.

3.5 The Capacitor Filter

We need a constant output voltage with no ripples at the rectified output. Therefore, the main function of a filter circuit is to minimize the ripple content in the rectifier output, this is necessary in order to prevent the beak down of the electronics component from fluctuation. Smoothening for conversion of raw D.C from output of rectifying circuit to fine D.C is then necessary. This is a simple form of filter in which a capacitor is connected across the rectifier output in parallel with the load, as shown in fig 3. The rectified output wave is shown as a broken lines. This cause the capacitor to be charged to about the maximum potential difference of the rectifier wave as at point A the rectifier output voltage now drops, leaving the capacitor discharges through the load, enabling the load potential to be maintained at a high value.

The potential of the capacitor drops slightly as it is discharging, but at point B, the next wave from the rectifier builds up the capacitor potential difference again to point C where the process is repeated. This gives a conservable reduction in the magnitude of the ripple. The value of the capacitor must be such that its' reactance at the ripple frequency is small compared with the load resistance. A microfarad, 25volts capacitor was used for this project.

$V_r = \frac{V_p}{2fcr}$

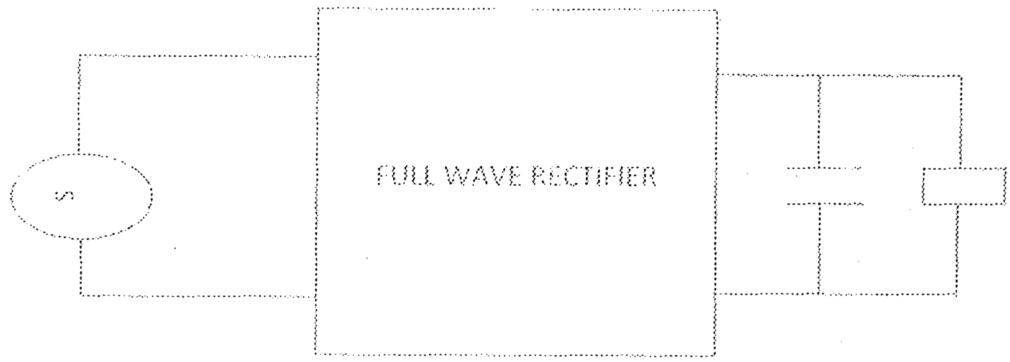


Fig 3.2 Full wave rectifier

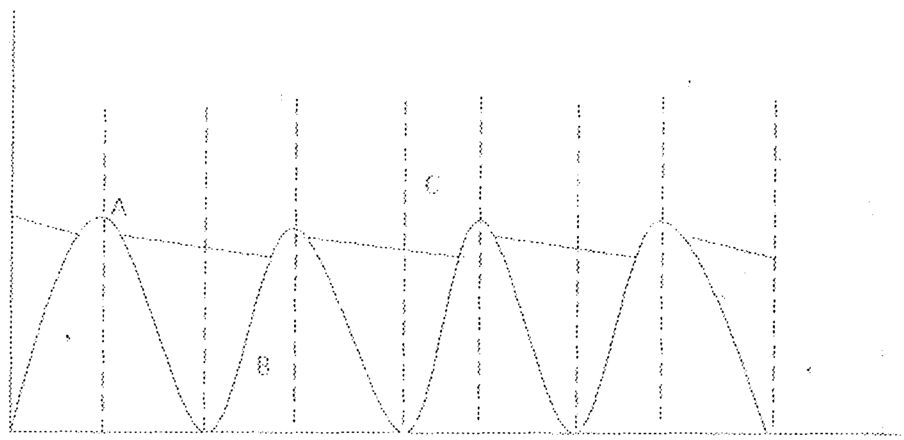


Fig 3.3 rectifier output waveform

3.6 Switching Circuit

A relay is an electrically controlled switch. in the usual type, a coil pulls an armature when sufficient coil current flows. A small current energized a coil, which creates a magnetic field that brings two contacts together, closing a circuit, which might carry many times the power, which energized the coils. .

The primary use of relay is in remote switching because it is important to keep the electronic circuit electrically isolated from the AC power line, relays are useful to switch AC power while keeping the control signals electrically isolated.

A relay is remotely and electrically operated switch containing one or more pairs of contacts that are available to effect the operation of other devices in the same or another electrical circuit also a relays are electron mechanical device that open or closes an electrical in response to a signal, which may be voltage, current, power, frequency, speed, temperature, pressure, flow, level, or any other physical phenomenon in case of this project the relays are operated by voltage in the circuit.

The relays consist of an operating coil located on an electromagnet in which armature is free to slide .

The output from the op-amps is incapable to operate the relays. However, its output is fed through a resistor into the base of transistors TR1-TR5. The collector current from biased transistor operates the relays and establishes the contact for the passage of current through them. The type of transistor used in this project is C1815 which has the following specification; power rating 360MVA, Collector current 100mA. Collector emitter voltage 20v VCB 30V, VBE 5mV.

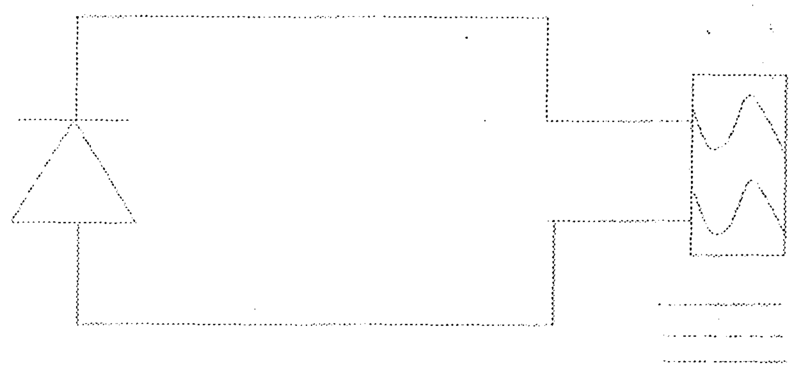


Fig 3.4 switching circuit

3.7. Comparator

The op-amps used in this project are general purpose electronics devices. This has the following characteristic.

1. High voltage gain
2. Infinite input impedance
3. Zero output impedance
4. Wide band width, with high degree of stability against temperature and any other environmental change.

The LM 324N consist of two independent voltage comparators, which operate from a single power supply over a wide range of voltages. The comparator circuit designed is to compare a voltage from the sensing circuit, which is fed to the non-inverting input of the comparator through a voltage divider network.

The output of the comparator circuit used is to control the switching circuit. In this project, the output voltage from the LM 324N is less than 12 volts and the voltage rating of the relays used is 12v, so since this cannot drive the relay there is need of transistors in the circuit for driving the relays.

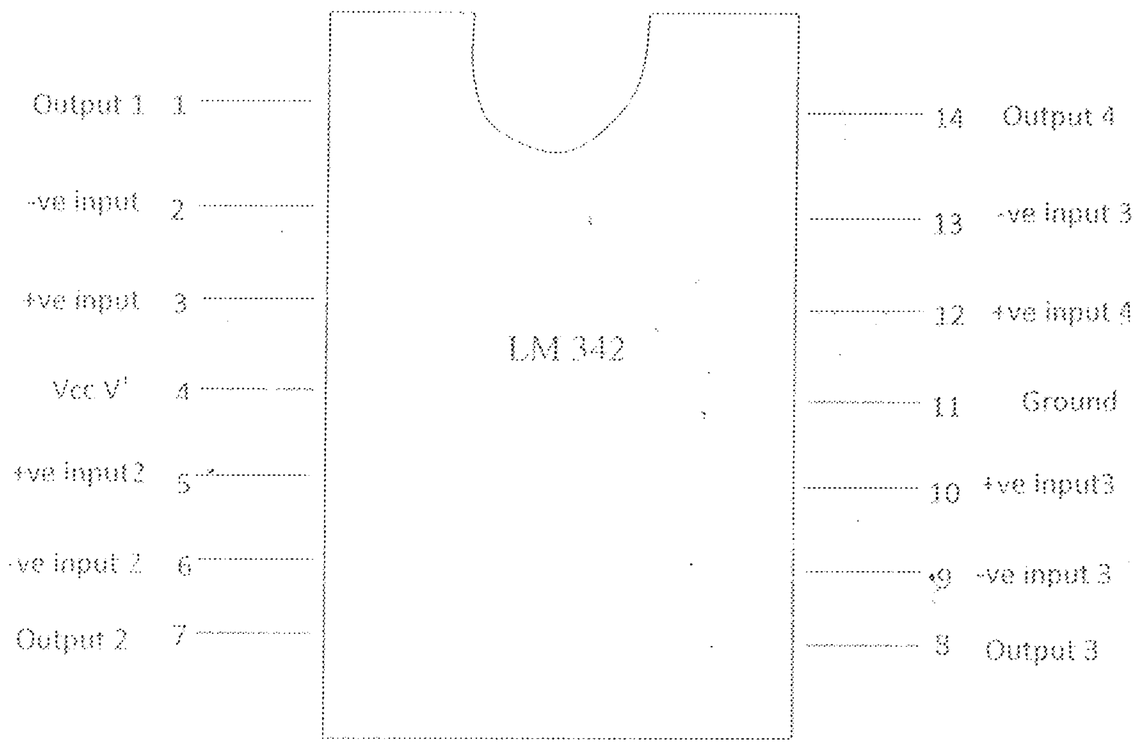


Fig 3.5 pin connection of LM 324

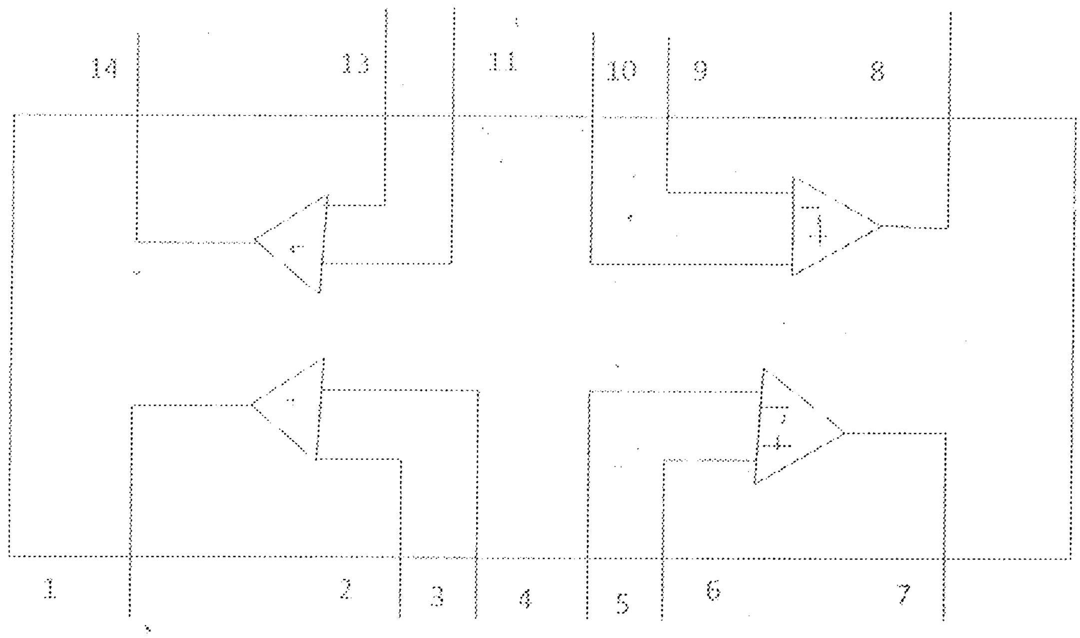


Fig 3.6 internal connection of LM 324

3.8 Control Unit

In this design, there are two-control circuits that monitor the behavior of the overall design. One of the controls circuits monitor the unregulated input voltage input voltage while the other monitors the regulated output to deliver to the load.

The control circuit consists of the regulation circuit and the switching circuit. The control circuits employ the principle of comparator for the operation where we have both the sensing and the reference voltages to compare. The resultant effect transferred to the output to perform some switching operation on the switching circuit.

3.9 Regulation

By controlling the amount of doping and the geometry of the junction a Zener diode is manufactured with breakdown occurring at a given reverse voltage (usually 6-18v) and to handle a given range of current (several milli-amperes). Carl Zener discovered this special kind of diode, the breakdown voltage, called Zener or reference voltage, is reproducible, as it does not result in the destruction of the diode. It finds use as voltage regulator in D.C power supplies. Regulation simple means stabilization of the voltage, which is achieved by the use of Zener diode as the voltage regulation. Since the OP-amps 342 in the switching control circuit is used as comparators. Therefore one of the inputs must be constant voltage will serve as voltage. This is achieved by the use of 6.5v Zener diode regulator.

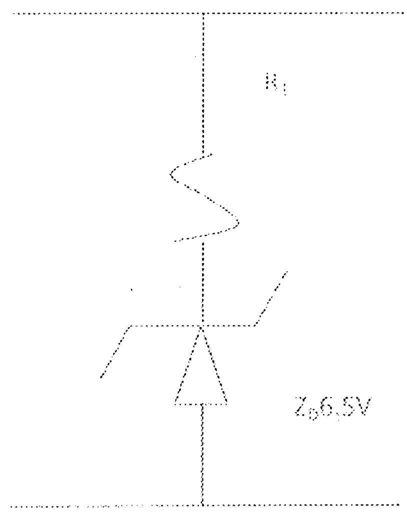


Fig 3.7 Regulation Unit

3.10 Transformer Basis

A transformer is a static (or stationary) piece of apparatus by means of which electric power in one circuit is transformed into electric power of the same frequency in another circuit. It can raise or lower voltage in a circuit but with a low voltage and delivers it at a lower voltage, it is called a step down transformer. The physical basis of a transformer is mutual induction between two circuits linked by a common magnetic flux

Basically, a single phase transformer consists of two windings, primary and secondary.

An autotransformer consists of a single coule wound on a magnetic core. The part of the coil common to both input and output sides of the transformer is called the common winding and the rest of the coil is called the series winding .

This is a specific type of transformer where the primary and secondary coils are connected in series with each other. The advantage of this connection is that, it has lower, smaller excitation current requirement, weight less and is cheaper than the equivalent two-winding transformer.

Often it becomes necessary to change the voltage in the transformer winding to allow for a varying input voltage on the transformer. Hence, the output voltage is held related to changing the transformer ratio.] Under-load tap change was used with the help of relay, which switches or changes the taps of the transformer for a different level of input according to the design specification.

When a load is connected to the secondary, a current will flow in the secondary winding that tends to produce an additional magnetic flux $\varphi 2$. $\varphi 2$ is a demagnetizing fluz that weakens the main flux φ. The supply voltage V_p, however, fixes the primary voltage. Thus, the primary winding must draw a current Ip from the supply so that it produces a flux $\varphi 1$ equl and opposite to $\varphi 2$. So, whatever the load, $\varphi 1$ and $\varphi 2$ always cancel out each others, and therefore never exist as separate fluxes.

This means that the magnetic flux φ is constant at all loads, so the iron loss also will be constant at all loads and will be the no-load value.

Advantage of a transformer and it's uses

1. A transformer is an electromagnetic device altering the ratios between voltage and current in the two electrical sub systems that couples.
2. Transformers are frequently used as impedance changing devices in measurement and instrumentation circuits.
3. Transformers are used for electrical isolation between circuits. This serves as a safety measure and to remove D.C components from complex waveforms.

3.11 Transistor

Transistors are semi conduct devices used as amplifier or switches. Transistors work in a similar fashion as mechanical switches with the advantage that, there are electrically controlled, and then switched at every faster rate. A transistor may be switched OFF and ON or ON and OFF in millionths of seconds or less. If a transistor is connected in a such away that when a voltage is applied across the base emitter terminal of an n-p-n transistor so that the p-type is positive with respect to the n-type, the p-n base emitter junction will be forward biased and current will flow in the base. This base current will cause the transistor to conduct between the collector and the emitter terminal. If the current is of sufficient magnitude, it will cause the transistor to conduct strongly.

In the ON state, the collector voltage is very small typically 0.35v or less silicon and even less for germanium transistors. Hence, nearly all the supply voltage appled is across the load giving the man circuit current (the collector current).

$$IC = \frac{Vcc - vcE}{RL} \approx Vcc \; as Vc \gg VcE$$

The base emitter junction reversed biased is when a negative voltage applied is across it, so no current fed is to be the base. Since base current is necessary to produce significant current flow through the transistor, the application of reverse bias results practically to zero collector's current.

In fact, there is a very small collector current known as the reverse collector situation current ICbo. Due to the flow of minority carriers across the collector bias junction which act as a reverse bias diode.

Under this condition, we may the transistor is in it is off or cut off state. In the off state, IC and the main circuit current is visually zero. The off state of the transistor is equivalent to a switch S when open.

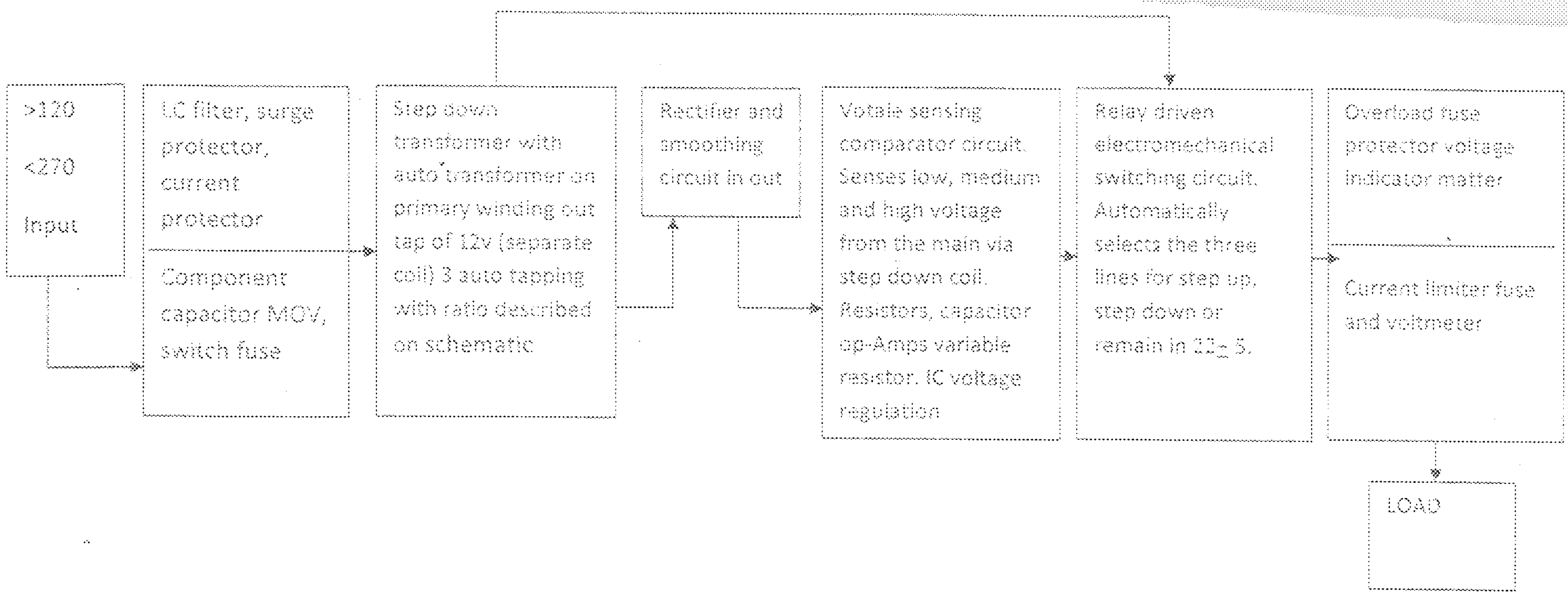


Fig 3.8 block diagram of automatic voltage

3.12 Voltage Referaces

The simplest form of voltage reference is the zener diode. Basically, it is a diode operated in the reverse bias region, which current begins to flow at some voltage and increase dramatically with further increase in voltage. To use it as a reference, you simple provide a roughly constant current, this is often done with a resistor from a higher supply voltage, forming the most primitive kind of regulated supply.

Zener diodes are available in selected voltage from 2V to 200V volts with power rating from a fraction of a watt to 5 watts and tolerance of 1% to 20%. For the purpose of this project, 6.5 volts zener diode was used to reference the voltage at the input of the comparator. The zener diode has the following characteristics, zener voltage 6.5 tests current 7.5ma, tolerance 5% max power 0.4w.

3.13 Theory of operation

The main supply down to 12v by 220/12v autotransformer. The output is rectified by diodes D1-D4, by a full-wave bridge rectifier to D.C A capacitor is connected in parallel across it to smoothen the in coming D.C voltage. The output from the fitting network is connected directly to the main circuit. The output rectifier voltage is used to drive transistors and relays.

The limiting resistor reduces the current flowing into the zener diode. The zener diode holds the base potential irrespective of the cariation in the load.

The a.c supply voltage Vp will produce an alternating magnetic flux in the iron core and assuming no magnetic leakage, φ will also link with the secondary winding.

These flux links with both primary and secondary windings and will induce the same value of electromagnetic force in each turn (v).

Therefore,

Induced e.m f in primary/induced e.m.f in secondary.

$$\frac{V_p}{V_s} = \frac{N_p}{N_s}$$

The no-load current of a transformer is very small causing negligible volt drop, so the induced e.m f in the primary will be almost equal to the supply voltage Vp and the induced e.m f in the secondary terminal voltage Vs. therefore Vp/Vs is approximately equal to Np/Ns.

For all practical purposes, it can be said that the voltage ratio of s single phase transformer is the same as the turn ratio losses. Thus the output is almost equal to the input i.e Ip Vpcos φp is approximately equal to Is Vscos φs.

But primary and secondary power factors are almost the same. Therefore IpVp is approximately equal to IsVs, Ip/Is which is approximately equal to Ns/Np.

For practical purpose, the current ratio is inversely proportional to the turns ratio.

3.14 Design, theory and specification

Output voltage 220v, it should be noted that the voltage is constant from the mains, but it is used for simplicity. The voltage stabilizer to be constructed has 1000VA as the specified rating with the IEE regulation.

In Nigeria the electricity is generated at the frequency of 50H, the flux density is termed to be 1.4 tesla, it has been proved that there is no 100% efficiency of transformer, hence, 90% efficiency is chosen for this density. The current density and space factors are 257(A/cm) and 0.5 respectively.

3.15 Design Calculation

For the objective of this project to be achieved, the following design assumptions were made.

i. Standard frequency is 50Hz
ii. Efficiency is 90%, since 100% efficiency is not practically realistic
iii. Space factor, s------0.5
iv. Staking factor, k----0.55
v. Current density for power transformer ---------257A

For the design, the power rating is 2KVA and the secondary winding should have 5 tapping recall.

E1 = primary voltage

E2 = secondary voltage

N1 = number of turns in the primary

N2 number of turns in the secondary

Power output is = 90% power input

Using PF $cos\theta = 1$

Voltage per turns = $E/_T = KS$

$$E/_T = 0.55 \times 0.5$$

$$E/_T = 0.275$$

$$T = E/_{0.275}$$

Let the secondary turn be labeled T_0 T_6

$$T_0 = 170/_{0.275} = 618\ turns$$

$$T_2 = 220/_{0.275} = 800\ turns$$

$$T_3 = 245/_{0.275} = 891\ turns$$

$$T_4 = 258/_{0.275} = 938\ turns$$

$$T_5 = 279/_{0.275} = 982\ turns$$

Current in the winding

$$I_p = VA/_{0.9V_p} = 1000VA/_{0.9} \times 220 = 5.05A$$

$$IS_0 = 1000/_{120} = 8.33A$$

$$IS_1 = 1000/_{150} = 6.66A$$

$$IS_2 = 1000/_{180} = 5.55A$$

$IS_4 = {}^{1000}/_{210} = 4.76A$

$IS_5 = {}^{1000}/_{240} = 4.16A$

$IS_6 = {}^{1000}/_{270} = 3.70A$

For the gauge of wire used,

Output is 1000 watts

Power factors (P.F) is unit at output voltage.

Choose maximum current density $(J) = = {}^{13mp}/_{mm^2}$. Cross sectional Area of

Coil is in mm^2.

Minimum area of copper required (min) mm^2

$= \frac{I_p}{I_{max}} = \frac{8.33}{13} = 0.64mm^2$ (for the input)

Minimum area of copper required

$= \frac{I_p}{I_{max}} = \frac{4.16}{13} = 0.32mm^2$ (for the output)

For the conversion table,

$= 0.64mm^2$ is approximately SWG 14.

$0.32mm^2$ is approximately SWG 16.

When SWG is the standard wire gauge

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

Let $Iz = Zener\ current$

$P = power\ rating$

$R_s = Current\ limiting\ Resistor$

$V_i = Voltage\ in$

$I_s = Full\ load\ current\ through\ the\ resistor$

For

$P = 0.5w; Vz = Vo = 9v$

Then

$I_z = {}^{P}/_{V} = {}^{0.5}/_{9} = 0.056A$

But

$I_z = Is = 0.056$

Therefore

$R_s = {}^{Vi}/_{I} = {}^{12}/_{0.056} = 215.82\Omega$

$Aprox. = 216\Omega$

CHAPTER FOUR

4.0 Construction

On appropriately coupling the control circuit with the auto-transformer which was implemented on a bread board, the construction of the AVR is achieved. The whole system is housed in a metallic casing which equally serves a heat sink for the transformer during operation, and traps electromagnetic interferences (EMI) generated as a result on the switching .The casing is perforated appropriately to allow for ventilation of the system during operation.

4.1 Testing of Components

Every constructed stage staring from the rectifier circuit, switching circuit, the autotransformer output, the voltage level indicators, was tested to see if they function perfectly according to the design.

The system was tested using television, radio, video and refrigerator. When each was connected to the output voltage of the AVR, all were functioning.

Prior the construction of the circuit, tests were carried out on the components to be used to ascertain that the auto-transformer used in good condition, a continuity test was carried out on it with multimeter set at the ohmic value.

Component such as resistors, capacitors transistors, diodes, op-amps and relay were tested appropriately, before the commencement of the construction.

Having tested the component to be used and found to be in good condition. The circuit design was first developed on the board. This was done to effect any necessary modification without having been soldered them, this also allows the observation of the performance of the circuit r\before transforing it to the board.

CHAPTER FIVE

5.0 Conclusion and Recommendation

5.1 Conclusion

This project was specially designed to meet the extreme condition of fluctuation of the supplied voltage which is very hazardous to many voltage sensitive devices Therefore, this project is intended to provide a regulated voltage of 220v within the input of 120V to 270V variations.

Because of its simplicity and number of components involved, the system constructed is easy to maintain in case of faults. Judicious choice of components based on available ensures ease of replacements when there is any failure.

5.2 Recommendation

Since most electronic products are designed with integrated circuit and are very sensitive to the variations in voltage, it is recommended that they should be connected to an AVR for protection against these changes in voltage as this can lead to break down of appliances.

The AVR should be used for load not greater than its capacity that is, it is advisable that the rating of the AVR should be slightly greater than that of the equipment it is meant to protect.

With more research into the construction and development of more AVRs, it is recommended that they should be constructed with an over voltage cut of facility to spare the equipment connected to this regulator from being damaged. Or they should be connected with an in-built alarm system SO that at the point the voltage is too high and it is dangerous to plug any sensitive equipment then the alarm will sound for caution.

The construction of this project has not just been easy and straight forward, so it is recommended that student should be exposed to more practical work before embarking on final year projects to easy some of the problem like those encountered during the compilation of this project.

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